WoodWorks™
WOOD PRODUCTS COUNCIL

Mid Rise Design: Opportunity and Implementation

"The Wood Products Council" is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES), Provider #G516.

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

As increases in urban density become necessary to address growing populations, many building designers and developers are leveraging wood's ability to achieve multiple, simultaneous objectives. Wood is a code-compliant solution to the challenge of how to cost-effectively increase density while creating vibrant and sustainable communities. Yet many familiar with the design of two- to four-story wood structures are not aware that the International Building Code allows five stories and more of wood-frame construction for residential uses such as student, senior and affordable housing, and for business, mercantile and military occupancies. Through an overview of design, detailing, and construction considerations, this presentation is intended to give architects and engineers the confidence to break into this growing market segment. Heights and areas will be discussed, including allowable increases, as will fire-resistive design, detailing for performance, shrinkage, structural framing, acoustics, and fire-rated assemblies.

Learning Objectives

1. In the context of a shift toward greater urban density, discuss how mid-rise, wood-frame construction meets housing needs while creating vibrant sustainable communities.
2. Discuss allowable construction types, occupancies, and building heights/stories/areas for wood-frame mid-rise buildings per the current International Building Code.
3. Identify fire resistance and protection requirements for wood-frame wall assemblies in Type III and Type V buildings.
4. Examine detailing best practices to achieve performance requirements for acoustics, lateral bracing, shrinkage effects, and floor-to-wall interfaces.

"The Wood Products Council" is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES), Provider #G516.

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Outline

- Need for Mid-Rise Construction (Urban Densification)
- Mid-rise Building Types/Configurations
- Maximizing Height & Area
- Fire Ratings & Requirements

Outline

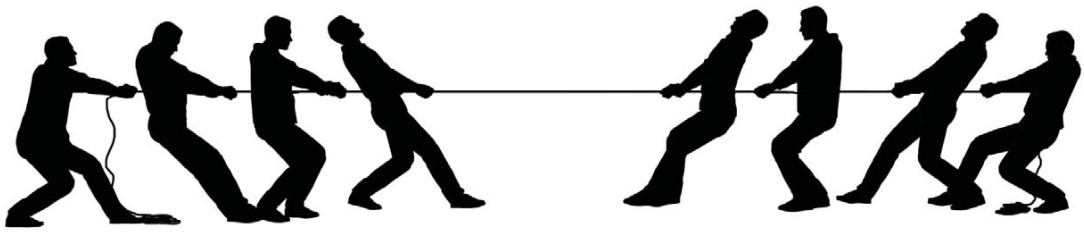
- Need for Mid-Rise Construction (Urban Densification)
- Mid-rise Building Types/Configurations
- Maximizing Height & Area
- Fire Ratings & Requirements

Global Population Boom

Global Population
> 7 billion now
9.0 billion by 2050
30% increase

Urban Population
5.3 billion by 2050
66% increase

Need for Sustainable Multi-Family & Mixed Use Structures



Economically Meet
Urban Housing Needs

Increase
Environmental
Responsibility

These 2 items don't need to be in opposition-
Wood framing helps them work together!

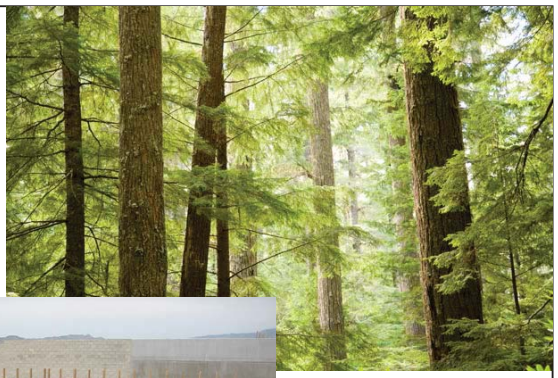
Need for Sustainable Multi-Family & Mixed Use Structures

Mid-Rise Wood
Frame Construction
provides a common
ground for both

How?

