Fire Safety Considerations for Mass Timber Buildings

Holmes

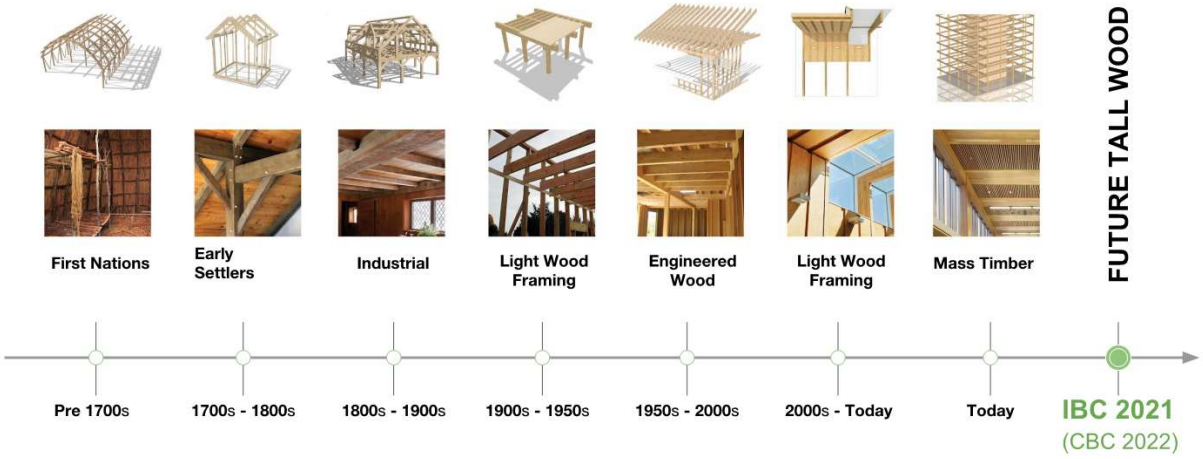
Mass Timber Enclosure Symposium

Presented by; Bevan Jones
February 11, 2020

Outline

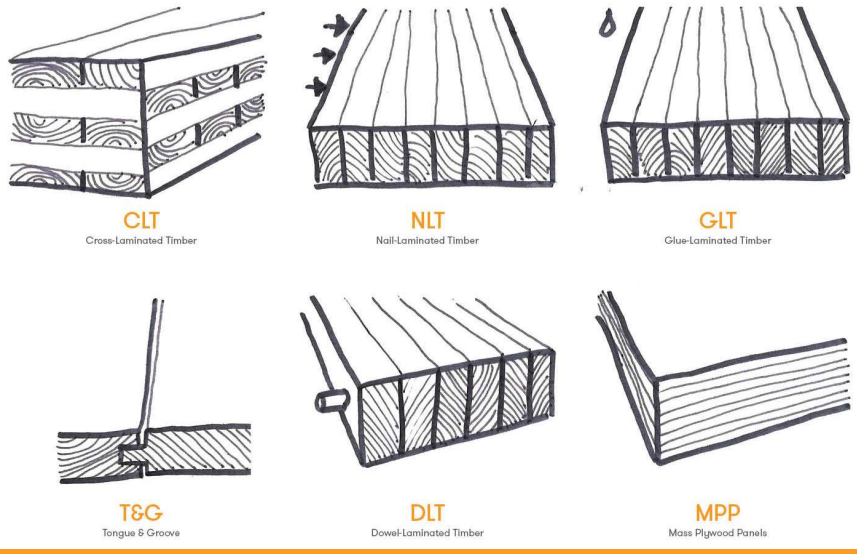
1. General Principles
   - Mass timber v light frame
   - Fire behavior
2. Building Code Overview
   - Construction types
   - Heights and areas
   - Understanding limitations
3. Determining Fire Resistance
   - Prescriptive design
   - Performance based
4. Approvals Process
   - Working with authorities
   - Peer review
   - Testing

