Exploring Tall Wood & Mixed-Use Building Analysis

March 6, 2024

Presented by
Jessica Scarlett, EIT
WoodWorks

Apex Plaza / Courtesy William McDonough + Partner

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John W. Olver Design Building at UMass Amherst
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Learn Tools Events Award Gallery Why Wood? About

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Building Systems

- Light-Frame
- Mass Timber / CLT
- Off-Site / Panelized Construction
- Hybrid

Building Types

- Multi-Family / Mixed Use
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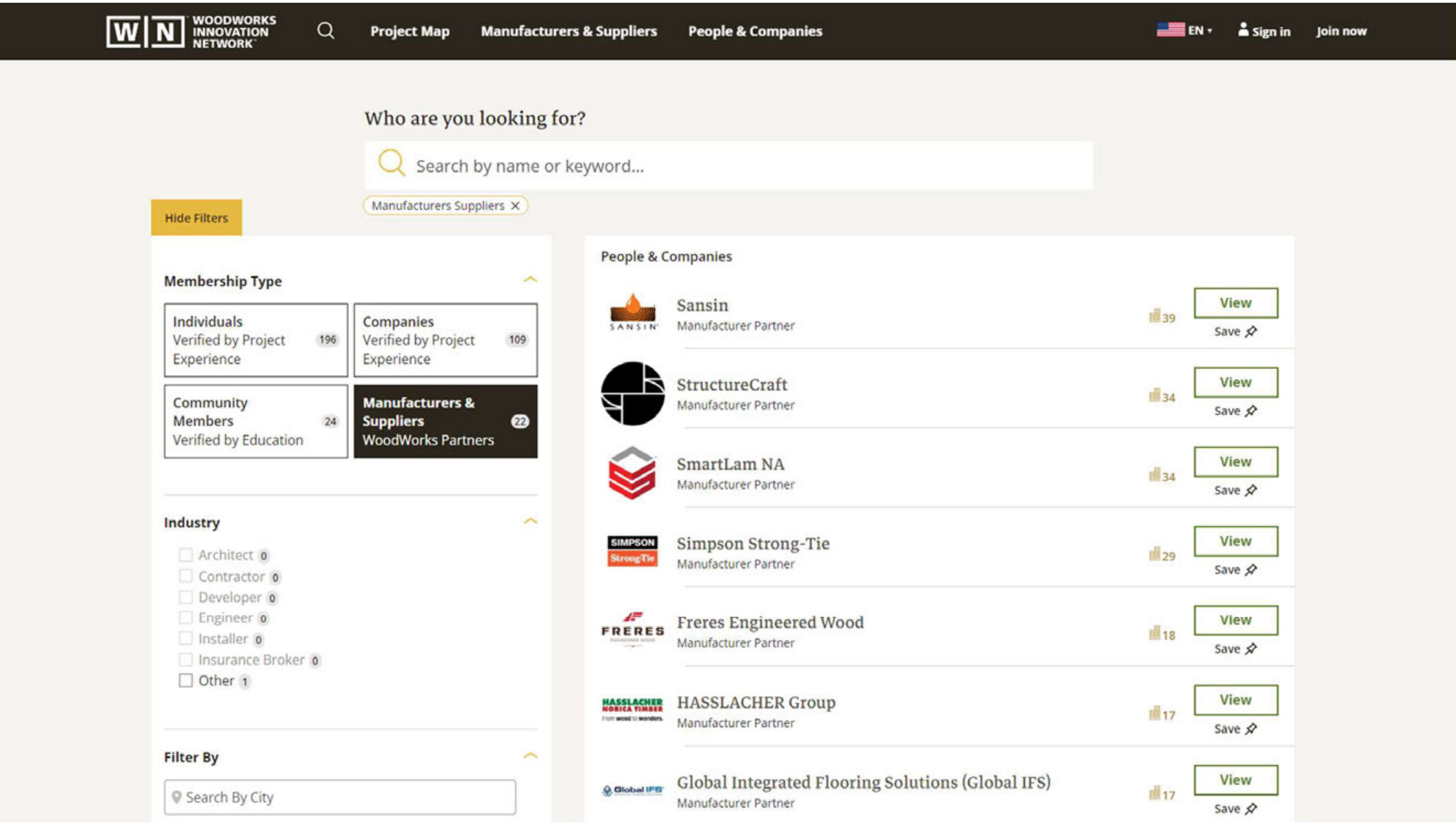
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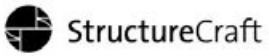

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Agenda

Exploring Tall Wood & Mixed-Use Building Analysis

AIA Course	**12:00 pm – 12:55 pm**	***Taking the Guesswork out of Mixed-Use Building Analysis*** Q&A
	12:55 pm - 1:05 pm	Break
	1:05 pm – 2:00 pm	***Exploring Tall Wood: New Code Provisions for Tall Timber Structures*** Q&A

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Course Description

While mixed-use buildings—which combine multiple occupancy types and/or functions in a single structure—are common, determining how to apply their unique mix of code requirements can be a daunting task. To simplify code analysis associated with these buildings, this presentation covers logical, code-compliant steps for a number of topics, including determining allowable building size, separation needs, detailing requirements, and the application of special provisions. With an emphasis on the use of wood framing in Construction Types III, IV and V, examples, calculations, and details will be presented to demonstrate how to navigate the various code requirements associated with mixed-use buildings while maximizing building size and meeting fire and life safety needs.

Learning Objectives

1. Review the basic fire and life safety requirements associated with mixed-use, wood-frame structures.

2. Become familiar with the differences between Construction Types III, IV and V as defined by the International Building Code.

3. Highlight options for determining allowable building size of mixed-use facilities, including separated and non-separated occupancies, incidental uses and podiums.

4. Demonstrate how to achieve separation of occupancies with fire barriers, fire walls and horizontal assemblies.

Course Description

As interest in and use of mass timber in the U.S. has grown, so too has interest in pushing these timber structures to greater heights. Using international examples of successful tall wood buildings as precedent, some designers have proposed tall wood projects in the states using a project-specific performance-based design approach. In order to provide a uniform set of code provisions for these tall wood buildings, the International Code Council established an ad hoc committee on tall wood buildings that proposed a set of code changes allowing up to 18 stories of mass timber construction. Those code changes were announced as approved in January 2019 and will become part of the 2021 International Building Code. Following a brief discussion of history and motivators, this presentation will introduce the new tall wood code provisions and construction types, as well as the technical research and testing that supported their adoption.

Learning Objectives

1. Review the global history of tall wood construction and highlight the mass timber products used in these structures.

2. Explore the work and conclusions of the ICC Ad Hoc Committee on Tall Wood Buildings in establishing 14 new code provisions for the 2021 IBC that address tall wood construction.

3. Discuss differences between the new tall wood mass timber construction types and existing construction types.

4. Identify the key passive fire-resistance construction requirements and active systems that enable taller wood buildings to be built safely.

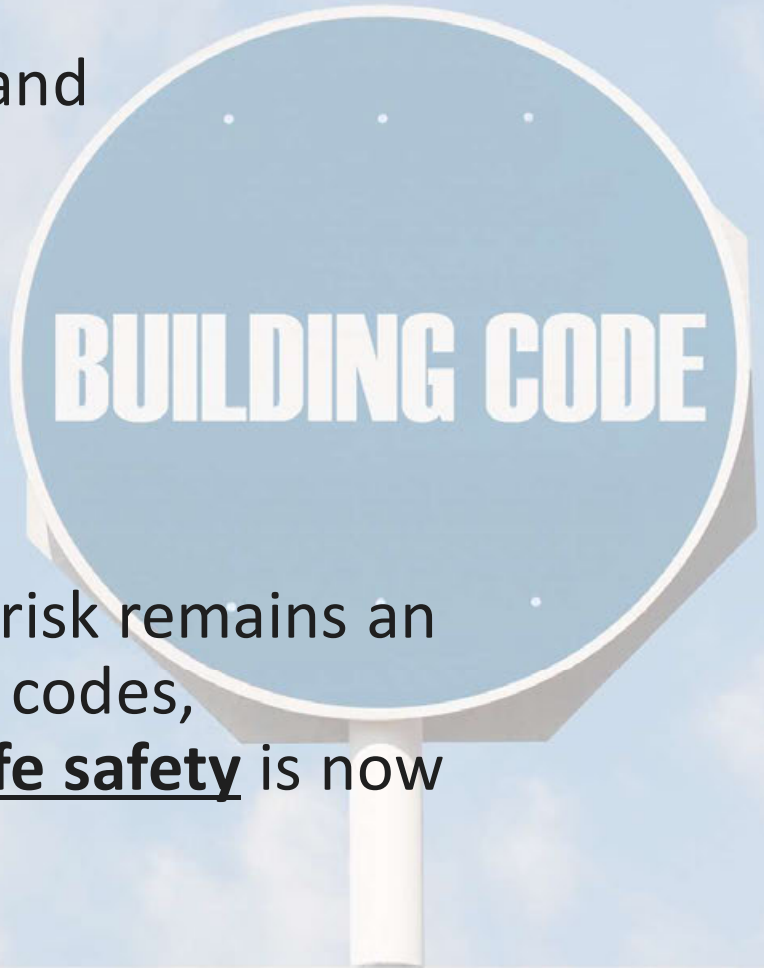
Mixed-use development is a type of urban development that blends residential, commercial, cultural, institutional, or industrial uses, where those functions are physically and functionally integrated, and that provides pedestrian connections.

Source: Thrall

Fire and Life Safety

IBC

As a result of extensive research and advancements in fire technology, today's building codes are more comprehensive and complex



While the principle of equivalent risk remains an important component in building codes, perspectives have changed and **life safety** is now the paramount fire issue.

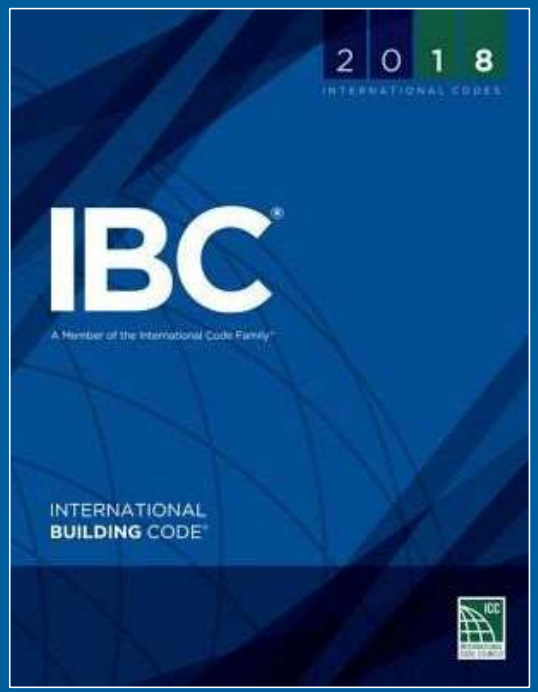
Fire and Life Safety

IBC

Minimum provisions to achieve life safety:

- Fire detection, notification & suppression systems
- Adequate means of egress
- Limitation of fire spread
- Structural fire resistance
- Prevention of smoke migration

Outside scope of presentation



Fire and Life Safety

IBC

The building code:

- Controls building size
- Regulates materials used
- Stipulates fire resistance

But…

The code still allows flexibility in building design, configuration, construction type, materials and other choices

Building Configuration Options

Start with the lowest common denominator option and work up. Don’t assume that a certain construction type, occupancy separation, etc. will be required simply based on use of certain materials or presence of certain occupancies.

Image: Neo Studio

Building Configuration Options

National market data also indicates that many commercial occupancies including hotels, multi-family, office, retail and restaurants can be framed with wood, including in mixed-use applications, when considering building size


BUDGET

Allowable Building Size

IBC Chapter 5

Allowable building size a *function* of:

- Capability of fire department to access building
- Building use
- Construction type

Fire Department Access

IBC 202

Mid-Rise vs. High-Rise

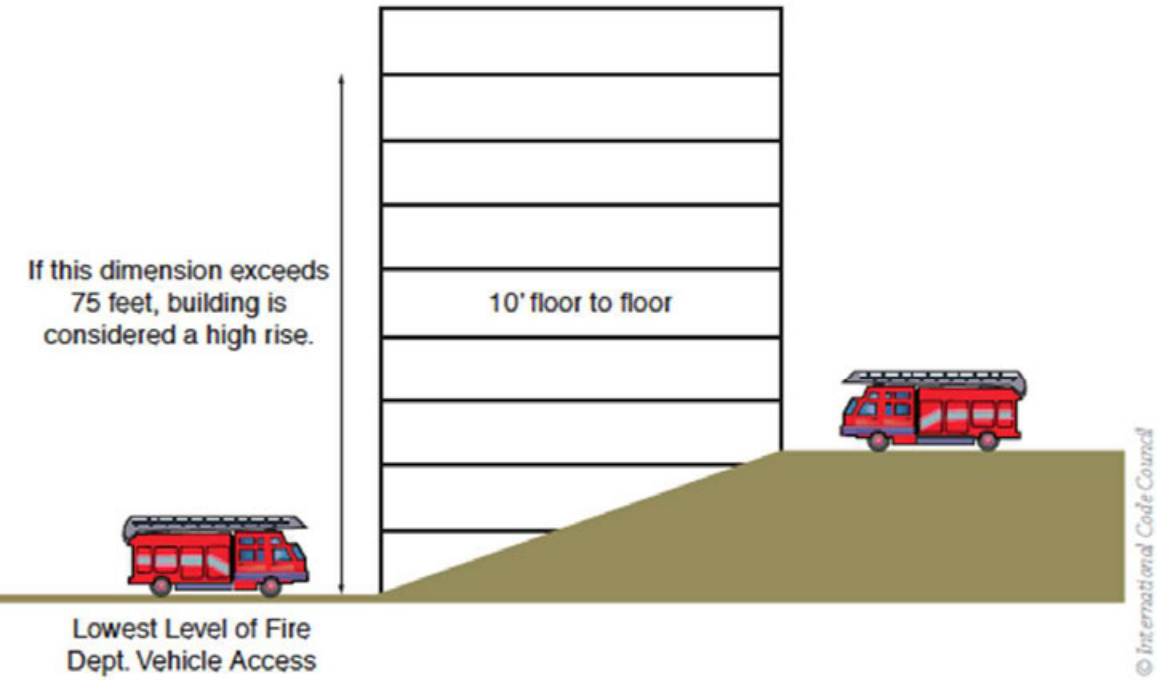


FIGURE 6-6 Determination of high-rise building

High-Rise Building:

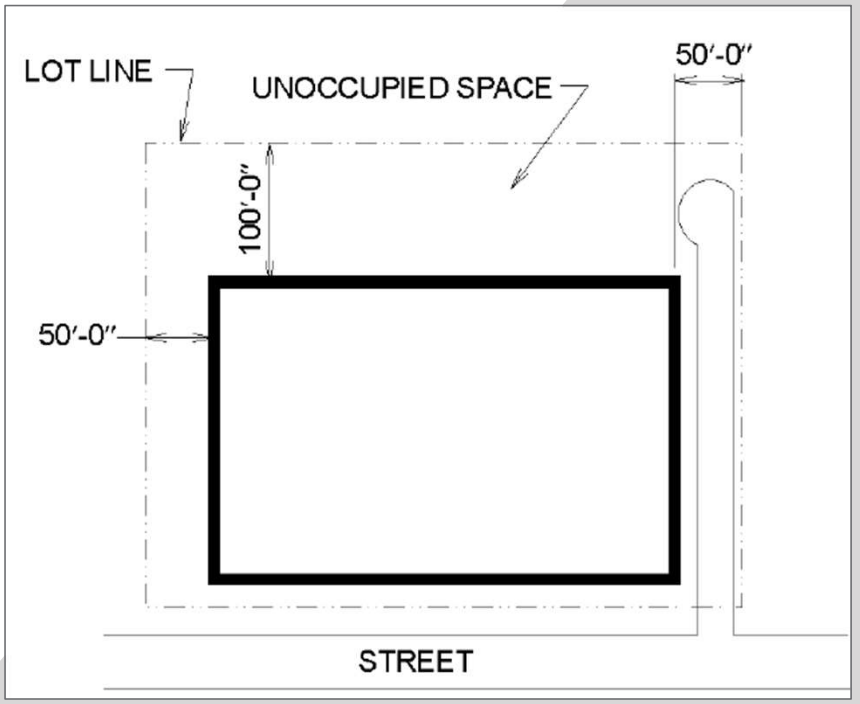
A building with an occupied floor located more than 75 feet above the lowest level of fire department vehicle access.

Fire Department Access

IBC 506

Frontage

Frontage provides access to the structure by fire service personnel, a temporary refuge area for occupants as they leave the building in a fire emergency and a reduced exposure to and from adjacent structures. Larger building area possible with certain amount of frontage



Occupancy Groups

IBC Chapter 3

Mixed use buildings often have 2, 3 or more different occupancy groups. Common examples include:

A: *Assembly*: restaurant, theater, arena, lecture hall
B: *Business*: office building, college, bank
M: *Mercantile*: retail store, sales room
R: *Residential*: apartment, dormitory, hotel
S: *Storage*: parking, bulk material storage

Construction Types

IBC 602

Type III

Exterior walls non-combustible (may be FRTW)
Interior elements any allowed by code

Type V

All building elements are any allowed by code

Types III and V are subdivided into **A** (protected) and **B** (unprotected)

Type IV (Heavy/Mass Timber)

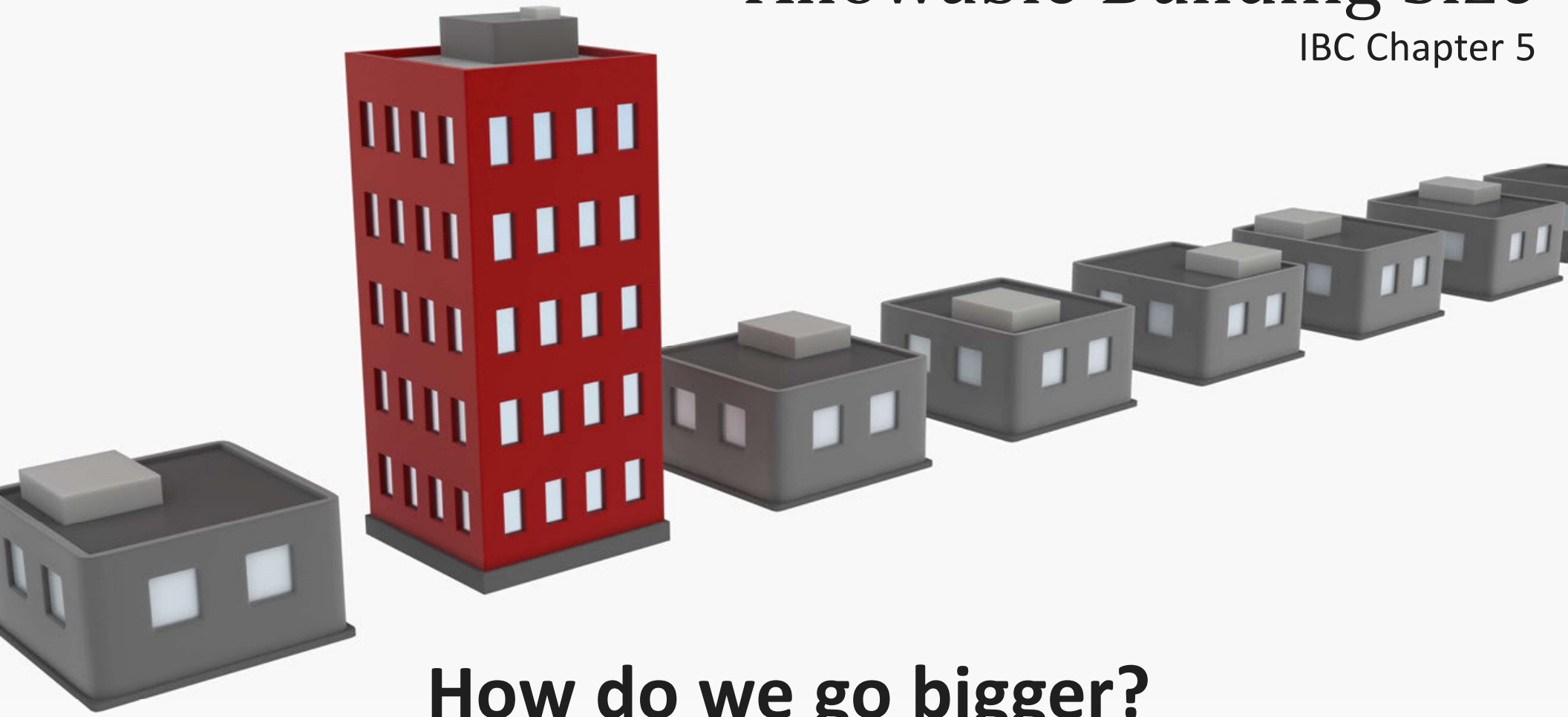
Exterior walls non-combustible (may be FRTW)
Interior elements qualify as Heavy Timber (min. sizes, no concealed spaces)

Construction Type Differences

	IIIA	IIIB	IV	VA	VB
Ext Wall Material	FRTW	FRTW	FRTW	Any wood	Any wood
Ext Bearing Wall Rating	2 Hr	2 Hr	2 Hr	1 Hr	0 Hr
Interior Elements	Any wood	Any wood	Heavy Timber	Any wood	Any wood
Fire Wall Materials	Non-combustible	Non-combustible	Non-combustible	Any	Any
Building Size	Typ 2nd largest; often same # of stories as IV but smaller area	Comparable to VA, larger in some cases, smaller in others	Typ largest; often same # of stories as IIIA but larger area	Comparable to IIIB; often 1-2 stories less than IIIA and IV	Smallest; often 1 story less than VA and 1/2 to 2/3 area of VA

Allowable Building Size

IBC Chapter 5



How do we go bigger?

