The Future of Wood Construction- Upcoming Code Changes for 2021 IBC related to Tall Wood Construction

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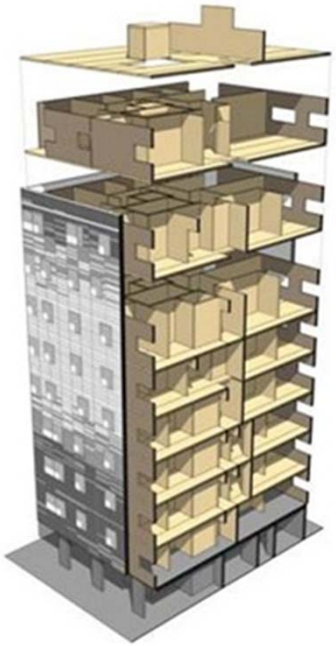
AMERICAN WOOD COUNCIL

Glued-laminated Timber (GLT)

Nail Laminated Timber (NLT)

Photo courtesy of Structurecraft

Recently-Developed Forms of Mass Timber



Cross-Laminated Timber (CLT)

mass timber ≠ conventional frame

TWB AD HOC OBJECTIVES

TWB identified performance objectives to be met:

- No collapse under reasonable scenarios of complete burn-out of fuel without automatic sprinkler protection being considered
- No unusually high radiation exposure from the subject building to adjoining properties to present a risk of ignition under reasonably severe fire scenarios
- 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

TWB AD HOC OBJECTIVES (CONT'D)

TWB identified performance objectives to be met:

- No unusual fire department access issues
- Egress systems designed to protect building occupants during design escape time, plus a factor of safety
- Highly reliable fire suppression systems to reduce risk of failure during reasonably expected fire scenarios. Degree of reliability proportional to evacuation time (height) and risk of collapse.

TWB COMMITTEE

Fire Work Group created fire test scenarios to study and validate the TWB code change proposals

- Test structure represented multi-story condo
- 30 ft x 30 ft interior dimensions
- Corridor and stair included in the structure
- UL "modern furnishings" fuel load imposed → 570 MJ/m^2
  - fuel load was approximately 85th percentile of Group R fuel loads from survey of Group R's

MULTI-STORY FIRE TEST STRUCTURE

- Purpose: Perform tests of realistic fire scenarios applicable to tall wood construction in order to evaluate occupant and firefighter tenability for egress and suppression efforts, and to provide data necessary to guide further development of relevant code and standard provisions

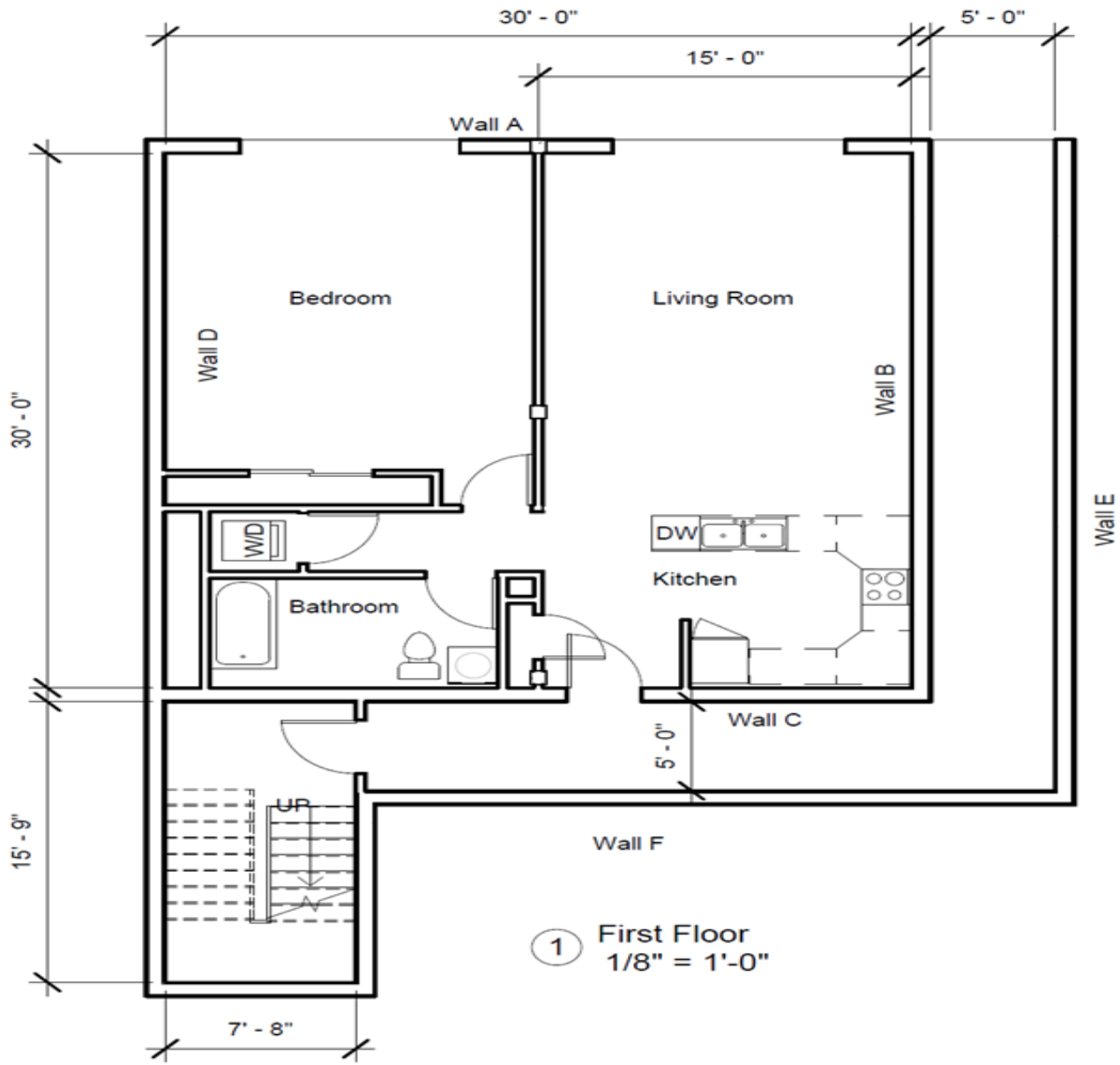
- Conducted at U.S. government facilities (ATF)
- Supervised by U.S. Forest Product Laboratory staff