Mass Timber Evolution in North America



Fire Safety Considerations for Mass Timber Buildings

Mass Timber



Fire Safety Considerations for Mass Timber Buildings

Mass Timber

Fire Safety Considerations for Mass Timber Buildings

Mass Timber

Larger elements of wood have inherent resistance to fire and are slow-burning

Smaller elements of wood are less resistant to fire and rely on protection from burning

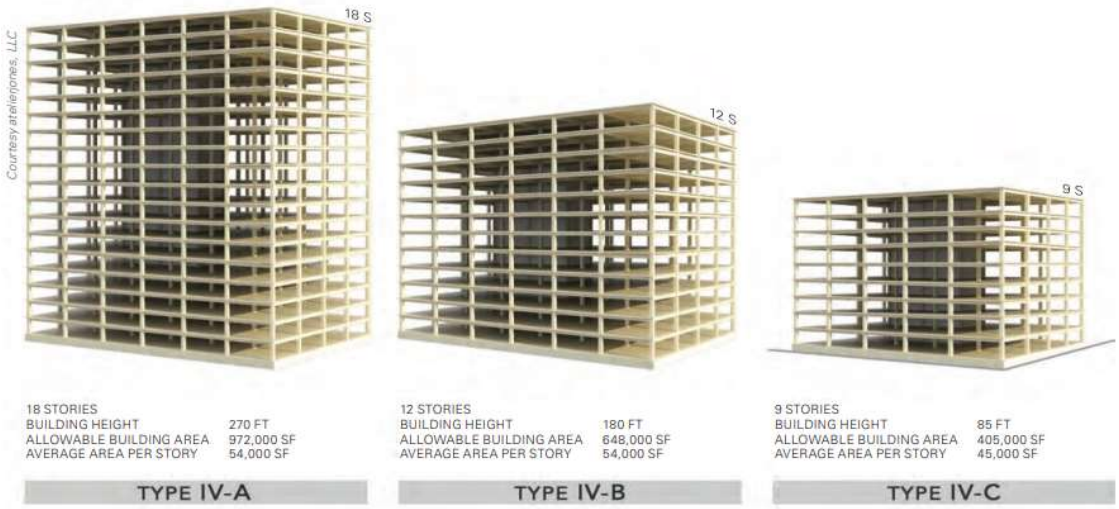
Fire Safety Considerations for Mass Timber Buildings

Application (IBC)

- Most typical application is **Type IV – Heavy Timber** (602.4)
- Heavy timber complying with 2304.11 and without concealed spaces
- Permitted in combustible construction **Type III** (602.3) and **Type V** (602. 5)
- Also permitted in **Type I** and **Type II** (602.2), per:
  - Combustible material in Types I and II (603)
  - Heavy Timber per Table 601 Note C
- *IBC 2021 Provisions under specific state adoption (e.g. WA, OR,..)*

New Code – IBC 2021

Representative Building Sizes, Business Occupancy



Group B (Office)

III-A, IV-HT & IV-C*

IV-C* and IV-B*

IV-B* and IV-A*

Construction Type	Stories	Max Height	Mass Timber	Sprinklers	Primary Frame Fire Rating	Stair Tower	Concealed Spaces
III-A	6	85’	Exposed	Yes	1 HR	Mass Timber	Yes
IV-HT							No
IV-C*	9				2 HR		Yes
IV-B*	12	180’	Partially Exposed				
IV-A*	9-18	270’	Fully Protected		3 HR	Noncombustible	

*Subject to state/city adoption process

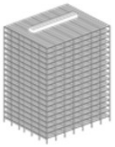
Fire Safety Considerations for Mass Timber Buildings

Group R-2 (Residential)

III-A, IV-HT & IV-C*

IV-C* and IV-B*

IV-A*



I-A and I-B

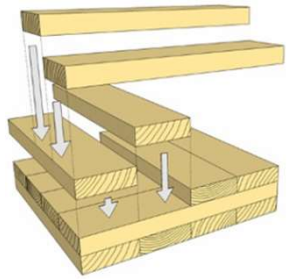
Construction Type	Stories	Max Height	Mass Timber	Sprinklers	Primary Frame Fire Rating	Stair Tower	Concealed Spaces
V-A	4	60’	Exposed	Yes	1 HR	Mass Timber	Yes
III-A	5	85’					No
IV-HT							
IV-C*	8				2 HR		Yes
IV-B*	12	180’	Partially Exposed				
IV-A*	18	270’	Fully Protected		3 HR	Noncombustible	
I-B	12	180’	N/A		2 HR		
I-A	Unlimited	Unlimited			3 HR		