Mid-Rise Construction

Why Wood?

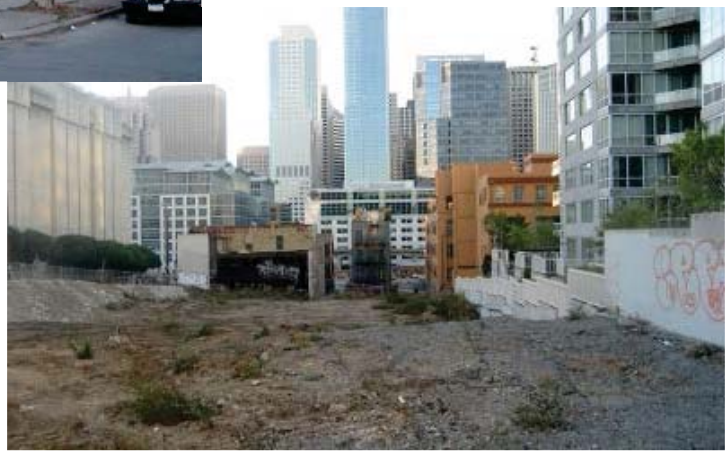


- Wood Costs Less
- Wood is Versatile
- Wood Meets Code
- Wood is Durable
- Wood is Renewable

Using Wood Helps Reduce Your Environmental Impact

Wood Products Play a Significant Role in Modern Economy

Urban Infill Development



Case Study: Wood Buildings Aim High

AvalonBay Stadium

Location: Anaheim, CA

251 Apts., 13K sf retail/restaurant

Type III modified

50% of their projects are podium

Semi-balloon framed with 16” I-joist at exterior walls

Architect: Withee Malcolm Architects

Engineer: VanDorpe Chou Associates

Developer/Contractor: AvalonBay Communities

Photo credit: Arden Photography

Carbon Case Study: High Density

AvalonBay Stadium- Anaheim, CA

Climate Change Advantage

For information on the calculations in this chart, visit woodworks.org

Volume of wood used: 5,200 cubic meters / 183,600 cubic feet of lumber and sheathing

U.S. and Canadian forests grow this much wood in: 15 minutes

Carbon stored in the wood: 3,970 metric tons of CO_2*

Avoided greenhouse gases: 8,440 metric tons of CO_2*†

Total potential carbon benefit: 12,410 metric tons of CO_2

Equivalent to:

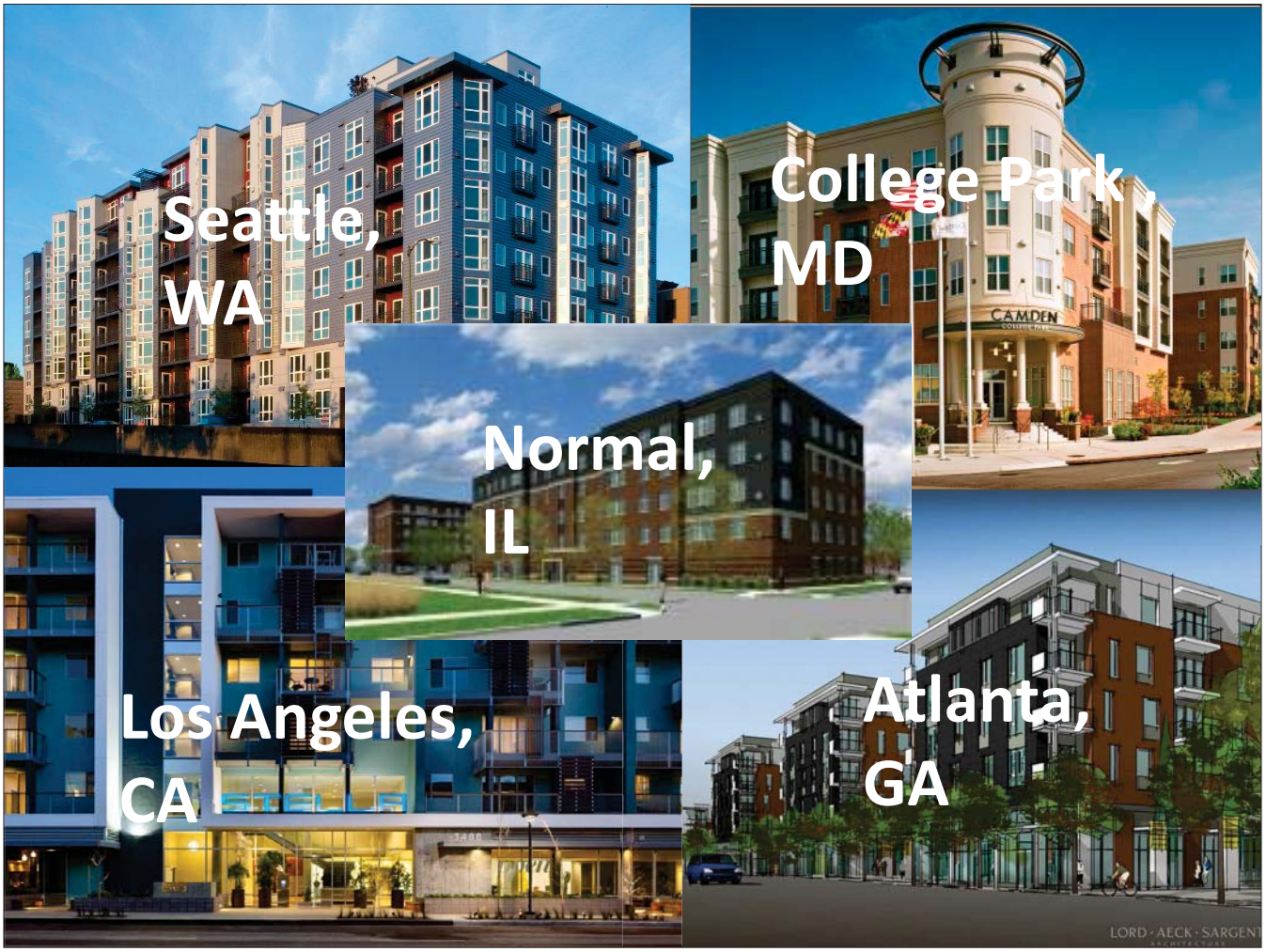
2,370 cars off the road for a year

Energy to operate a home for 1,050 years

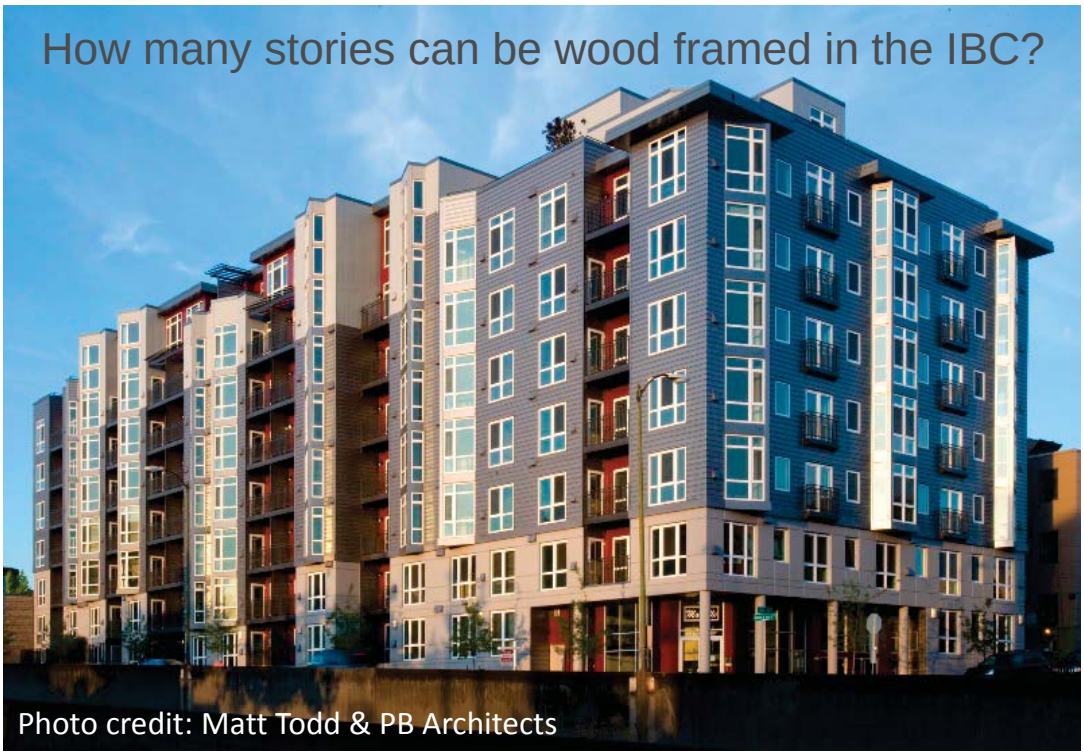
Source: US EPA 2010

Outline

- Need for Mid-rise Construction (Urban Densification)
