Commercial Construction Consulting. Inc.

Adaptive Re-Use of Heavy Timber Buildings

Boston Society of Architects

Codes Committee

January 15, 2020

Presented by Doug Anderson, Mgr, Code Advisory Group

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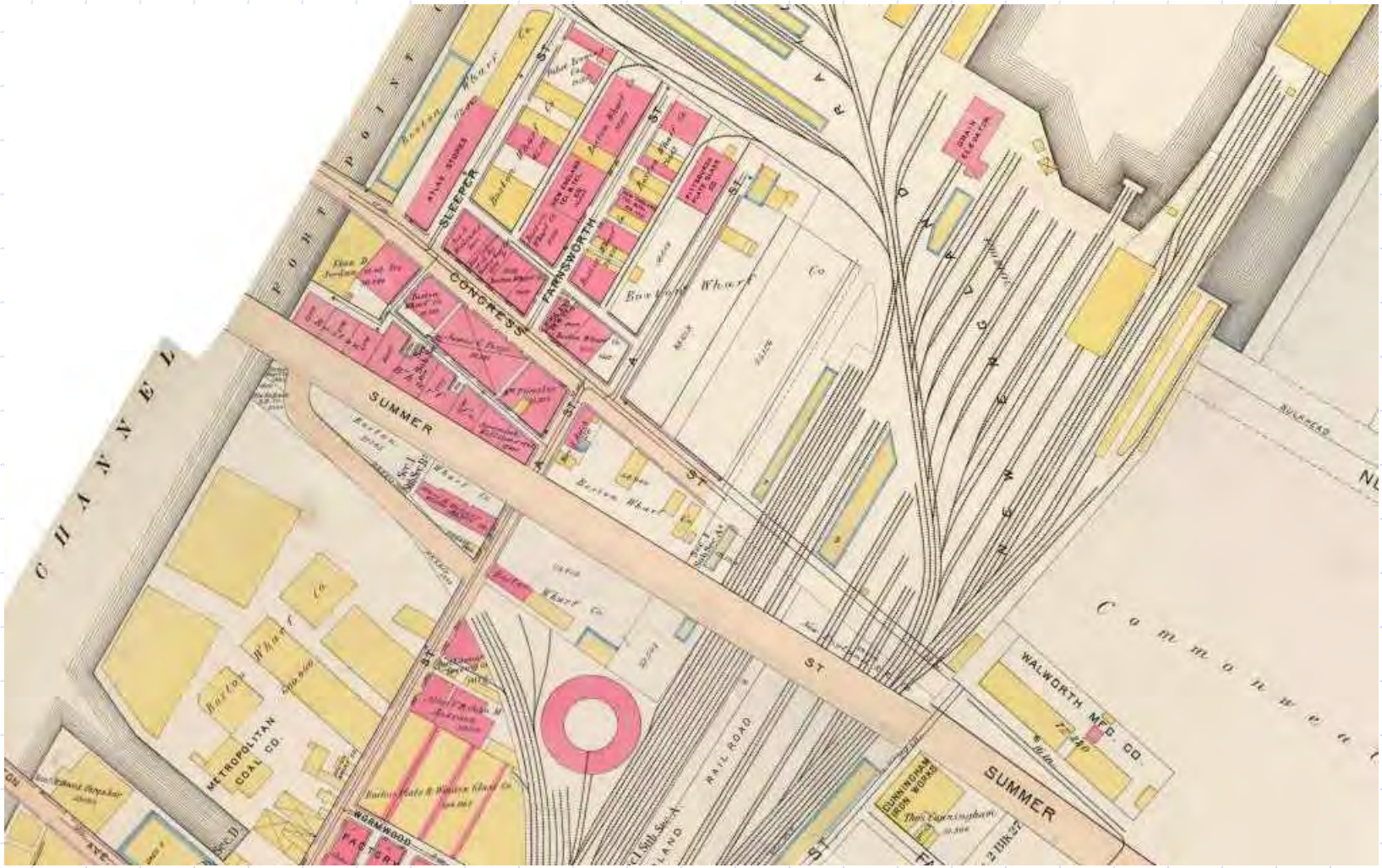
Learning Objectives

- Identifying “heavy timber” buildings
- Determination of most ideal construction type based on proposed change of use
- Construction issues encountered when retrofitting new building systems
- Use a case study of a renovated high rise heavy timber building to understand the code complications with existing building requirements
- The Future: Tall Wood Buildings