*Subject to state/city adoption process

Fire Safety Considerations for Mass Timber Buildings

Section 2304.11 – Heavy Timber

- Minimum dimensions of HT (Table 2304.11)
- **Walls**: 4-in thick for interior walls and partitions. CLT permitted in exterior walls (2304.11.2)
- **Floors**: minimum 4-in thick (2304.11.3)
- **Roof Decks**: not less than 3-in nominal depth, constructed as per floors (2304.11.4)
- IV-HT floor construction shall be **without concealed spaces**
- IV-A, B or C permits concealed spaces (encapsulated)



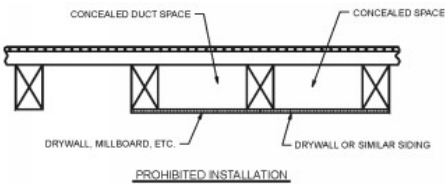
Typical CLT layup

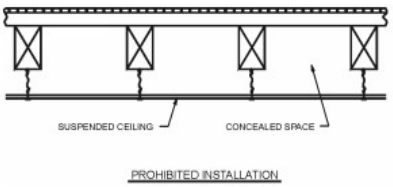
Typical NLT layup

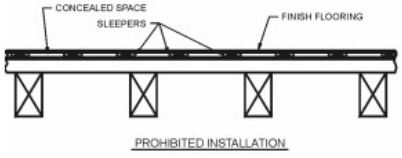
Fire Safety Considerations for Mass Timber Buildings

Concealed Spaces

- Concealed spaces **prohibited** within Type IV-HT construction (602.4)
  - Soffits
  - Plenums
  - Suspended ceilings
  - Raised access floors
- Concealed spaces **permitted** within Type IV-A, B and C construction
  - Require encapsulation with non-combustible protection:
    - Type IV-C: 40 mins (1 x 5/8" Type X)
    - Type IV-A and B: 80 mins (2 x 5/8" Type X)
- Remember draft stopping and sprinkler protection requirements!
- Potential to address through *alternative means and methods of construction.*







Fire Safety Considerations for Mass Timber Buildings

Surface Finishes

- Pass/fail criteria are identified in Chapter 8
- **Heavy Timber is exempt**, with exception of:
  - Interior exit stairways
  - Interior exit ramps
  - Interior exit passageways

--> Example:
Office (SP): Class B, (NSP): Class A

- Dependent on wood species of face panels – AWC-DCA 1 is a good reference
- Mass Timber elements have been tested to achieve Class A and B
- Exposed mass timber in exit ways – recommend review with AHJ early


Design for Code Acceptance 1

Flame Spread Performance of Wood Products Used for Interior Finish

Wood and wood-based products are widely used as interior wall, ceiling, and floor surfaces in all types of buildings. Appearance, acoustical qualities, and interior design versatility have made wood surfaces highly desired by architects, designers, and building occupants. This publication briefly describes building code flame spread regulations on products used in interior finish and presents performance data on a range of wood products.

Flame Spread Requirements

Most code requirements for wood interior finish materials are expressed in terms of flame spread index numbers. These values are determined in a standard fire test which evaluates the surface burning characteristics of a material. Different maximum flame spread indices are permitted depending upon building occupancy, location of the material in the building, and the presence of sprinklers. Flame spread indices in this publication are provided for wood materials that qualify for various building design requirements.

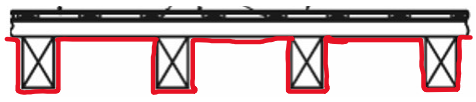
Test Method

The standard fire test used to evaluate flame spread characteristics of wood building materials in the United States is ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*.

