Proposed draft for Mass Timber Task Force Guide

Date: 12/4/2023, Revised per notes take during 12/11/2023 Mass Timber Task Force Meeting

Edits by: Marco Lo Ricco~~,~~ and Laura Hasburgh USDA, Forest Service, Forest Products Laboratory

Shared with: Jordan Komp, Thornton Tomasetti and Laura Hasburgh, USDA FPL

3.1 Structural Design

The structural design should follow, at a minimum, the requirements of the National Design Specification referenced by the current version of the Wisconsin Commercial Building Code. The structural calculations provided to the AHJ should include calculations for both the standard design scenario and for any scenario that is based on performance-based design. A fire design scenario, where members rely on charring of the structure, for example, should be included in the performance-based design review.

3.1.1 Checking standards for updates regarding mass timber construction: Since the ~~2021~~ 2018 edition of the NDS added information pertaining to mass timber construction, the design team should check the most recent edition of this code-referenced standard for updates. The Special Design Provisions for Wind and Seismic (SDPWS), a companion reference to the NDS, provides both general and specific information for the design of prequalified mass timber lateral force-resisting systems.

3.1.2 Classification of structural components: Generally, structural components are categorized as part of the gravity or lateral force-resisting systems, but many components dual as members of both gravity and lateral load transfer. The design team should indicate the functions (gravity, lateral, or both) of mass timber structural components to facilitate review. To date, few mass timber lateral systems have been prequalified for seismic design, making use of alternative means and methods more likely for mass timber lateral systems. In addition, critical gravity system components, such as columns supporting multiple levels, should be identified for evaluation of structural and fire performance criteria if aspects of the design are beyond the scope of standard code provisions.

3.1.3 Determining need for performance-based structural design: In the context of mass timber buildings, there may be many reasons to implement a performance-based design. One common scenario pertains to fire safety, such ~~when~~as when exposed wood and the ~~the~~ insulative char ~~of timber~~layer ~~is, used~~are used to justify the fire endurance of the structure in lieu of the prescriptive encapsulation requirements of the standard code provisions. Other reasons may include use of mass timber components in lateral systems that have yet to be prequalified by code reference standards.

3.1.4 Identifying the model code used for design: Model codes, such as the International Performance Code for Buildings and Facilities (ICCPC), are designed to complement the standard IBC when the alternative means and methods provisions apply. The model used for performance-based design should be referenced to provide the peer reviewer and AHJ with a framework to evaluate the structural design methods.

3.1.5 Performance objectives: The level of performance and model code used for performance-based design should be clearly defined at the outset of a project. The design team should clearly communicate to reviewers the intent and criteria of performance-based design scenarios.

Commented [ML1]: Define "standard design scenario."

Commented [ML2]: Define "fire scenario."

Commented [HLFW3R2]: In the fire protection world, "fire scenario" is typically defined as "a set of conditions that defines the development of fire and the spread of combustion products throughout a building or portion of a buildings, the reactions of people to fire, and the effects of combustion products." Ultimately, fire scenarios describe factors critical to the outcome of fires, such as fire protection features, ignition sources, the nature and configuration of the fuel, fire characteristics, ventilation, occupants, and conditions of the supporting structure.

This is very different from the definition you put below so either we need to include the word "design" or come up with a different term.

3.1.6 Levels of performance: In all scenarios, the design ~~should~~ shall perform at least equivalent to the standard safety objectives of the code. Often, performance-based design is implemented to achieve performance objectives that are higher than code minimums. ~~In the fire scenario context, for example, if the standard code specifies a two-hour fire rating, then the performance-based design must meet that requirement as a minimum. Project stakeholders, however, may decide to exceed minimum requirements and opt for a three-hour fire endurance rating.~~ Whether the performance objectives meet or exceed the standard code design objectives should be clearly communicated in the introduction to the structural design. Generally, life safety and collapse prevention are the most common fundamental concerns, but project stakeholders may agree to higher safety or serviceability objectives than what is required by code.

3.1.# Structural Fire-Resistance

The design team shall provide clear documentation of what structural elements are considered exposed, protected with non-combustible materials, and/or partially protected. The design team shall clearly identify the required minimum fire resistance rating of each element per current prescriptive requirements and clearly outline the methods used to meet or exceed the minimum prescriptive fire resistance requirements.

For elements where the fire protection is provided by a combination of a non-combustible material and charring layer, the contribution of each toward the overall fire rating should be documented; with the contribution of the non-combustible materials (where applicable) providing a minimum of 2/3 of the overall required fire rating. For additional information on non-combustible protection, see Section 3.2.5.

The utilization of NDS provisions and calculations for the determination of char rates is a well-established and industry recognized procedure. For the scope of this guideline, the following additional items shall be considered:

- Load and resistance factor design (LRFD) Fire Factors: Fire Design Specification (FDS) for Wood Construction has included additional Fire Factors (not currently covered in NDS) for the use of Fire Factors with LRFD provisions.
- Extreme Event Loading: For loading in a fire scenario, the designer is referenced to the most current edition of the Fire Design Specification (FDS) for Wood Construction.

For exposed timber members (without non-combustible material) requiring fire ratings beyond the current provisions, the design team shall provide specific testing results to verify the char rates utilized for design. The char rates shall not be reduced beyond those calculated based on extrapolation of the current char rate models.

3.2.1 Minimum Fire-Resistance Ratings (FRR's)

Primary Structural Frame:

Buildings up to 180'-0" or 12 stories: 2 hours[1]

Buildings taller than 180'-0" or 12 stories: 3 hours[1, 2]

[1.] Roof support rating is permitted to be reduced by one hour where supporting a roof only (not including additional occupancies/loading)

[2.] For buildings not greater than 420 feet in building height, the fire-resistance rating of floor framing elements (e.g. CLT slabs and glulam beams) shall be permitted to be reduced to 2 hours.

Bearing Walls:

Refer to primary structural frame[3, 4]

[3.] No reduction for roof framing is permitted

[4.] Minimum fire-rating for exterior walls to be based on fire separation distance

Non-Bearing Walls and Partitions: 0 hours

Floor Construction and Associated Secondary Structural Members: 2 hours

Roof Construction and Associated Secondary Structural Members:

Buildings up to 180'-0" or 12 stories: 1 hour

Buildings taller than 180'-0" or 12 stories: 1.5 hours

Structural Connections

Fire-Resistance Rating to match, at a minimum, the lower of the connecting member(s) FRR.

Connections

Commented [HLFW4]: Connections need to be discussed by the Task Group.

Bearing type connections should utilize noncombustible protection, or require load tested (under a fire event) to achieve the FRR noted in section 2.1.1.

i. Connections utilizing intumescent paint for noncombustible protection should be load tested (under a fire event) to confirm compatibility between materials
ii. At the AHJ's discretion, the use of engineering analysis could be provided to validate the fire-resistance rating of connections per section 2304.10.1 of IBC 2021 - All other mass timber connections should be load tested (under a fire event) for the specified fire rating. - Testing should meet the requirements of Section 2.1.3

3.1.7 Referencing analysis models developed for standards outside the jurisdiction: Should the team consider sourcing material that has been developed for design according to other building codes, the design team should provide documentation, calculations or testing reports, demonstrating that serviceability and strength parameters meet or exceed those required or documented in the NDS.

Many mass timber and connection hardware products are used successfully around the world, where engineered forest products have been developed for construction and code standards are generally on par with The International Building Code (IBC). Load factors and statistical or analytical models used in codes outside the United States, however, differ, so it is recommended the team translate design methodologies from other standards into NDS parameters or values. Conversion factors should be clearly stated for evaluation.

The design team shall justify to the AHJ and Peer Reviewer, the use of the design recommendations, factors, and equations that are sourced from other codes. If a building code in another jurisdiction, such as the Eurocode or Canadian Standards Association, provides a design methodology that is useful, the design team is responsible for demonstrating that the methodology meets or exceeds governing code standards, such as the NDS or IBC, and fulfills project-specific performance-based design objectives.

3.1.8 Validation by testing to local standards: If analysis models or prior test data is not readily translated to NDS parameters or values, products may be tested and evaluated for compliance with IBC- or NDS-referenced standards, such as the ANSI/APA PRG 320 Standard for Performance-Rated Cross-Laminated Timber, ANSI/APA A190.1 Product Standard for Structural Glued Laminated Timber, or applicable qualification provisions for connections performance in wood materials.

3.1.9 Citing other references used for design: If references outside the scope of building codes and associated standards are used to justify the design, those references should be cited to acknowledge state-of-the-art research, analysis, and design checks used on the project.

References published by various research institutions or industry and professional organizations may be useful for mass timber design, such as the:

1. *CLT Diaphragm Design for Wind and Seismic Resistance* (Woodworks)
2. *U.S. Mass Timber Floor Vibration Design Guide* (Woodworks)
3. CLT composite decking or slab research (numerous sources)
4. *Hybrid Steel Frames with Wood Floors* (AISC)
5. *2022 Fire Design Specification (FDS) for Wood Construction*
6. *CLT handbook: U.S. Edition*

(Listing is not comprehensive nor indicative of the order of importance of these documents.)

Sources of technical information should be clearly identified to facilitate review of the technical approach.