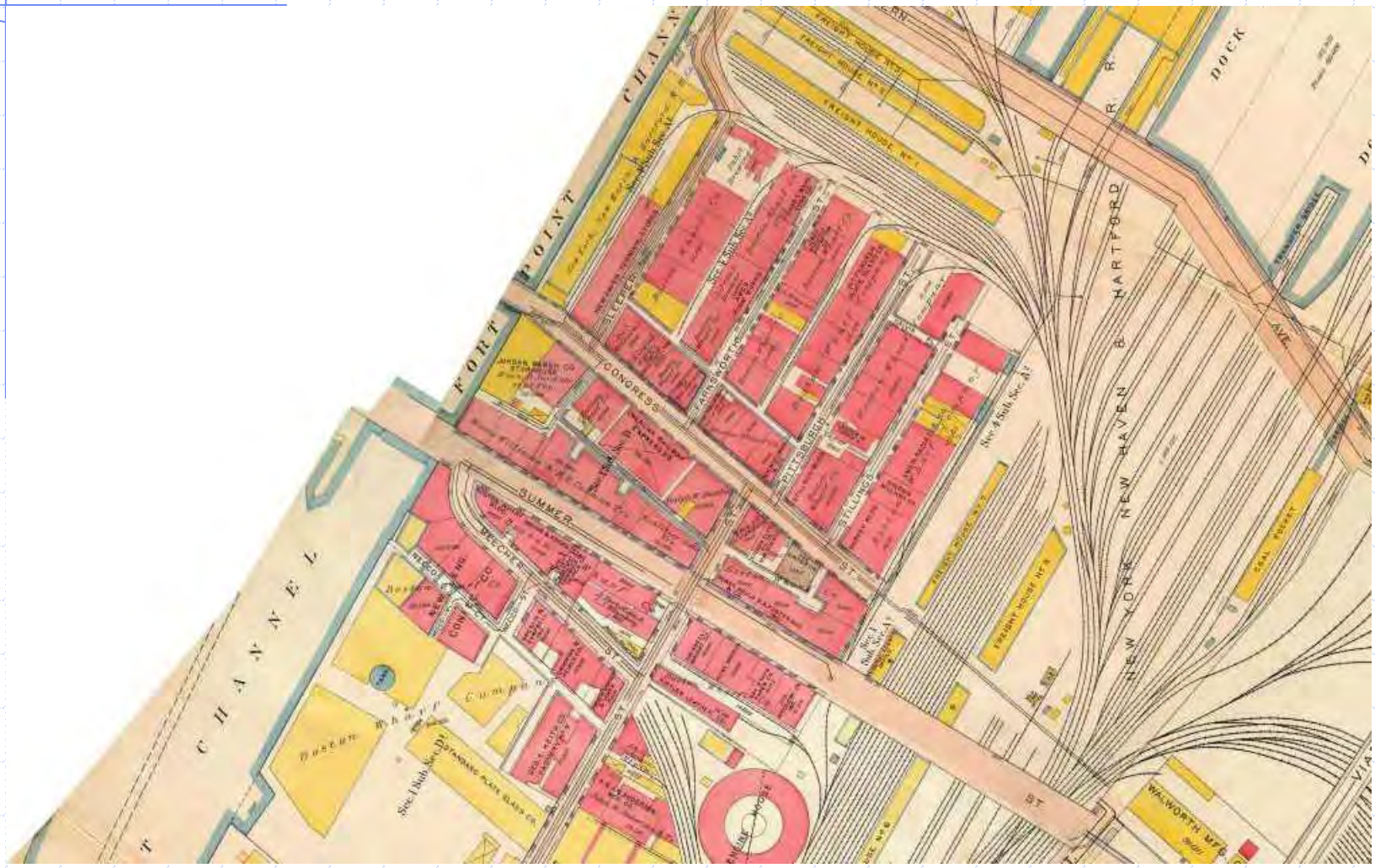
Heavy Timber

Fort Point, 1899



BRA

Fort Point, 1919



BRA

Heavy Timber

- 1901 Boston Building Law

"Second class building" means all buildings not of the first class (incombustible), the external and party walls of which are of brick, stone, iron or other equally substantial and incombustible material.

BPL

Heavy Timber

1901 Boston Building Law

- The external and party walls above the foundation of every building of the first or second class hereafter built, other than dwellings, forty feet or less in height, shall be sixteen inches thick to the top of second floor, and twelve inches for the remaining height...

Heavy Timber

- 1901 Boston Building Law
  - The ends of all wooden floor or roof beams in second class buildings shall enter the wall to a depth of at least four inches, unless the wall is properly corbelled so as to give a bearing of at least four inches; and the ends of all such beams shall be so shaped or arranged that in case of fire they may fall without injury to the wall.

Heavy Timber

- 1901 Boston Building Law
- Sect. 49. Every column shall rest upon a cap or plate sufficient to properly distribute the load. Columns set one above another shall have proper connections. All bearing parts of columns or plates shall be turned or planed to true surfaces. The commissioner may require columns to be drilled for inspection.

Heavy Timber

- Materials in Boston predominately southern yellow pine

Deflection. — Modulus of Elasticity.

White pine,	750,000
Spruce,	900,000
Yellow pine (long-leaved),	1,300,000
White oak,	860,000

Table from 1901 Boston Building Law

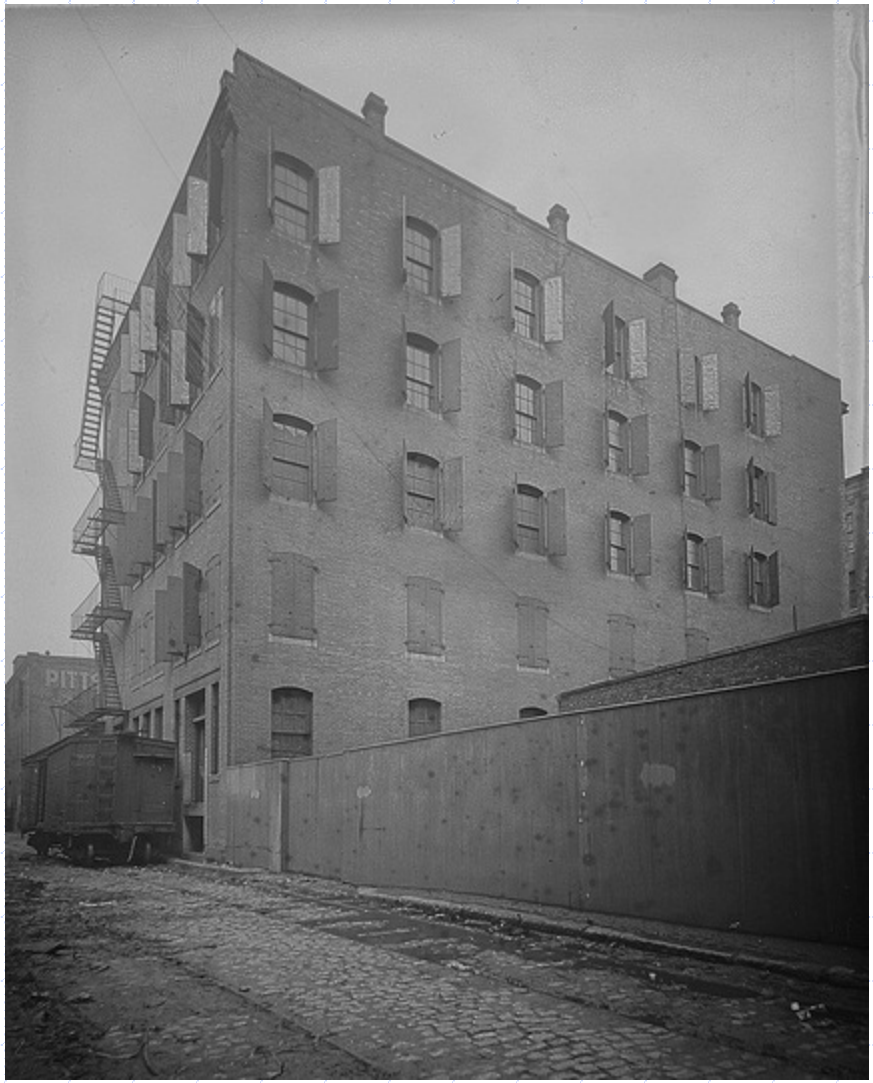
Heavy Timber

- 780 CMR: Massachusetts State Building Code which is 2015 IBC with Amendments
- Heavy Timber is defined in Section 602.4 of the 2015 IBC

Heavy Timber

IBC 602.4: Type IV

- Exterior walls of non combustible materials
- Interior of solid or laminated wood without concealed spaces.
- FRT permitted in exterior walls with 2 hr or less rating
- Cross Laminated Timber permitted if protected



Heavy Timber

Columns (602.4.1)

- Not less than 8” nominal when supporting floor loads
- Not less than 6” by 8” nominal when supporting roof and ceiling loads only

BPL

Heavy Timber

Floor Framing (602.4.2)

- Not less than 6” nominal in width
- Not less than 10” nominal in depth
- Arches and trusses not less than 8” nominal in any direction