ATF FIRE TEST SCENARIOS

Test	Description	Date	Duration
Test 1	All mass timber surfaces protected with 2 layers of 5/8" Type X GWB – Establishes baseline.	5/23/17	3 hours
Test 2	30% of CLT ceiling area in living room and bedroom exposed – Represents Max. exposure in Type IV-B.	5/31/17	4 hours
Test 3	Two opposing CLT walls exposed – one in bedroom and one in living room (there is a partition wall) – Type IV-B.	6/20/17	4 hours
Test 4	All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – normal activation	6/27/17	6 minutes
Test 5	All mass timber surfaces fully exposed in bedroom and living room (except bathroom). Sprinklered – 23 min delayed activation	6/29/17	30 minutes

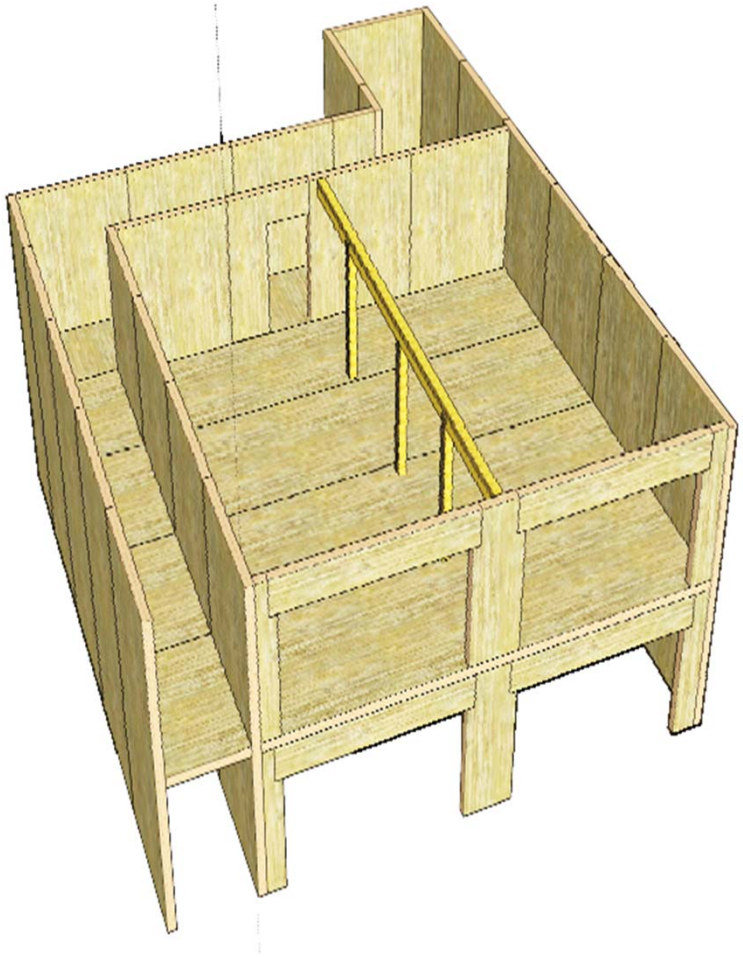
ATF FIRE TEST PLAN

- Tests 1 through 3: unlikely scenario in which automatic sprinklers fail to activate and fire service unable to respond
- Test 4: normal sprinkler activation
- Test 5: automatic sprinklers fail to activate, but are later manually charged by fire service



TWO-STORY STRUCTURE

- Two stories, one apartment per level
- Each apartment: 30 ft x 30 ft
- Ceiling height: 9 ft
- 5-ply CLT
  - Douglas fir-Larch species group
  - Lamination Thickness: 1.375 inches
  - CLT Thickness: 6.875 inches
  - Polyurethane Adhesive
- Corridor around each apartment and a stairwell