- Mid-rise Building Types/Configurations
- Maximizing Height & Area
- Fire Ratings & Requirements



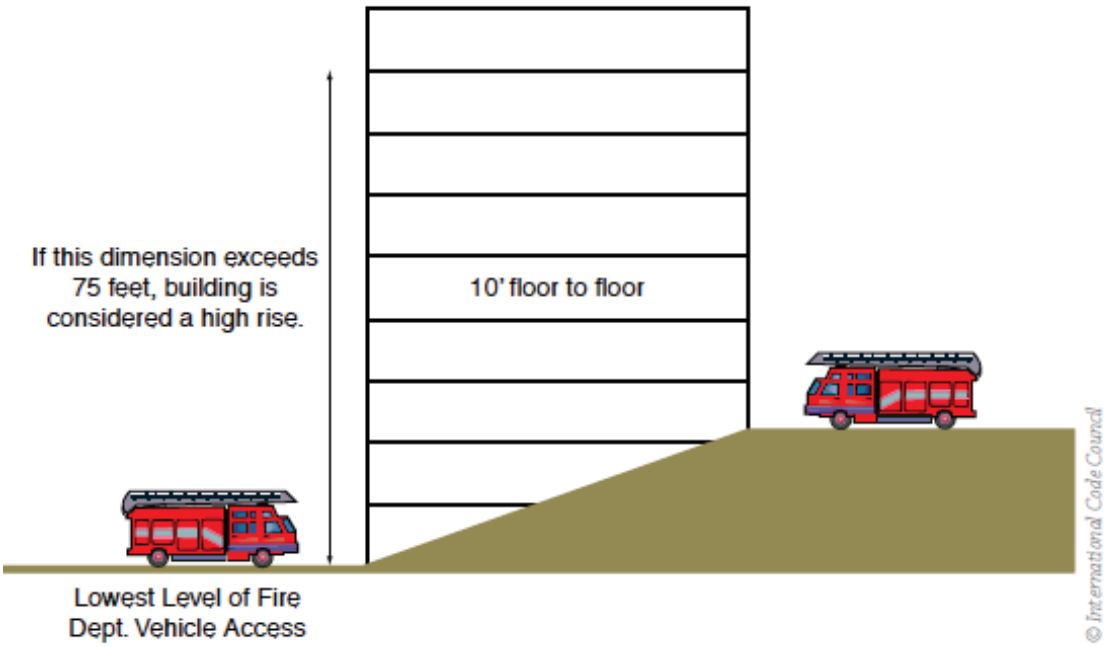
Wood Mid-Rise Construction



Marselle Condos, Seattle, WA

6 stories for Offices, 5 stories for Residential
+ Mezzanine + Multi-Story Podium