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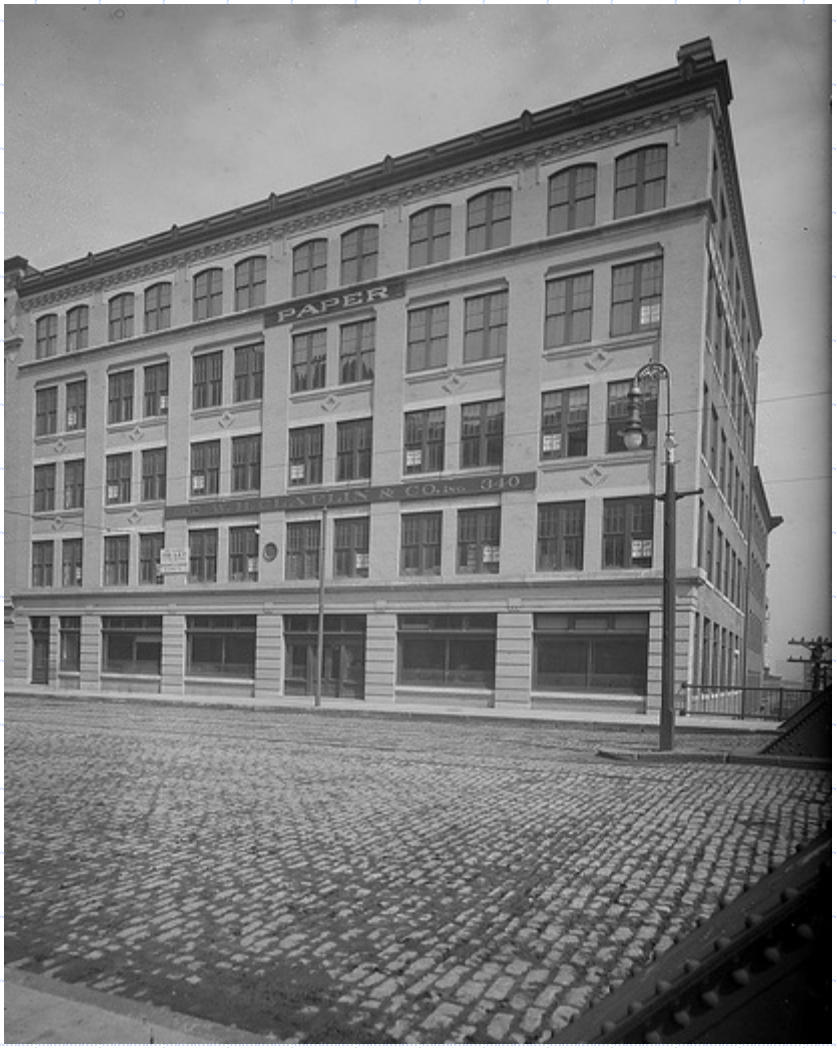
Heavy Timber

Floors (602.4.4)

Planks, splined or T/G, not less than 3” nominal in thickness covered with 1” nominal T/G flooring laid crosswise



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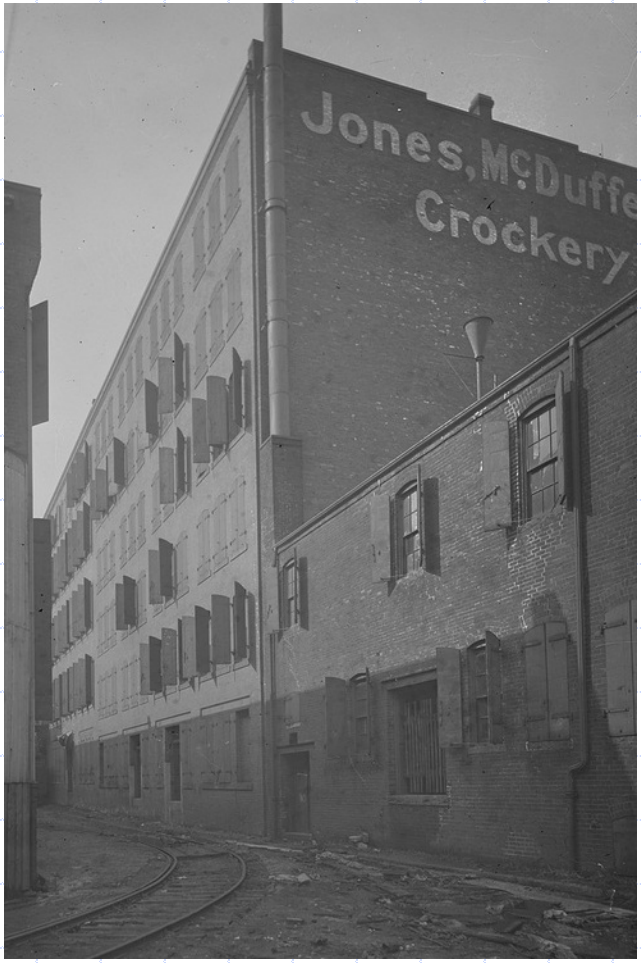
Heavy Timber

Roof Framing (602.4.3)

- Not less than 6” nominal in width
- Not less than 8” nominal in depth for lower half and not less than 6” for upper half
- Arches and trusses not less than 4” nominal in width and not less than 6” in depth.

BPL



Heavy Timber

Roofs (602.4.5)

- Planks, splined or T/G, not less than 2” nominal in thickness; or
- 1 1/8” wood structural panel; or
- Planks not less than 3” nominal in width

BPL

Heavy Timber

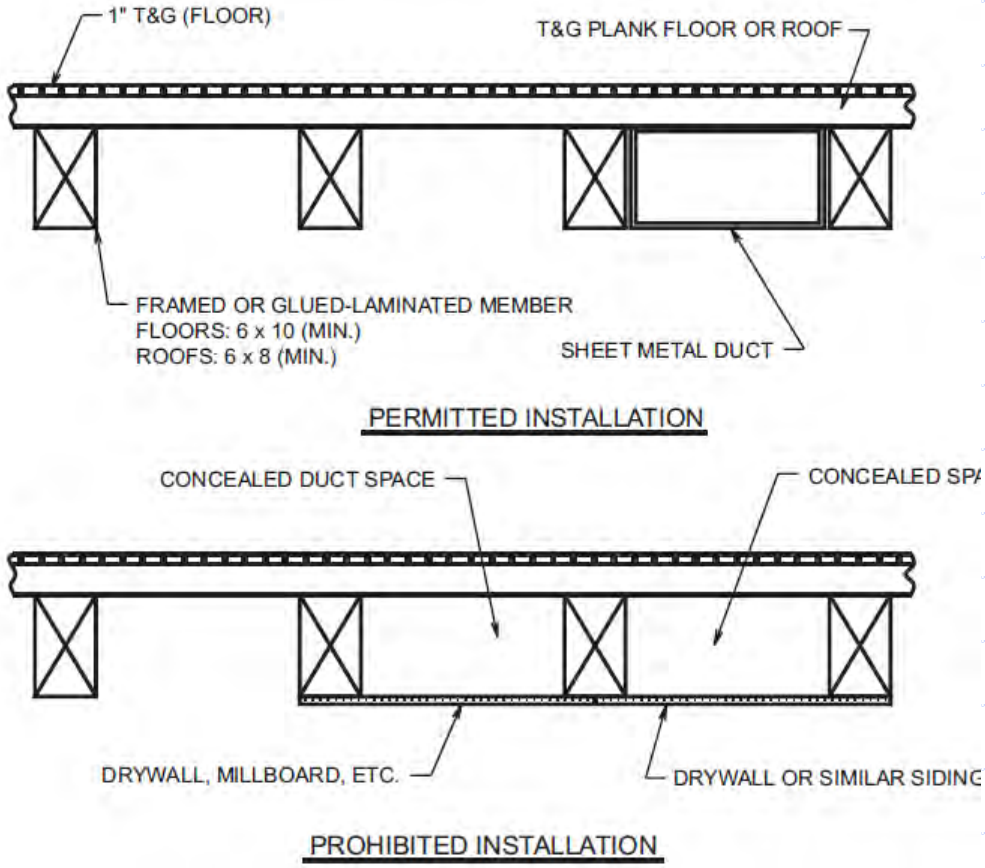
Partitions (602.4.6)