Sprinkler Requirements

IBC 903.2

- NFPA 13 or 13R sprinkler system required in all new group R fire areas
- NFPA 13 sprinkler system required in most commercial facilities of any size regardless of construction type or materials used
- Example: Occupancy Group a-2 (restaurant, casino, banquet hall):
  - If Fire Area Exceeds 5,000 sf, or
  - If occupant load is 100 or more

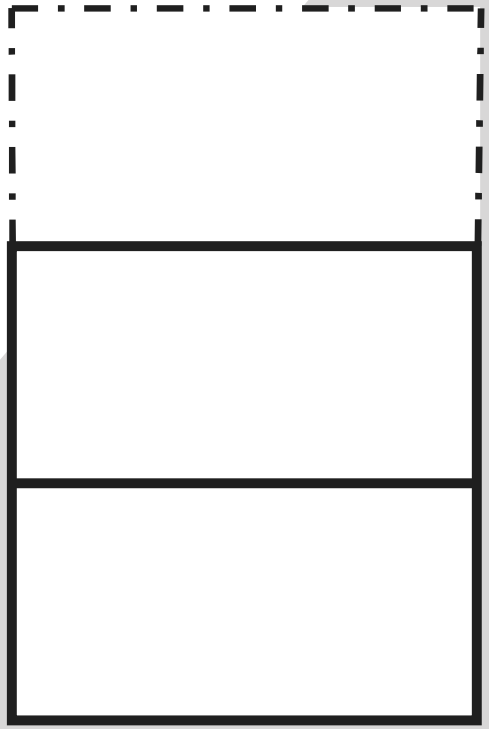
Allowable Building Height

IBC 2018 Tables 504.3 & 504.4

Building Height Increase

Buildings equipped throughout with an NFPA 13 or 13R* sprinkler system are allowed an additional **1 story and 20 ft** over nonsprinklered conditions

*NFPA 13R limited to 60 ft & 4 stories

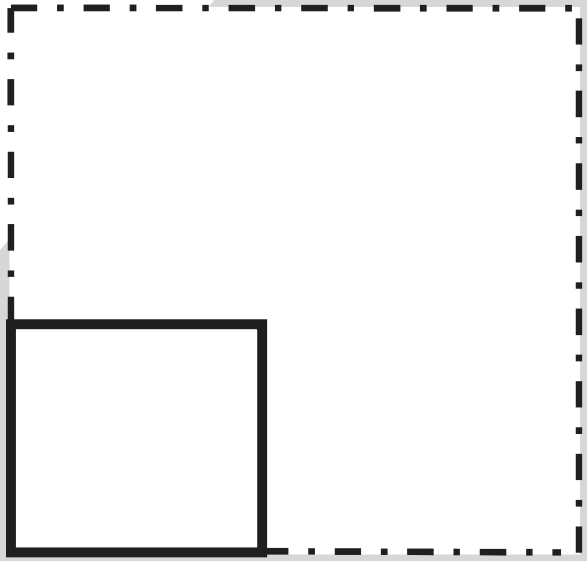


Allowable Story Area

IBC 2018 Table 506.2

Floor Area Increase

Buildings equipped throughout with an NFPA 13 sprinkler system can be increased **300% (single story buildings)** or **200% (multi-story buildings)** over nonsprinklered conditions

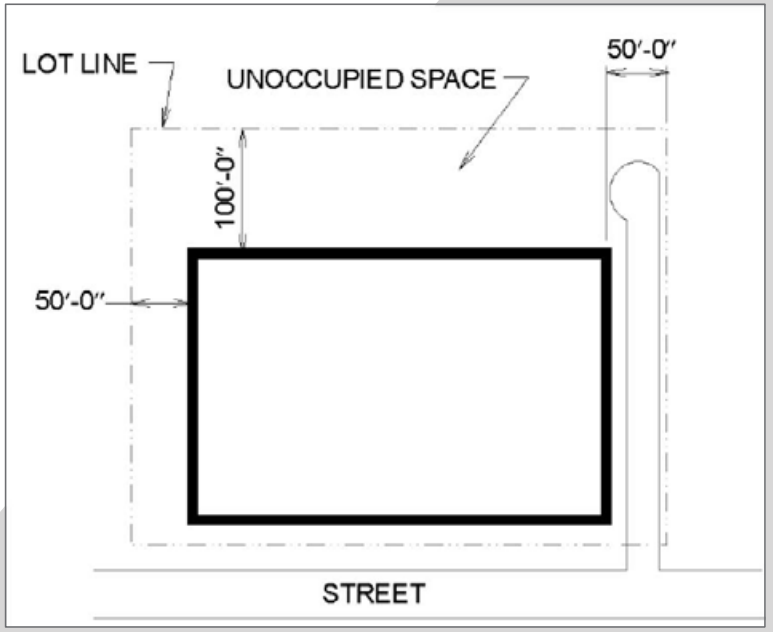


Allowable Story Area

IBC 506.3

Area Frontage Increase

Buildings with minimum levels of open frontage can add **up to 75%** of allowable nonsprinklered area to total floor area



Allowable Building Size

IBC Chapter 5

Business (B) Occupancies with NFPA 13 Sprinkler System

Construction Type Allowable Limit	IIIA	IIIB	IV (HT)	VA	VB
Stories	6	4	6	4	3
Height (ft)	85	75	85	70	60
Story Area (ft^2)	106.9k	71.3k	135k	67.5k	33.8k
2 story: Total Bldg Area (ft^2)	213.8k	142.5k	270k	135k	67.5k
3+ story: Total Bldg Area (ft^2)	320.6k	213.8k	405k	202.5k	101.3k

Assumes full frontage increase

Allowable Building Size

In low- to mid-rise building types, many designers accustomed to steel and concrete default to type II construction

However, nearly identical building sizes can be achieved with wood framing in type IIIA or IIIB

Additionally, market data analysis has shown that majority of commercial & multi-family buildings can be type V construction

Why is the construction type selection so important?

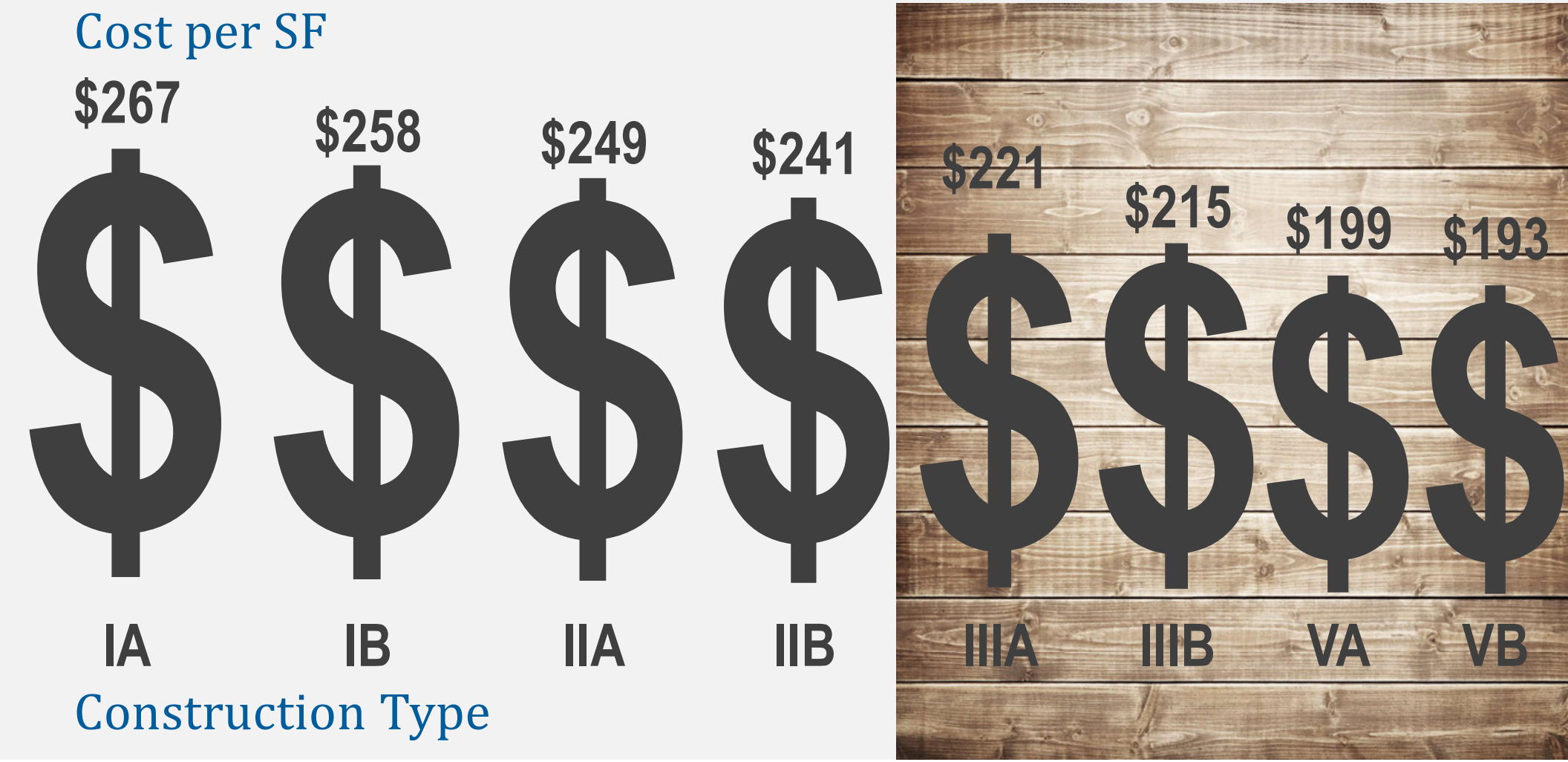
ICC Building Valuation Data, **M occupancies**, February 2023

Cost per SF

Construction Type

ICC Building Valuation Data, **R-1 occupancy**, February 2023

Cost per SF

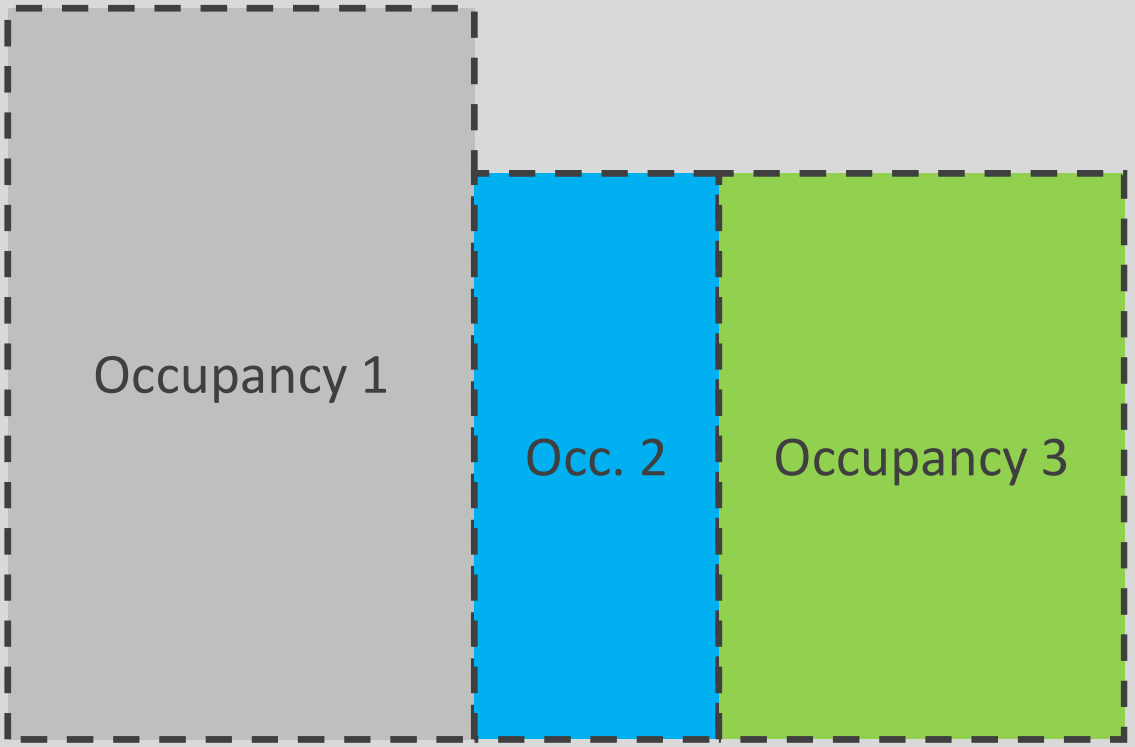


Construction Type

What about mixed occupancies?

Mixed Occupancy Buildings

IBC 508



Mixed Occupancy Buildings

IBC 508

Specifically, start with unseparated occupancies, using special provisions and/or other special design allowances as needed. Work up from there.

Mixed Occupancy Buildings

IBC 508

Example: Urban Infill Project

3 story building

- 1 story below grade: 12,000 sf parking
- 1st floor: 9,500 sf parking, 1,200 sf insurance agency, 1,300 sf print shop
- 2nd floor: 2,400 sf martial arts studio, 9,600 sf apartments
- 3rd floor: 12,000 sf apartments

NFPA 13 sprinkler system throughout building; enclosed parking garage, grade to mean roof height = 38 ft

Mixed Occupancy Buildings

IBC 508

Using lowest common denominator, try type VB construction:

	S-2	B	R-2	Actual Building
Allow. # stories	3	3	3	3
Allow. height	60 ft	60 ft	60 ft	38 ft
Allow. area/floor	40,500 sf	27,000 sf	21,000 sf	12,000 sf
Allow. Total area	121,500 sf	81,000 sf	63,000 sf	36,000 sf

Most restrictive occupancy group, R-2 works for whole building.

Use non-separated, type VB construction

Mixed Occupancy Buildings

IBC 508

- Incidental Uses (509)
- Accessory Occupancies (508.2)
- Unique Occupancy Combinations (303)
- Roof Top Occupancies (Ch. 5)
- Special Provisions (510)
- Nonseparated Occupancies (508.3)
- Separated Occupancies (508.4)
- Separate Buildings – Firewalls (503.1 & 706)
- Covered and Open Malls (402)

Credit: Boye Architecture

Outside scope of presentation

Incidental Uses

IBC 509

- Ancillary function associated with an occupancy
- Pose GREATER risk than the main occupancy
- Examples:
  - Laundry room over 100 sf
  - Refrigerant machinery room
  - Incinerator room
  - Furnace room
  - Boiler room
  - Vocational shop in a school

Incidental Uses

IBC 509

Limitations:

- Each area not more than 10% of story
- Have fire resistance rated separation (fire barrier or horizontal assembly), smoke separation and/or sprinkler systems per Table 509 and Section 509.4
  - Many permit use of sprinklers in lieu of rated separation
- NOT classified as a different occupancy.
- Allowable area and height per main occupancy

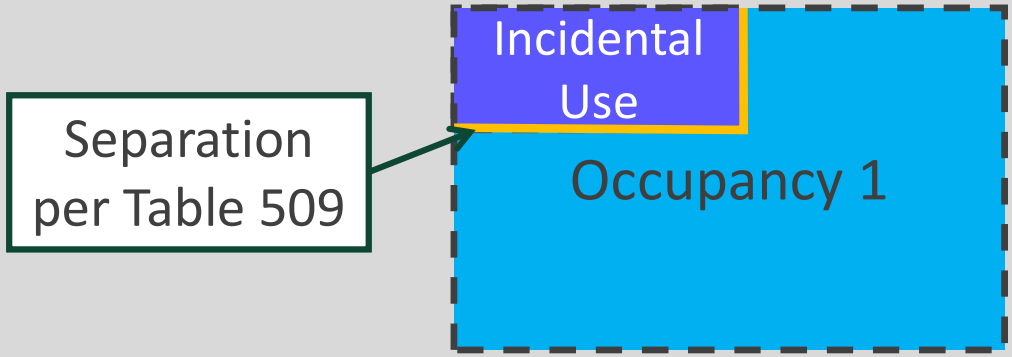


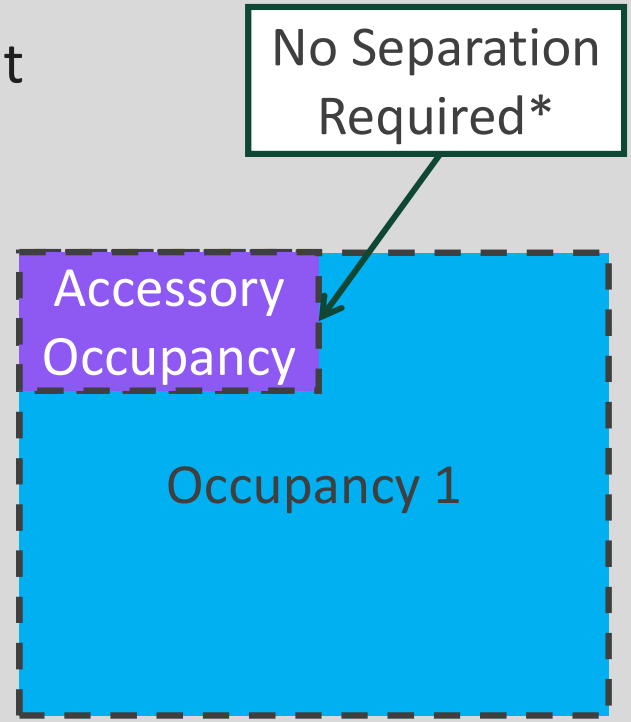
Photo Sean Hackbarth/Flickr

Accessory Occupancies

IBC 508.2

- Ancillary to the main occupancy
- Aggregate accessory area not greater than:
  - 10% of the main occupancy on same floor
  - Table 506.2 non-sprinklered allowable area limit of accessory occupancy
- No separation between occupancies required*
- Allowable building area and height per main occupancy

*Hazardous occupancies require separation
*Residential separations per Section 420 still apply



Small Assembly Spaces

IBC 303.1.1 & 303.1.2

Small Assembly Spaces:

» A building or tenant space used for assembly purposes with an occupant load of less than 50 persons shall be classified as a Group B occupancy.

Example: small café

Small Assembly Spaces Accessory to Other Occupancies:

» Occupant load less than 50 persons or less than 750 sf in area - can be classified as a Group B occupancy or as part of main occupancy

Examples:

» *Conference room in office building*

» *Fitness center in hotel*

Rooftop Decks

IBC 503.1

Many mixed use buildings, especially apartment buildings, are implementing occupiable roof top decks, either for individual use or as a gathering space

Historically, code didn't offer much except for basic exit provisions but several design routes have been used, plus new guidance in 2018.

Typically these spaces do not have a roof and therefore aren't classified as stories per the definition of a story (IBC 202).