ATF FIRE TEST #1 - ALL MASS TIMBER PROTECTED

All mass timber surfaces protected with 2 layers of 5/8” Type X GWB

ATF FIRE TEST #1 - ALL MASS TIMBER PROTECTED

Photos provided by U.S. Forest Products Laboratory, USDA

ATF FIRE TEST #2 – 30% CLT CEILINGS EXPOSED

30% of CLT ceiling area in living room and bedroom exposed

Live load applied using water barrels

ATF FIRE TEST #2 – 30% CLT CEILINGS EXPOSED

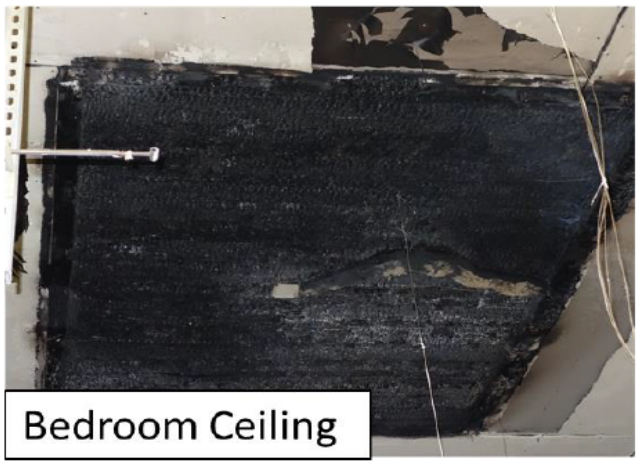

Ignition


Living Room / Kitchen Flashover


Bedroom Flashover


Decay Phase


Living Room Ceiling


Bedroom Ceiling

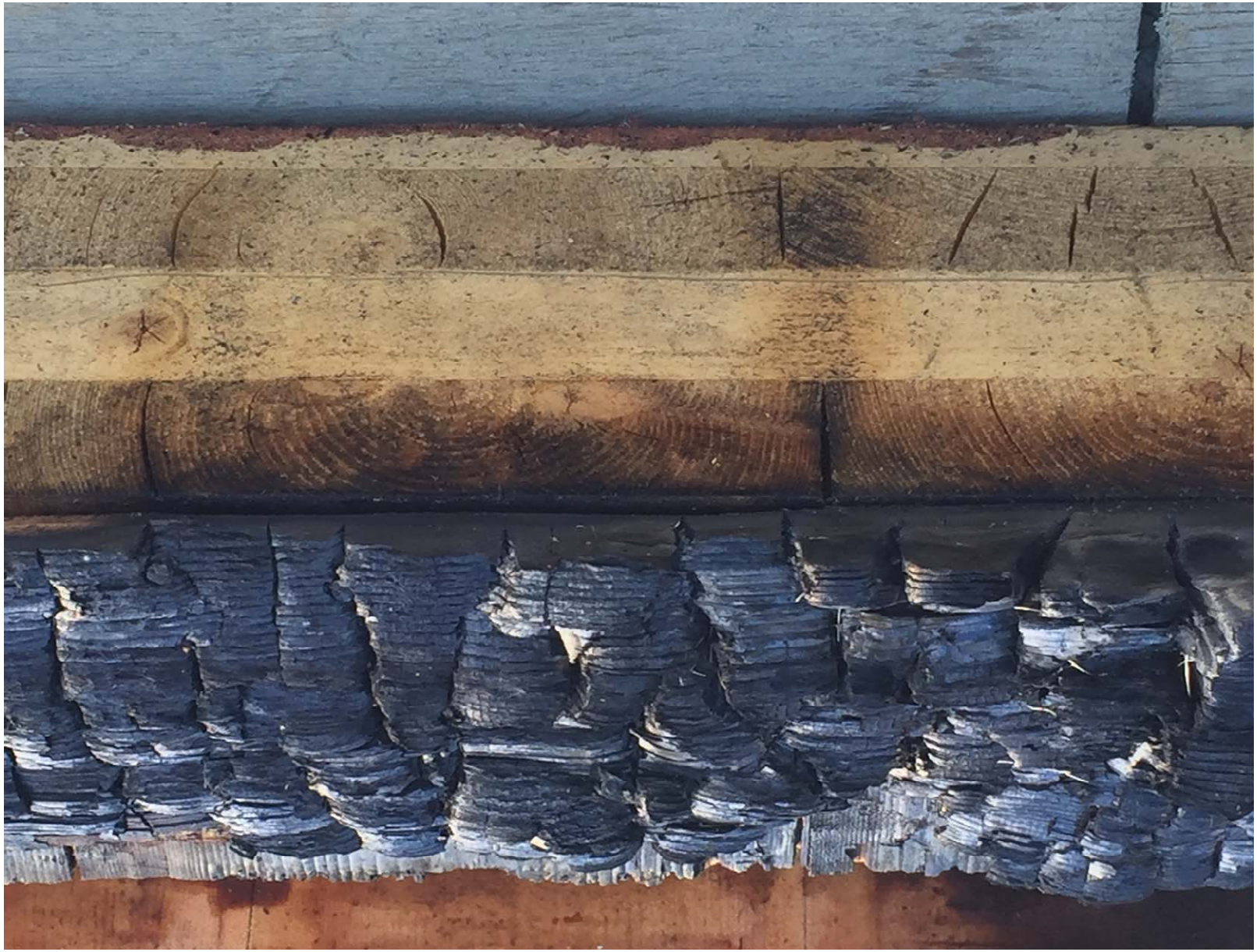
Photos provided by U.S. Forest Products Laboratory, USDA

ATF FIRE TEST #2 – 30% CLT CEILINGS EXPOSED

Post-Fire Condition of Glulam After Gypsum Removal

- Fire intensity decreased subsequent to consumption of furnishings and contents (known as *decay phase*)
- Exposed mass timber surfaces self-extinguished in the decay phase
- Mass timber surfaces protected with 2 layers of 5/8” Type X GWB remained mostly uncharred