- Solid wood construction not less than 2-1” boards; or
- Laminated construction 4” thick; or
- 1 hour fireresistance rating

BPL

Heavy Timber

- IBC 602.4
  - ..."interior building elements are of solid or laminated wood **without concealed spaces**."



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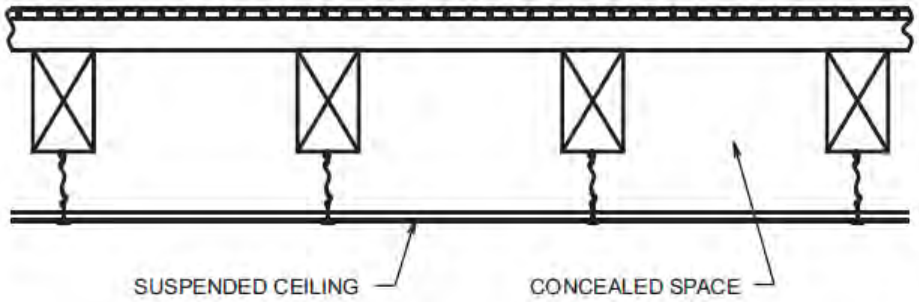
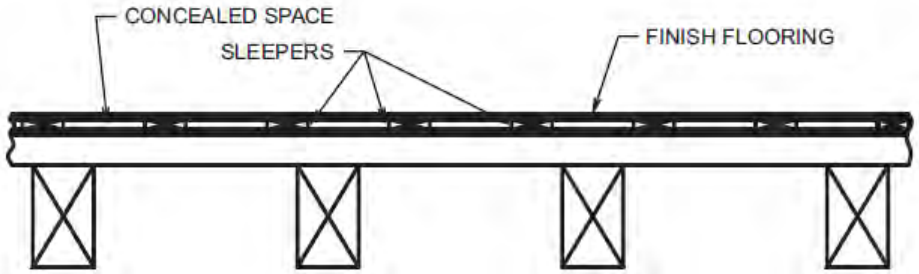


PROHIBITED INSTALLATION



PROHIBITED INSTALLATION

Heavy Timber

- Type IV: Is it appropriate for today's adaptive re-use?
  - 780 CMR 6th Edition Table 601 and Sec 2304 permitted non-timber elements at one hour rated (columns, beams)
  - 780 CMR 9th Edition does not permit non-heavy timber elements except interior bearing walls

Heavy Timber

Heavy Timber

- Compare Type III with Type IV

FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (hours)

BUILDING ELEMENT	TYPE III		TYPE IV
	A[d]	B	HT
Primary structural frame[g] (see Section 202)	1	0	HT
Bearing walls Exterior[f, g] Interior	2 1	2 0	2 1/HT
Nonbearing walls and partitions Exterior	See Table 602		
Nonbearing walls and partitions Interior[e]	0	0	See Section 602.4.6
Floor construction and secondary members (see Section 202)	1	0	HT
Roof construction and secondary members (see Section 202)	1[b, c]	0	HT

Heavy Timber

- Compare Type III with Type IV

Height and Area Limitations

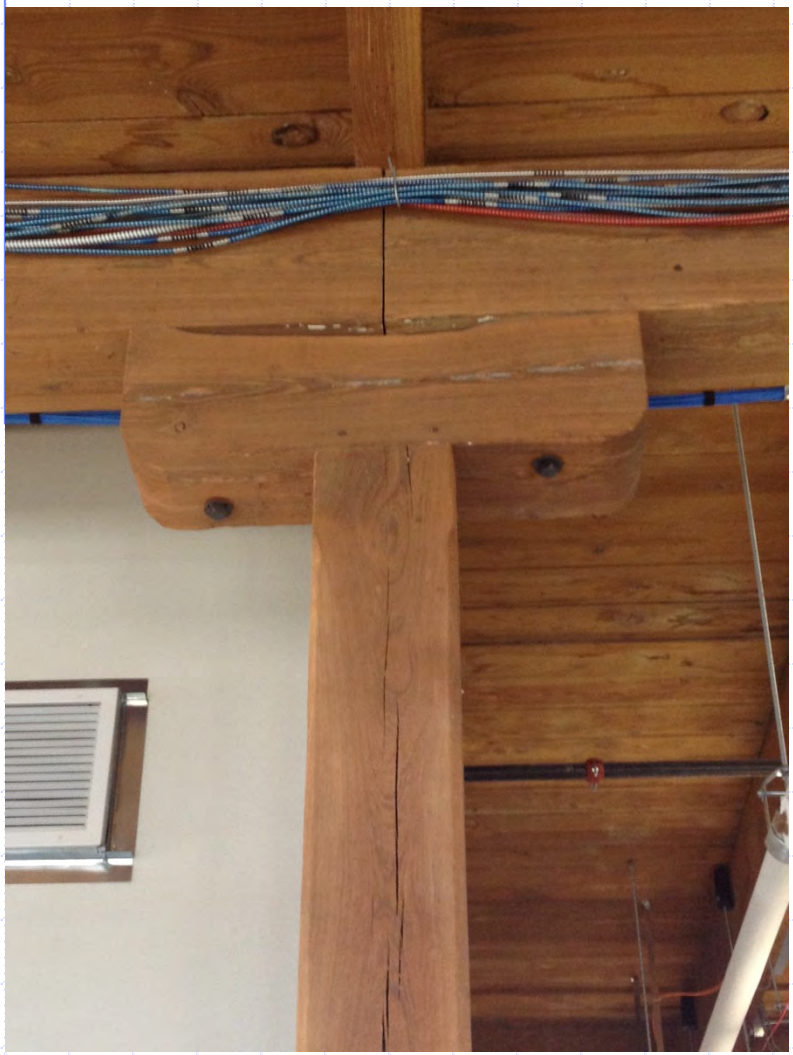
	IIIA	IIIB	IV
Group B	5 St, 65’ 28,500	3 St, 55’ 19,000	5 St, 65’ 36,000
Group R-2	4 St, 65’ 24,000	4 St, 55’ 16,000	4 St, 65’ 20,500