Commented [HLFW5]: Does the Task Group want to have references for each section or one larger section at the end indicating various applicable references? I prefer the later since many of these references would be repeated between sections because they cover multiple topics.

Commented [ML6]: Details of these example publications should be provided in a bibliography.

3.2 Fire Safety

The fire safety features (passive and active) beyond those described in the structural section of this guide shall provide the same protection, or greater, to meet the goals of life safety for occupants, safe access for firefighters, and protection of property. This section provides an overview of additional fire protection features that shall be included to ensure fire safety in timber buildings.

3.2.1 Prevention of Ignition and Control of Fire Development/Spread

The risk of accidental fire must be reduced. Additionally, should a fire occur, the severity, duration, and spread must be controlled. The risk of ignition is accomplished by ensuring potential ignition sources are away from combustible materials and by selecting equipment with fire-safe features and design.

In the case of ignition, the rate of fire development and subsequent heat and smoke production must be controlled. For mass timber structures, this can be achieved by compartment geometry to reduce radiant feedback, proper selection of construction materials including interior finishes and exterior walls designs, ventilation control including pressurization and smoke extraction systems, compartmentalization with fire walls and smoke barriers, and adequately designed suppression systems.

3.2.2 Fire Detection and Notification

A fire detection system that provides early detection must be installed throughout any mass timber structure. The system shall notify occupants, emergency personnel, and activate any active fire protection systems such as a smoke extraction system, door releases, or a suppression system. The system operation must be well documented and agreed upon by the location fire department.

3.2.3 Fire Suppression

Automatic fire suppression systems are required for all mass timber structures and properly designed in accordance with NFPA 13 for each hazard identified within the structure. When approaching design considerations outside of the prescriptive requirements, additional redundancies within the fire suppression system (sprinkler system and standpipe system) shall be considered.

iii. Dual water supply for buildings 120 feet and above (IBC 403.3.2)

i. Water supply in accordance with 2021 IFC 3313 and 2021 IBC 3313

Notes regarding 3.2.4 iii.)

[F]403.3.2Water supply to required fire pumps.

In buildings that are more than 420 feet (128 000 mm) in building height, required fire pumps shall be supplied by connections to no fewer than two water mains located in different streets. Separate supply piping shall be provided between each connection to the water main and the pumps. Each connection and the supply piping between the connection and the pumps shall be sized to supply the flow and pressure required for the pumps to operate.

Exception: Two connections to the same main shall be permitted provided the main is valved such that an interruption can be isolated so that the water supply will continue without interruption through no fewer than one of the connections.

3.2.4 Egress

- All egress paths shall be maintained with non-combustible construction.
- Stairwells and elevator shafts shall be of non-combustible construction.

3.2.5 Passive Fire Protection

Passive fire protection systems are intended to prevent the premature collapse of a structure in a fire (structural stability and limit the spread of fire and products of combustion (smoke) from the room of fire origin to other areas of a structure. See Section 3.1.# on structural fire resistance and structural stability. To limit the spread of fire and smoke, compartmentation, fire and smoke barriers, protection of openings (fire stopping, fire doors, and fire glazing), and proper building envelope design to prevent external fire spread shall be designed given additional consideration.

Of particular concern in mass timber structures is the intersection of walls/ceilings and beams/columns. These areas have been shown to promote smoldering combustion and may fail if not properly installed. Details must be provided and application of any protective materials (e.g. fire caulking, coatings, coverings, etc.) shall be inspected prior to occupancy.

3.2.5.1 Concealed Spaces

There shall be no exposed mass timber in concealed spaces; concealed space permitted only with noncombustible protection as required for the interior mass timber.

1. Prohibition of concealed spaces 4HT has been removed. – (KA comment – concealed spaces language in the IBC and its commentary are not in agreement. For discussion.) gypsum detailing

a. Lean on prescriptive method. (KA comment – gypsum detailing requirements have been defined by Fire Design Specification for Wood Construction – Wood Products Council.)

3.2.5.1 Exterior Walls (Façade):

- " Exterior side of exterior walls protected by a non-combustible material—e.g., 5/8" Type X gypsum sheathing"

- " No combustible exterior wall coverings except for certain water-resistant barriers"

- " No exposed mass timber on the inside and outside surfaces of exit enclosures and elevator hoistways in high-rise buildings (occupied floor > 75 feet from lowest fire department access)"

- " Noncombustible construction only for exit enclosures and elevator hoistways greater than 12 stories or 180 feet"

3.2.5.1 Non-combustible Protection:

Shall follow IBC 2021 section 722.7. Korb previously noted some general concerns regarding discrepancies in the IBC 2021 code (section 722.7). It is recommended that the guideline specify specific detailing requirements in lieu of relying on a reference to IBC 2021.

"Proposal FS81-18 (new IBC 722.7) defined the level of noncombustible protection required and how to achieve this level, including a prescriptive method recognizing 1/2" Type X gypsum board providing 25 minutes of protection and 5/8" Type X gypsum board providing 40 minutes of protection. Proposal FS5-18 (new IBC 703.6) defined methods to determine the level of noncombustible protection provided by other applied materials through using the E119 test procedure. FS73-18 (IBC 718.2.1) added mass timber as a fire blocking material."

3.2.5.2 Joints and Intersections:

Sealing of adjacent mass timber elements per 703.7. Sealants shall meet the requirements of ASTM C920. Adhesives shall meet the requirements of ASTM D3498.

Fire blocking materials to meet the requirements of IBC Section 718.2.1

3.2.5.2.3 A new code section, IBC 703.7, was included in proposal FS6-18. It required that certain adhesives be applied at abutting edges and intersections of fire resistance-rated mass timber elements unless the assembly has been shown to provide the required FRR without utilizing sealants.

3.4 Fire Engineering Consultant and Peer Review

TT Thoughts: For buildings higher than 12 stories or 180' (only)

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Qualifications and Selection

- Previous Mass Timber Experience

- Selected by Ownership/Design to be approved by AHJ

-Scope

1. Review mass timber framing and connections protection in concealed areas

2. Review mass timber connections in exposed connections

3. Review gypsum detailing per requirements of Section 3.2.2.2.

4. Smoke evacuation

5. Review testing provided by manufacturers for compliance with relevant standards

TT Thoughts:

Qualifications and selection

For each project higher than 12 stories or 180', a Mass Timber Peer Review Panel (MTPRP) shall be convened

The MTPRP shall be a panel or a structural engineering firm with at least three (3) members with previous experience in relevant mass timber buildings

The MTPRP shall be selected by the Building Official based on their qualifications applicable to the Mass Timber Peer Review of the project. The Building Official may request the opinion of the Project Sponsor and EOR on proposed SPRP members, with the Building Official making the final decision on the MTPROP membership.

The MTPRP shall bear no conflict of interest with respect to the project and shall not be part of the design team for the project.

The MTPRP provides their professional opinion to and acts under the instruction of the building official

Review scope

To provide an independent, objective, technical review of those aspects of the building design that relate to the structural performance of the building according to the requirements and guidelines described on this building, and to advise Building Officials whether the design generally conforms to the intent of this documentation and other requirements set forth by the Building Official

Review structural calculations, under normal conditions and under a fire scenario; including the use of foreign codes, where applicable.

The MTPROP shall be convened as early in the structural design phase as practicable.

3.2.2.3 Fire Testing/Certification Requirements:

Testing to be completed, and results certified, by an independent, accredited 3rd party testing agency. Testing procedure and results to be reviewed for approval by Project AOR, EOR, Fire Engineer, and AHJ.

Glossary terms

Standard design scenario includes load combinations that would typically drive the structural design. In the context of the International Building Code (IBC), the standard design scenario includes the prescribed load combinations. In the context of the International Performance Code for Buildings and Facilities (IPCC), the standard design scenario includes "expected loads" in combinations. Designers may use standard load combinations or develop their own rational engineering models of load combinations to meet performance requirements. Standard load combinations prescribe load cases and factors. Load combinations developed for performance-based design use Mean Recurrence Intervals, or Mean Return Periods, and probability models to set criteria and manage risks. Risk criteria of the performance-based design cannot be greater than the risks assumed in the development of standard load combinations.

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Fire design scenarios typically consider reduced magnitudes of live and transient loads acting in combination during the fire and reduced structural capacity if mass timber structural components are expected to char. The scenarios, furthermore, may include the effects of standard time-temperature profiles and fire configurations, representative of minimum prescriptive building code requirements, or custom time-temperature profiles and fire placement configurations to develop custom performance objectives. Again, risks of collapse during the performance-based scenarios cannot be greater than the risks assumed in the prescribed standard models.

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References

An Alternate Procedure for the Design and Permitting of (Tall) Mass Timber Buildings

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~~3-23-2023~~6-10-2024

An Alternative Procedure for the Design and Permitting of (Tall) Mass Timber Buildings

~~2023~~ 2024 Edition

A consensus document developed by the Wisconsin Mass Timber Task Force

Task Force Active Members:

Richard Paur, Chairperson

Justin Gavin

Wisconsin Department of Safety and Professional Services Representative

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TABLE OF CONTENTS - DRAFT

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IDEA: what inspectors look for, methodology of inspection

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IDEA: Add F&Q section, Mechanical Section

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Appendix - DRAFT

I. References and Recommended Resources

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I believe Marco (FPL) offered to spearhead

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~~IDEA: Intro to mass timber as a construction method (American Wood Council for help)~~

About the Mass Timber Task Force

The Mass Timber Task Force was created under Wis. Stat. § 227.13 to advise the Department and the Commercial Building Code Council on matters relating to development of mass timber guidelines.