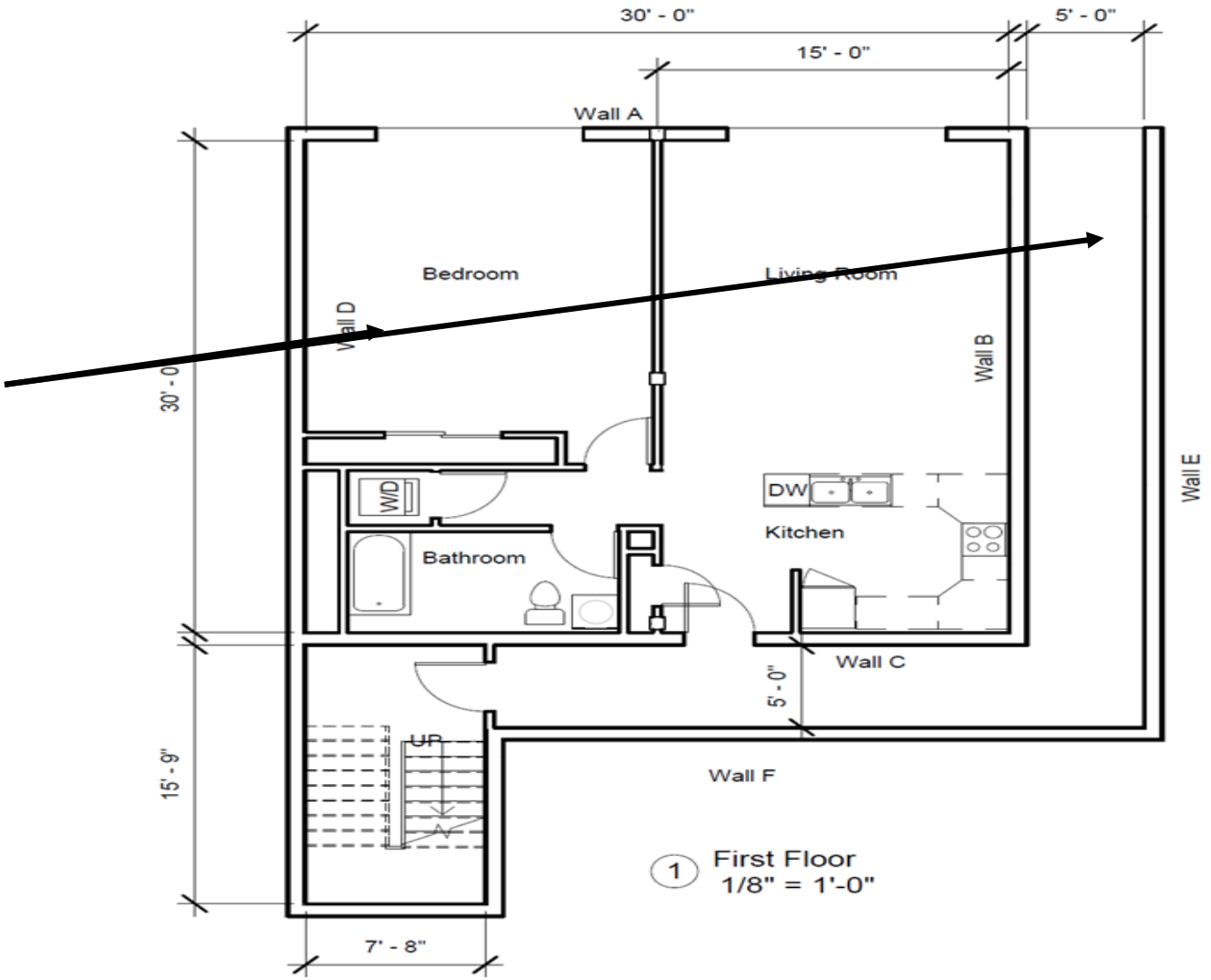
SECTION OF EXPOSED (OBTUSE ANGLE)



SECTION OF EXPOSED CEILING (90º ANGLE)

ATF FIRE TEST #3 – EXPOSED WALLS

Two opposing CLT walls exposed one in bedroom and one in living room



ATF FIRE TEST #3 WALLS EXPOSED

Mass Timber Contribution declining

ATF FIRE TEST #4 – SPRINKLERS, EXPOSED

All mass timber surfaces fully exposed in bedroom and living room

Sprinkler – normal activation

TEST #5 – DELAYED SPRINKLERS

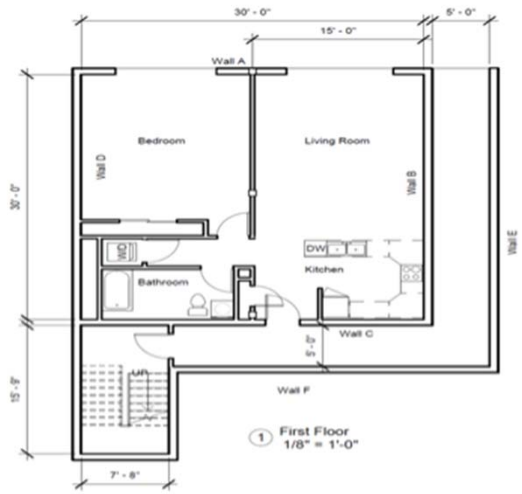
All mass timber surfaces fully exposed in bedroom and living room.

Sprinkler – water delayed for 20 minutes after sprinkler activation within the test compartment…approximately 23 minutes from ignition

- Flashover conditions were reached in the kitchen, and the bedroom was very near reaching flashover
- The sprinkler system effectively suppressed the fire

ATF FIRE TEST RESULTS – EVENT LOG

Test No.	Time After Ignition (mm:ss)				
	Flashover (600°C) Living Room	Flashover (600°C) Bedroom	Flames in Hallway	Compartment door Fails	Sprinkler Activation
1 1st floor	13:27	17:20	26:51	57:46	N/A
2 2nd floor	11:42	17:20	30:38	63:59	N/A
3 2nd floor	12:37	17:00	13:06 (door frame installation error)	29:42 (door frame installation error)	N/A
4 1st floor	-	-	-	-	2:37
5 1st floor	-	-	-	-	23:00



- Tests 2 and 3 terminated at 4 hours with no re-growth
- Flashover in living room consistent around 12-13 minutes.
- Time to Flashover in bedroom more consistent at around 17 minutes.
- Flames to breach 20 minute door into hallway was about 27-30 minutes.
- Test 3 – 20 minute door failed early because the door was not properly installed.