Mid-Rise vs. High-Rise Definition – IBC 202



Determination of high-rise building

Walk-up/ Tuck Under

First floor walk up units with private garage

Benefits:

- Eliminates need for S-2 parking garage
- Can be all wood
- Least expensive overall but lowest densification rates

Wrap-Around

Walk up units surround parking structure

Benefits:

- Enhanced security
- Centralized access to parking
- Visual appeal from street
- More expensive than walk/up tuck-under
- 5 story yields 60-80 units/acre

Podium

Multiple stories of wood over an elevated concrete deck

Benefits:

- Increased number of stories
- Accommodates Mixed-use occupancies
- Most expensive but can allow increased density

Podium

4 stories of residential over podium (parking or retail)

- 60-80 units/acre

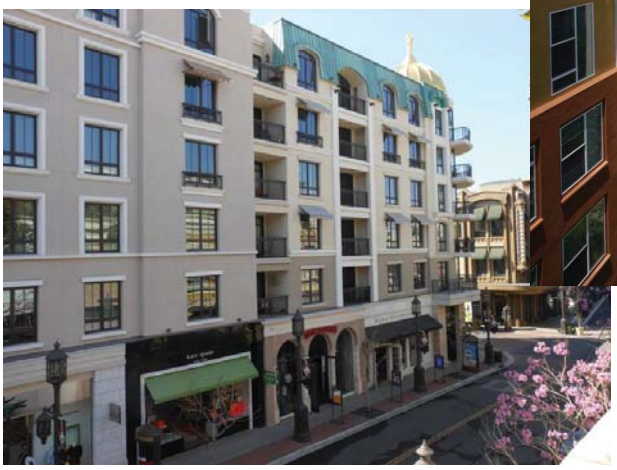
Inman Park Condos, Atlanta, GA
Davis & Church