Rooftop Decks

IBC 503.1

Occupied Roofs Code Development

2012 IBC section 1021 contains exit provisions for occupied roofs

2015 IBC clarified egress requirements for occupied roofs (IBC 1006.3)

2018 IBC further recognizes occupied roofs. 2018 IBC provisions:

- 302.1: Occupied roof classified as occupancy it most closely resembles
- 503.1.4: Permitted to be used as an occupied roof if the occupancy of the roof is an occupancy that is permitted by code for the story immediately below the roof. Area of the occupied roofs is not required to be included in the building area. Further exceptions for sprinklered buildings exist

Special Provisions

IBC 510.2

Horizontal Building Separation

Often called ***Podium provision***:

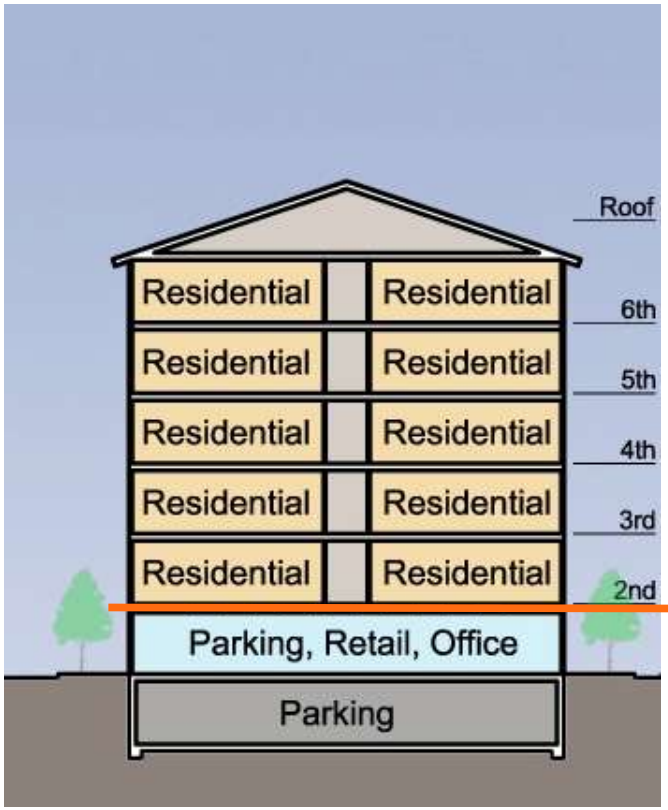
Considered separate buildings above and below for purposes of area calculations if:

- Overall height in feet is still limited to min of either building
- 3hr rated horizontal assembly
- Building below is Type 1A with sprinklers

Occupancy restrictions above and below

Special Provisions

IBC 510.2



IBC Provisions for Mixed-Use podium have been evolving.

IBC	2006	2009	2012	2015	2018
Section	509.2	509.2	510.2	510.2	510.2
Upper Occupancy	A, B, M, R or S				
Lower Occupancy	S-2 Parking	A, B, M, R or S-2 Parking		Any Except H	
Podium Height	1 Story		1 Story	No Restriction	

3Hr

Type IA

2015 & 2018 IBC allow multiple podium stories above grade

Special Provisions

IBC 510.2

5-Story Possibilities

4 stories of type V
over 1-story podium

Photo: Gables Residential

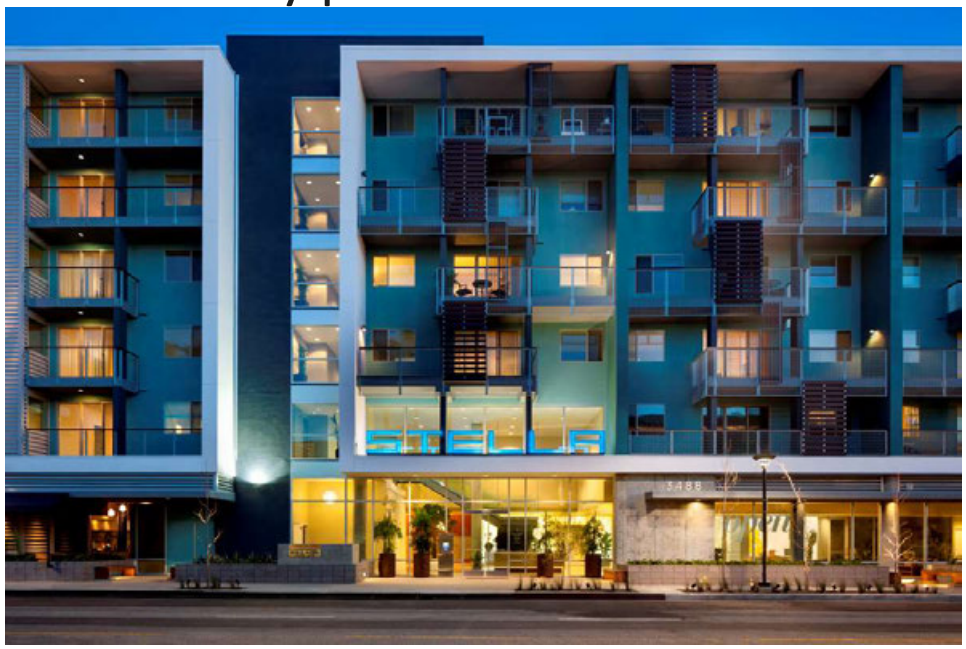
5 stories of type III

Special Provisions

IBC 510.2

6- & 7-Story Possibilities

5 stories of type III
over 1-story podium



5 stories of type III
over 2-story podium

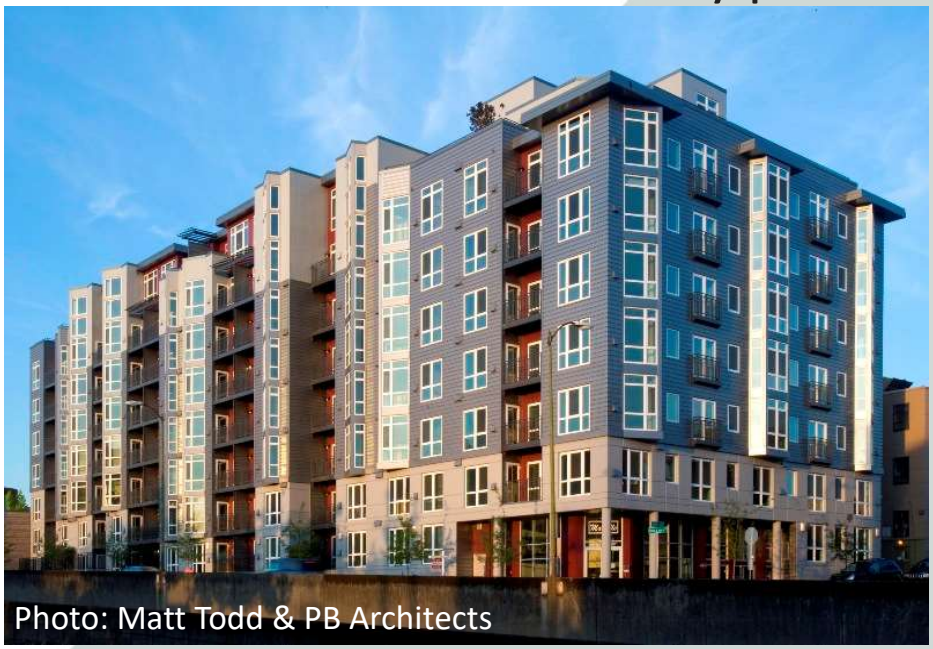


Photo: Matt Todd & PB Architects

Nonseparated Occupancies

IBC 508.3

Nonseparated Occupancies

IBC 508.3

Nonseparated Occupancies

Most restrictive of all occupancies apply for:

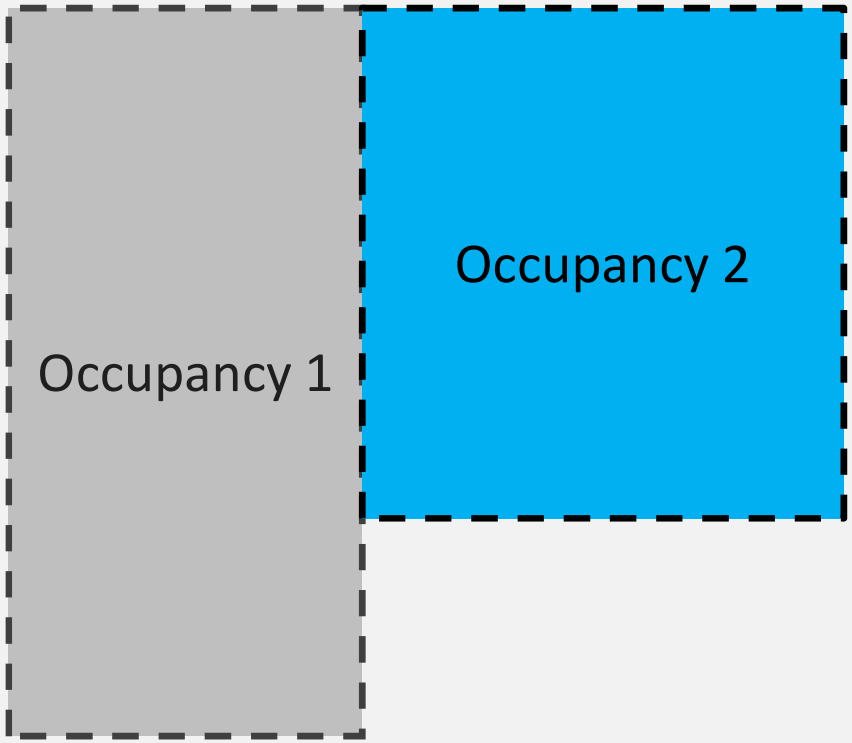
» Fire Protection Systems (Ch. 9)

» Allowable Height and Area (Ch. 5)

Other requirements (i.e. egress, others) based on individual occupancy of each portion

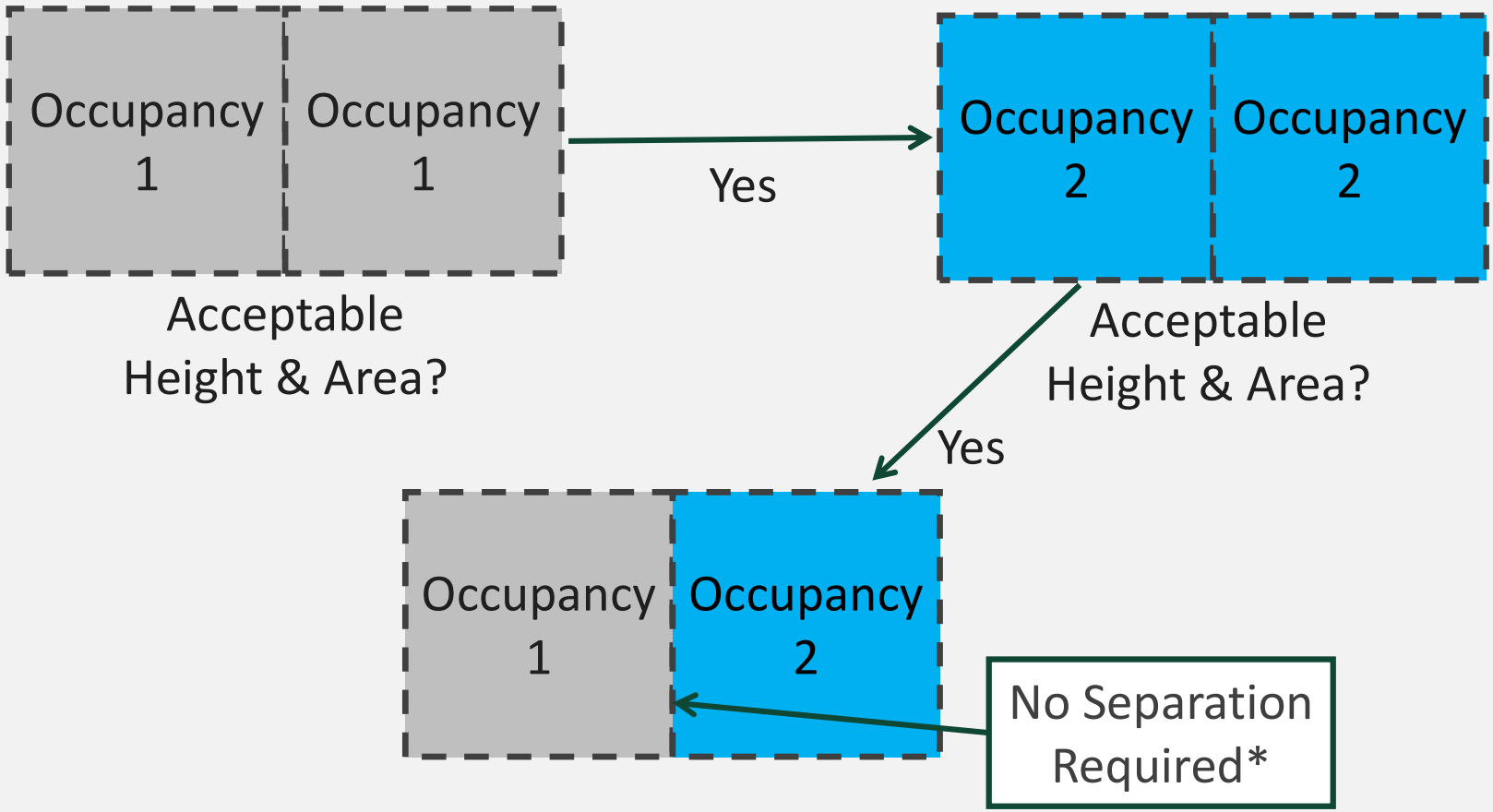
No fire separation between occupancies required*

*Hazardous occupancies require separation.



Nonseparated Occupancies

IBC 508.3



Nonseparated Occupancies

IBC 508.3

Multi-story, Nonseparated Occupancy Buildings

Image: Ware Malcomb

Nonseparated Occupancies

IBC 508.3

Multi-Story Nonseparated Occupancies Example

» 3 story building on college campus

» Total building area = 61,200 sf

» 1st floor:

  » (2)-800 sf coffee/snack bars,

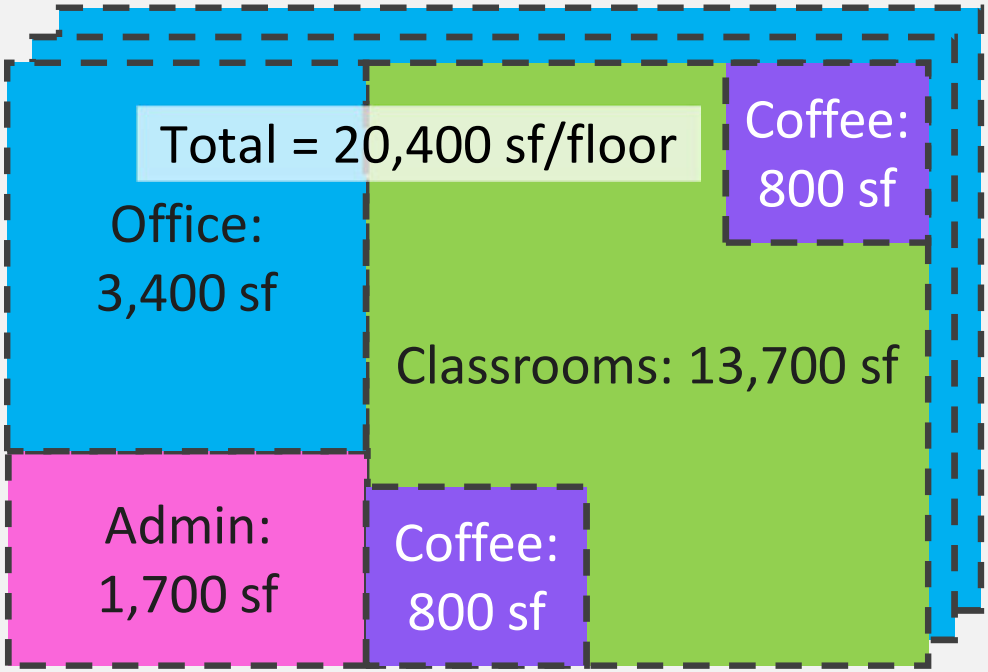
  » 13,700 sf of classrooms,

  » 1,700 sf admin,

  » 3,400 sf offices

» 2nd & 3rd floors: 20,400 sf of offices

» NFPA 13 sprinkler required throughout building

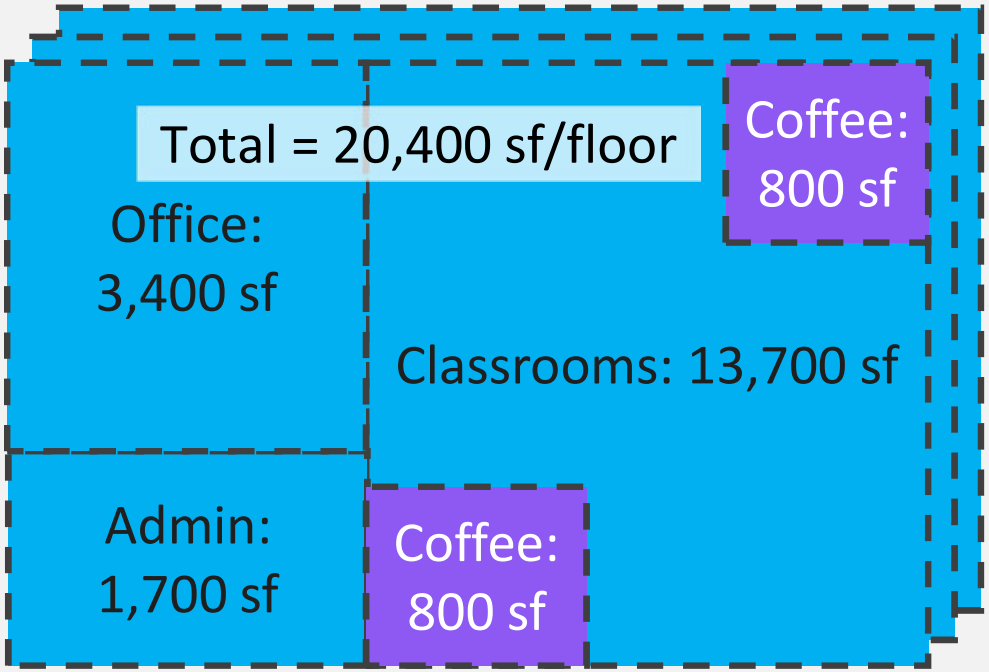


Nonseparated Occupancies

IBC 508.3

Multi-Story Nonseparated Occupancies Example (con't)

- Classrooms for higher than 12th grade: Group B
- Admin & offices: Group B
- Coffee/snack bar: Group A-2
- May be able to use "small assembly" provision (IBC 303.1.1) – Group B
  - Or may be able to call accessory occupancies – Group B

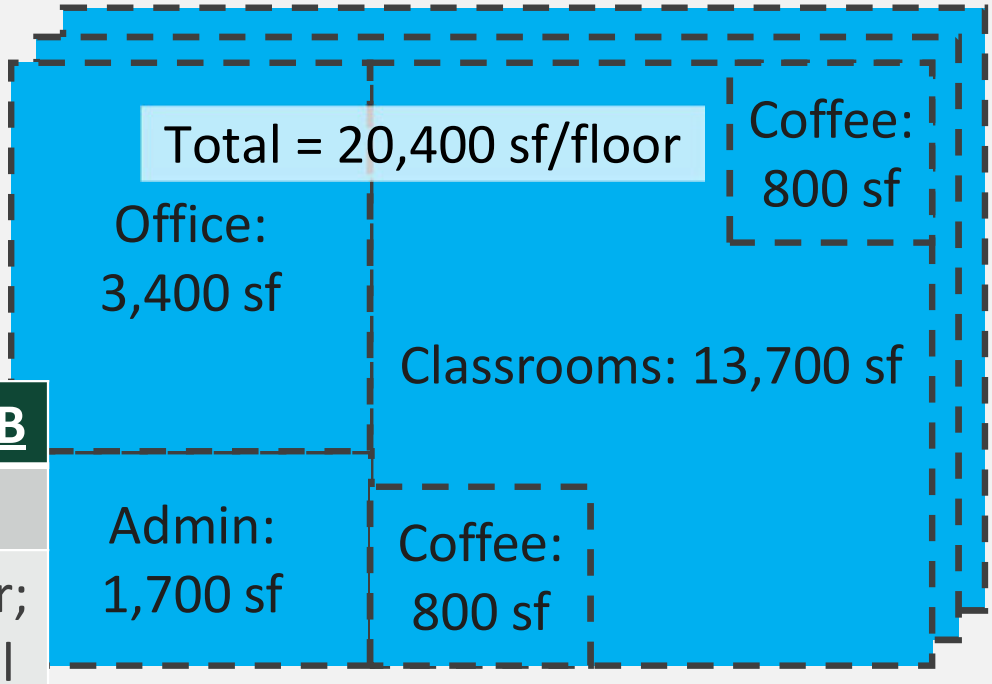


Nonseparated Occupancies

IBC 508.3

Multi-Story Nonseparated Occupancies Example (con't)

» If coffee/snack areas meet provisions for small assembly spaces or accessory occupancy, entire building is group B and can use **Type VB construction**



Allowable Heights and Areas for Group B

	Height	Area
Type VB	3 stories; 60 ft	27,000 sf/floor; 81,000 sf total

Nonseparated Occupancies

IBC 508.3

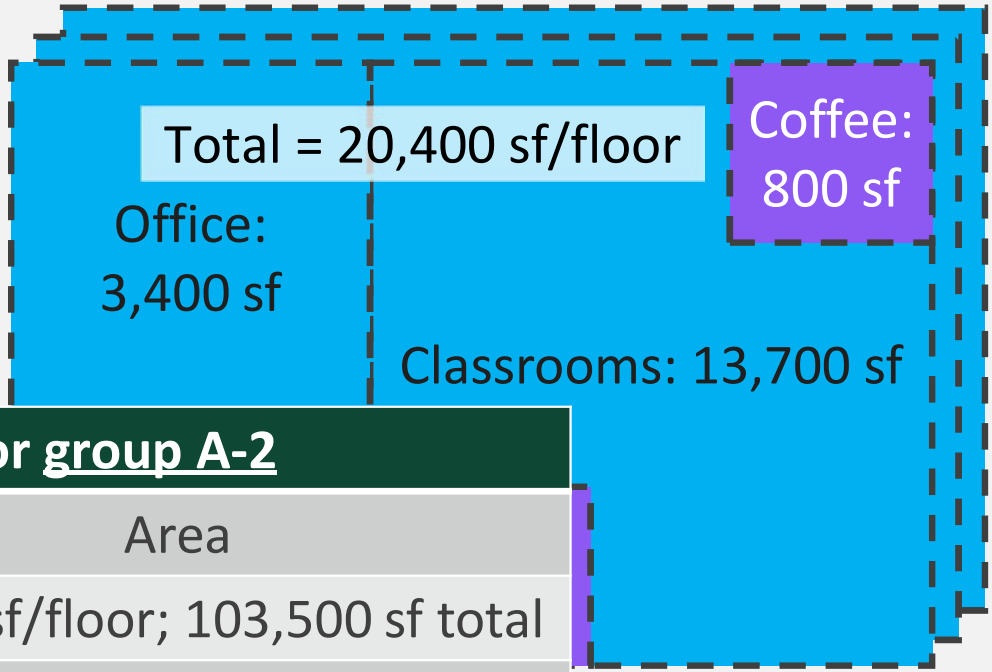
Multi-Story Nonseparated Occupancies Example (con't)

» If coffee/snack areas don't meet provisions for small assembly spaces, they are group A-2.