ATF FIRE TESTS

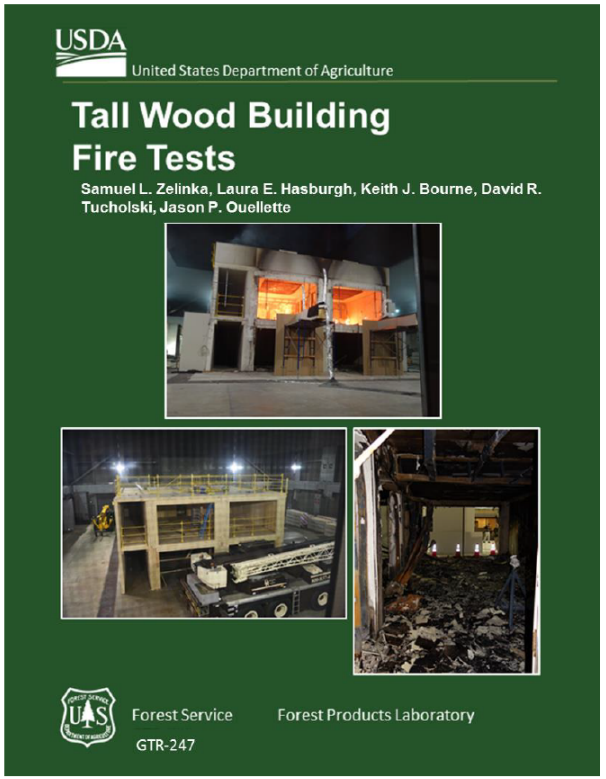
Full Report on FPL Website:

https://www.fpl.fs.fed.us/documnts/fplgtr/fpl_gtr247.pdf

Fire Test Videos on AWC Website:

www.awc.org/tallmasstimber

Link to you tube videos available on this page



TWB COMMITTEE PROPOSALS

Type of Construction -- Comparison			
Feature	**Type IVA**	**Type IVB**	**Type IVC**
Description of new Type IV types	100 % Noncombustible (NC) protection on all surfaces of Mass Timber (MT)	100% NC protection on all surfaces of mass timber (MT) except for limited exposed mass timber (MT) elements	100% exposed mass timber (MT) except: shafts, concealed spaces, and outside of exterior walls.
Permitted Materials			
structural building elements	MT or NC	MT or NC	MT or NC
Nonloadbearing Exterior Walls	MT or NC	MT or NC	MT, NC
Nonloadbearing Interior Walls	MT or NC	MT or NC	MT, NC
Shaft and Exit Enclosures			
Highrise* to 12 stories or 180 feet: *see IBC definition of highrise	NC or MT protected with 2 (or 3 when 3 hr FRR) layers of 5/8" type X;	NC or MT protected with 2 layers of 5/8" type X gypsum or equiv each side of enclosure;	NC or MT protected with one layer of 5/8" type X gypsum each side of shaft or enclosure.
Above 12 stories or 180 feet:	NC	Not Permitted	Not Permitted

TYPE OF CONSTRUCTION

TYPE IV-A Mass Timber with noncombustible protection

- Noncombustible protection shall provide 2/3 of the required Fire Resistance Rating for Building Elements (Table 601, 602)
- Taller buildings therefore not permitted to have exposed mass timber

TYPE IV-B Mass Timber with limited portions of noncombustible protection omitted

- limits on how much mass timber can be exposed
- limits on how close exposed areas can be to one another

TYPE IV-C Mass Timber with no requirement for noncombustible protection, except certain features

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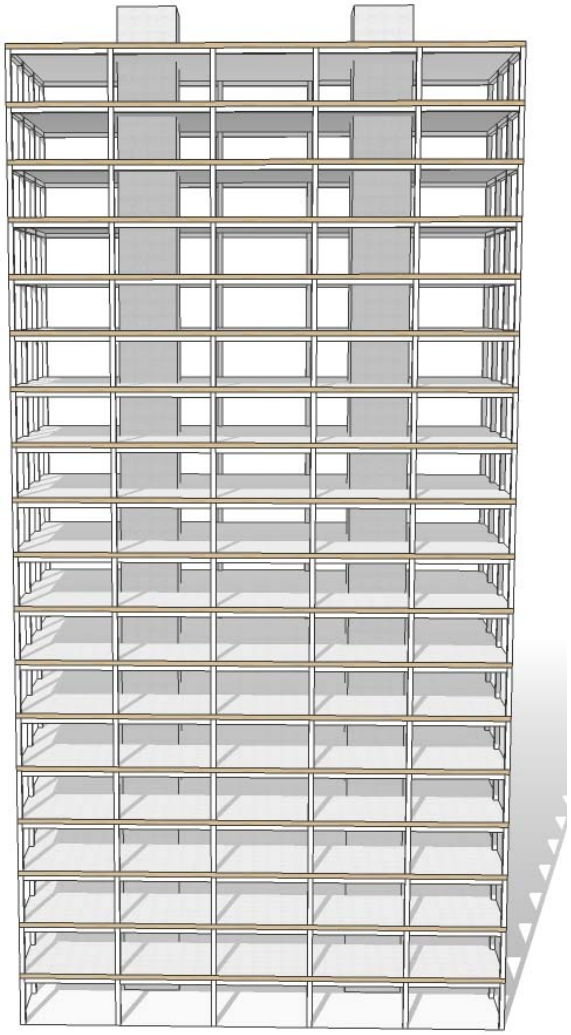
TYPE OF CONSTRUCTION IV-A