The agency utilized informal conferences and consultations to obtain the viewpoint and advise of interested persons with respect to contemplated rule making. The agency appointed a committee of experts, interested persons or representatives of the public to advise it with respect to any contemplated rule making. The committee shall have advisory powers only.

Members:

Paur, Richard (Chairperson)

Hasburgh, Laura

Komp, Jordan

Korb, Jason

Lo Ricco, Marco

Mazmanian, Michael

Roden, Erich

Timmer, Alexander

Gavin, Justin

~~[A]104.11 Alternative materials, design and methods of construction and equipment. The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety. Where the alternative material, design or method of construction is not approved, the building official shall respond in writing, stating the reasons why the alternative was not approved.~~

~~[A]104.11.1 Research reports. Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from approved sources.~~

Commented [JK6]: Previous Idea: Intro to Mass Timber as a construction method (AWC)?

Is this necessary beyond what is already included, and/or for the intended audience? I would think only if we want to discuss how Mass Timber is permitted in other countries?

1. Intent, Scope, and Justification

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1.1 Intent

The intent of the guidebook is to provide a framework for design professionals to work with permitting officials to facilitate the approval of (tall) Mass Timber structures, utilizing a performance-based design approach. The alternative design methods and materials described in this guidebook must provide, at a minimum, an equivalent level of quality, strength, fire resistance, durability, and safety, as buildings of similar height, occupancy, and area; as they relate to the Wisconsin Commercial Building Code, with references to the International Building Code.

1.2 Scope

The scope of this guidebook is to identify a methodology for the design, review, and approval of mass timber or composite mass timber buildings beyond the prescriptive provisions of IBC Type IV construction.

1.3 Justification

The Wisconsin Commercial Building Code (CBC) and the International Building Code (IBC) have existing provisions for alternative building materials, as well as the use of a performance-based design approach, both in lieu of a standard prescriptive code approach.

Alternate Building Materials

SPS 361.03 (6): *"Nothing in chs. SPS 361 to 366 is intended to prohibit or discourage the design and utilization of new building products, systems, components, or alternate practices, provided written approval from the department is obtained first."*

SPS 361.50 (2): *"Materials, equipment, and products that meet the intent of chs. SPS 361 to 366 and which are not approved under sub. (1) shall be permitted if approved in writing by the department.*

Approval of materials, equipment, and products shall be based on sufficient data, tests, and other evidence that prove the material, equipment, or product meets the intent of the standards specified in chs. SPS 361 to 366.

Tests, compilation of data, and calculations shall be conducted by a qualified independent third party."

Performance Based Design

IBC 2021 – Appendix O: *"Appendix O provides an optional design, review and approval framework for use by the building official. Typical uses would include cases of alternate methods in Chapter 1, select areas of the code that require a rational analysis such as Section 909 and elsewhere. It simply extracts the relevant administrative provisions from the ICC Performance Code into a more concise, usable appendix format for a jurisdiction confronted with such a need. Currently there are multiple, varying jurisdictional rules and procedures in many communities regarding procedure and none in even more. The building official is often left alone to reach*

decisions not just on the merits of a design, but must first also decide on the submittal and review process. As an appendix, the provisions herein are entirely optional to a jurisdiction. This appendix can be adopted, adopted with local modifications, or even used on a case-by-case basis as part of a Memorandum of Understanding or similar legal agreement between the jurisdiction and the owner/design team. It simply represents another tool for the jurisdiction to reach for in cases of need; it neither encourages nor creates any additional opportunity for performance-based design."

The utilization of alternative building materials and design methods are contingent on approvals from the Wisconsin Department of Safety and Professional Services (DSPS). This guidebook outlines practices that have been used prior to the establishment of the Task Force, focusing on their implementation with respect to (tall) Mass Timber structures.

This guide would recommend the mass timber design align with the performance objectives utilized by the Ad Hoc Committee on Tall Wood Buildings (TWB) in providing guidance on the development of future code change proposals, primarily:

1. *No collapse under reasonable scenarios of complete burnout of fuel without automatic sprinkler protection being considered.*
2. *No unusually high radiation exposure from the subject building to adjoining properties to present a risk of ignition under reasonably severe fire scenarios.*
3. *No unusual response from typical radiation exposure from adjacent properties to present a risk of ignition of the subject building under reasonably severe fire scenarios.*
4. *No unusual fire department access issues*
5. *Egress systems designed to protect building occupants during the design escape time, plus a factor of safety.*
6. *Highly reliable fire suppression systems to reduce the risk of failure during reasonably expected fire scenarios; the degree of reliability should be proportional to evacuation time (building height) and risk of collapse.*

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2. Permitting and Variance Process

For projects utilizing the alternate design methods and materials outlined in this guide, the following permitting and variance process in recommended.

2.1 Preliminary Meeting

~~*Note: peer review should be included here*~~

A preliminary meeting, likely occurring in the Concept/Schematic Design phase of the project, to introduce the project to the Authority Having Jurisdiction (AHJ), including the following items:

1. Project Location
2. Project Parameters (Height, Number of Stories, Material Exposure,…)
3. Project Timeline
4. Unique/critical project details
5. Design Team Proposed Variance Path (e.g. utilizing this guide)
6. Preliminary AHJ/Fire Department Questions
7. Schedule Next Steps

It is recommended the following parties are in attendance:

1. Authority Having Jurisdiction
2. Fire Department
3. Ownership
4. Architect on Record (A.O.R.)
5. Engineer on Record (E.O.R.)
6. Fire Engineer (if on-board)
7. Contractor (if on-board)
~~7.~~8. Peer Reviewer (if on-board)

2.2 Process Approval

Based on the introductory meeting, and initial feedback from the AHJ/Fire Department, the design team should formally propose a Variance/Permitting Approval Process (e.g. the Alternate Materials provision, the use of this guide…), including what, if any, supplemental testing, reports, or documentation will be provided in the formal variance.

After reviewing the proposal, the AHJ should formally approve or reject the variance **process**, including any required modifications or supplement documentation to the design team proposal.

2.3 Petition for Variance

Based on the previously accepted variance process, the design team/ownership should formally issue a "Petition for Variance" (or potentially multiple variances depending on the project).

The petition should include the following:

1. The code section(s) being petitioned
2. The variance request
3. The intent of the code section being petitioned
4. Petitioner's comments, including what supplemental documentation (e.g. letters, reports, test results, peer reviews, fire engineering) will be provided with the future issuance of the Permit Documents

If deemed acceptable, the AHJ should provide "Conditional Approval" of the Petition for Variance, noting any specific conditions of approval (e.g. the petitioner carrying out all items noted in the original petition).

If deemed unacceptable, the AHJ should clarify why the petition was rejected, or note what modifications would be required for approval.

~~2.4~~ Issuance of Permit Documents
2.4

~~Outline the Standard Permitting Process (Drawings, Specifications, Calculations)~~

It is recommended the following ~~The~~ permit documents (at a minimum) should ~~also~~ be issued to the AHJ, as well as the previously approved Independent Third Party Peer Reviewer, if applicable (refer to ~~s~~Section 3.4 for additional information regarding the peer review process)

1. Design Narrative
    a. Justification to the AHJ and Independent Third Party Peer Reviewer for use of proposed Mass Timber design/construction. Including code references, recommended design methodology, and associated code design factors and equations.
        i. If the team is proposing the use of Mass Timber elements or hardware sourced outside the United States, it is recommended the design team provide supplement documentation demonstrating design equivalency between Eurocode (or other foreign code) serviceability and strength parameters, with those documented in the applicable United States design standards (e.g. NDS and ANSI). The design team shall justify to the AHJ and Peer Reviewer, the use of the design recommendations, factors, and equations provided by these codes, in accordance with American Standards.
    b. Description of each mass timber component (structural and non-structural), delineating primary and secondary framing members
2. Construction Documents (e.g. drawings and specifications for all disciplines/trades)

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~~a.~~ Structural: Typical Mass Timber framing schedules, material properties, and assumed loading (e.g. loading diagrams)

a.

b. Architectural: XXXXXXXX

c. MEPFP: XXXXXXX

d. Other: XXXXXXX?