» **Use non-separated occupancies, Type VA construction**

» Group B OK per previous

» Group A-2 per below



Allowable Heights and Areas for group A-2		
	Height	Area
Type VA	3 stories; 70 ft	34,500 sf/floor; 103,500 sf total
Type VB	~~2 stories; 60 ft~~	~~18,000 sf/floor; 54,000 sf total~~

Separated Occupancies

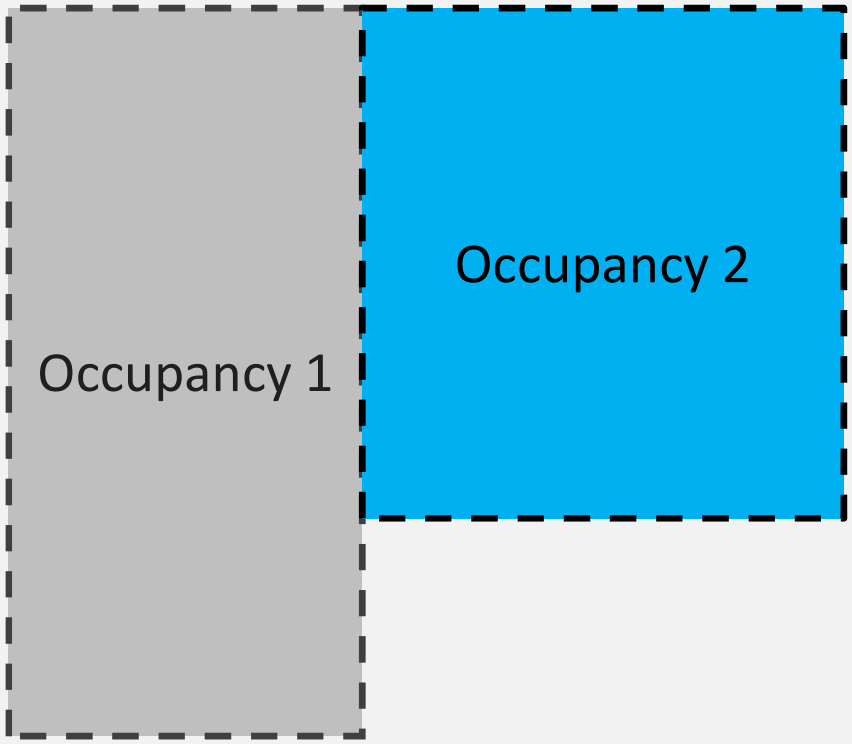
IBC 508.4

Separated Occupancies

IBC 508.4

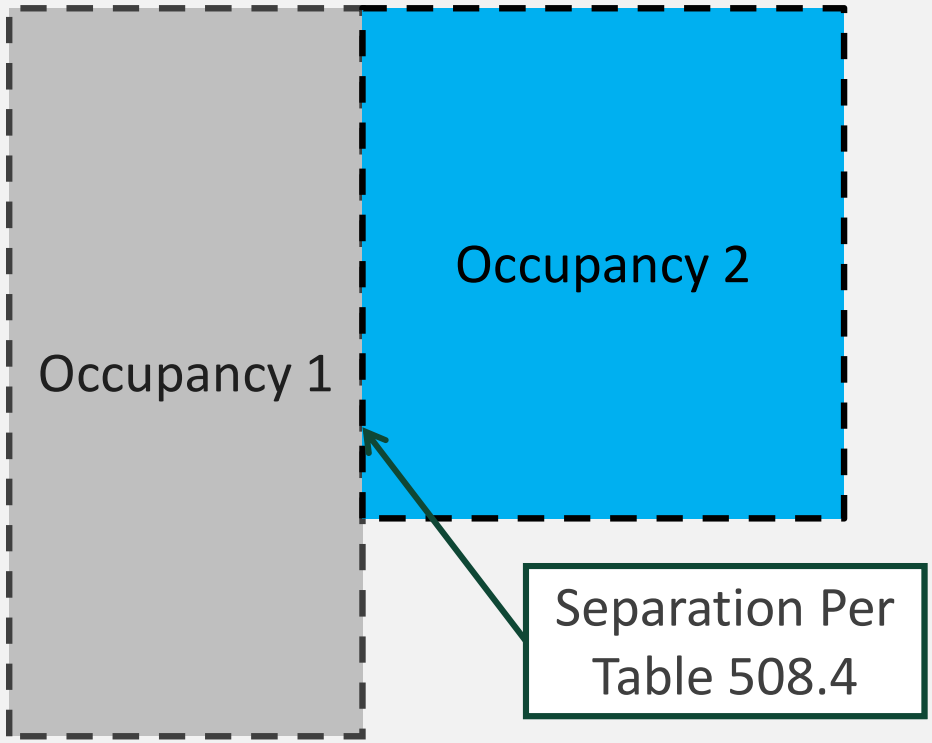
Separated Occupancies

- Requirements of code for each portion based upon occupancy of that portion
- Allowable height of each occupancy based upon construction type and occupancy
- Allowable area of each story
  - Sum of actual area over allowable area of each occupancy ≤ 1.0



Separated Occupancies

IBC 508.4



Check performed for each story. Separation by fire barriers and horizontal assemblies

$$\frac{A1}{\text{Allowable Area for Occupancy 1}} + \frac{A2}{\text{Allowable Area for Occupancy 2}} \leq 1.0$$

Separated Occupancies

IBC Table 508.4

OCCUPANCY	A, E		I-1[a], I-3, I-4		I-2		R[a]		F-2, S-2[b], U		B[e], F-1, M, S-1	
	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS
A, E	N	N	1	2	2	NP	1	2	N	1	1	2
I-1[a], I-3, I-4	—	—	N	N	2	NP	1	NP	1	2	1	2
I-2	—	—	—	—	N	N	2	NP	2	NP	2	NP
R[a]	—	—	—	—	—	—	N	N	1[c]	2[c]	1	2
F-2, S-2[b], U	—	—	—	—	—	—	—	—	N	N	1	2
B[c], F-1, M, S-1	—	—	—	—	—	—	—	—	—	—	N	N
H-1	—	—	—	—	—	—	—	—	—	—	—	—
H-2	—	—	—	—	—	—	—	—	—	—	—	—
H-3, H-4	—	—	—	—	—	—	—	—	—	—	—	—
H-5	—	—	—	—	—	—	—	—	—	—	—	—

Separation accomplished with:

- Walls: fire barriers (IBC 707)
- Floors: horizontal assemblies (IBC 711)

S = Sprinklered
NS = No Sprinkler
NP = Not Permitted
N = No Separation Required

Separated Occupancies

IBC 508.4

Multi-story, Separated Occupancy Buildings

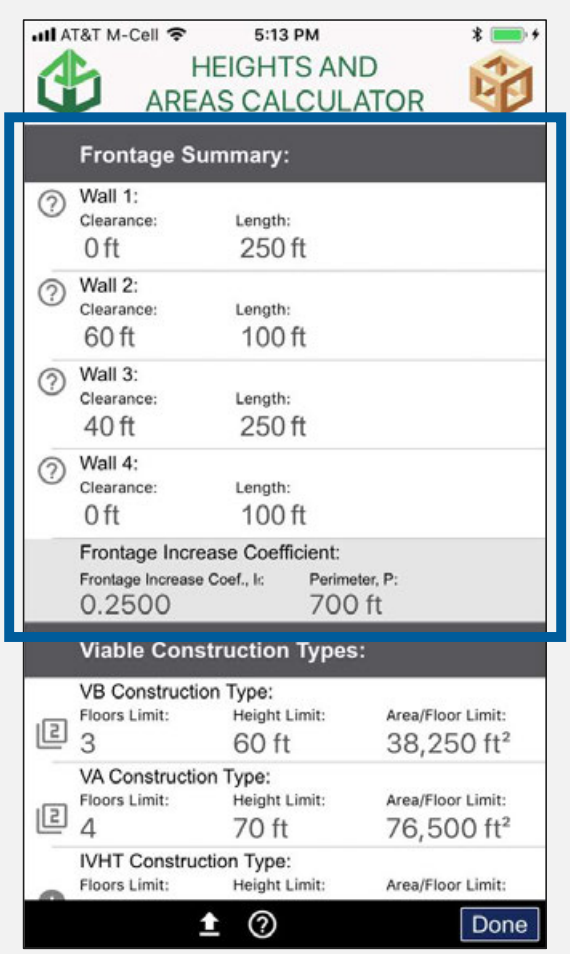
Image: CUBE 3 Studio LLC & Rixon Photography

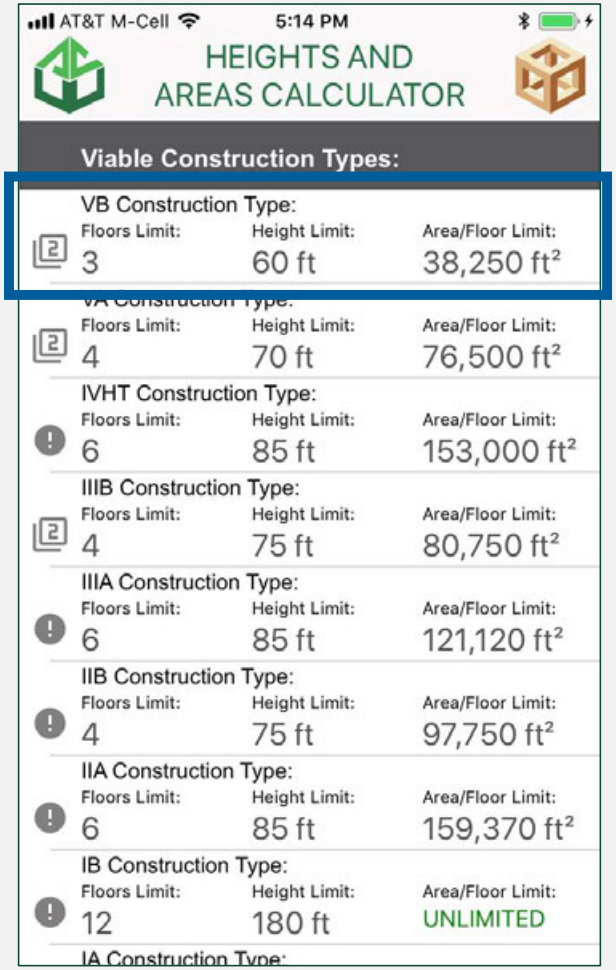
Allowable Building Size

Heights and areas calculator – free tool

http://www.woodworks.org/design-and-tools/design-tools/online-calculators/

Handles Separated & Nonseparated Occupancies (Check “both”)

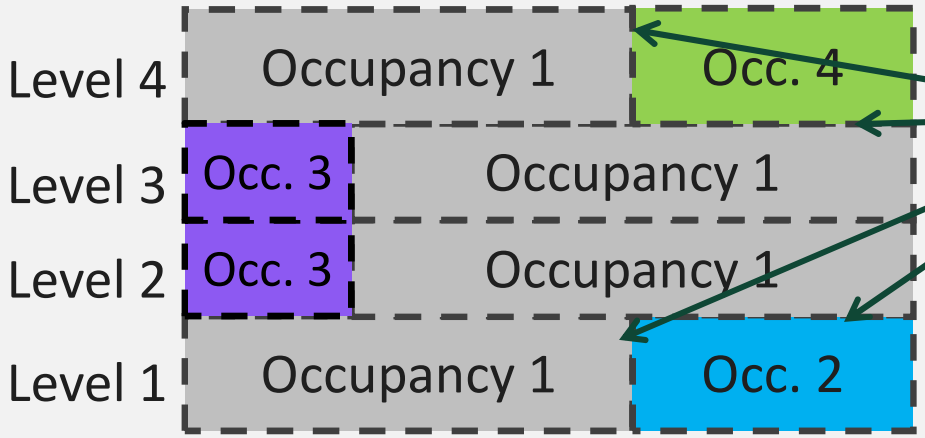




Separated Occupancies

IBC 506.2.4 & 508.4

Multi-Story Separated Occupancies



Elevation view

Separation Per Table 508.4

(Also between occ. 1 & occ. 3)

Sum of ratios

actual area/allowable area

for all occupancies per floor:

≤ 1.0 for 1 story building

≤ 2.0 for 2 story building

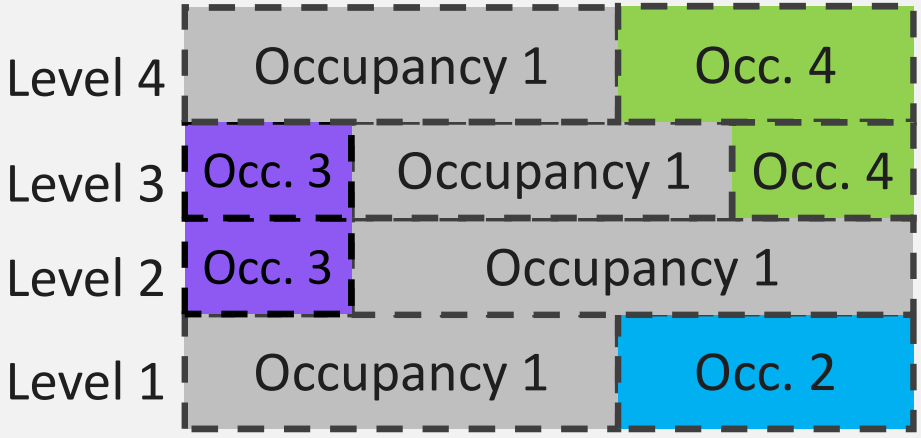
≤ 3.0 for 3+ story building

No floor can have a ratio > 1.0

Separated Occupancies

IBC 508.4

Multi-Story Separated Occupancies Example



Elevation view

- 4 story building
- Total building area = 120,000 SF
- Occupancy 1 = apartments (R-2)
- Occupancy 2 = retail (M)
- Occupancy 3 = restaurant (A-2)
- Occupancy 4 = professional offices (B)
- IBC section 903.2.8 requires buildings containing group R fire areas to be sprinklered throughout the building
- Provide NFPA 13 sprinkler throughout building

Separated Occupancies

IBC 508.4

Multi-Story Separated Occupancies Example (con't)

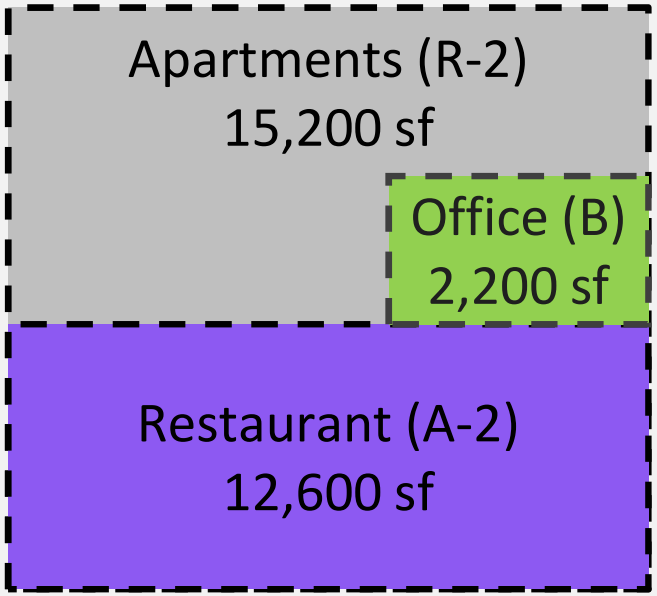
Level 1 Floor Plan

Level 2 Floor Plan

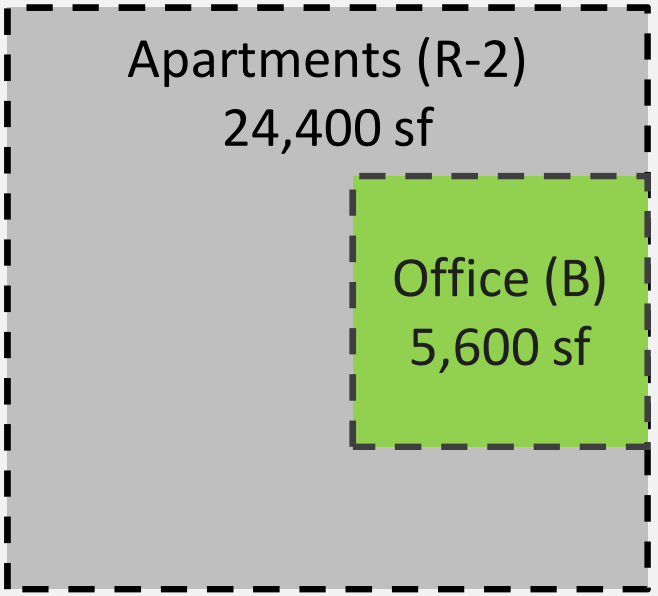
Separated Occupancies

IBC 508.4

Multi-Story Separated Occupancies Example (con't)



Level 3 Floor Plan



Level 4 Floor Plan

Separated Occupancies

IBC 508.4

Multi-Story Separated Occupancies Example (con't)

Allowable Floor Area / # of stories (from Tables 504.4 and 506.2)				
	IIIA	IIIB	VA	VB
Group A-2	42,000 sf / 4	28,500 sf / 3	34,500 sf / 3	18,000 sf / 2
Group B	85,500 sf / 6	57,000 sf / 4	54,000 sf / 4	27,000 sf / 3
Group M	55,500 sf / 5	37,500 sf / 3	42,000 sf / 4	27,000 sf / 2
Group R-2	72,000 sf / 5	48,000 sf / 5	36,000 sf / 4	21,000 sf / 3

With full NFPA 13 sprinkler increases but no frontage increase

Separated Occupancies

IBC 508.4

Multi-Story Separated Occupancies Example (con't)

Level 1 Floor Plan

- Try construction type VA:
  21,000/36,000 + 9,000/42,000
  = 0.80 < 1.0: OK

- Allowable height & stories:
  R-2: 70 ft, 4 stories: OK
  M: 70 ft, 4 stories: OK

Separated Occupancies

IBC 508.4

Multi-Story Separated Occupancies Example (con't)