Building Elements	
Maximum Height	270’
Number of Stories (except H’s)	9 - 18
Exposed Mass Timber	Fully Protected
Sprinklers	Yes
Primary Frame FRR	3 hours
Floor FRR	3 hours
Fire Resistance from Non-com	120 minutes
Stairs Tower	Non-combustible
Concealed Spaces	Permitted
Floor Topping	Noncombustible

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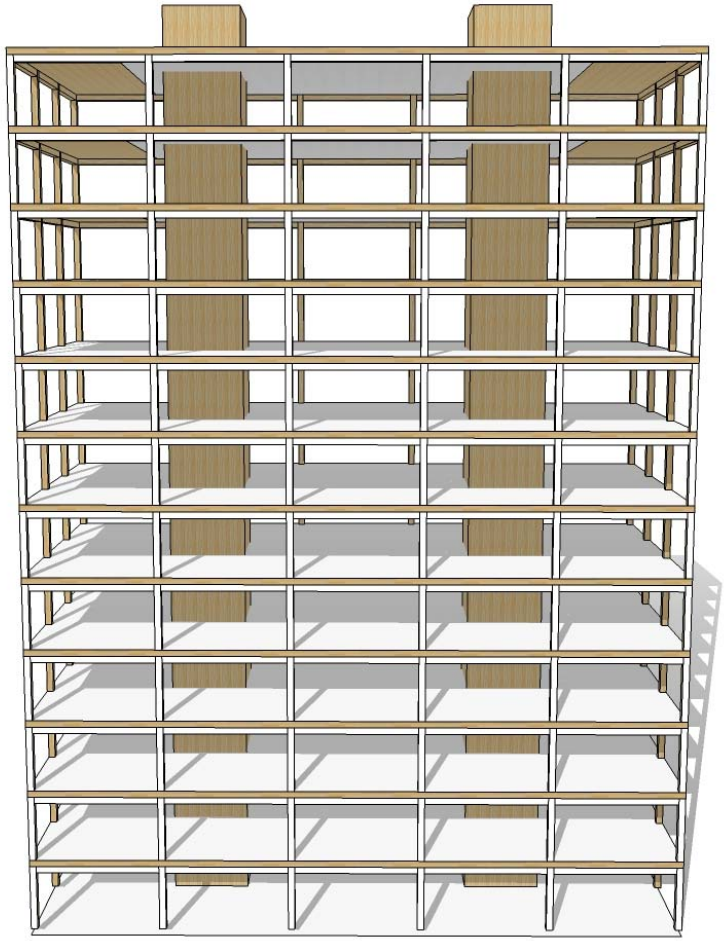
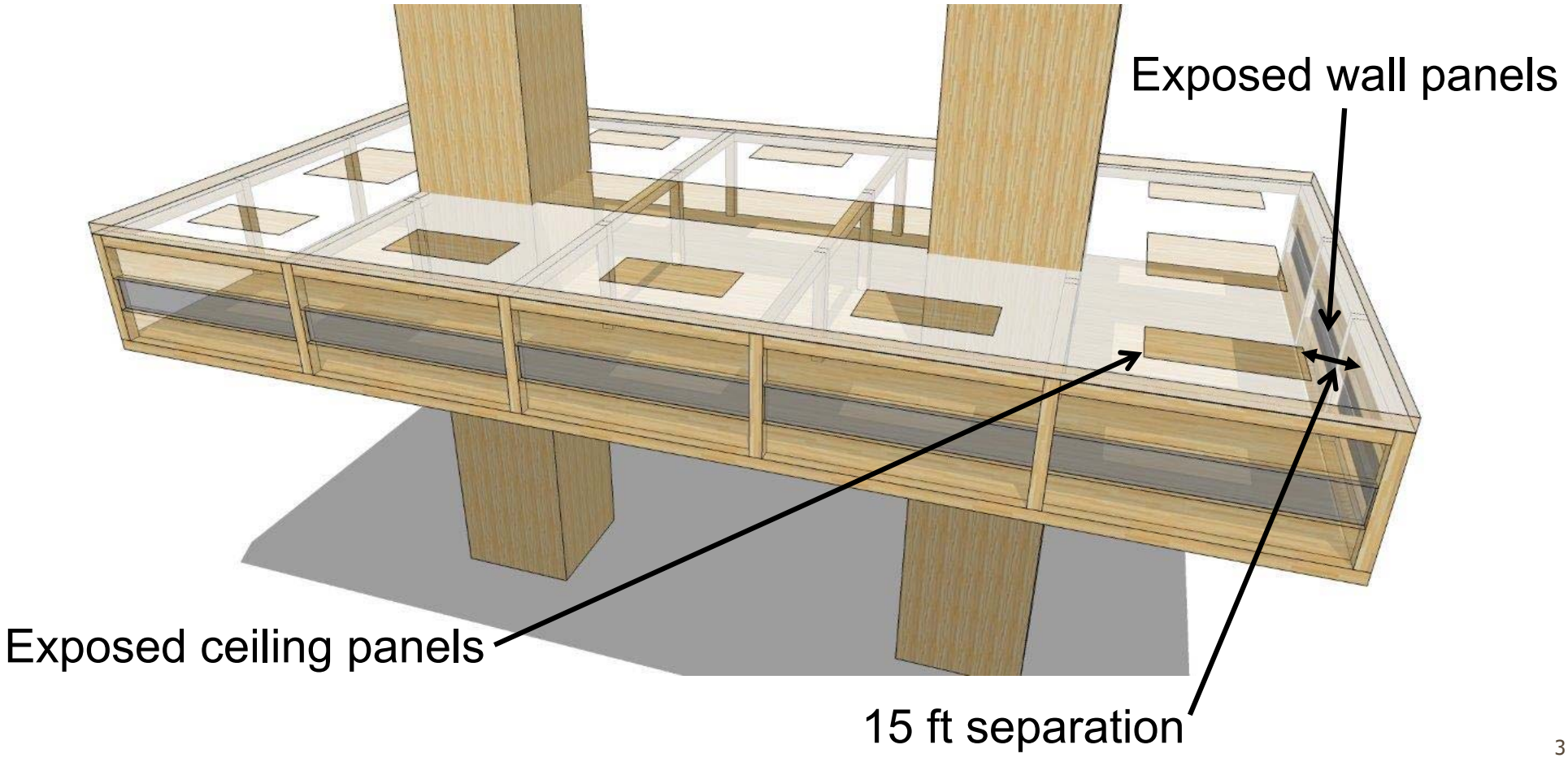
TYPE OF CONSTRUCTION IV-B