3. Structural Calculations
   a. Standard strength and serviceability calculations, both for Mass Timber and non-Mass Timber elements. These calculations should consider both standard design scenarios (load combinations) as well as the fire safety scenario(s), in the event the members are relying on encapsulation or charring of the structure to meet an prescribed endurance rating.
   b. Should the team consider sourcing material (timber/hardware) outside of the United States, it is recommended the team provide an additional equivalent Eurocode design for the controlling members/designs. The peer reviewer (where applicable) should review and comment on the conversion factors from codes outside the United States to NDS parameters/values.
4. Additional Documentation
   a. Additional information required to supplement standard code previsions, design drawings, and structural calculations; which could include material or member certifications, such as:
      i. Glulam fire test reports (e.g. char rates beyond 2 hours)
      ii. CLT compliance with PRG-320 (2018 or beyond) to avoid heat delamination
      iii. CLT un-restrained load-bearing floor/ceiling assembly fire test results, in compliance with ASTM E119-16a *Standard Test Methods for Fire Tests of Building Construction and Materials*
      iv. Connection load-bearing fire-test(s) in compliance with ASTM E119-16a, or supplemental fire engineering per IBC 2021, Section 2304.10.1
      v. Proprietary component testing/ICC reports/documentation/calculations
      vi. Documentation for provisions and standards associated with materials (timber/hardware) sourced outside of the United States (or not in accordance with typical US testing/standards).

~~3.1.3 Submittal requirements~~

~~1. Calculations~~

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Calculations provided to the AHJ should address the:

a. Fundamental structural design scenario through analysis of standard load combinations, and

b. Fire safety scenario, where members rely on encapsulation or charring of the structure to meet an endurance rating and prevent collapse.

2. Design and construction documents

Drawings should include a narrative explaining the use of mass timber structural components and delineate framing members and panels used as slabs or decking. Schedules for beams, columns, braces, and connections, should be provided, as customary for communicating the design of any structural material.

A loading plan should also communicate the loads to which mass timber components are designed. Layups and assumed design stress limits, modulus of elasticity in each orthogonal direction, and shear modulus in each orthogonal direction should be listed in the general notes section of the plan set.

3. References

The sources of substantiating information from tests, design standards, engineering reports and research articles should be clearly cited in the peer review calculations.

1. U.S. standards

a. Because the recent 2021 edition of the NDS specifically address cross-laminated timber (CLT), it is recommended the design team utilize the latest version of this design standard.

b. For main lateral-force resisting systems (MLFRS) including CLT diaphragms and shear walls, in particular, designers should reference 2021 Special Design Provisions for Wind and Seismic (SDPWS) as a general framework. It is likely that future editions of these documents will include more detailed and specific information on mass timber systems, to supplement the current general framework.

c. AWC technical report No. 10, Calculating the Fire Resistance of Wood Members and Assemblies provides guidance for calculating the fire endurance of timber structures with architecturally exposed surfaces.

d. ANSI/APA PRG 320: Standard for Performance-Rated Cross-Laminated Timber is referenced by building codes. Mass timber panels beyond the scope of this document should demonstrate performance with testing and calculations to demonstrate equivalent or enhanced performance.

e. ANSI A190.1-2022 Product Standard for Structural Glued Laminated Timber is referenced by building codes. Mass timber framing beyond the scope of this document should demonstrate performance with testing and calculations to demonstrate equivalent or enhanced performance.

3. Foreign Standards

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~~Where current state of the art research and documents associated with mass timber fall outside of the United States, references des to foreign codes should check underlying assumptions of design equations and compare models with the design philosophies developed in the United States.~~

~~The design team should justify to the AHJ and Peer Reviewer, the use of the design recommendations, factors, and equations provided by these codes, in accordance with U.S. Standards.~~

~~If the team specifies material (timber/hardware) sourced outside of the United States, the design team should provide documentation providing equivalency between Eurocode serviceability and strength parameters with those documented in the NDS and applicable ANSI standards. For these materials, it is recommended the team provide an additional equivalent Eurocode design for the controlling members/designs. The peer reviewer (where applicable) should review and comment on the conversion factors from codes outside the United States to NDS parameters/values.~~

~~2.5 Issuance of Permit Documents~~

~~Outline the Standard Permitting Process (Drawings, Specifications, Calculations)~~

~~The permit documents should also be issued to the previously approved Independent Third Party Peer Reviewer, if applicable (refer to section 3.4 for additional information regarding the peer review process)~~

~~Update per Peer Review / AHJ Comments~~

~~2.6~~2.5 Permit Approval

Prior to formal issuance of the permit, all AHJ and Peer Review comments should be addressed to the satisfaction of the AHJ.

Formal Issuance Process

~~i.~~ Buildings approved under type IV construction

i.

ii. Review of design team Documentation (refer to section 2.4);

iii. XXXXXXXXXX

~~i.~~

~~1. Structural package~~

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E.g. review of 3rd party peer review comments, questions/clarifications from AHJ, formally signing the variance, formal permit issuance...

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a. For members with fire protection based on a protective char layer, supplemental calculations to be provided for both standard occupancy, and extreme event (fire) scenarios.

2. Glulam fire test report (for chars beyond 2 hours)

3. CLT compliance with PRG 320 (2018 or beyond) to avoid heat delamination

4. CLT un-restrained load-bearing floor/ceiling assembly fire test (where fire performance not proved by char) in compliance with ASTM E119-16a *Standard Test Methods for Fire Tests of Building Construction and Materials*

5. Connection load-bearing fire test (for connections) in compliance with ASTM E119-16a, or supplemental fire engineering per IBC 2021, Section 2304.10.1.

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~~3.~~ **Analysis, Design, and Detailing**

~~Outline of Section~~

~~*3.1 Structural design*~~

~~3.1.1 Performance objectives~~

~~1. Load combinations~~

~~2. Fire endurance rating~~

~~3. Serviceability criteria~~

~~4. Redundancy and progressive collapse mitigation~~

~~3.1.2 Scope of performance-based design~~

~~1. Load path classifications~~

~~2. Lateral force-resisting system~~

~~3. Hybrid system~~

~~4. Composite action~~

~~5. Integrity~~

~~3.1.3 Submittal Requirements~~

~~1. Calculations~~

~~2. Drawings~~

~~3. Substantiating documents~~

~~1. U.S. standards~~

~~2. Voluntary design guides and technical resources~~

~~3. Foreign standards~~

~~4. Test Data~~

~~3.1.4 Proprietary components~~

3.

~~For Type IV construction, beyond the prescriptive requirements of the adopted building code, it is noted that an alternate, performance-based, pathway is available for design and permitting.~~

~~The goal of this chapter is to provide guidance on design parameters, as well as any necessary supervision by third party professionals (where required), to meet the performance goals agreed to with the AHJ.~~

~~3.1 Structural Design~~

For Type IV construction, beyond the prescriptive requirements of the adopted building code, it is noted that an alternate, performance-based, pathway is available for design and permitting.

The goal of this chapter is to provide guidance on design parameters, as well as any necessary supervision by third party professionals (where required), to meet the projects performance goals. These performance goals/objectives, which should be agreed to between all project stakeholders (design team, ownership, AHJ…) early in the approval process; and could include (among other topics) design load combinations, fire endurance ratings, serviceability criteria, and structural load path (including redundancy/progressive collapse mitigation).~~The structural design should follow, at a minimum, the requirements of the National Design Specification referenced by the current version of the Wisconsin Commercial Building Code.~~

3.1 Structural Design Considerations

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The structural design should follow, at a minimum, the requirements of the National Design Specification referenced by the current version of the Wisconsin Commercial Building Code; however, performance-based design objectives may be set higher than typically required by code to minimize damage to the structure, architectural and/or mechanical systems, and building contents.

Standard code required load combinations (e.g. ASCE/SEI 7) should be addressed, at a minimum, clarifying if supplemental or enhanced requirements are being considered (similar to the performance based design approach taken for high seismic regions of the country). These additional considerations/enhancements could consider structural redundancy (progressive collapse) and structural integrity (rotational compatibility/ductility, structural and non-structural) depending on the site/project specific requirements.

The design (and documentation) should clearly define the structural load path and system, including defining primary, secondary, and main lateral force resisting members (including the role, or multiple roles, each individual members may serve). At this time, it is worth noting that as of the original writing of this document, current building codes and design standards contain very few prequalified mass timber lateral systems. Additionally, innovative structural systems such as hybrid and composite mass timber are being developed; emphasizing the need for an alternate (performance-based) design approach (beyond the limited prequalified systems currently referenced in building codes).

~~The performance-based structural design of mass timber systems should meet or exceed the minimum requirements of the National Design Specification (NDS) referenced by the current version of the Wisconsin Commercial Building Code.~~

~~Often, performance-based design objectives may be set higher than typically required by code to minimize damage to structures, architectural and mechanical systems, and building contents. Higher performance objectives may result in buildings that exceed safety standards and need less repair when hazardous events occur.~~

~~Project stakeholders should determine at the outset whether the performance objectives~~ ~~The structural calculations provided to the AHJ should include calculations for both the standard design scenario and for a fire scenario, where members rely on charring of the structure.~~

~~Given the recent additions to the 2021 NDS, it is recommended the design team utilize the additional requirements of this updated design standard, particularly with respect to the lateral design requirements included in the 2021 Special Design Provisions for Wind and Seismic~~

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~~(SDPWS).~~ Given continual/ongoing updates/revisions to national design standards, it is recommended the design team utilize and/or at least consider/review, the additional requirements of these updated design standards and state of the art research (e.g. considering the lateral design requirements of 2021 Special Design Provisions for Wind and Seismic (SDPWS), even for building codes referencing earlier versions of IBC). It is also noted that this state of the art research may come from sources outside of the United States. Refer to Chapter X for recommended references/design guides associated with many of the topics discussed above.