Level 2 Floor Plan

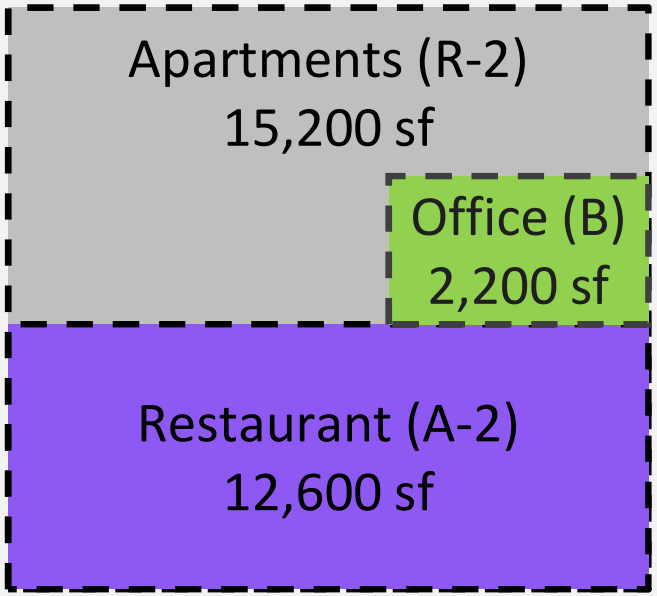
- Try construction type VA:
  17,400/36,000 + 12,600/34,500
  = 0.85 < 1.0: OK

- Allowable height & stories:
  R-2: 70 ft, 4 stories: OK
  A-2: 70 ft, 3 stories: OK

Separated Occupancies

IBC 508.4

Multi-Story Separated Occupancies Example (con't)



Level 3 Floor Plan

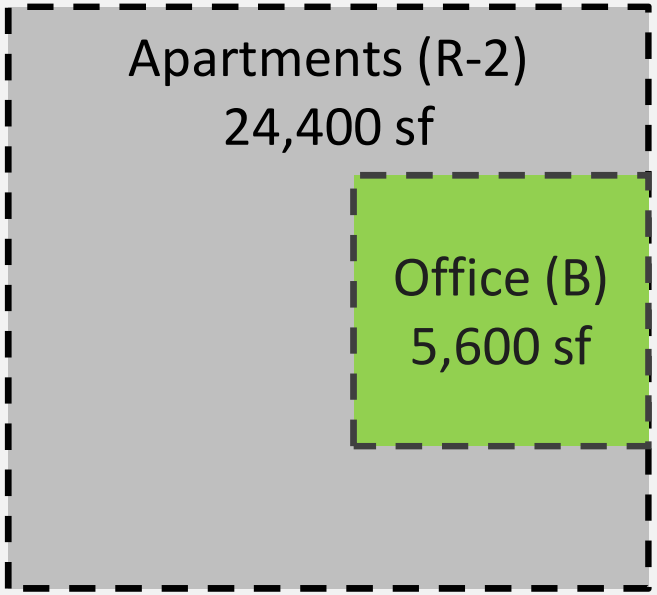
- Try construction type VA:
  15,200/36,000 + 12,600/34,500 +
  2,200/54,000 = 0.83 < 1.0: OK

- Allowable height & stories:
  R-2: 70 ft, 4 stories: OK
  A-2: 70 ft, 3 stories: OK
  B: 70 ft, 4 stories: OK

Separated Occupancies

IBC 508.4

Multi-Story Separated Occupancies Example (con't)



Level 4 Floor Plan

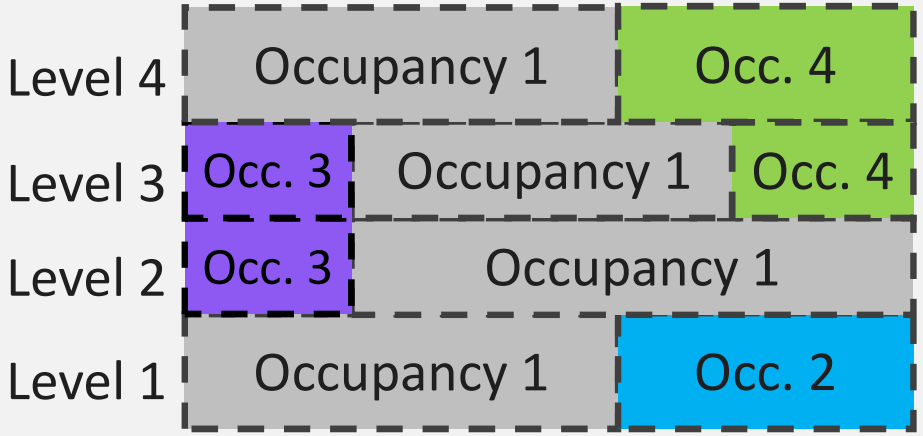
» Try construction type VA:
24,400/36,000 + 5,600/54,000
= 0.78 < 1.0: OK

» Allowable height & stories:
R-2: 70 ft, 4 stories: OK
B: 70 ft, 4 stories: OK

Separated Occupancies

IBC 508.4

Multi-Story Separated Occupancies Example (con't)



Elevation view

0.78

0.83

0.85

0.80

3.26 > 3.0: *Inadequate*

sum of ratios of
actual area/allowable area
for all occupancies per floor

Type VA can't be used.

Use type IIIB.

Separated Occupancies

IBC Table 508.4

OCCUPANCY	A, E		I-1[a], I-3, I-4		I-2		R[a]		F-2, S-2[b], U		B[e], F-1, M, S-1	
	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS
A, E	N	N	1	2	2	NP	1	2	N	1	1	2
I-1[a], I-3, I-4	—	—	N	N	2	NP	1	NP	1	2	1	2
I-2	—	—	—	—	N	N	2	NP	2	NP	2	NP
R[a]	—	—	—	—	—	—	N	N	1[c]	2[c]	1	2
F-2, S-2[b], U	—	—	—	—	—	—	—	—	N	N	1	2
B[e], F-1, M, S-1	—	—	—	—	—	—	—	—	—	—	N	N
H-1	—	—	—	—	—	—	—	—	—	—	—	—
H-2	—	—	—	—	—	—	—	—	—	—	—	—
H-3, H-4	—	—	—	—	—	—	—	—	—	—	—	—
H-5	—	—	—	—	—	—	—	—	—	—	—	—

Separation accomplished with:

- Walls: fire barriers (IBC 707)
- Floors: horizontal assemblies (IBC 711)

S = Sprinklered
NS = No Sprinkler
NP = Not Permitted
N = No Separation Required

Fire Barriers

IBC 707

What is a fire barrier?

- May be constructed with any materials permitted by the construction type
- Occupancy separation: Fire resistance ratings per IBC Table 508.4
- Required to extend from top of the foundation/floor below to underside of floor/roof sheathing, slab or deck above
- Supporting construction required to have same fire-resistance rating as the fire barrier being supported
- Other requirements for openings, penetrations, joints

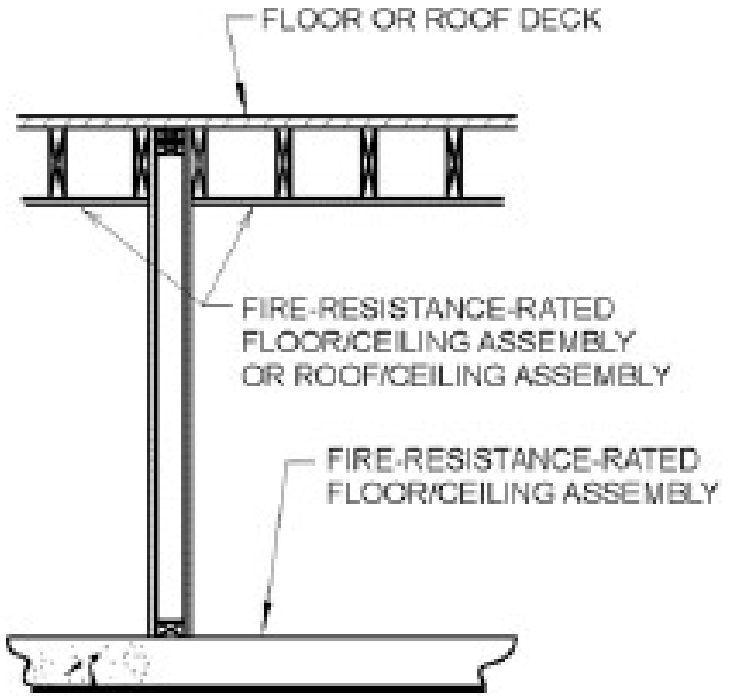


Image: IBC Code Commentary

Fire Barriers

IBC 707

Common detailing method: fire barrier & membrane extend to underside of floor deck above

Horizontal Assemblies

IBC 711

What is a horizontal assembly?

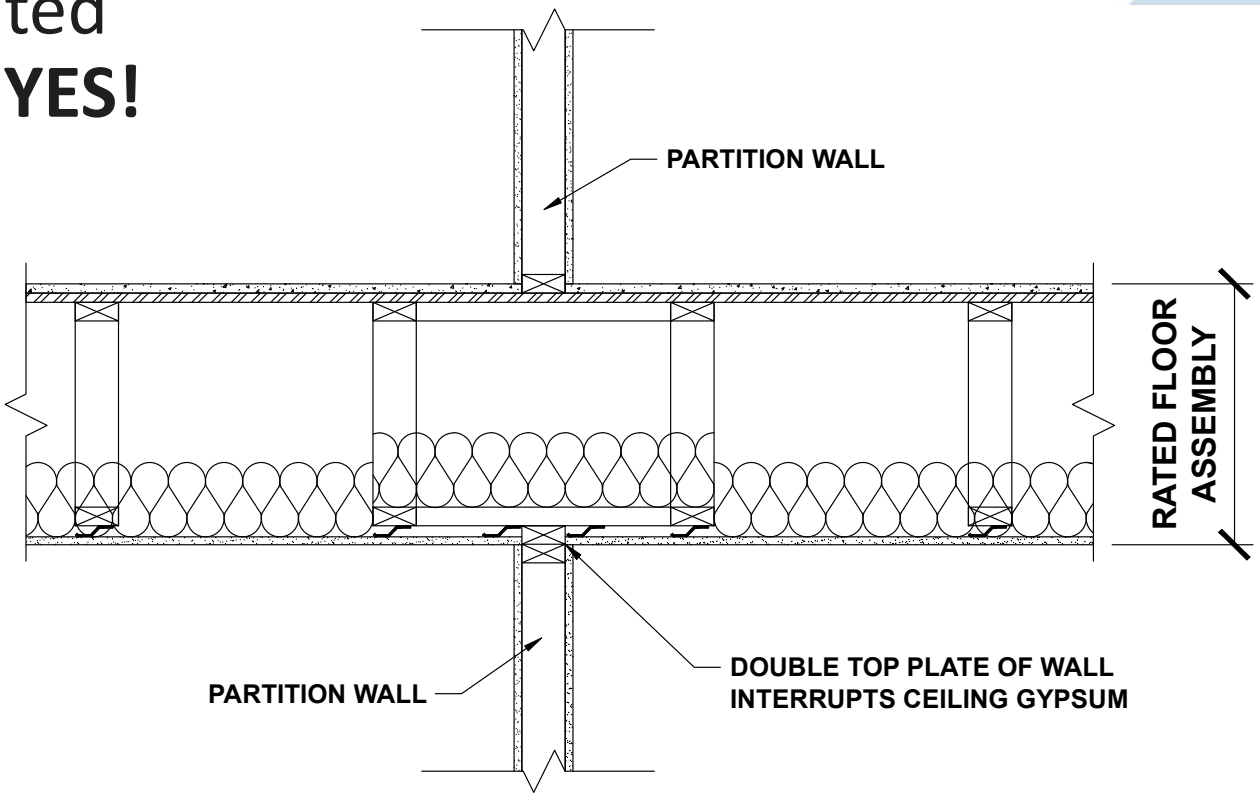
- A floor or roof assembly required to have a fire resistance rating such as for occupancy separations and fire area separations
- May be constructed with any materials permitted by the construction type
- Occupancy separation: Fire resistance ratings per IBC Table 508.4
- Required to be continuous without vertical openings except as permitted in IBC 712
- Supporting construction required to have same fire-resistance rating as the fire barrier being supported (with exceptions per 711.4)
- Other requirements for openings, penetrations, joints

Horizontal Assemblies

IBC 711

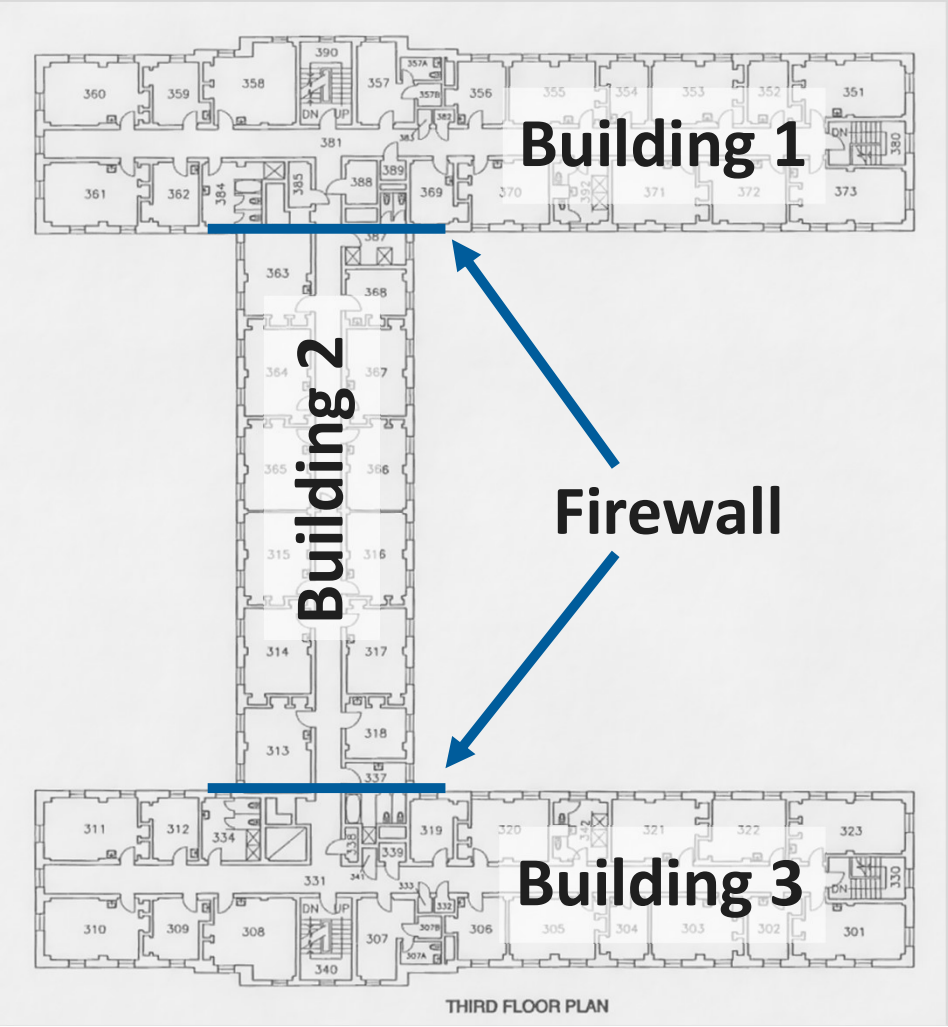
Can a wall interrupt the ceiling gypsum of a rated horizontal assembly? **YES!**

- 712.1.4 references 714 for penetrations
- IBC 2012 714.4.1.2, Except. 7: Permitted if wall is rated to match horizontal assembly
- IBC 2015 714.4.2, Except. 7: Permitted if wall is covered with type X gypsum each side



INTERIOR WALL TO FLOOR INTERSECTION

Building Configuration Options



These building configurations may lend themselves well to use of firewalls at building intersections.

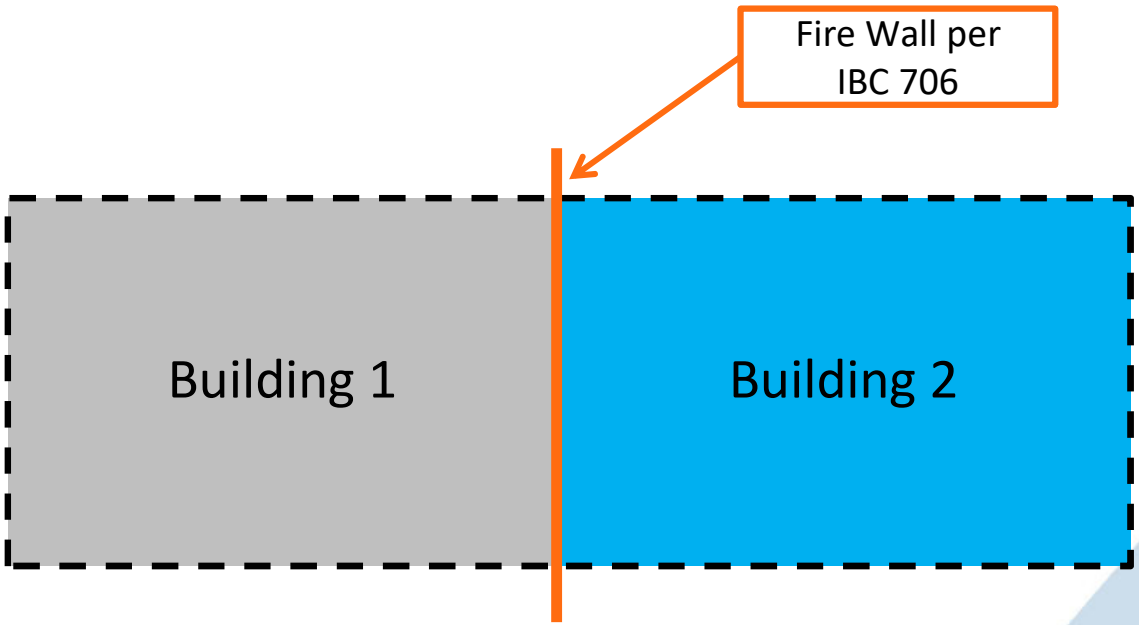
Minimize length/impact of firewall while maximizing allowable building area may allow lower construction type (i.e. type IIIB instead of IIIA)

Fire Walls

IBC 706

Separate buildings with fire walls

- Each portion of a building separated by one or more fire walls shall be considered to be a separate building



Fire Walls

IBC 706

Opportunity for Wood Framed Fire Walls:

- Permitted in type V construction
- Fire Walls in type III and IV construction are required to be constructed of non-combustible materials
- Opportunity for wood frame bearing walls on each side of fire wall to meet structural stability requirements