The test procedure exposes candidate materials in a horizontal, rectangular tunnel that is 17¾" in width by 12' in height and 25' long. The tunnel is equipped with two gas burners at one end that direct a flame onto the surface of the test material under a controlled air flow. Flame spreads along the surface of the material as the test progresses. Distance of the flame travel and the rate at which the flame front advances during a

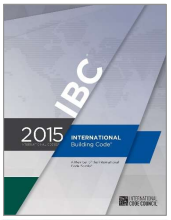
Exposed Mass Timber

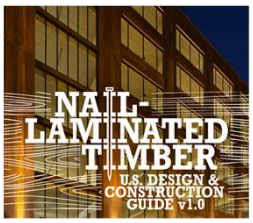
- Type IV-C (2-HR): Fully Exposed
- **Type IV-B (2-HR): Partially Exposed (80mins by NC material)**
- Type IV-A (3-HR): Fully Protected (120mins by NC material)
- Partially exposed:
  - Ceiling: 20% of floor area of dwelling unit, or fire area (integral beams included)
  - Wall: 40% of floor area of dwelling unit, or fire area (integral columns included)
  - Wall + Ceiling: ratio < 1.0
  - Unprotected areas separated > 15'
- Floor covered with min. 1" NC layer
- Rib-decks and similar system have increased surface area → reduced exposed ceiling area
- AMM for increased exposed mass timber:
  - Testing of Gen. 2.0 panels (PRG320-2018)
  - Fire modelling
  - Improved fire protection (passive + active)

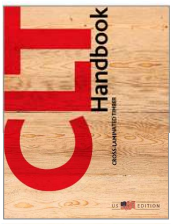


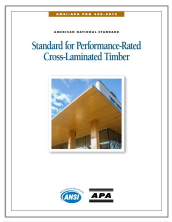
Fire Resistance Rating (FRR)

- Section 703 – ASTM E119/UL 263 standard furnace test, OR
- 703.3 – Methods of determining fire resistance:
  - Designs documented in approved sources.
  - Prescriptive designs per 721
  - **Calculations per 722 (→ NDS 16)**
  - Comparative engineering analysis (to an approved assembly)
  - Alternative protection methods per 104.11 (equivalence)
  - Designs certified by an approved agency.









Fire Resistance Rating (FRR)

- Instances where code may require higher FRR's:
  - Fire barriers (and supporting construction):
    - Occupancy separations;
    - Shaft enclosures;
    - Exit passageways;
    - Atrium separation;
    - Incidental uses, etc
  - Firewalls
  - Exterior walls
- Supporting construction provisions may dictate FRR's to primary structural frame, connections and floors.

FRR by Encapsulation

- Protection with non-combustible linings (e.g.: gypsum) per Section 722.6
- Membrane protection applies to fire-side only (Table 722.6.2(1))
  - E.g.: 5/8-inch Type X provides 40 minute protection
- For Type IV-A and IV-B – NC protection shall be at least 2/3 of required FRR
  - E.g.: 2-HR CLT floor in Type IV-A shall be protected with 80 mins NC protection (2 x 5/8" Type X gypsum)
- AWC-DCA 4 provides further reference.

Fire Encapsulation

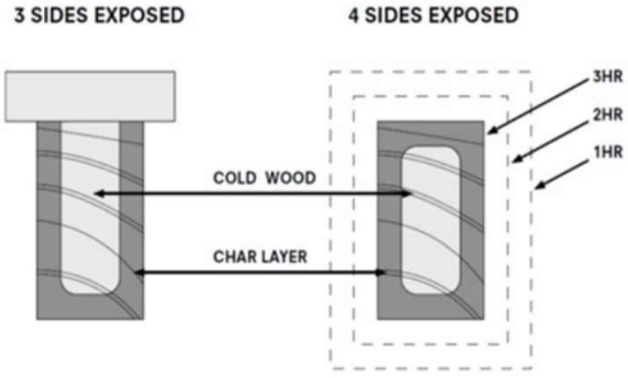
1. Mass Timber Structure
2. 2 layer ⅝" type x Gypsum Board

Exposed FRR - Charring

- Section 722.1 – fire resistance of **exposed** wood structures shall be calculated per Chapter 16 of ANSI/AWC National Design Specification for Wood Construction (NDS-16).
- Structural stability:

Induced Stress (fire) < Member Strength

Glulam beam after 90 min fire test (APA)



NDS-16: Char Rate

NLT
1.5”/HR

DLT
1.5”/ HR

CLT
1.9”/HR

GLULAM
1.5”/ HR

LVL
1.5”/ HR

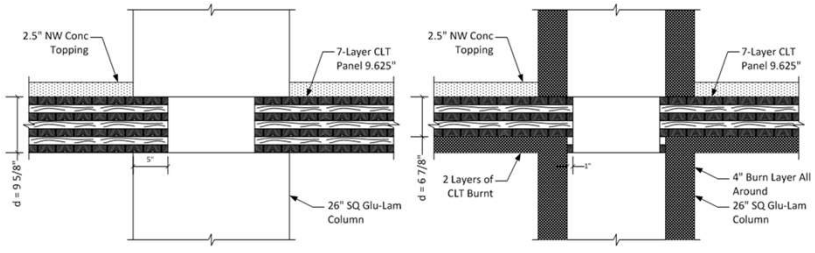
LSL
1.5”/ HR

* PER NDS 2015

Fire Safety Considerations for Mass Timber Buildings

NDS-16: CLT

- Fire performance is dependent on manufactured system
- Char rate for CLT is increased as a result of the glue interface at laminations
  - E.g.: CLT panel with 1-3/8” laminates results in 1.9” char depth after 1-HR exposure
- Reduced section properties for CLT shall be calculated based upon manufacturer published data

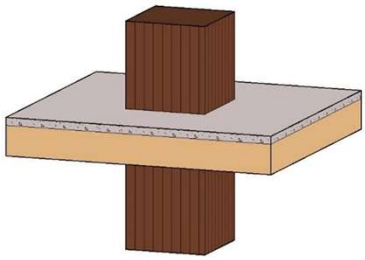


Service Condition **Fire Condition**

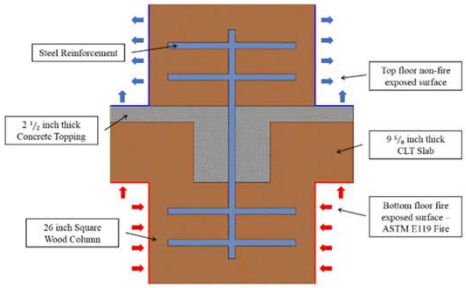
Fire Safety Considerations for Mass Timber Buildings

Performance Based FRR

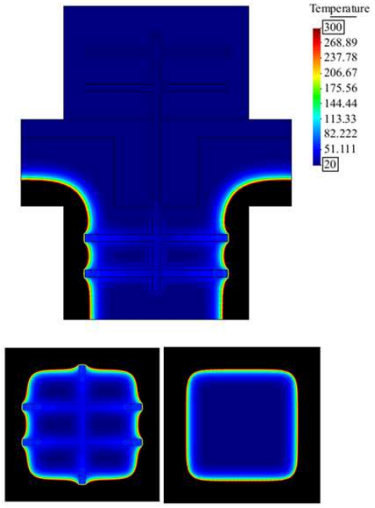
- Thermal-finite element assessment of assemblies
- Support engineering judgement of untested systems
- Protection details for connections
- Furnace and realistic building fires



Assembly Selected for Fire Analysis



Square Column to Slab Connection



Fire Safety Considerations for Mass Timber Buildings

Approvals Process

- Develop code compliance path (prescriptive vs performance) → achieve design goals
- Early and frequent engagement of Building and Fire authorities (SD phase)
- Determine necessary testing program, engineering judgments and AMM's:
  - Penetrations, joints
  - Head-of-wall, edge of slab at curtain wall
  - Connection protection
  - % exposed mass timber
  - Structural-lateral system
  - Floor diaphragm
- Peer reviewer → familiar with mass timber design (early engagement)
- Working with manufacturers and GC for constructability, manufacturing and fabrication

Fire Safety Considerations for Mass Timber Buildings

Holmes

holmesfire.com