Building Elements	
Maximum Height	180’
Number of Stories (except H’s)	6 - 12
Exposed Mass Timber	Partially
Sprinklers	Yes
Primary Frame FRR	2 hours
Floor FRR	2 hours
Fire Resistance from Non-com	80 minutes
Stairs Tower	Mass Timber
Concealed Spaces	OK if Protected
Floor topping	Noncombustible

TWB COMMITTEE PROPOSALS

602.4.2.2.4 Separation Distance Between Unprotected Mass Timber Elements. In each *dwelling unit* or *fire area*, unprotected portions of mass timber walls and ceilings shall be not less than 15 feet from unprotected portions of other walls and ceilings, measured horizontally along the ceiling and from other unprotected portions of walls measured horizontally along the floor.



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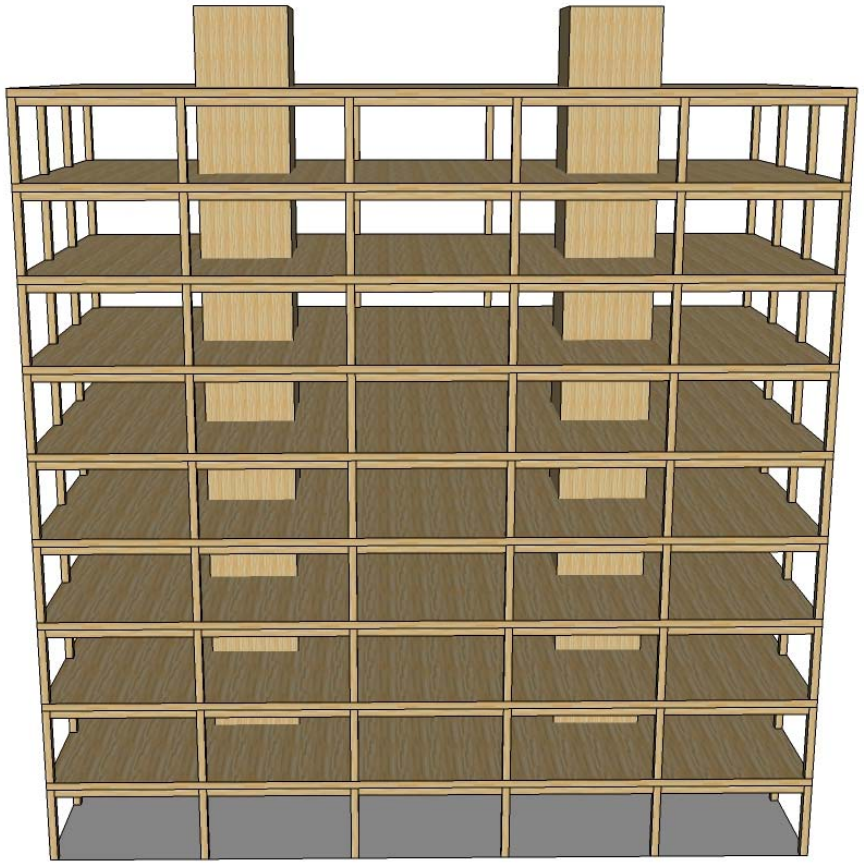
TYPE OF CONSTRUCTION IV-C



Building Element	
Maximum Height	85’
Number of Stories	4 - 9
Exposed Mass Timber	Fully Exposed
Sprinklers	Yes
Primary Frame FRR	2 hours
Floor FRR	2 hours
Stairs Tower	Mass Timber
FRR from Non-combustibles	0 hours
Concealed Spaces	OK if Protected
Floor topping	No requirement

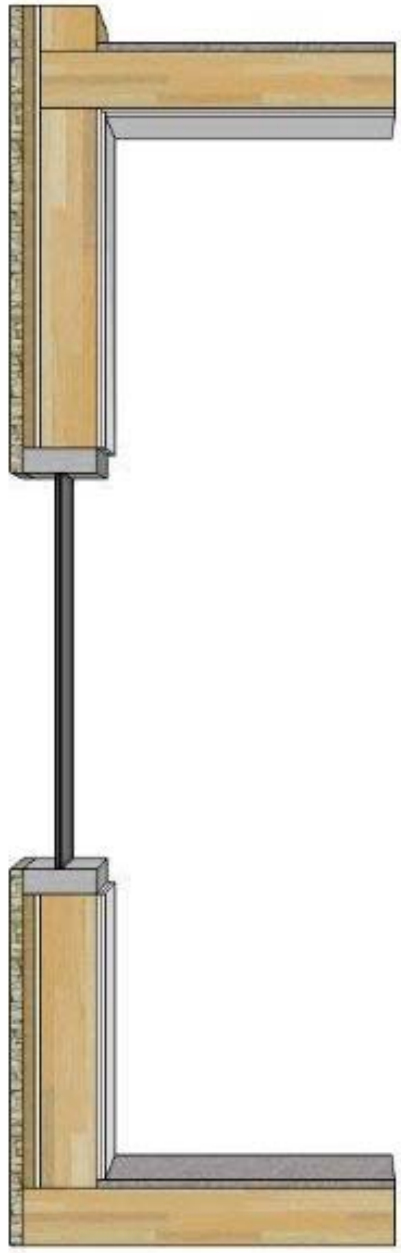
TYPE OF CONSTRUCTION

- Each Type of Construction based on test conditions in at least 1 of the 5 ATF fire tests
- Fire Test Plan developed by TWB Fire Work Group
- Test Plan included testing of various “generic” connections as recommended by the Structural Work Group
- Both panel mass timber (CLT) and other mass timber (glulam beams and columns) were tested