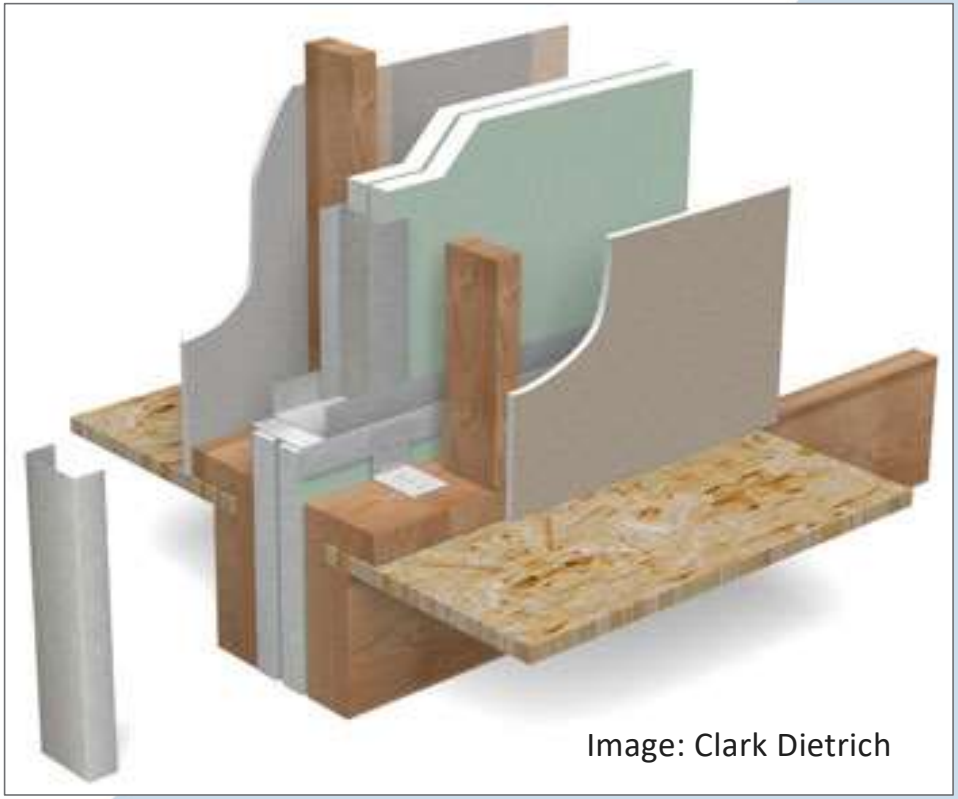


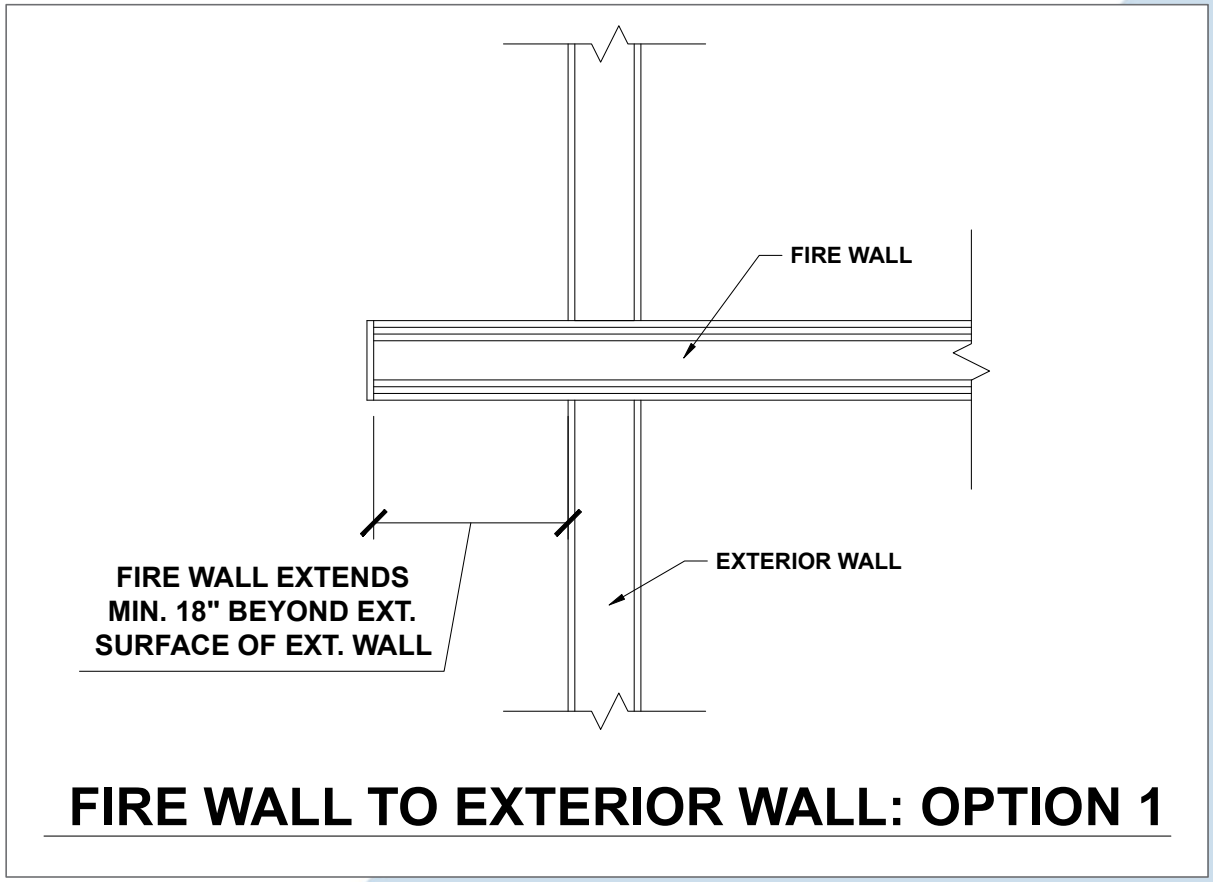
Image: Clark Dietrich

Fire Walls

IBC 706

Horizontal Continuity

- Fire walls are required to be continuous from exterior wall to exterior wall



Fire Walls

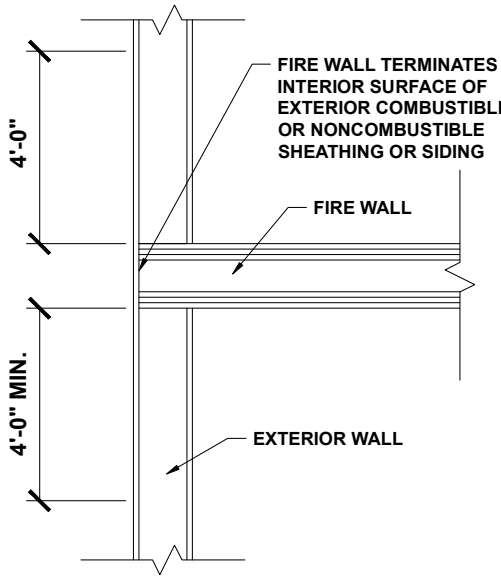
IBC 706

Horizontal Continuity

- Fire walls are required to be continuous from exterior wall to exterior wall

ALTERNATIVES:

1. **EXTERIOR WALL RATED FOR 1 HR MIN. 4FT EACH SIDE (OPENING PROTECTION REQ'D)**
2. **NONCOMBUSTIBLE SHEATHING/SIDING EXTENDS MIN. 4FT EACH SIDE**
3. **BUILDING ON EACH SIDE OF THE FIRE WALL IS EQUIPPED THROUGHOUT WITH AN NFPA OR NFPA 13 SPRINKLER SYSTEM**



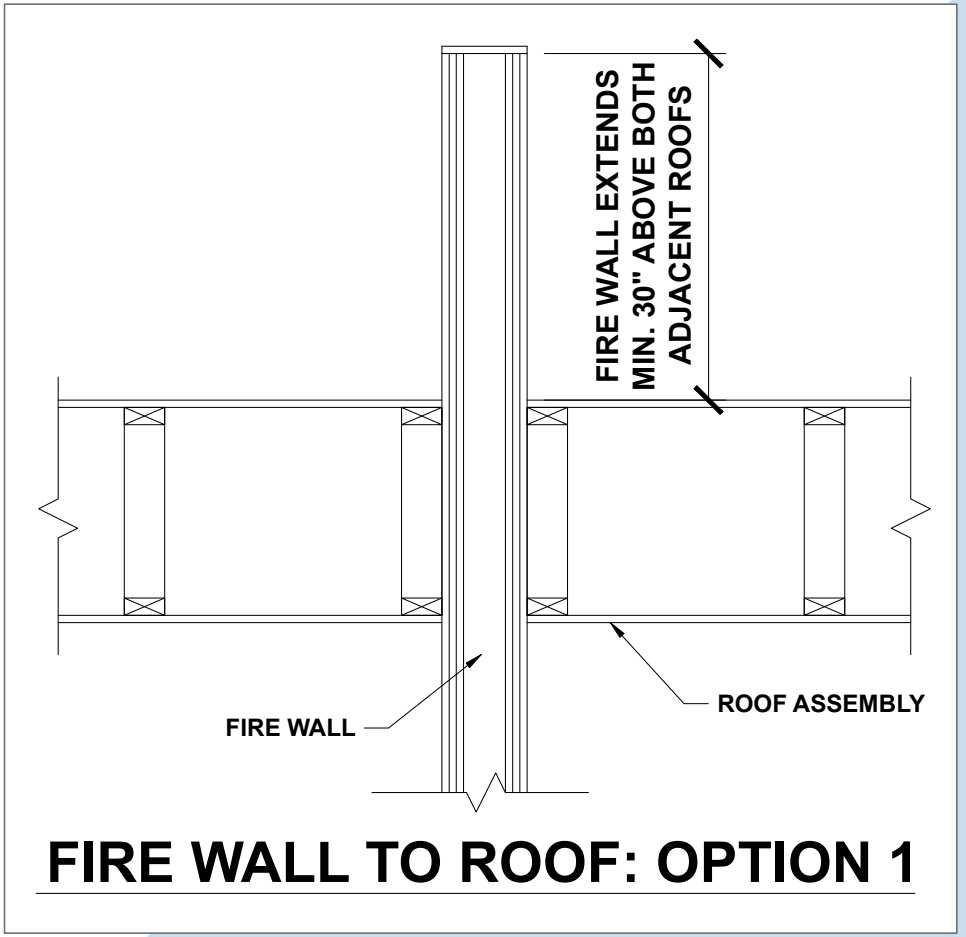
FIRE WALL TO EXTERIOR WALL: OPTION 2

Fire Walls

IBC 706

Vertical Continuity

- Fire walls are required to be continuous from foundation to roof



Fire Walls

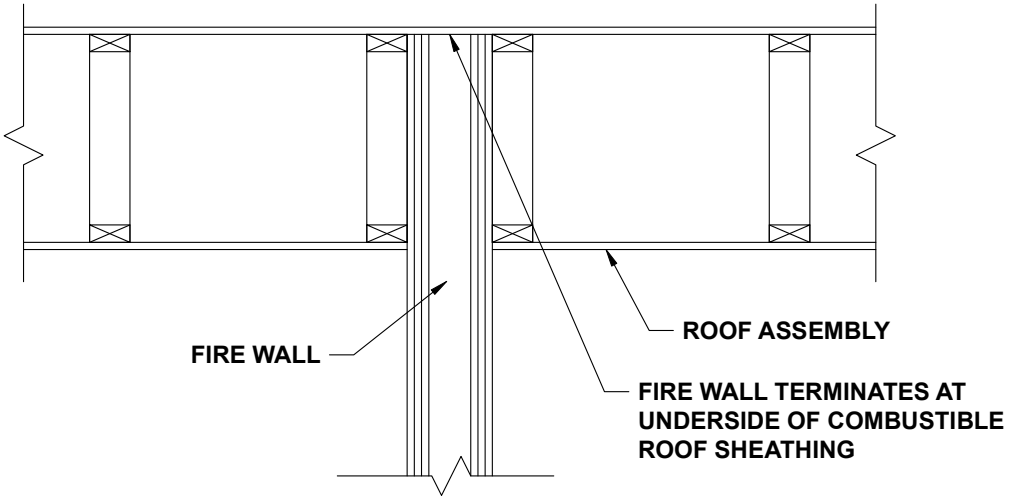
IBC 706

Vertical Continuity

- Fire walls are required to be continuous from foundation to roof

IN CONSTRUCTION TYPES III, IV OR V

- **NO OPENINGS IN ROOF WITHIN 4FT OF FIRE WALL**
- **MIN. CLASS B ROOF COVERING**
- **ROOF SHEATHING/DECK MIN. 4FT EACH SIDE OF WALL IS FRT OR UNDERSIDE OF SHEATHING IS COVERED WITH $\frac{5}{8}$" TYPE X GYPSUM**

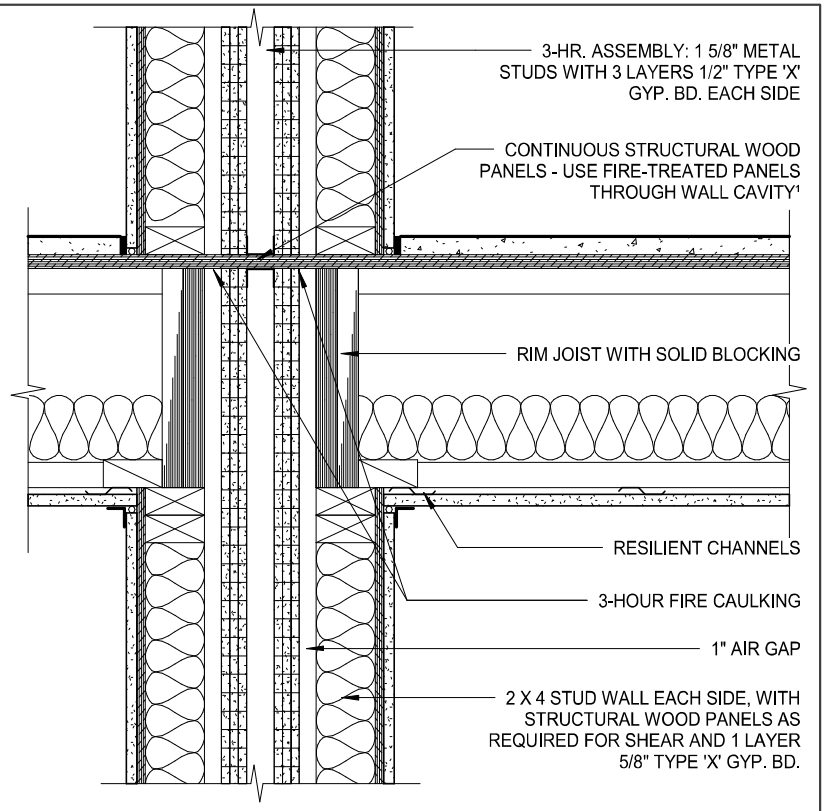


FIRE WALL TO ROOF: OPTION 2

Fire Walls

IBC 706

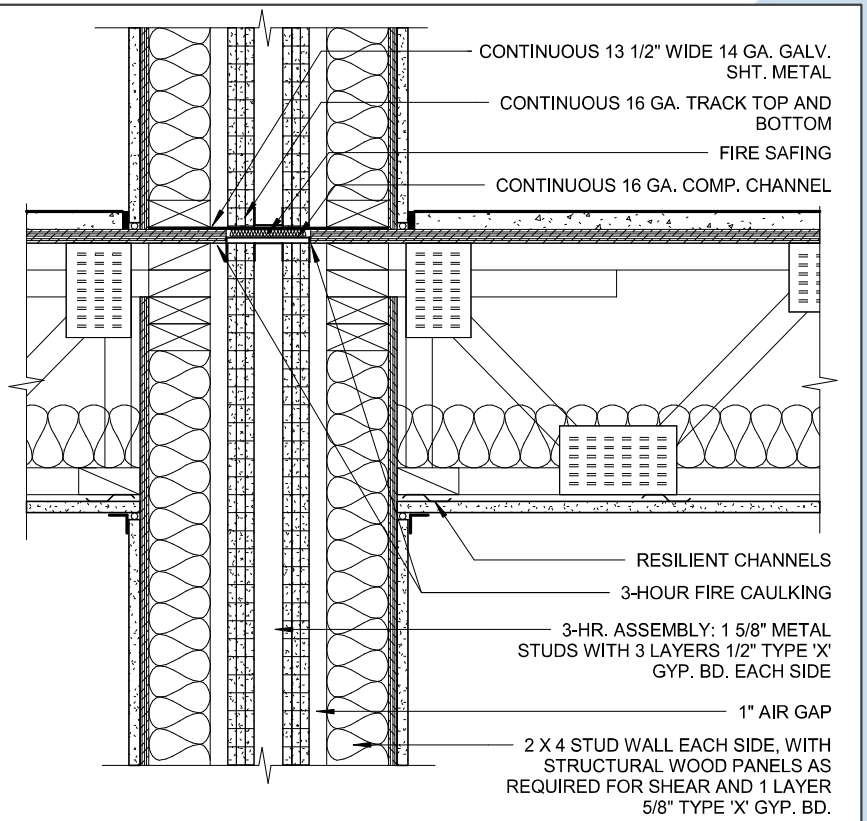
Seismic Diaphragm Continuity



[1]CONSULT LOCAL JURISDICTION HAVING AUTHORITY FOR ACCEPTANCE OF FIRE-TREATED WOOD PANELS RUNNING THROUGH 3-HOUR ASSEMBLY IN THIS APPLICATION.

3-HOUR FIRE WALL AT FLOOR/CEILING

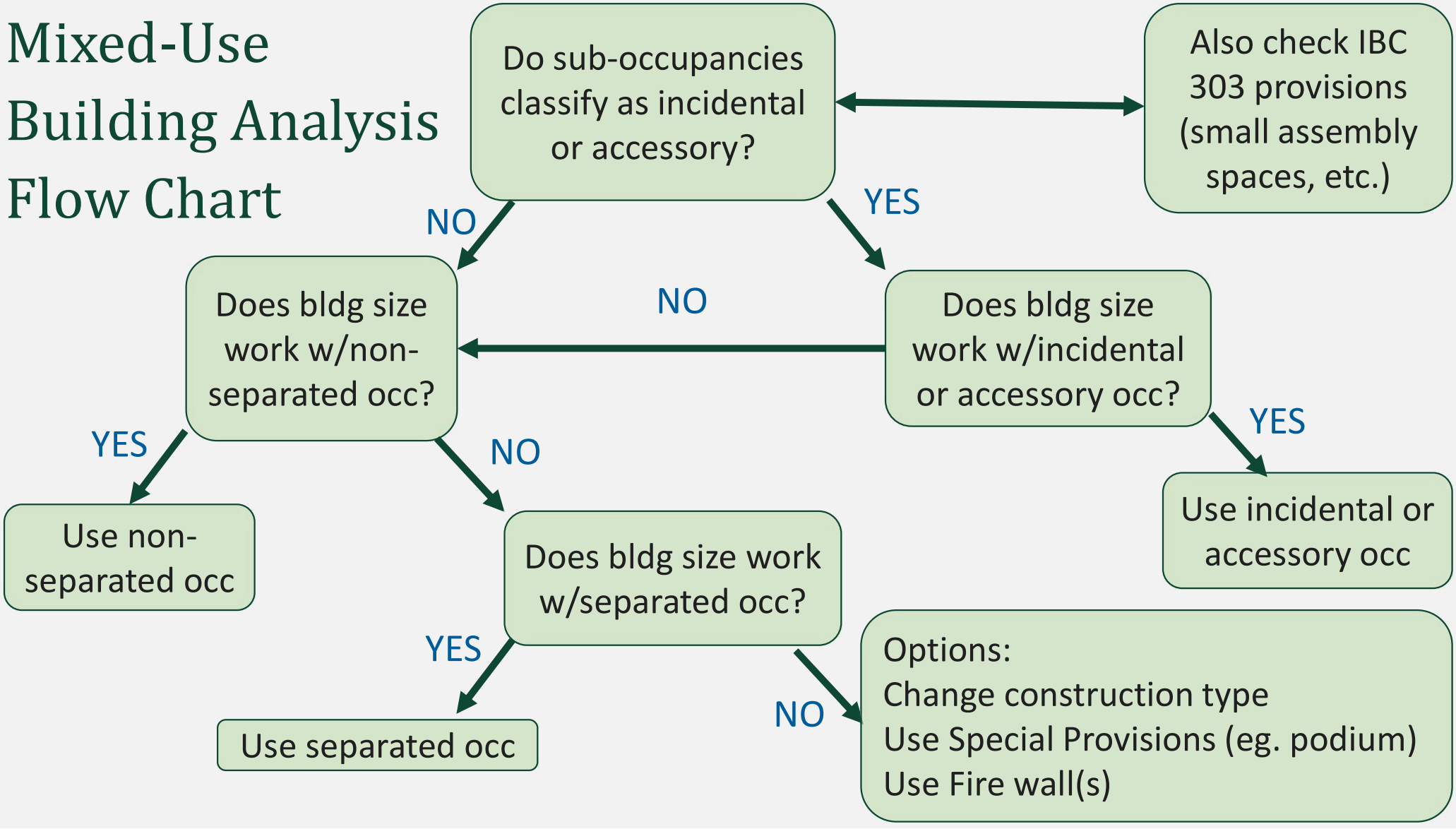
I-JOIST FRAMING WITH WOOD PANEL DIAPHRAGM RUNNING THROUGH FIRE WALL



3-HOUR FIRE WALL AT FLOOR/CEILING

WOOD TRUSS FRAMING WITHOUT WOOD PANEL DIAPHRAGM RUNNING THROUGH FIRE WALL

Mixed-Use Building Analysis Flow Chart




BREAK
TIME!