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3.2 Non-Structural Design Considerations

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What other none-structural considerations do we want to add?

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Serviceability considerations, including lateral drifts, floor deflections, and floor vibrations may often control, or at least provide significant guidance towards, the overall design of a structure (beyond standard strength designs/calculations). Additionally, due to the lightweight nature of mass timber construction, there are frequently additional non-structural design principals (e.g. acoustic design, sound mitigation, and thermal/energy performance) that need to be considered during design.

The reader is once again encouraged to review Chapter X for additional references associated with the topics above.

3.3 Fire Endurance Considerations

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Performance-based fire designs may choose to modify the fire endurance durations/requirements from the code required minimum ratings, for a given occupancy/structure type. The design team should provide clear documentation noting what structural elements are considered exposed, concealed and/or partially concealed, and the associated fire rating of each element. Structural calculations provided to the AHJ should include calculations for both the standard design scenario and for any fire scenario(s), particularly where members rely on charring of the structure to achieve this rating.

For elements where the fire protection is provided by a combination of a non-combustible material and a wood charring layer, the contribution of each towards the overall fire rating should be documented; with the contribution of the non-combustible materials (where applicable) providing a minimum of 2/3 of the overall required fire rating.

Any supplement testing to be completed (potentially as part of the project's variance process), should be certified by an independent, accredited 3rd party testing agency. The testing procedure and results should be reviewed for approval by Project AOR, EOR, Fire Engineer, and AHJ.

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~~Serviceability~~

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~~While strength is essential for structural design, serviceability considerations such as deformations, floor deflections and lateral drift often control design.~~

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- Redundancy and progressive collapse mitigation

  Structural redundancy and measures to prevent disproportionate collapse of building structures, because of a single component failure, is typically addressed via prescriptive detailing measures in standard building codes. Performance-based design objectives specific to progressive collapse mitigation may be defined in the absence of prescriptive guidance for mass timber structures.

- Structural integrity

  The ability of gravity framing to displace and rotate in compatibility with the lateral force-resisting system shall be generally checked in accordance with reference standards, such as ASCE/SEI 7. In addition, the displacement and rotation compatibility of non-structural mechanical and architectural components shall be checked for the expected structural movements.

- Utility penetrations through beams or panels may affect both structural strength and fire safety, particularly in exposed mass timber components that are not encapsulated with ignition barriers.

- Connection ductility may be necessary for the performance of mass timber components in seismic lateral force-resisting systems or in other extreme loading conditions. The rotational capacity and strengths of connections relying on ductility should be substantiated by tests and analysis.

- Load path classifications

  The International Building Code generally defines BEARING WALL STRUCTURE or FRAME STRUCTURE based on whether walls or columns are the primary supports for vertical loads. In addition, structural systems are defined by the load path for lateral resistance of forces. The performance-based design package should state whether mass timber structural components are elements of the gravity or lateral force-resisting system or serve dual functions in both vertical and lateral load paths.

~~Lateral Force-Resisting System~~

~~Currently, design standards referenced by the building codes contain few prequalified mass timber lateral systems and mostly prescriptive requirements for encapsulation of mass timber components for fire safety. For innovative systems that do not match the details of prequalified mass timber systems, the structural submittal to the AHJ should include peer-reviewed calculations. Such calculations may address both standard design load combinations and fire endurance to demonstrate that the structure will meet or exceed the minimum time of fire rating required by code occupancy.~~

~~Hybrid system~~

~~Mass timber structural components may be configured in hybrid structural systems to work in unison with steel or concrete construction. The role of mass timber components should be clearly defined in the submittal, both in project narrative and on the plans general notes.~~

~~Composite action~~

~~Concrete or cementitious toppings are commonly used in mass timber decking systems. Whether these toppings are intended for composite action between the concrete and mass timber products should be clearly expressed in the structural submittal and drawings. Composite behavior of concrete topping and mass timber panel substrate may have a significant impact on the structural performance of both the decking of the gravity system and the lateral stiffness of the diaphragm.~~

~~Submittal documentation~~

3.3.1 Minimum Fire-Resistance Rating (FRR's) Recommendations

~~Fire endurance~~

~~Performance-based fire designs may choose to enhance the duration of fire endurance from the minimum required for occupancy and structure type. For example, a structure that requires a two-hour fire rating may set objectives for three-hour ratings.~~

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~~The design team should provide clear documentation of what structural elements are considered exposed, concealed and/or partially concealed. The design team should clearly identify the fire rating of each element.~~

~~Should the team consider sourcing material (timber/hardware) outside of the United States, the design team should provide documentation providing equivalency between Eurocode serviceability and strength parameters with those documented in the NDS. For these materials, it is recommended the team provide an additional equivalent Eurocode design for the controlling members/designs. The peer reviewer (where applicable) should review and comment on the conversion factors from codes outside the United States to NDS parameters/values.~~The design team shall justify to the AHJ and Peer Reviewer, the use of the design recommendations, factors, and equations provided by these codes, in accordance with American Standards.

~~In addition to the code requirements above, it is recommended that the design utilize, where possible, state of the art research and design documents (as applicable), including the latest versions of the following documents:~~

~~2. CLT Diaphragm Design for Wind and Seismic Resistance (Woodworks)~~
~~3. U.S. Mass Timber Floor Vibration Design Guide (Woodworks)~~
~~4. Current CLT Composite Research (where applicable)~~
~~5. Hybrid Steel Frames with Wood Floors (AISC) (where applicable)~~
~~6. 2022 Fire Design Specification (FDS) for Wood Construction~~

~~Where current state of the art research and documents associated with mass timber fall outside of the United States, if you need to go outside this, the governing codes should be referenced including:~~

~~7. EuroCode 5~~
~~8. Canadian Code (CSA)~~

~~The design team shall justify to the AHJ and Peer Reviewer, the use of the design recommendations, factors, and equations provided by these codes, in accordance with American Standards.~~

~~3.1.1 Performance objectives~~

~~The performance-based structural design of mass timber systems should meet or exceed the minimum requirements of the National Design Specification (NDS) referenced by the current version of the Wisconsin Commercial Building Code.~~

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~~Often, performance-based design objectives may be set higher than typically required by code to minimize damage to structures, architectural and mechanical systems, and building contents. Higher performance objectives may result in buildings that exceed safety standards and need less repair when hazardous events occur.~~

~~Project stakeholders should determine at the outset whether the performance objectives are intended to be on par or better than objectives underlying minimum code requirements.~~

1. ~~Load combinations~~

   ~~Performance-based design should address the standard load combinations specified by ASCE/SEI 7 and list whether load cases follow minimum or enhanced requirements. For instance, seismic or wind requirements may be enhanced to mitigate higher magnitude earthquakes or wind events than those typically considered standard for design.~~

2. ~~Fire endurance~~

   ~~Performance-based fire designs may choose to enhance the duration of fire endurance from the minimum required for occupancy and structure type. For example, a structure that requires a two-hour fire rating may set objectives for three-hour ratings.~~

3. ~~Serviceability~~

   ~~While strength is essential for structural design, serviceability considerations such as deformations, floor deflections and lateral drift often control design.~~

4. ~~Redundancy and progressive collapse mitigation~~

   ~~Structural redundancy and measures to prevent disproportionate collapse of building structures, because of a single component failure, is typically addressed via prescriptive detailing measures in standard building codes. Performance-based design objectives specific to progressive collapse mitigation may be defined in the absence of prescriptive guidance for mass timber structures.~~

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5. Structural integrity

The ability of gravity framing to displace and rotate in compatibility with the lateral force-resisting system shall be generally checked in accordance with reference standards, such as ASCE/SEI 7. In addition, the displacement and rotation compatibility of non-structural mechanical and architectural components shall be checked for the expected structural movements.

a. Utility penetrations through beams or panels may affect both structural strength and fire safety, particularly in exposed mass timber components that are not encapsulated with ignition barriers.

b. Connection ductility may be necessary for the performance of mass timber components in seismic lateral force-resisting systems or in other extreme loading conditions. The rotational capacity and strengths of connections relying on ductility should be substantiated by tests and analysis.

A concise way to compare code minimum requirements and enhanced objectives of performance-based design may be accomplished in tabular form in the calculations and drawing submittal.

3.1.2 Scope of performance-based design

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1. Load path classifications

The International Building Code generally defines BEARING WALL STRUCTURE or FRAME STRUCTURE based on whether walls or columns are the primary supports for vertical loads. In addition, structural systems are defined by the load path for lateral resistance of forces. The performance-based design package should state whether mass timber structural components are elements of the gravity or lateral force-resisting system or serve dual functions in both vertical and lateral load paths.

2. Lateral Force-Resisting System

Currently, design standards referenced by the building codes contain few prequalified mass timber lateral systems and mostly prescriptive requirements for encapsulation of mass timber components for fire safety. For innovative systems that do not match the details of prequalified mass timber systems, the structural submittal to the AHJ should include peer-reviewed calculations. Such calculations may address

both standard design load combinations and fire endurance to demonstrate that the structure will meet or exceed the minimum time of fire rating required by code occupancy.