Heavy Timber

Joist Hangers

Heavy Timber

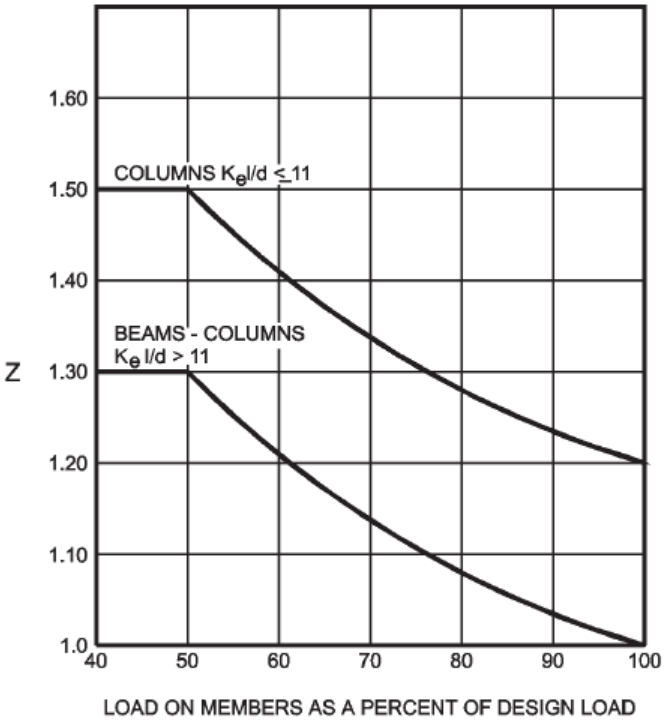
Column Capitals



Heavy Timber

How does heavy timber achieve a one hour rating?

- 2.54*Zb* (4 -(*b*/*d*)) for beams which may be exposed to fire on three sides.
- *b* = The breadth (width) of a beam or larger side of a column before exposure to fire (inches).
- *d* = The depth of a beam or smaller side of a column before exposure to fire (inches).
- *Z* = Load factor, based on Figure 720.6.3(1).*d*)) for beams which may be exposed to fire on three sides.



Heavy Timber

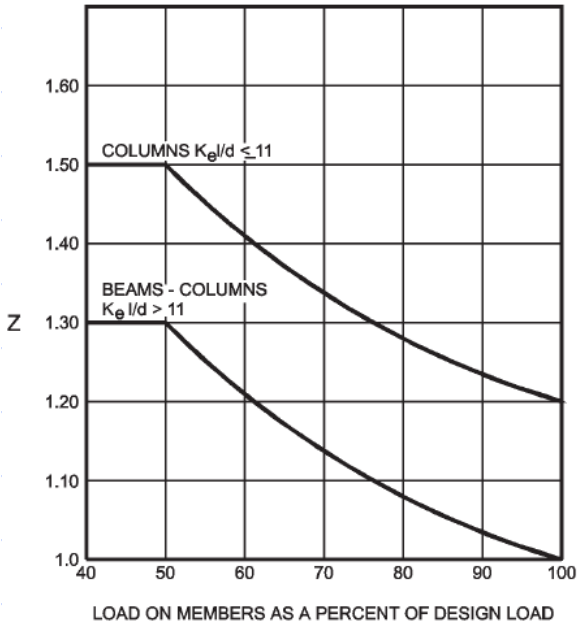
How does heavy timber achieve a one hour rating?

- 2.54*Zb* (4 -(*b/d*)) for beams which may be exposed to fire on three sides.

- *b* = 10”
- *d* = 12”
- *Z* = Load factor, 50%

(2.54)(1.30)(10)[(4-(10/12)] = 104 minutes

- **721.6.1.1 Maximum fire-resistance rating.** Fire-resistance ratings calculated using the methods in Section 721.6 shall be limited to a maximum of 1-hour.



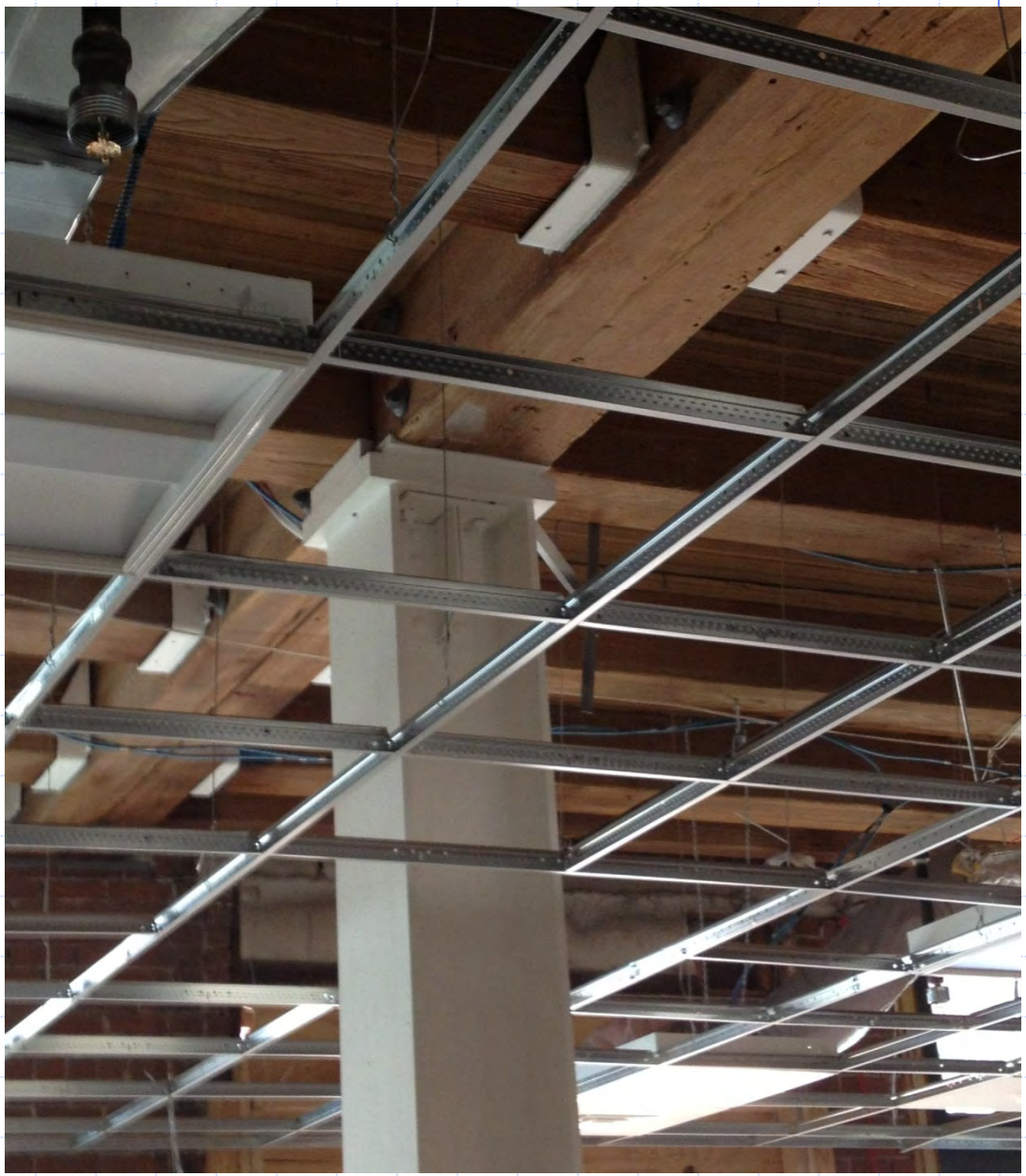
Heavy Timber

Fireresistance rated

721.6.3.3 Fastener protection. Where minimum 1-hour fire resistance is required, connectors and fasteners shall be protected