Podium

5 stories over retail

- 100-120 units/acre

AvalonBay Stadium, Anaheim, CA
VanDorpe Chou Associates



Inman Park Condos, Atlanta, GA
Davis & Church

Podium

5 stories over residential podium

- 120-140 units/acre

16 Powerhouse, Sacramento, CA
D&S Development
LPA Sacramento

Mezzanine & Podium

5 stories with mezzanine + residential podium

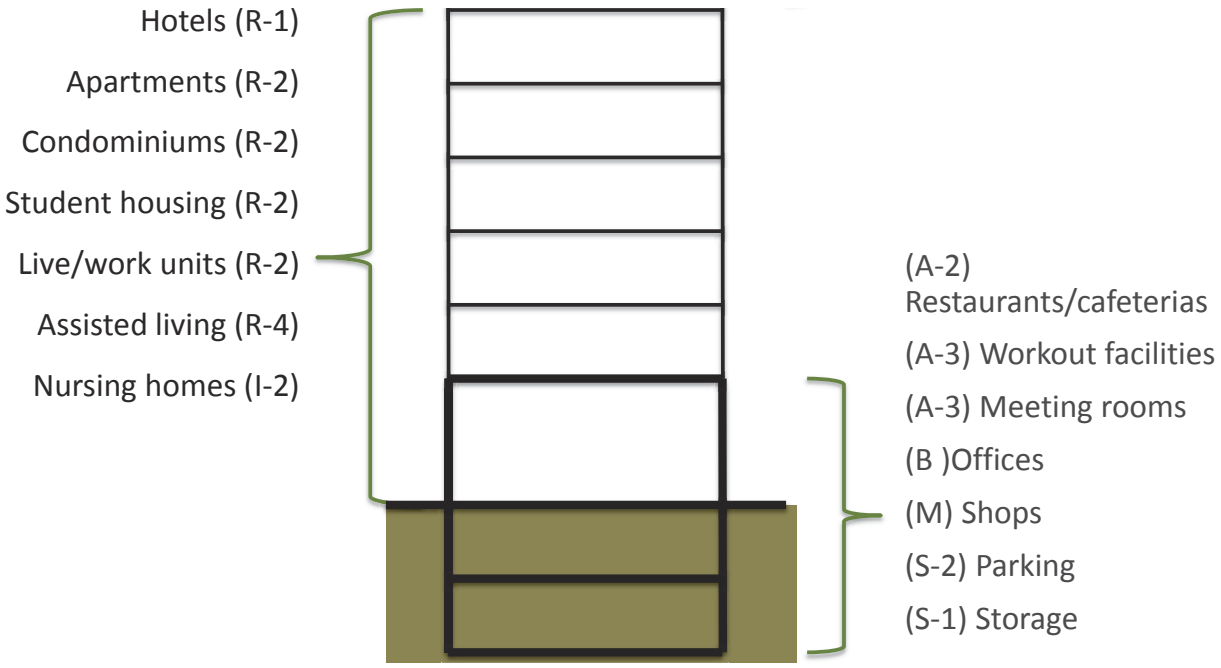
- 125-145 units/acre

120 Union, San Diego, CA
Togawa Smith Martin

Outline

- Need for Mid-rise Construction (Urban Densification)
- Mid-rise Building Types/Configurations
- Maximizing Height & Area
  1. Construction Types
  2. Tabulate Areas & Stories
  3. Allowable increases
  4. Mezzanine & Special Design Provisions
- Fire Ratings & Requirements

Typical Mid-rise Occupancy



Mid-Rise Construction Types

Type III
- Exterior walls non-combustible
- Interior elements any allowed by code

Type V
- All building elements are any allowed by code

Types III and V can be subdivided to A (protected) or B (unprotected)

Type IV (Heavy Timber)
- Exterior walls non-combustible
- Interior elements qualify as Heavy Timber

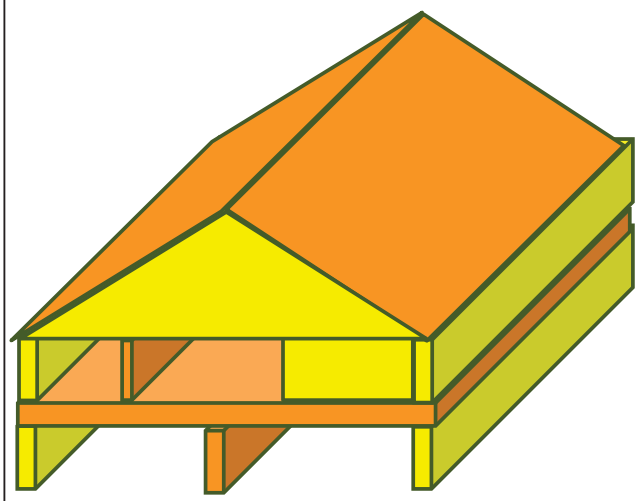
More on fire ratings a little later…

Heights and Areas – IBC Table 503

GROUP		TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
	HEIGHT (feet)	UL	160	65	55	65	55	65	50	40
		STORIES(S) AREA (A)								
M	S A	UL UL	11 UL	4 21,500	2 12,500	4 18,500	2 12,500	4 20,500	3 14,000	1 9,000
R-1	S A	UL UL	11 UL	4 24,000	4 16,000	4 24,000	4 16,000	4 20,500	3 12,000	2 7,000
R-2	S A	UL UL	11 UL	4 24,000	4 16,000	4 24,000	4 16,000	4 20,500	3 12,000	2 7,000
R-3	S A	UL UL	11 UL	4 UL	4 UL	4 UL	4 UL	4 UL	3 UL	3 UL
R-4	S A	UL UL	11 UL	4 24,000	4 16,000	4 24,000	4 16,000	4 20,500	3 12,000	2 7,000
S-1	S A	UL UL	11 48,000	4 26,000	2 17,500	3 26,000	2 17,500	4 25,500	3 14,000	1 9,000
S-2[b, c]	S A	UL UL	11 79,000	5 39,000	3 26,000	4 39,000	3 26,000	5 38,500	4 21,000	2 13,500
U[c]	S A	UL UL	5 35,500	4 19,000	2 8,500	3 14,000	2 8,500	4 18,000	2 9,000	1 5,500