3. Hybrid system

Mass timber structural components may be configured in hybrid structural systems to work in unison with steel or concrete construction. The role of mass timber components should be clearly defined in the submittal, both in project narrative and on the plans general notes.

4. Composite action

Concrete or cementitious toppings are commonly used in mass timber decking systems. Whether these toppings are intended for composite action between the concrete and mass timber products should be clearly expressed in the structural submittal and drawings. Composite behavior of concrete topping and mass timber panel substrate may have a significant impact on the structural performance of both the decking of the gravity system and the lateral stiffness of the diaphragm.

3.1.3 Submittal documentation

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3.2 Fire Resistance Requirements and testing recommendations

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The design team should provide clear documentation of what structural elements are considered exposed, concealed and/or partially concealed. The design team should clearly identify the fire rating of each element. For elements where the fire protection is provided by a combination of a non-combustible material and charring layer, the contribution of each toward the overall fire rating should be documented; with the contribution of the non-combustible materials (where applicable) providing a minimum of 2/3 of the overall required fire rating.

Testing to be completed, and results certified, by an independent, accredited 3rd party testing agency. Testing procedure and results to be reviewed for approval by Project AOR, EOR, Fire Engineer, and AHJ.

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~~3.2.1 Minimum Fire-Resistance Ratings (FRR's)~~

~~Primary Structural Frame Recommendations:~~

~~Building Type~~ Element	Minimum Fire-Resistance Rating
Primary Structural Frame:	
~~Type IV-B – Up to 180 ft.~~ Buildings up to 180'-0" or 12 stories	2 hours[1]
~~Type IV-A – Up to 270 ft.~~ Buildings taller than 180'-0" or 12 stories	3 hours[1,2]
Bearing Walls	Refer to primary structural frame[3, 4]
Non-Bearing Walls and Partitions	0 hours
Floor Construction and Associated Secondary Structural Members	2 hours
Roof Construction and Associated Secondary Structural Members:	
Buildings up to 180'-0" or 12 stories	1 hour
Buildings taller than 180'-0" or 12 stories	1.5 hours
Structural Connections	FRR to match, at a minimum, the lower of the connection member(s) FRR

~~Buildings up to 180' 0" or 12 stories: 2 hours[1]~~

~~Buildings taller than 180' 0" or 12 stories: 3 hours[1, 2]~~

[1.] Roof support rating is permitted to be reduced by one hour where supporting a roof only (not including additional occupancies/loading)

[2.] For buildings not greater than 420 feet in building height, the fire-resistance rating of floor framing elements (e.g. CLT slabs and glulam beams) shall be permitted to be reduced to 2 hours.

~~Bearing Walls: Create Table for this section~~

~~Refer to primary structural frame[3, 4]~~

[3.] No reduction for roof framing is permitted

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4. Minimum fire-rating for exterior walls to be based on fire separation distance

~~Non-Bearing Walls and Partitions: 0 hours~~

~~Floor Construction and Associated Secondary Structural Members: 2 hours~~

~~Roof Construction and Associated Secondary Structural Members:~~

~~Buildings up to 180' 0" or 12 stories: 1 hour~~

~~Buildings taller than 180' 0" or 12 stories: 1.5 hours~~

~~Structural Connections~~

~~Fire-Resistance Rating to match, at a minimum, the lower of the connecting member(s) FRR.~~

~~3.2.2~~3.3.2 Mass Timber Fire-Resistance Rating Validation

~~3.2.2.1~~3.3.2.1

National Design Standards~~s~~ (Char Method)

Primary and Secondary Structure:

The utilization of NDS provisions and calculations for the determination of char rates is a well-established and industry recognized procedure. For the scope of this guideline, it is recommended the following (additional) items ~~shall~~ be considered:

~~Additional factors that are not currently spelled out in the National Design Standards may include:~~

- ~~–~~Load Resistance ~~F~~Factored Design Fire Factors: 2022 Fire Design Specification (FDS) for Wood Construction has included additional Fire Factors (not currently covered in NDS) for the use of Fire Factors with LRFD provisions (Table 3.2.5).
- ~~–~~Extreme Event Loading: For loading in a fire scenario, the designer is referenced to the 2022 Fire Design Specification (FDS) for Wood Construction section 3.1.3.4.
- Char Calculations Beyond 2 Hours: For members requiring fire ratings beyond the current NDS provisions, it is recommended the design team provide specific testing, verifying the char rates utilized for design. It is recommended that the char rates not be reduced beyond those calculated based on extrapolation of the current NDS equations.

~~- Char Calculations Beyond 2 Hours: For members requiring fire ratings beyond the current NDS provisions, the design team shall provide specific testing, verifying the char rates utilized for design. It is~~

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~~recommended that the char rates not be reduced beyond those calculated based on extrapolation of the current NDS equations.~~

For projects utilizing Douglas Fir, American Spruce or European Spruce, the design team is advised to refer to the 3-hour testing provided by the USDA Forest Product Laboratory for the Ascent project.

Connections of Primary and Secondary Members: ~~**Update title for Connections:**~~

- Bearing type connections should utilize noncombustible protection, or require load testinged (under a fire event) to achieve the FRR noted in section 2.1.1.
  - ~~i.~~ Connections utilizing intumescent paint for noncombustible protection should be load tested (under a fire event) to confirm compatibility between materials
  - ~~ii.~~ At the AHJ's discretion, the use of engineering analysis could be provided to validate the fire-resistance rating of connections per section 2304.10.1 of IBC 2021
- All other mass timber connections should be load tested (under a fire event) for the specified fire rating.
- Testing should meet the requirements of Section 2.1.3

3.3.2.2 Non-Combustible Protection

Gypsum detailing requirements to follow IBC 2021 section 722.7. ~~TT: Korb previously noted some general concerns regarding discrepancies in the IBC 2021 code (section 722.7). It is recommended that the guideline specify specific detailing requirements in lieu of relying on a reference to IBC 2021~~

~~Korb: Has a lot more that is codified? General requirements. Sealant. ASPM requirements. Specific materials for fire protection. Gypsum must be met. 2 years ago implemented. Special inspections required based on building officials. Who is appropriate qualifications? Daily/monthly/yearly reports. Up to the special inspector to work with owner, contractor.~~

~~"Proposal FS81-18 (new IBC 722.7) defined the level of noncombustible protection required and how to achieve this level, including a prescriptive method recognizing 1/2" Type X gypsum board providing 25 minutes of protection and 5/8" Type X gypsum board providing 40 minutes of protection. Proposal FS5-18 (new IBC 703.6) defined methods to determine the level of noncombustible protection provided by other applied materials through using the E119 test procedure. FS73-18 (IBC 718.2.1) added mass timber as a fire blocking material."~~

~~Minimum 2/3 rating from non-combustible materials (if utilized?)~~

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Commented [KJ16]: Typical comment: Can we use the word "should"?

Cannot require, but should we say "recommend"?

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Commented [KJ19]: There was a lot of discussion on this topic, but it needs to be resolved/finalized. I would recommend Jason Korb (KA) work with Laura (FPL) to make any recommended updates:

Korb previously noted some general concerns regarding discrepancies in the IBC 2021 code (section 722.7). It is recommended that the guideline specify specific detailing requirements in lieu of relying on a reference to IBC 2021

Has a lot more that is codified? General requirements. Sealant. ASPM requirements. Specific materials for fire protection. Gypsum must be met. 2 years ago implemented. Special inspections required based on building officials. Who is appropriate qualifications? Daily/monthly/yearly reports. Up to the special inspector to work with owner, contractor.

"Proposal FS81-18 (new IBC 722.7) defined the level of noncombustible protection required and how to achieve this level, including a prescriptive method recognizing 1/2" Type X gypsum board providing 25 minutes of protection and 5/8" Type X gypsum board providing 40 minutes of protection. Proposal FS5-18 (new IBC 703.6) defined methods to determine the level of noncombustible protection provided by other applied materials through using the E119 test procedure. FS73-18 (IBC 718.2.1) added mass timber as a fire blocking material."

Minimum 2/3 rating from non-combustible materials (if utilized?)

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Sealants: Sealing of adjacent mass timber elements per 703.7. Sealants shall meet the requirements of ASTM C920. Adhesives shall meet the requirements of ASTM D3498.

Fire Blocking: Materials to meeting the requirements of 718.2.1

~~A new code section, IBC 703.7, was included in proposal FS6-18. It required that certain adhesives be applied at abutting edges and intersections of fire resistance-rated mass timber elements unless the assembly has been shown to provide the required FRR without utilizing sealants.~~

~~3.2.2.2~~

3.3.2.3 Fire Testing/Certification Requirements:

Testing to be completed, and results certified, by an independent, accredited 3rd party testing agency. Testing procedure and results to be reviewed for approval by Project AOR, EOR, Fire Engineer, and AHJ.

~~i.Testing to be completed, and results certified, by an independent, accredited 3rd party testing agency. Testing procedure and results to be reviewed for approval by Project AOR, EOR, Fire Engineer, and AHJ.~~

~~3.2.3~~3.3.3 Exposure

Primary and Secondary Structure:

The floor assembly should contain a non-combustible material no less than 1" in thickness above the mass timber floor. No additional limits are directly required of the primary and secondary structural exposure, contingent on meeting the fire-resistance ratings specified in Section 2.1.1.