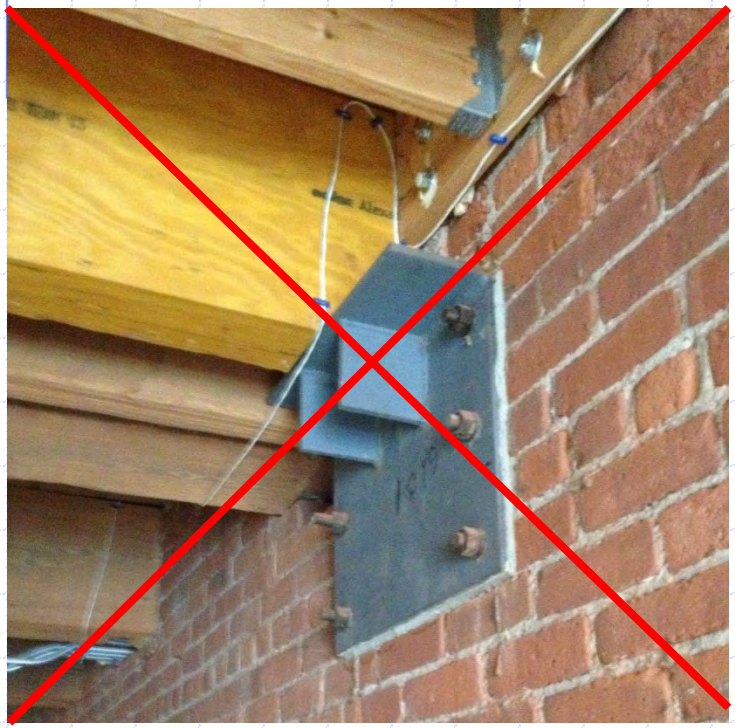
Heavy Timber

- One hour column



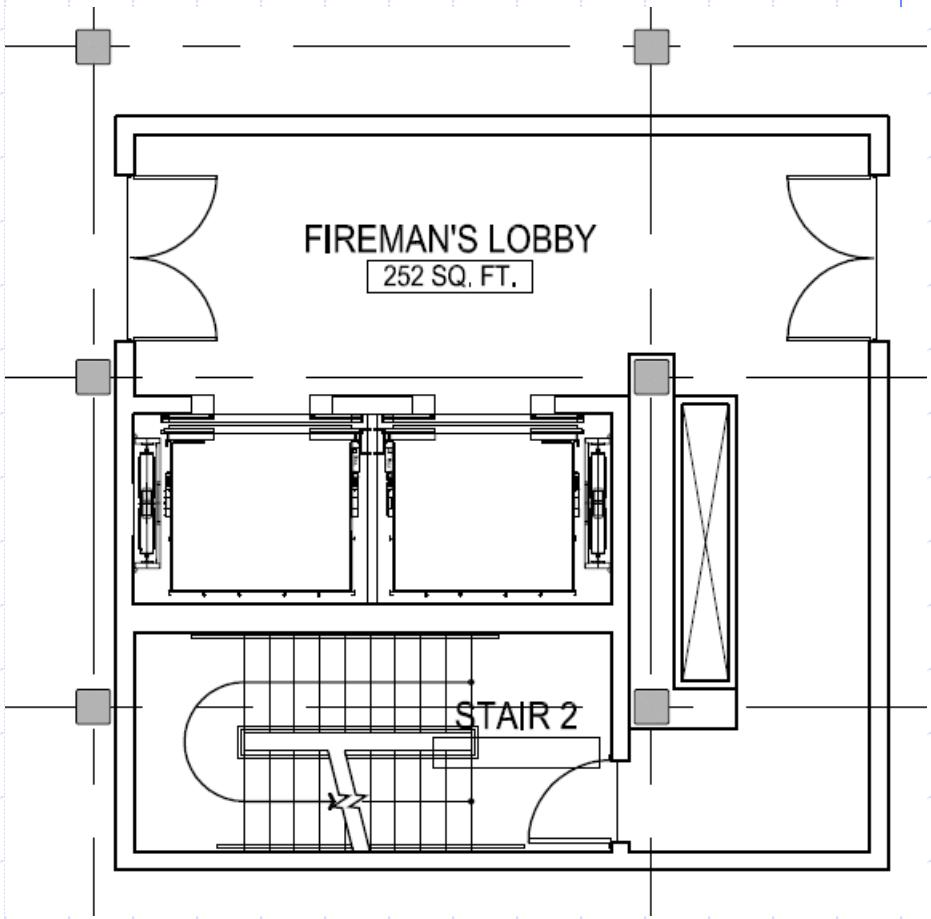
Heavy Timber

How to address new stairs and hoistways with two hour ratings?