Type III Construction

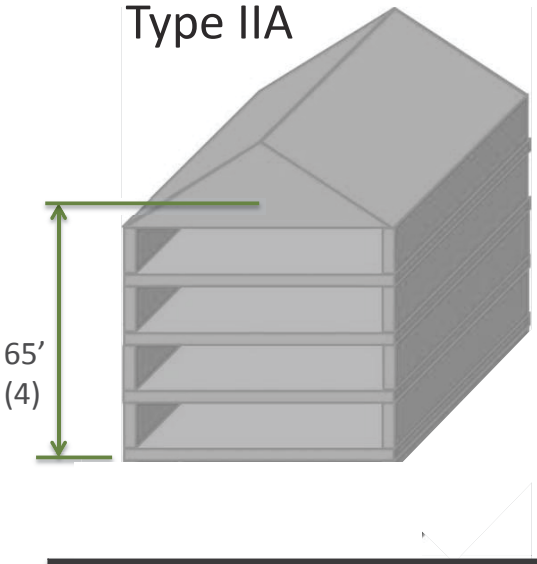
Exterior walls are of noncombustible materials and interior building elements are of any material. Fire Retardant Treated (FRT) wood is permitted in exterior walls of 2hr fire rating or less.



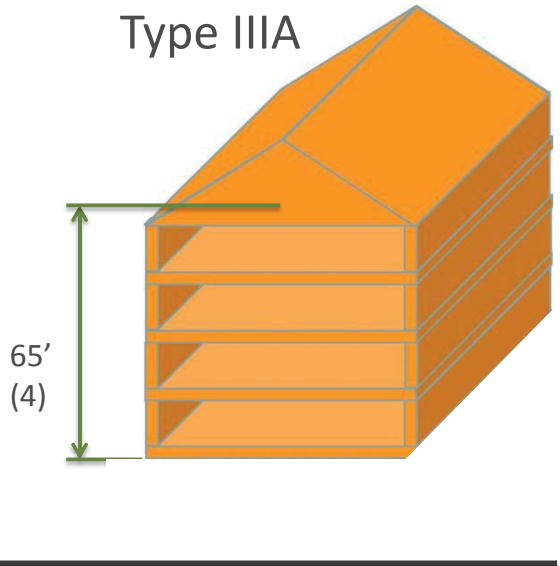
- Non combustible
  - Exterior walls
- Fire Retardant Treated allowed
  - Exterior walls if fire rating is 2hr or less
- Heavy Timber
  - HT used in place of 1hr rating or less
- Untreated Lumber
  - All interior elements