~~Committee to consider if we want to discuss exposure of mass timber walls (not columns) and slabs (e.g. separation of 15 feet if exposing walls/ceilings in a dwelling unit)~~

Concealed Spaces:

~~*Strong and clear stance*~~

It is the committee's opinion that mass timber should not be permitted in concealed spacings with the following exceptions: (1) non-combustible protection is provided within the interior (mass timber) space or (2) significant project specific testing/data is obtained and approved by the AOR/EOR, AHJ, and independent third party peer reviewer.

~~i.Korb~~

~~1. Prohibition of concealed spaces 4HT has been removed. **(KA comment – concealed spaces language in the IBC and its commentary are not in agreement. For discussion.)** gypsum detailing~~

~~a. Lean on prescriptive method. **(KA comment – gypsum detailing requirements have been defined by Fire Design Specification for Wood Construction – Wood Products Council.)**~~

Commented [KJ20]: A new code section, IBC 703.7, was included in proposal FS6-18. It required that certain adhesives be applied at abutting edges and intersections of fire resistance-rated mass timber elements unless the assembly has been shown to provide the required FRR without utilizing sealants.

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Commented [KJ21]: Any additional guidance/recommendations required? (I don't necessarily think so, but just confirming)

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Commented [KJ22]: Committee to consider if we want to discuss exposure of mass timber walls (not columns) and slabs (e.g. separation of 15 feet if exposing walls/ceilings in a dwelling unit

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Commented [KJ23]: Committee wanted a strong and clear stance.

Additional Korb Commentary:

Prohibition of concealed spacings in Type IVHT has been removed. However, the concealed spaces language in the IBC and its commentary are not in agreement. Further discussion required.

Provide additional commentary on gypsum detailing.

Lean on prescriptive method: gypsum detailing requirements have been defined by Fire Design Specification for Wood Construction (WPC)

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Exterior Walls (Façade):

The committee would note the following recommendations, consistent with the XXXXXXX

- *"Exterior side of exterior walls protected by a non-combustible material—e.g., 5/8" Type X gypsum sheathing"*
- *"No combustible exterior wall coverings except for certain water-resistant barriers"*
- *"No exposed mass timber on the inside and outside surfaces of exit enclosures and elevator hoistways in high-rise buildings (occupied floor > 75 feet from lowest fire department access)"*
- *"Noncombustible construction only for exit enclosures and elevator hoistways greater than 12 stories or 180 feet"*

3.3.4 Additional Recommendations:

Water Supply:

- Dual water supply for buildings 120 feet and above, in accordance with IBC 403.3.2 (2021), and including the following exception:
    i. *"Exception: Two connections to the same main shall be permitted provided the main is valved such that an interruption can be isolated so that the water supply will continue without interruption through no fewer than one of the connections"*
- Water supply in accordance with 2021 IFC 3313 and 2021 IBC 3313

~~*Notes regarding 3.2.4 iii.)*~~

~~*[F]403.3.2Water supply to required fire pumps.*~~

~~*In buildings that are more than 420 feet (128 000 mm) in building height, required fire pumps shall be supplied by connections to no fewer than two water mains located in different streets. Separate supply piping shall be provided between each connection to the water main and the pumps. Each connection and the supply piping between the connection and the pumps shall be sized to supply the flow and pressure required for the pumps to operate.*~~

~~*Exception: Two connections to the same main shall be permitted provided the main is valved such that an interruption can be isolated so that the water supply will continue without interruption through no fewer than one of the connections.*~~

Sprinklers:

i. Building fully sprinklered with an NFPA 13-compliant sprinkler system

Smoke Evacuation; Fire Department thoughts?

Type 1A Construction?

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3.4 Fire Engineering Consultant:

TT Thoughts:

For buildings higher than 12 stories or 180' (only)
Qualifications and Selection
- Previous Mass Timber Experience
- Selected by Ownership/Design to be approved by AHJ
-Scope

1. Review mass timber framing and connections protection in concealed areas

2. Review mass timber connections in exposed connections

3. Review gypsum detailing per requirements of Section 3.2.2.2.

4. Smoke evacuation

5. Review testing provided by manufacturers for compliance with relevant standards~~*Previous committee thoughts:*~~

~~3.2.4 **Sacrificial Protective layer** – of the encapsulation materials. For the purposes of the guidebook, the structural design of the building is beyond the char layer as defined in the International Building Code or the Wisconsin Commercial Building Code. You need to provide a bit more protection.~~
~~[KA Input]~~
~~2.1.1 **Sacrificial Protective layer** – of the encapsulation materials. For the purposes of the guidebook, the structural design of the building is beyond the char layer as defined in the International Building Code or the Wisconsin Commercial Building Code **(KA input – prescribed char rate is 1.5 in/ HR. Samples tested at FPL charred at rates between 1.29 and 1.31 in/ hr – can this count as extra protection? Species previously untested must pass their own 2 or 3 hour test.)**~~

~~2.1.2 Two Areas of Fire Rating~~
~~Minimum fire resistance (2-3 hours) primary and secondary structure.~~
~~Clearly well codified.~~
~~The area of exposed areas~~
~~IBC limits 2.1.3 Meet code minimum or higher objectives.~~
~~a.~~
~~3.3 Fire Consultant~~
~~2.2.1Qualification selection. Previous Mass Timber experience. When do we want to require a fire consultant. Limit on number of stories. It is KA recommendation to require a fire engineer for a structure over twelve stories that is not fully encapsulated.~~
~~i. Scope of fire consultant. - Fire protection of connections. Concealed systems. Gypsum. Smoke evacuation (KA recommendation – smoke evacuation is in HVAC engineer's scope). May require of testing. They review and or review of the test. Criteria or beta testing of what would qualify fire consultant~~
~~ii. Specify of the test we want to take place. Their role is to make sure the test gives results that the designer can utilize. Experts appropriate test how/when/where~~
~~iii. Marco Lo Ricco~~

Commented [KJ26]: Is the committee comfortable with TT's thoughts/recommendations below? If so, I can "formalize" the language.

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Commented [WBD27]: Need to define more protection

Commented [WBD28R27]: UL Rating for engineers to have a reference to what we are looking for.

Commented [WBD29R27]: Mr. Korb. KA will look into this.

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Commented [WBD31]: Type IV buildings as described above?

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1. Fire endurance
2. When fire endurance calculations suffice or when fire testing is required. Endurance calculations may be used for fire endurance. Trying to address calculations or testing is needed.

3.4 Fire rating documentation and justification

i. Until such time as it is formally adopted by the IBC the documentation provided - just as important as the plan. Project by project basis.

i. Envision you have your structural package. Specific char calculations. Heat effected zone. Mass Timber additional fire test. Documentation for any additional testing codified limits. CLT or floor system. Prg 320 correct glue. Review from fire consultant. Unique connectors for testing and data in the package.

3.5 Peer Review

TT Thoughts:

i. 3.4.1 Qualifications and selection

6. For each project higher than 12 stories or 180', a Mass Timber Peer Review Panel (MTPRP) shall be convened. d

7. The MTPRP shall be a panel or a structural engineering firm with at least three (3) members with previous experience in relevant mass timber buildings.

8. The MTPRP shall be selected by the Building Official based on their qualifications applicable to the Mass Timber Peer Review of the project. The Building Official may request the opinion of the Project Sponsor and EOR on proposed SPRP members, with the Building Official making the final decision on the MTPROP membership.

9. The MTPRP shall bear no conflict of interest with respect to the project and shall not be part of the design team for the project.

10. The MTPRP provides their professional opinion to and acts under the instruction of the building official.

ii. 3.4.2 Review scope

11. To provide an independent, objective, technical review of those aspects of the building design that relate to the structural performance of the building according to the requirements and guidelines described on this building, and to advise Building Officials whether the design generally conforms to the intent of this documentation and other requirements set forth by the Building Official

12. Review structural calculations, under normal conditions and under a fire scenario; including the use of foreign codes, where applicable.

The MTPROP shall be convened as early in the structural design phase as practicable.

XXXXXXX

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Commented [KJ32]: These are TT's thoughts. Originally there were differing opinions on the peer review, but I believe the concensus was that a peer review is valuable, but the team wanted to make it clear what types of projects required these peer reviews.

If the committee agrees, I can formalize the thoughts below.