Heavy Timber

- New interior framing; or
- Prescriptive FRR of Section 721



Heavy Timber

- Unreinforced Masonry Walls

Heavy Timber

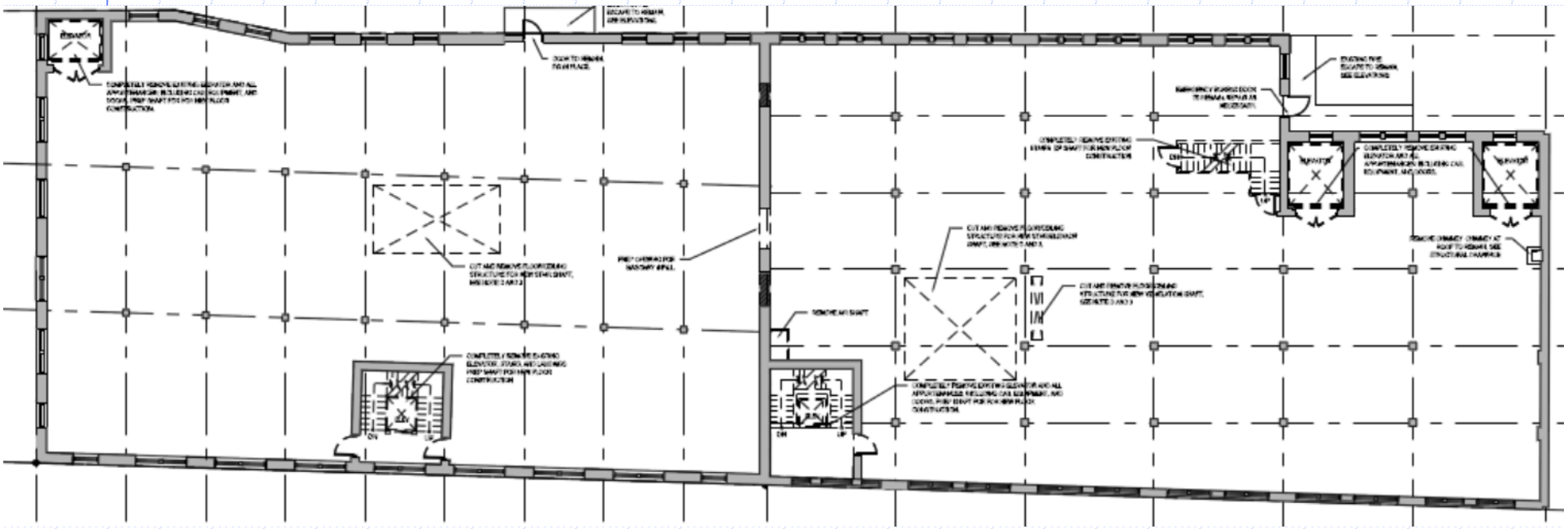
- Seismic Upgrades

Heavy Timber

- Seismic Upgrades

Heavy Timber

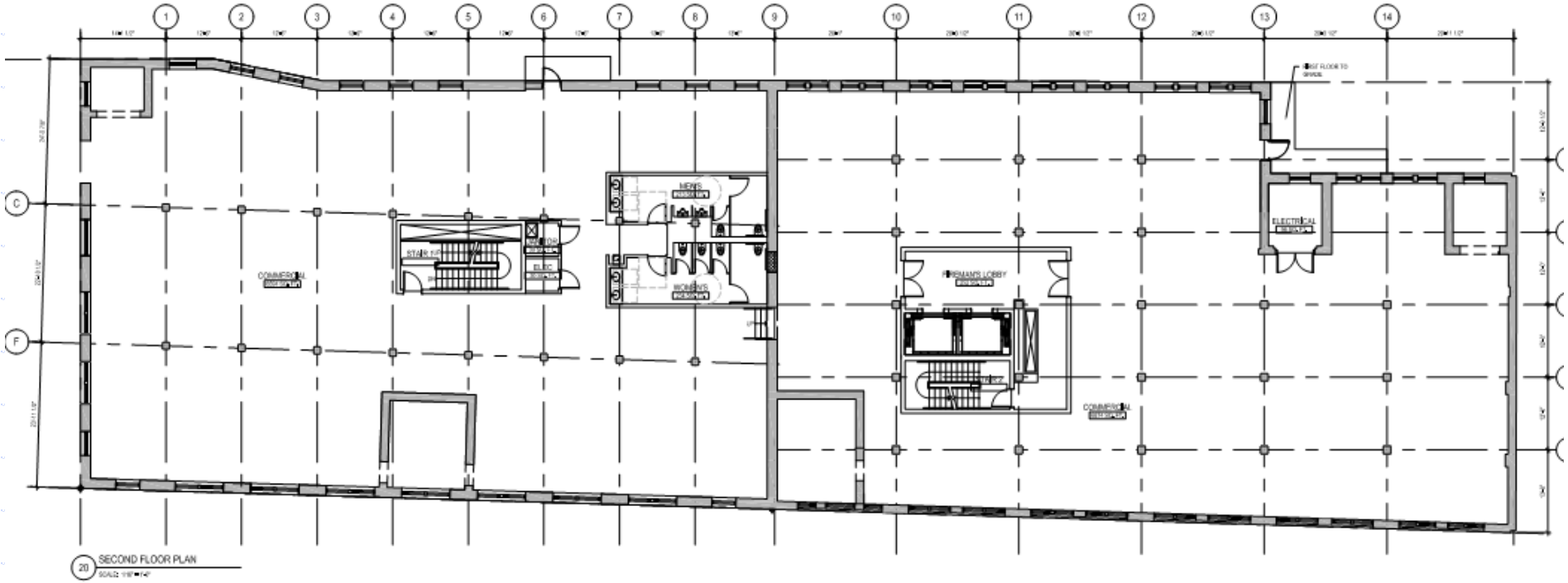
- High Rise Adaptive Re-use



TAT

Heavy Timber

- High Rise Adaptive Re-use



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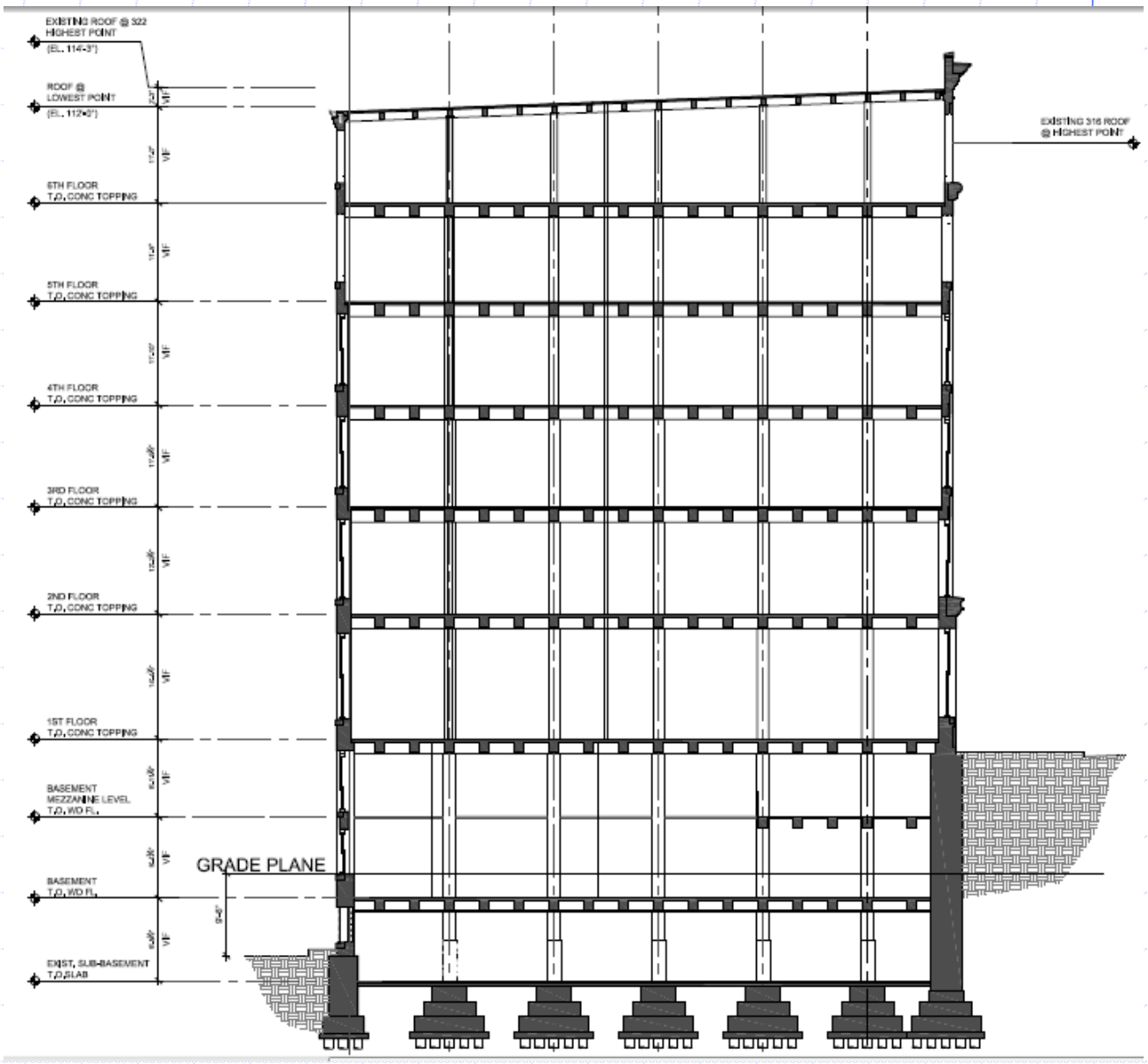