Exploring Tall Wood:
New Code Provisions for Tall Timber Structures

Presented by Jessica Scarlett

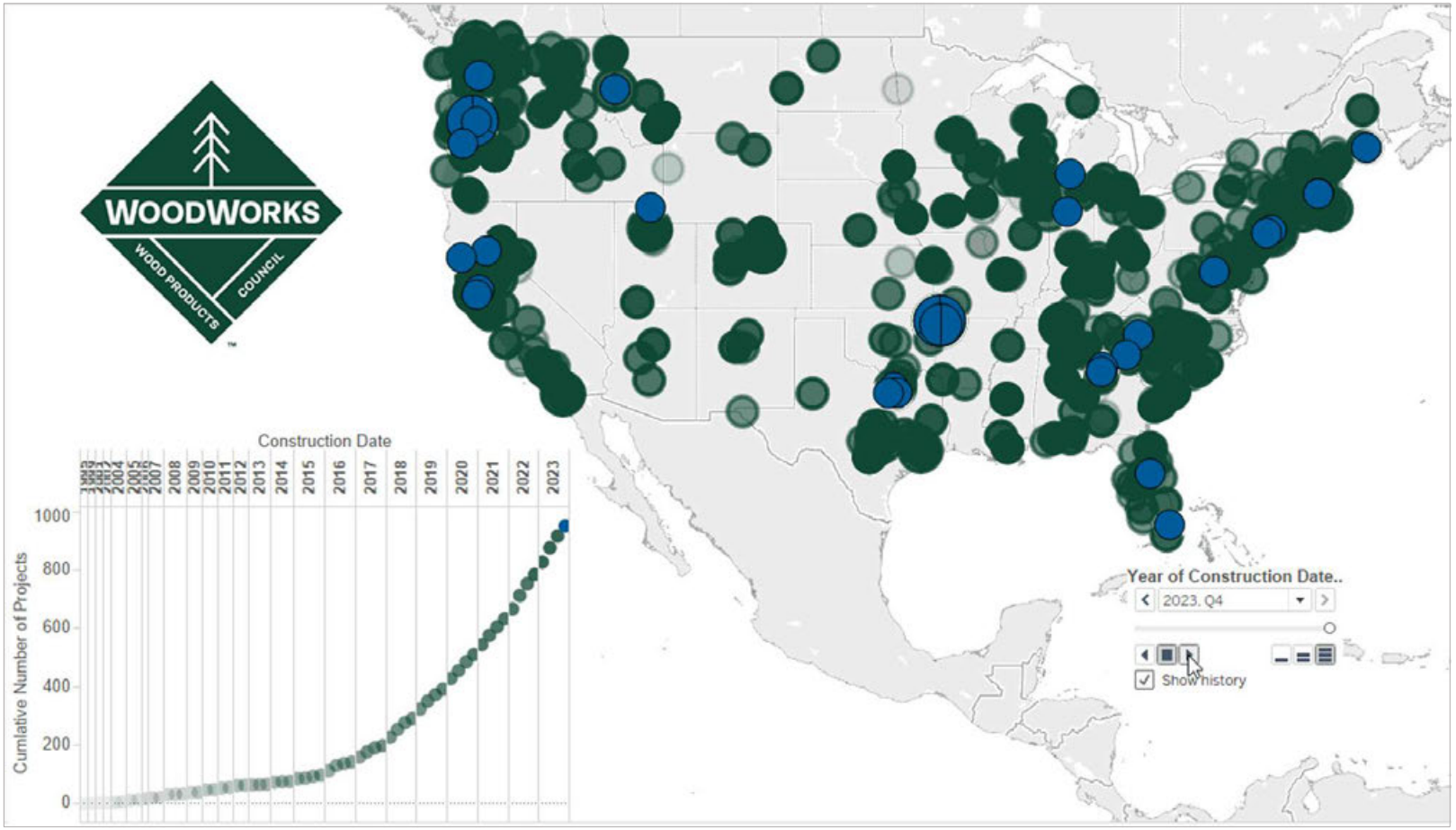
Image: Hickok Cole

TALL MASS TIMBER ASSESSING THE WHAT

Brock Commons, Vancouver, BC | Architect: Acton Ostry| Image Courtesy naturallywood

Current State of Mass Timber Projects

In the US, year-end 2023



12 tall wood projects already under construction or built.

Carbon 12
Portland, OR
8 stories mass timber

Heartwood
Seattle, WA
8 stories mass timber

Minnesota Places
Portland, OR
8 stories – 7 mass timber

TimberView
Portland, OR
8 stories mass timber

1510 Webster
Oakland, CA
18 stories – 16 mass timber

Ascent
Milwaukee, WI
25 stories – 19 mass timber

Bakers Place
Madison, WI
15 stories – 12 mass timber

INTRO
Cleveland, OH
9 stories – 8 mass timber

11 E Lenox
Boston, MA
7 stories mass timber

80 M Street
Washington DC
10 stories – 3-story mass timber vertical addition

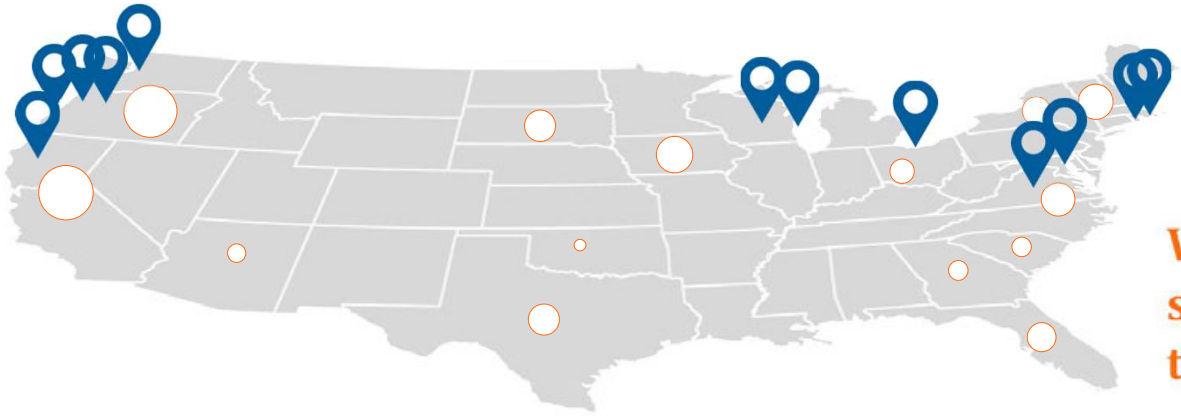
Apex Plaza
Charlottesville, VA
8 stories – 6 mass timber

Bunker Hill Housing
Boston, MA
6 stories mass timber

TALL WOOD

= 20 in-design tall wood projects

= tall wood project in construction or completed



WoodWorks is supporting 214 tall wood projects

INTRO, CLEVELAND

Type IV-B
Variance to expose ~50% ceilings

Photo: Harbor Bay Real Estate Advisors, Image Fiction | Architect: Hartshorne Plunkard Architecture

9 Stories | 115 ft
8 Timber Over 1 Podium

ASCENT, MILWAUKEE

Photo: Korb & Associates Architects |
Architect: Korb & Associates Architects

493,000 SF

259 APARTMENTS, MIXED-USE

Photo: Korb & Associates Architects | Architect: Korb & Associates Architects

11 E LENOX, BOSTON, MA

7 STORIES

70 FT

Passive House

Multi-Family

Credit: H + O Structural Engineering

Credit: Monte-Frenah Design Studio

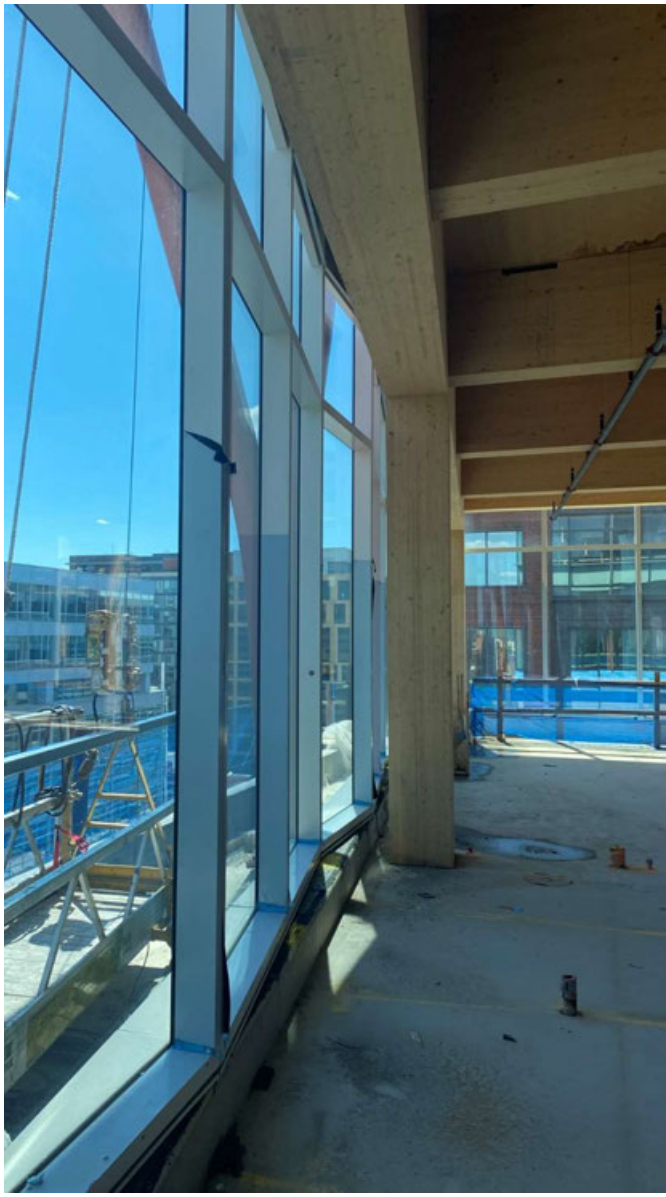
80 M ST, WASHINGTON, DC

Photo: Hickok Cole | Architect: Hickok Cole

80 M ST, WASHINGTON, DC

100,000 SF

2 NEW LEVELS OF CLASS A OFFICE SPACE
OCCUPIED PENTHOUSE
17’-0” CEILING HEIGHTS




NIR CENTER, PORTLAND, OR
~400,000 SF
235,000 SF Laboratory Space
25,000 SF Office Space
Ground Floor Retail
Photo: Hennebery Eddy Architects | Architect: Hennebery Eddy Architects
Hennebery Eddy Architects

TALL MASS TIMBER
UNDERSTANDING THE WHY

Brock Commons, Vancouver, BC | Architect: Acton Ostry| Image Courtesy naturallywood

New Buildings & Greenhouse Gasses

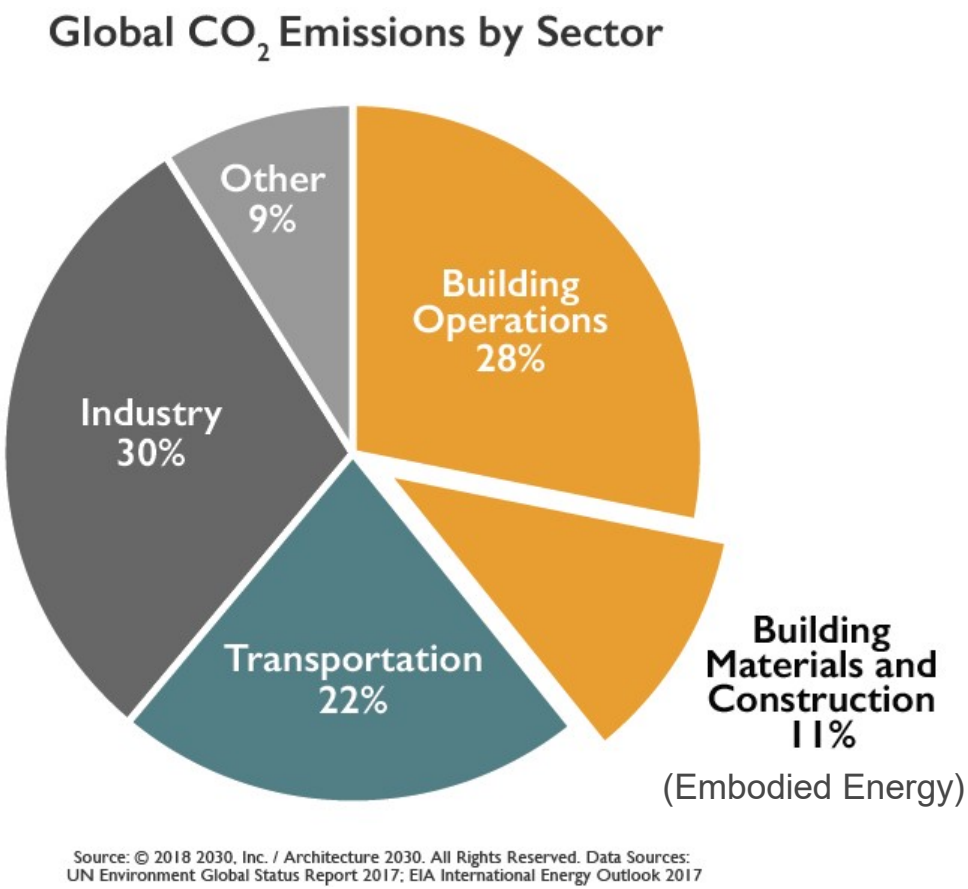


Image: Architecture 2030

Buildings generate nearly 40% of annual global greenhouse gas emissions (*building operations + embodied energy*)

Embodied Energy (11%): Concrete, iron + steel produce approximately 9% of this (Architecture 2030)

Carbon Storage

Wood ≈ 50% Carbon (dry weight)

Image: Kaiser + Path

Image: Lever Architecture

Tallhouse Boston

GLOBAL WARMING POTENTIAL & MATERIAL MASS

(PER BUILDING ASSEMBLY)

Source: Generate Architecture

The total global warming potential (GWP) of each option is shown with a breakdown by building assembly. The Concrete With Steel Frame and Concrete Flat Slab options have the highest GWP, with the bulk of the impact embedded in the floor slabs. The Timber Use 1 (Floor Slabs; Steel Frame) option offers a slight reduction in GWP, with the most of the savings also embedded in the floor slabs. The Timber Use 2 (Post, Beam, and Plate) option offers a relatively typical approach to building with timber, showing savings in floor slabs, beams and columns. Since Timber Use 3 and 4 are cellular approaches with load-bearing walls, these options included steel podiums to accommodate the ground floor program. Timber Use 3 shows how a hybrid approach with light gauge metal yields GWP savings in structural walls and exterior walls, despite the addition of the podium. Lastly, Timber Use 4 emphasizes how a completely cellular CLT

Biophilic Design, Connection to Forests

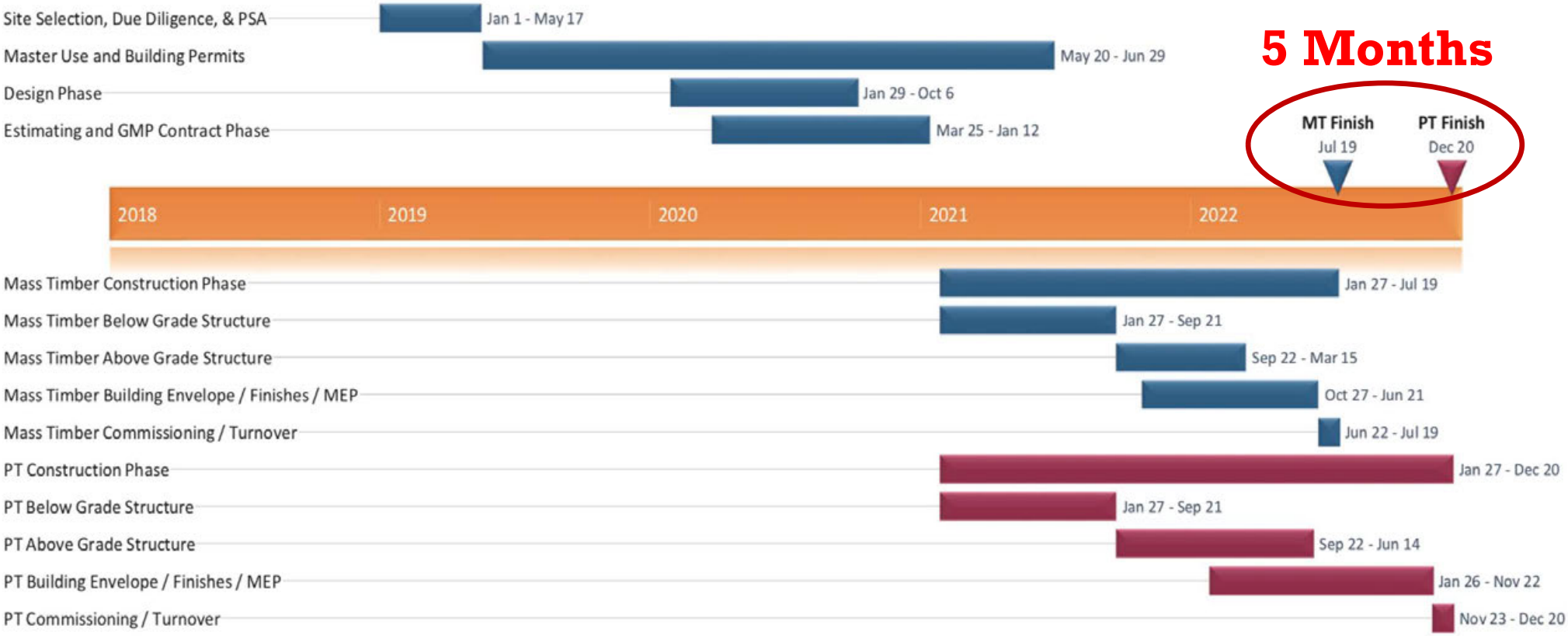
George Fox University – Canyon Commons
Hacker | Photo: Jeremy Bittermann

Tall Mass Timber: Structural Warmth is a Value-Add

TMBR (unbuilt) Minneapolis, MN | Images: D/O Architects

Construction Impacts: Labor Availability

Construction Impacts: Schedule



Seattle Mass Timber Tower Study, Source: DLR Group | Fast + Epp | Swinerton Builders

TALL MASS TIMBER DEMONSTRATING THE HOW

Brock Commons, Vancouver, BC | Architect: Acton Ostry| Image Courtesy naturallywood

Glue Laminated Timber (Glulam)
Beams & columns

Cross-Laminated Timber (CLT)
Solid sawn laminations

Cross-Laminated Timber (CLT)
SCL laminations

Photo: Freres Lumber

Photo: StructureCraft

Photo: LendLease

Photo: LEVER Architecture

Dowel-Laminated Timber (DLT)

Photo: StructureCraft

Nail-Laminated Timber (NLT)

Photo: Think Wood

Glue-Laminated Timber (GLT)

Plank orientation

Photo: StructureCraft

Photo: StructureCraft

Photo: Ema Peter

Photo: Manasc Isaac Architects/Fast + Epp

TALL WOOD IN THE CODE


2018 IBC and All Previous Editions:
» Prescriptive Code Limit - 6 stories (B occupancy) or 85 feet
» Over 6 Stories - Alternate Means and Methods Request (AMMR) through performance based design
» Based on the 1910 Heights and Areas Act
Photo: Alex Schreyer

U.S. TALL WOOD
DEVELOPMENT AND CHANGES

Interest in tall wood projects in the US was rapidly increasing. Some building officials were reluctant to approved proposed plans, primarily due to lack of code direction and precedent

Empire State Bulding, New York City, New York, 1931

Photo: Seagate Mass Timber Inc
Pollux Chang photographer

U.S. BUILDING CODES
DEVELOPMENT AND CHANGES

5 Working Groups Created

- July 2016 – November 2017: 5 in-person meetings, numerous conference calls
- 82 issues addressed, one primary topic was **fire performance and life safety**