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Commented [KJ33]: I believe the following concerns have already been addressed/clarified above, but want to keep for the record:

Performance based approach. To verify prescriptive limitations. Requirements are peer review acting on behalf of the building owner. Due diligence for beyond code. Acting on part of city or building officials reviewing on their behalf. Foreign to DSPS practices. Contract that out? Would have to go through a petition. Special inspections – On the ownership team to run. The reviewer would not be from the state – independent reviewer. (For discussion – the EOR for Ascent performed the Sis. Pros and cons?) It could be a different structural firm outside the state. State could create the committee. Expertise – Not an additional ask for the plan review. Special inspections, the building owner/reviewer. The building official reviews and approves - selected

Joe Ricker

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2.4.1 Previous task force committee thoughts: Qualifications and selections

- *Performance based approach. To verify prescriptive limitations. Requirements are peer review acting on behalf of the building owner. Due diligence for beyond code. Acting on part of city or building officials reviewing on their behalf. Foreign to DSPS practices. Contract that out? Would have to go through a petition. Special inspections – On the ownership team to run. The reviewer would not be from the state – independent reviewer. (For discussion – the EOR for Ascent performed the Sis. Pros and cons?) It could be a different structural firm outside the state. State could create the committee. Expertise – Not an additional ask for the plan review. Special inspections, the building owner/reviewer. The building official reviews and approves – selected*
- *Joe Ricker*
  0. *We do have to remember work within the rules we do have. Existing systems or legislative action.*
- *Korb*
  0. *Peer review seems excessive. Everyone will have opinions. The data must speak for themselves.*
  0. *Lo ricco*
- *Prescriptive measures are approved. We do not need peer review. Peer review intended for performance-based route. More general approach.*
  0. *Roles*
  0. *Peer review*

  Technical. Review responsibilities

  Building Officials - Enough data, qualified, threshold for substantial evidence. Standard of care. Justifying analysis

  1 example: Exposed area. 18 story timber structure. Fully encapsulated. How much exposure would trigger a peer review. May be based on occupancy.
  1. *For areas outside the code. Needs to have some technical judgment in concert with the building review with the engineers. Backstop for building official for technical knowledge on the job.*
  0. *Mazmanian*

a. *Common practice? Always the option to use this approach for comfort. Always thresholds in the code. If you can use the codified approach, then it is not needed. If you exceed requirements, you must use a performance based approach should have a peer review is required.*

b. *Where to draw that line.*

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~~4.~~ **Construction and Post-Occupancy**

~~5.~~**4.**

~~6.~~

~~7.~~ Mass Timber construction to follow the general requirements of Type IV Construction, unless otherwise noted in this guide.

~~8.~~

4.1 During Construction

Construction requirements per 2021 IFC 3303.5

Standpipes

Dual water supply

Non-combustible protection installed on levels 4 stories below the active mass timber construction

Required wall coverings shall be installed on levels 4 stories below the active mass timber construction

~~TT Thoughts:~~1. The Mass Timber Guidebook shall reference 2021 IFC 3303.5. To establish preliminary meeting to review planned measure and timeline for implementation throughout the course of the project.

Outline regular meeting and inspection schedule. This may involve the inspection field staff and construction staff as it relates to Mass Timber construction.

- Should we include an inspection schedule, and would this be considered useful in the guidebook.

- Deviations and Field Modifications – Any substantial field modifications or deviations from the approved construction drawings should be reviewed with field inspector prior to implementation. (Example: structural modifications due to field variation – flange extension, component modification, etc.)
- If there are ~~substantial~~ field modifications from approved plan review the building construction, the initial plan review shall require a secondary plan review.or AHJ plan reviewer (CBC chapter 361 JG) or delegated associate before implementation.
- We are not requiring anything beyond the current WI commercial building code.
-

NFPA 33 – Mass Timber construction.

~~Construction requirements per 2021 IFC 3303.5~~

~~Standpipes~~

~~Dual water supply~~

~~Non-combustible protection installed on levels 4 stories below the active mass timber construction~~

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~~8.1 Required wall coverings shall be installed on levels 4 stories below the active mass timber construction~~

~~8.1.1 Special Inspections~~

4.2 Special Inspections

Mass timber special inspections

Follow the requirements of IBC 2021 (1705.5.3)…recommend including these requirements specifically in the guideline

Mass timber inspector qualification and selection

Previous experience in relevant mass timber buildings

Submit credentials to the city

Provide access to the plans prior the start of construction

Submit monthly reports to the city

- Strongly recommend requiring special inspections for all mass timber projects, but specifically in accordance with the goals of the task force, for any project designed outside the parameters of the prescriptive code path shall require special inspections
  - (Note: the only way we can require this in Wisconsin is as a condition of approval associated with a variance. Any project designed outside of the prescriptive path would require a variance as a path to approval.)

~~TT Thoughts:~~

~~Mass timber special inspections~~

This Guidebook shall f~~F~~ollow the requirements of IBC 2021 (1705.5.3) to ~~3)…~~recommend including these requirements specifically in the guideline.

In final document, DPD legal will have to reference table

Post Occupancy Inspection Guidance: Icc and American Wood Council.

Reference IBC and Fire Code. G7 ICC safety Guidelines for inspection. Wood construction in general

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~~Jordan Komp may be able to discuss the Ascent building special inspector selection process.~~

~~Structural engineers most likely do not need certification.~~

Currently adopt 2015. Recommendations for unique instances. Will have a variance for a new code, or agree to certain criteria.

Executive summary; 4 or more stories

4.2 Post Occupancy

~~Construction~~

The owner shall ensure that required passive protection remains in place over the life of the building, section 701.6 of the IFC.

~~**What lessons learned from post-occupancy evaluations of Mass Timber buildings are different from standard construction practices.**~~

- ~~**Building should be maintained and inspected as part of an annual fire inspection program.**~~
- ~~**Reference WI statute or local jurisdiction for commercial buildings. Aesthetically would be prudent**~~
- ~~**Distinction between fire inspection and structural inspections (typically not required) could be considered during a regular maintenance program.**~~
- ~~**Other factors that should be considered specifically related to mass timber buildings?**~~

~~**Reference specific codes, and site in our bibliography.**~~

DO WE WANT AN ADDITIONAL SECTION OF FIRE SAFETY?

~~Post occupancy inspections are recommended, however, they are not required.~~

~~Fire Safety Section~~

Standpipes – Do we need to define standpipes?

Dual water supply

Non-combustible protection installed on levels 4 stories below the active mass timber construction

Required wall coverings shall be installed on levels 4 stories below the active mass timber construction

~~Any project deviating from the current adopted code or prescriptive path shall require~~

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Commented [KJ38]: This section needs some work:

Committee Questions:

What lessons learned from post-occupancy evaluations of Mass Timber Buildings are different from standard construction practices?

Buildings should be maintained and inspected as part of an annual fire inspection program.

Reference WI statue or local jurisdiction for commercial buildings. Aesthetically would be prudent.

Distinction between fire inspection and structural inspections (typically not required) could be considered during a regular maintenance program.

Other factors that should be considered specifically related to mass timber buildings?

Reference specific codes, and site in our bibliography?

Post occupancy inspections are recommended, however, they are not required.

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I. Closing Remarks

Commented [KJ40]: Need to select committee members to develop a first draft

~~II.~~I. ReferencesBibliography

1. Voluntary design guides and technical resources

In addition to the code requirements above, it is recommended that the design cite state of the art research and design documents. Examples of documents to cite, wherever applicable, include:

[1] CLT Diaphragm Design for Wind and Seismic Resistance (Woodworks)

[2] U.S. Mass Timber Floor Vibration Design Guide (Woodworks)

[3] CLT Composite engineering testing reports or research articles

[4] Design Guide XX, Hybrid Steel Frames with Wood Floors (AISC)

[5] 2022 Fire Design Specification (FDS) for Wood Construction

This bibliography is not a comprehensive list and may grow in scope and detail, as the mass timber construction industry advances.

1. References

The sources of substantiating information from tests, design standards, engineering reports and research articles should be clearly cited in the peer review calculations.

1. U.S. standards

a. Because the recent 2021 edition of the NDS specifically address cross-laminated timber (CLT), it is recommended the design team utilize the latest version of this design standard.

b. For main lateral-force resisting systems (MLFRS) including CLT diaphragms and shear walls, in particular, designers should reference 2021 Special Design Provisions for Wind and Seismic (SDPWS) as a general framework. It is likely that future editions of these documents will include more detailed and specific information on mass timber systems, to supplement the current general framework.

Commented [KJ41]: Recommend Marco (FPL) be given the opportunity to spearhead the references/bibliography section

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c. AWC technical report No. 10, Calculating the Fire Resistance of Wood Members and Assemblies provides guidance for calculating the fire endurance of timber structures with architecturally exposed surfaces.

d. ANSI/APA PRG 320: Standard for Performance-Rated Cross-Laminated Timber is referenced by building codes. Mass timber panels beyond the scope of this document should demonstrate performance with testing and calculations to demonstrate equivalent or enhanced performance.

e. ANSI A190.1-2022 Product Standard for Structural Glued Laminated Timber is referenced by building codes. Mass timber framing beyond the scope of this document should demonstrate performance with testing and calculations to demonstrate equivalent or enhanced performance.

3. Foreign Standards

Where current state of the art research and documents associated with mass timber fall outside of the United States, references des to foreign codes should check underlying assumptions of design equations and compare models with the design philosophies developed in the United States.

1. CLT Diaphragm Design for Wind and Seismic Resistance (Woodworks)
2. U.S. Mass Timber Floor Vibration Design Guide (Woodworks)
3. Current CLT Composite Research (where applicable)
4. Hybrid Steel Frames with Wood Floors (AISC) (where applicable)
5. 2022 Fire Design Specification (FDS) for Wood Construction

Where current state of the art research and documents associated with mass timber fall outside of the United States, if you need to go outside this, the governing codes should be referenced including:

6. EuroCode 5
7. Canadian Code (CSA)

~~ii.3.1~~

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