Heavy Timber

- High Rise Wood Framed Buildings

2021 IBC is on track to adopt:

Type IV-A up to 18 stories, 270’
3 HR PSF, 2 hr floors

Type IV-B up to 12 stories, 180’
2 HR PSF, 2 hr floors

Type IV-C, up to 9 stories, 85’
2 HR PSF, 2 hr floors

Type IV-HT, up to 6 stories, 85’
HT PSF, HT floors

Mjøstårnet, Brumunddal, Norway

Heavy Timber

- High Rise Wood Framed Buildings

Types of Wood:

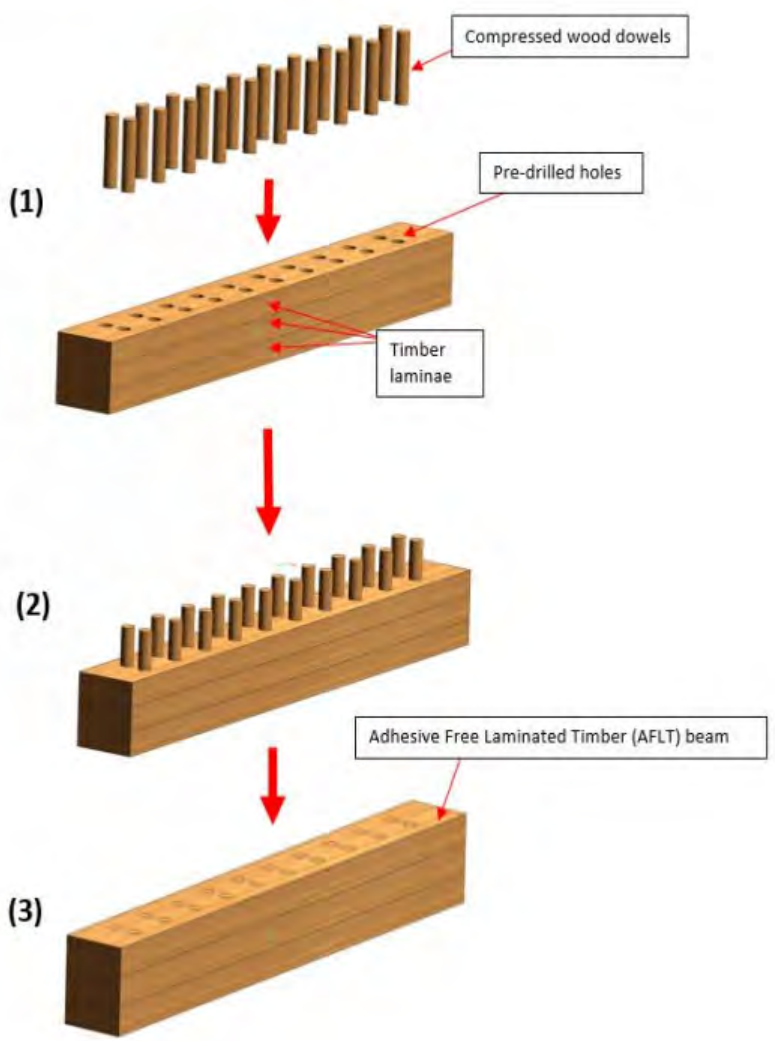
Laminated
Cross Laminated

Heavy Timber

- High Rise Wood Framed Buildings

Types of Wood:

Dowel Laminated



Heavy Timber

- High Rise Wood Framed Buildings

Type IV-A

3-hour fire-resistance-rated primary structural frame elements and bearing walls, with 2-hour fire-resistance-rated floors. Exposed timber surfaces must be entirely encapsulated. For certain occupancies or uses, Type IV A buildings are permitted to achieve eighteen stories and 270 feet in building height.

Heavy Timber

High Rise Wood Framed Buildings

Type IV-B

2-hour fire-resistance-rated primary structural frame elements and bearing walls, with 2-hour fire-resistance-rated floors. A calculated percentage of the exposed timber surfaces may remain exposed under this type, as established in Section 602.4.2.2.2 of the alternate. For certain occupancies or uses, Type IV B buildings are permitted to achieve twelve stories and 180 feet in building height.

Heavy Timber

High Rise Wood Framed Buildings

Type IV-C

2-hour fire-resistance-rated primary structural frame elements and bearing walls, with 2-hour fire-resistance-rated floors. Exposed timber surfaces are permitted to remain entirely exposed under this type. For certain occupancies or uses, Type IV C buildings are permitted to achieve nine stories and 85 feet in building height.

Heavy Timber

High Rise Wood Framed Buildings

FIGURE 3
Representative Building Sizes, Business Occupancy

Courtesy ateliersjones, LLC

18 STORIES	
BUILDING HEIGHT	270 FT
ALLOWABLE BUILDING AREA	972,000 SF
AVERAGE AREA PER STORY	54,000 SF

TYPE IV-A

12 STORIES	
BUILDING HEIGHT	180 FT
ALLOWABLE BUILDING AREA	648,000 SF
AVERAGE AREA PER STORY	54,000 SF

TYPE IV-B

9 STORIES	
BUILDING HEIGHT	85 FT
ALLOWABLE BUILDING AREA	405,000 SF
AVERAGE AREA PER STORY	45,000 SF

TYPE IV-C

Thank you for your time!

Questions?

This concludes The American Institute of Architects Continuing Education Systems Program

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