EXTERIOR WALL SECTION

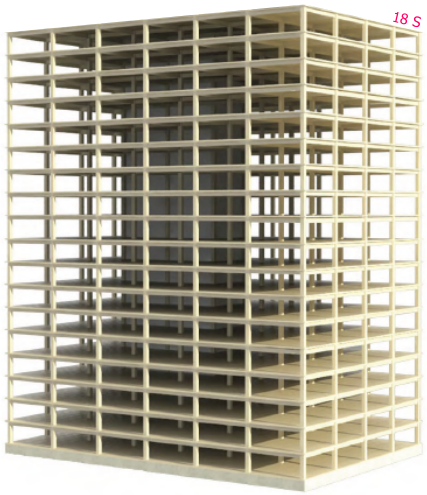
All material outboard of the
Mass Timber
MUST BE NONCOMBUSTIBLE
Except: water resistive barrier

1 layer
5/8 in. Type X GWB
Required on outside
Of exterior walls for
Type IV-A, B and C

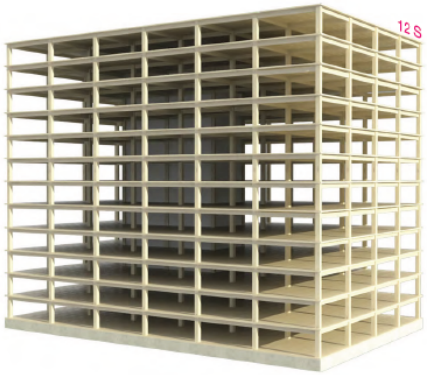


Feature	Type IVA	Type IVB	Type IVC
Floor Surface	1 inch of NC protection	1 inch of NC protection	No protection required
Roof	No NC protection on exterior roof surface, 2 layers of 5/8" type X gypsum on interior roof surfaces.	No NC protection on exterior roof surface, 2 layers of 5/8" type X gypsum on inside of roof deck.	No protection on roof surface or inside of roof deck is required (unless concealed space).
Concealed Spaces	No exposed MT in concealed spaces. NC protection in concealed spaces.	No exposed MT in concealed spaces. NC protection in concealed spaces.	No exposed MT in concealed spaces. One layer of 5/8" type x gypsum NC protection in concealed spaces.
Table 601, FRR			
Primary frame or bearing Wall: Floors: Roof:	3 hr FRR; 2 hr FRR; 1.5 hr FRR;	2 hr FRR; 2 hr FRR; 1 hr FRR;	2 hr FRR; 2 hr FRR; 1 hr FRR;
Fire Resistance Rating trade off	NO FRR reduction for sprinkler in 403.3.2.1	NO FRR reduction for sprinkler in 403.2.1	NO FRR reduction for sprinkler in 403.2.1

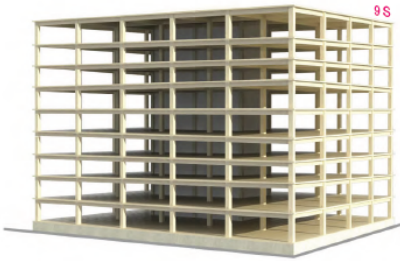
IBC TABLE 504.4 ALLOWABLE STORIES GROUP B



18 STORIES
BUILDING HEIGHT 270'
BUILDING AREA 432,000 SF



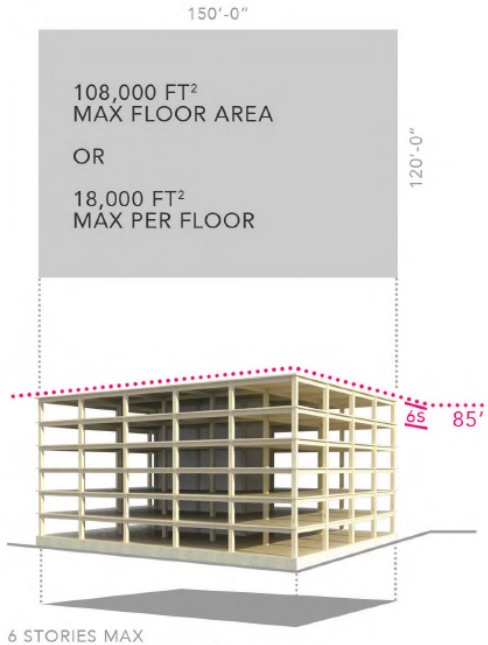
12 STORIES
BUILDING HEIGHT 180 FT
BUILDING AREA 288,000 SF



9 STORIES
BUILDING HEIGHT 85'
BUILDING AREA 180,000 SF

TYPE IV-A | TYPE IV-B | TYPE IV-C

IBC 2021



6 STORIES MAX
85'-0" MAX BUILDING HEIGHT
108,000 SQFT MAX AREA

TYPE IV- HT

IBC 2015

BUSINESS OCCUPANCY [GROUP B]

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http://www.awc.org/aboutus/staff