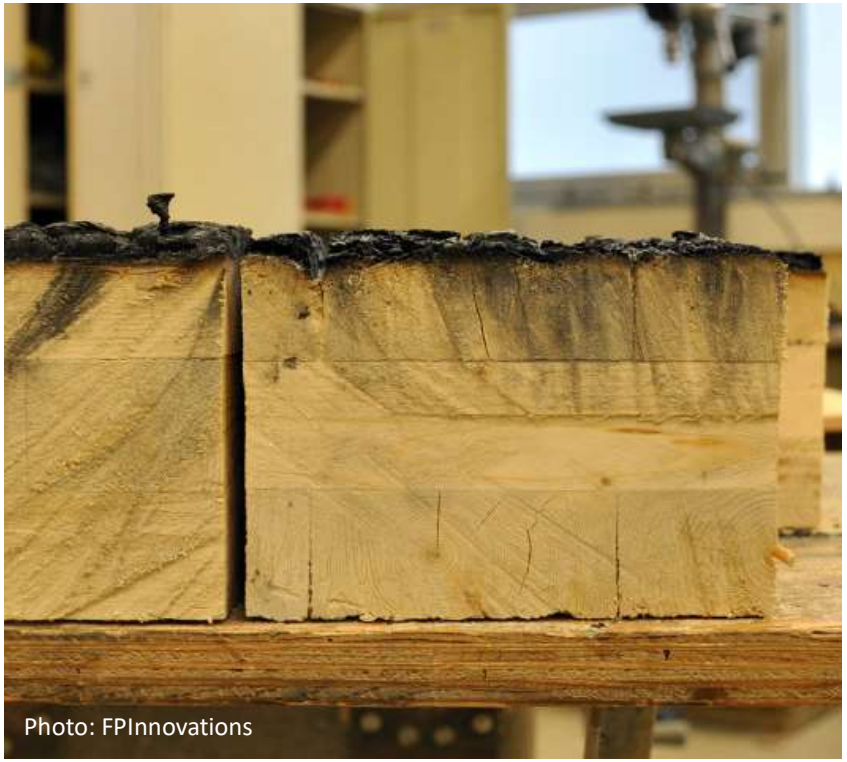
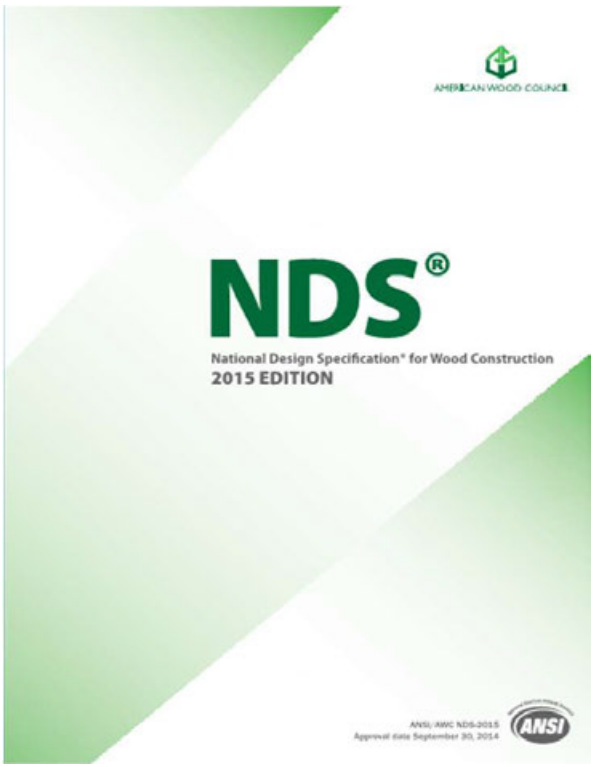


Photo: FPInnovations




NGC Testing Services

Fire Testing Laboratory

IAS ACCREDITED Testing Laboratory TL-216

TEST REPORT

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for

American Wood Council

222 Catoctin Circle SE, Suite 201
Leesburg, VA 20175

Fire resistance of mass timber for low- to mid-rise structures well understood, codified

U.S. BUILDING CODES
Tall Wood Ad Hoc Committee

Tests on exposed mass timber, gypsum-covered mass timber; normal sprinkler protection, delayed sprinkler protection

Majority of flames seen are from contents, not structure

U.S. BUILDING CODES
Tall Wood Ad Hoc Committee

Test	Description	Construction Type
Test 1	All mass timber surfaces protected with 2 layers of 5/8” Type X Gypsum. No Sprinklers.	IV-A
Test 2	30% of CLT ceiling area in living room and bedroom exposed. No Sprinklers.	IV-B
Test 3	Two opposing CLT walls exposed – one in bedroom and one in living room. No Sprinklers.	IV-B
Test 4	All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – normal activation	IV-C
Test 5	All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – 20 minute delayed activation	IV-C

U.S. BUILDING CODES
DEVELOPMENT AND CHANGES

ICC TWB Ad Hoc Committee proposals consisted 17 total code changes:

Requirements for the new Types of Construction:

- IBC Section 602.4 – Type of Construction (G108-18)
- IBC Section 703.8 – Performance Method for Fire Resistance from Noncombustible Protection (FS5-18)
- IBC Section 722.7 – Prescriptive Fire Resistance from Noncombustible Protection (FS81-18)
- IBC Section 703.9 – Sealants at Edges (FS6-18)
- IBC Section 718.2.1 – Fire and Smoke Protection (FS73-18)
- IBC Section 403.3.2 – High-Rise Sprinkler Water Supply (G28-18)
- IBC Section 701.6 – Owners' Responsibility (F88-18)

  IFC Section 3308.4 – Fire Safety During Construction (F266-18)

Allowable building size limits:

- IBC Table 504.3 – Building Height (G75-18)
- IBC Table 504.4 –Number of Stories (G80-18)
- IBC Table 506.2 – Allowable Area (G84-18)

Housekeeping changes:

- IBC Section 3102 – Special Construction (G146-18)
- IBC Appendix D – Fire Districts (G152-18)
- IBC Section 508.4 and 509.4 – Fire Barriers (G89-18)

- IBC Table 1705.5.3 Special Inspections (S100-19)
- IBC Section 110.3.5 Connection Protection Inspection (ADM35-19)
- IBC Section 2304.10.1 Connection Fire Resistance Rating (S170-19)

Photo: LendLease

ICC Online Governmental Consensus Voting Results, Ratified January 2019

Tall Wood Code Changes as submitted by TWB Ad Hoc Committee

Code Change	Final Action	CAH Results	PCH Results	OGCV Results/Final Action										Required Majority
					PCH	OGCV	TOTAL			PCH	OGCV	TOTAL		
FS5-18	**AS**	AS	AS	**AS**	186	479	665	88.8%	D	23	61	84	11.2%	Simple Majority
FS6-18	**AMPC 1**	AS	AMPC 1	**AMPC 1**	219	479	698	91.4%	D	6	60	66	8.6%	2/3 Majority
FS73-18	**AS**	AS	AS	**AS**	214	480	694	91.2%	D	8	59	67	8.8%	Simple Majority
FS81-18	**AM**	AM	AM	**AM**	183	485	668	91.6%	D	5	56	61	8.4%	Simple Majority
F266-18	**AMPC 1**	AM	AMPC 1	**AMPC 1**	211	455	666	89.9%	D	13	62	75	10.1%	Simple Majority
G28-18	**AS**	AS	AS	**AS**	215	514	729	94.1%	D	6	40	46	5.9%	Simple Majority
G75-18	**AM**	AM	AM	**AM**	161	386	547	69.0%	D	40	206	246	31.0%	Simple Majority
G80-18	**AS**	AS	AS	**AS**	160	382	542	67.9%	D	62	194	256	32.1%	Simple Majority
G84-18	**AS**	AS	AS	**AS**	172	383	555	71.8%	D	30	188	218	28.2%	Simple Majority
G89-18	**AM**	AM	AM	**AM**	177	482	659	88.7%	D	9	75	84	11.3%	Simple Majority
G108-18	**AM**	AM	AM	**AM**	219	471	690	70.6%	D	103	184	287	29.4%	Simple Majority

% of Vote in Favor of Code Change

% of Vote Req'd for Code Change Approval

SO WHAT'S CHANGED??

Since its debut, IBC has contained 9 construction type options

5 Main Types (I, II, III, IV, V) with all but IV having sub-types A and B

TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
A	B	A	B	A	B	HT	A	B

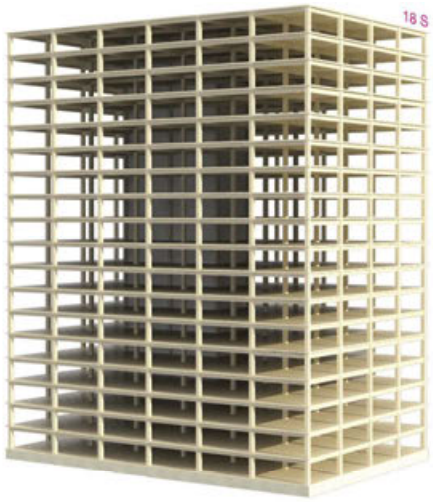
2021 IBC Introduces 3 new tall wood construction types:

IV-A, IV-B, IV-C

Previous type IV renamed type IV-HT

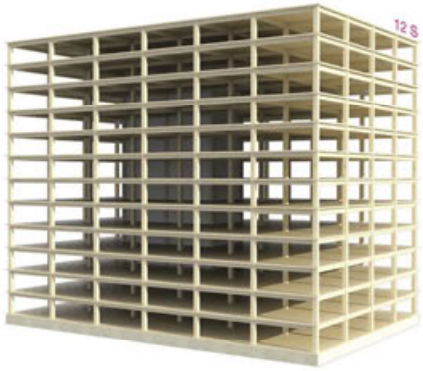
BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B

New Building Types



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

TYPE IV-A



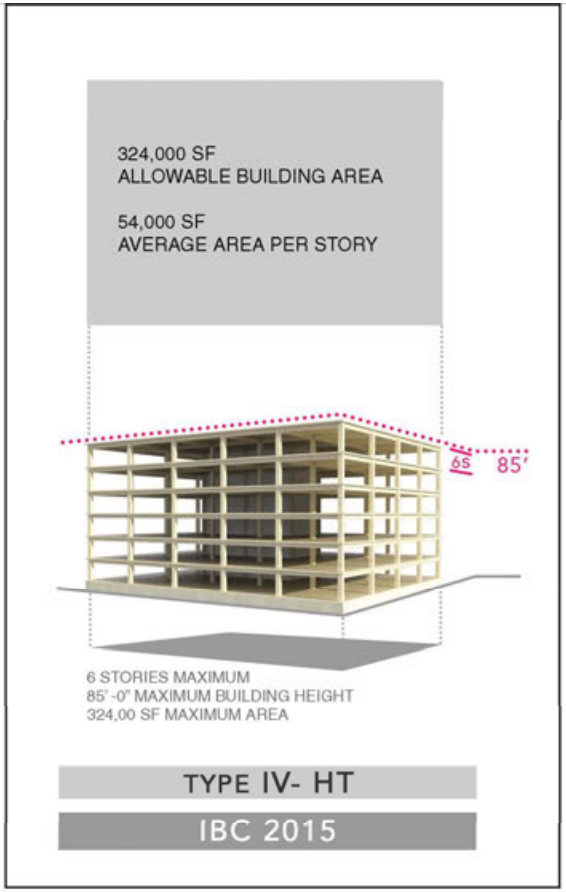
12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-B

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

TYPE IV-C

IBC 2021



TYPE IV- HT

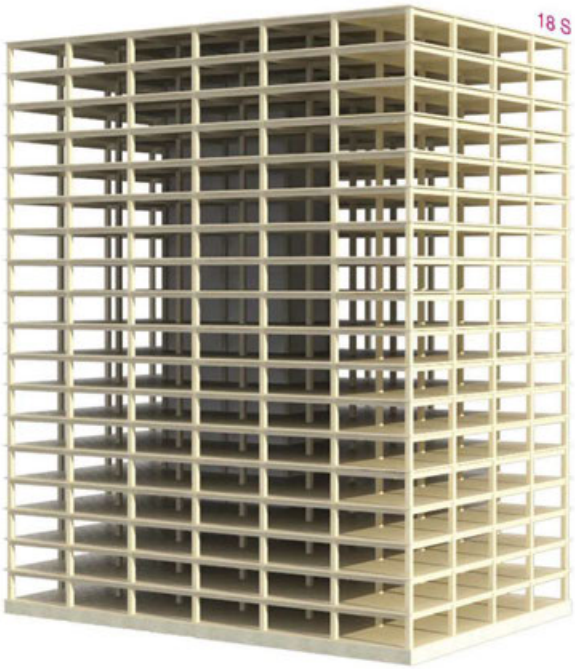
IBC 2015

BUSINESS OCCUPANCY [GROUP B]

*BUILDING FLOOR-TO-FLOOR HEIGHTS ARE SHOWN AT 12'-0" FOR ALL EXAMPLES FOR CLARITY IN COMPARISON BETWEEN 2015 TO 2021 IBC CODES.

Credit: Susan Jones, atelierjones

Type IV-A



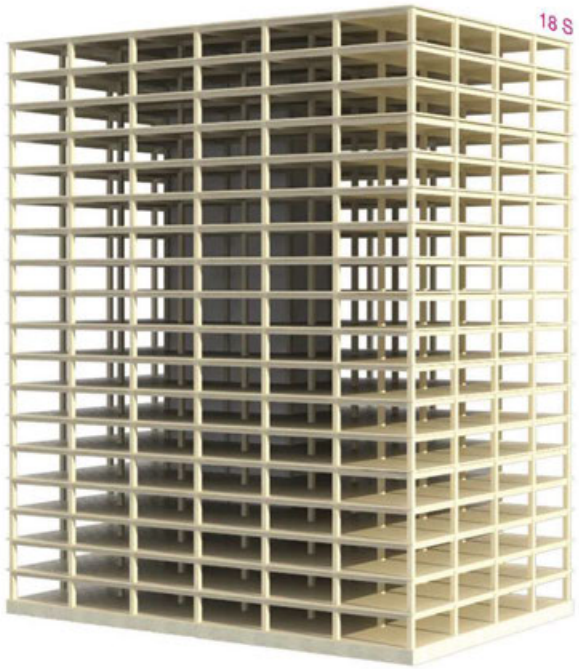
18 STORIES	
BUILDING HEIGHT	270'
ALLOWABLE BUILDING AREA	972,000 SF
AVERAGE AREA PER STORY	54,000SF

TYPE IV-A

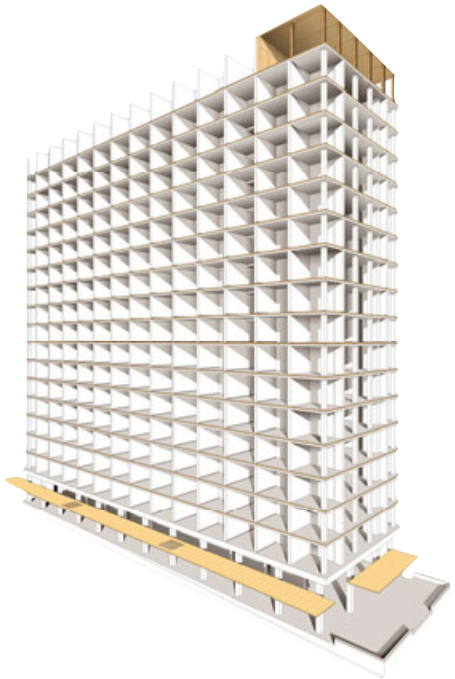
Credit: Susan Jones, atelierjones

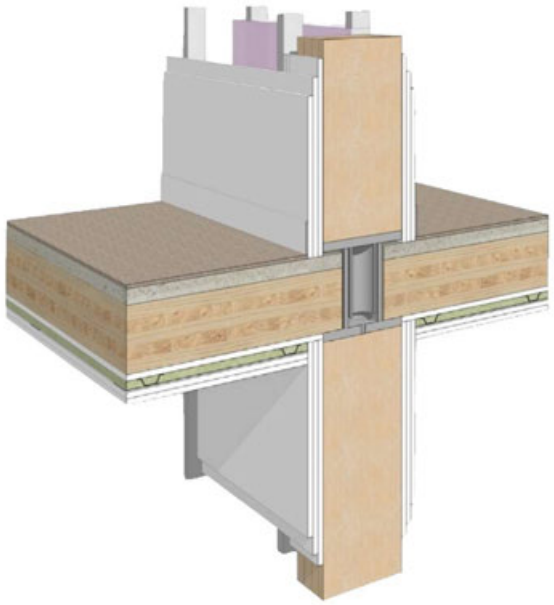
Photos: Structurlam, naturally:wood, Fast + Epp, Urban One

Type IV-A Protection vs. Exposed



Credit: Susan Jones, atelierjones

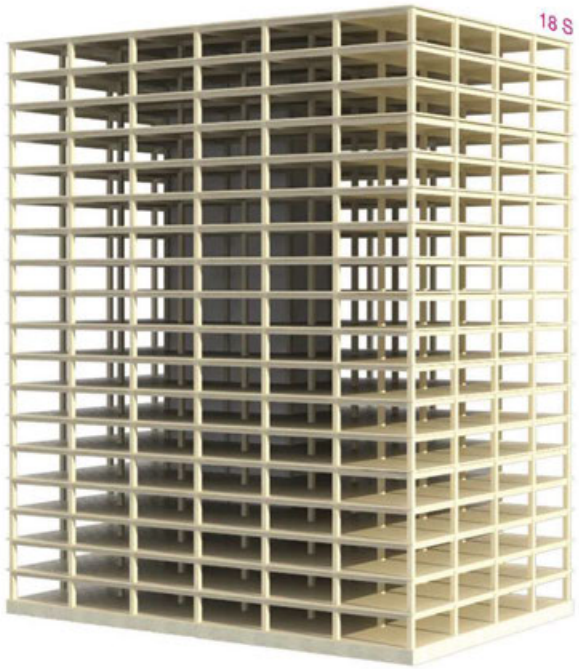




Credit: Acton Ostry Architects, Fast + Epp

100% NC protection on all surfaces of Mass Timber

Type IV-A Height and Area Limits



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

TYPE IV-A

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	18	270 ft	135,000 SF	405,000 SF
B	18	270 ft	324,000 SF	972,000 SF
M	12	270 ft	184,500 SF	553,500 SF
R-2	18	270 ft	184,500 SF	553,500 SF

Areas exclude potential frontage increase

In most cases, Type IV-A height & story allowances = 1.5 * Type I-B height & story allowances

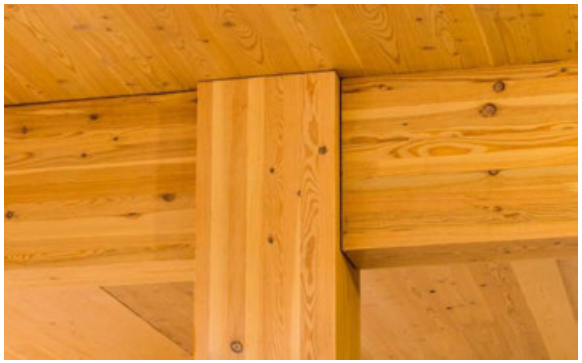
Type IV-A area = 3 * Type IV-HT area

Type IV-C

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

TYPE IV-C

Credit: Susan Jones, atelierjones



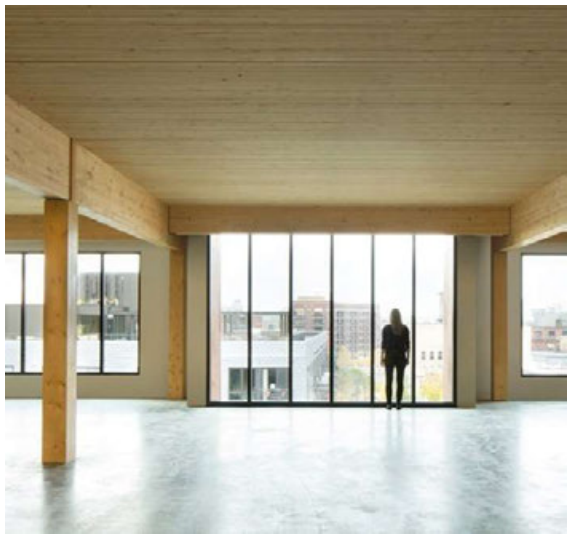
Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman

Type IV-C Protection vs. Exposed

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

TYPE IV-C

Credit: Susan Jones, atelierjones



Credit: Kaiser+Path, Ema Peter

All Mass Timber surfaces may be exposed

Exceptions: Shafts, concealed spaces, outside face of exterior walls

Type IV-C Height and Area Limits

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

TYPE IV-C

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	6	85 ft	56,250 SF	168,750 SF
B	9	85 ft	135,000 SF	405,000 SF
M	6	85 ft	76,875 SF	230,625 SF
R-2	8	85 ft	76,875 SF	230,625 SF

Areas exclude potential frontage increase

In most cases, Type IV-C height allowances = Type IV-HT height allowances, but add'l stories permitted due to enhanced FRR

Type IV-C area = 1.25 * Type IV-HT area

Credit: Susan Jones, atelierjones

Type IV-B

Credit: Susan Jones, atelierjones

Credit: LEVER Architecture

Type IV-B Protection vs. Exposed

Credit: Susan Jones, atelierjones

Credit: Kaiser+Path

NC protection on all surfaces of Mass Timber except limited exposed areas

~20% of Ceiling or ~40% of Wall can be exposed, see code for requirements

Type IV-B Height and Area Limits

Credit: Susan Jones, atelierjones

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	12	180 ft	90,000 SF	270,000 SF
B	12	180 ft	216,000 SF	648,000 SF
M	8	180 ft	123,000 SF	369,000 SF
R-2	12	180 ft	123,000 SF	369,000 SF

Areas exclude potential frontage increase

In most cases, Type IV-B height & story allowances = Type I-B height & story allowances

Type IV-B area = 2 * Type IV-HT area

Questions? Ask us anything.

Jessica Scarlett, EIT

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Survey

901 East Sixth, Thoughtbarn-Delineate Studio, Leap!Structures, photo Casey Dunn