Step 1 – Tabulated Height and Area

Type IIA



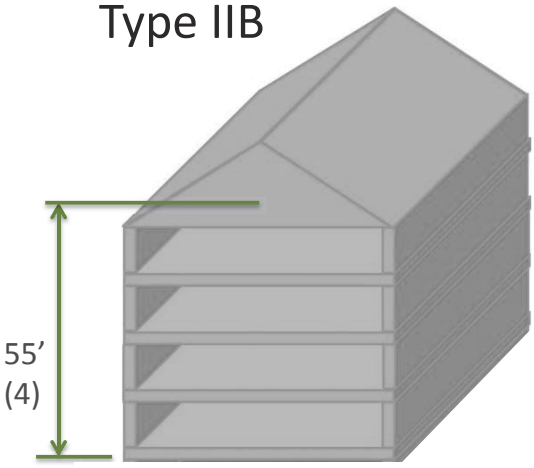
Type IIIA



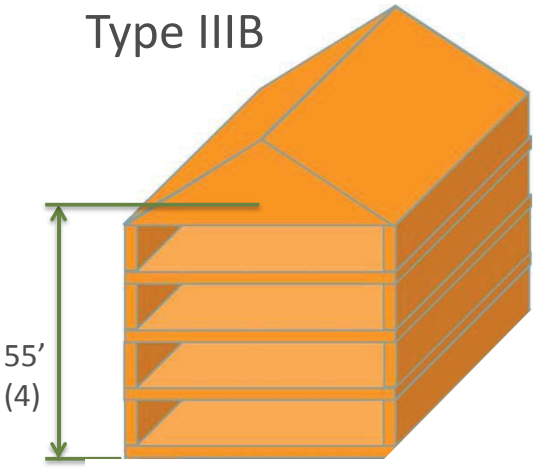
Occupancy	IIA	IIIA
R-1	24,000	24,000
R-2	24,000	24,000

Step 1 – Tabulated Height and Area

Type IIB

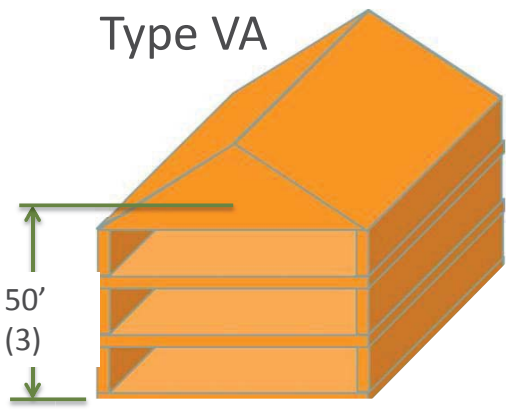


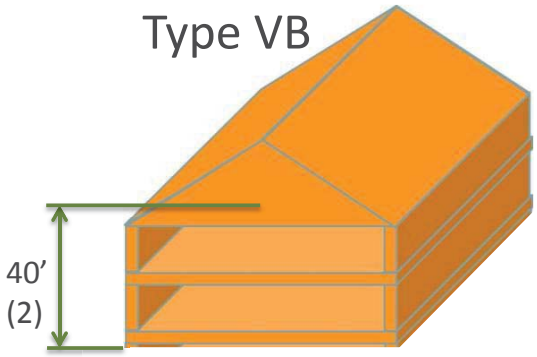
Type IIIB



Occupancy	IIB	IIIB
R-1	16,000	16,000
R-2	16,000	16,000

Step 1 – Tabulated Height and Area





Occupancy	VA	VB
R-1	12,000	7,000
R-2	12,000	7,000

Height Modification – IBC 504

IBC 504.2 Where a building is equipped throughout with an approved sprinkler system…

- maximum height is increased by 20 feet
- maximum number of stories is increased by one
- does not apply if using NFPA 13R sprinkler

Can be combined w/ frontage area increase - 506.2

Can be combined w/ sprinkler area increase - 506.3

- EXCEPT for I-2 occupancy of Type IIB, III and V construction and H occupancies or where sprinklers are used as substitution for 1hr fire resistance.

Automatic Sprinkler Increase – 504.2

504.2 Automatic sprinkler system increase.

….For Group R buildings equipped throughout with an approved automatic sprinkler system in accordance with Section 903.3.1.2, the value specified in Table 503 for maximum building height is increased by 20 feet (6096 mm) and the maximum number of stories is increased by one, but shall not exceed 60 feet (18 288 mm) or four stories , respectively.

- Section 903.3.1.2 references NFPA 13R sprinkler system.
- This 60', 4 story limitation does not apply when using NFPA 13 Sprinkler System

Area Modification – IBC 506

(Equation 5-1)

$$A_a = A_t + [A_t \times I_f] + [A_t \times I_s]$$

A_a = Allowable area per story (sq. ft.)

A_t = Tabular area per story (sq. ft.)

I_f = Area increase factor due to frontage

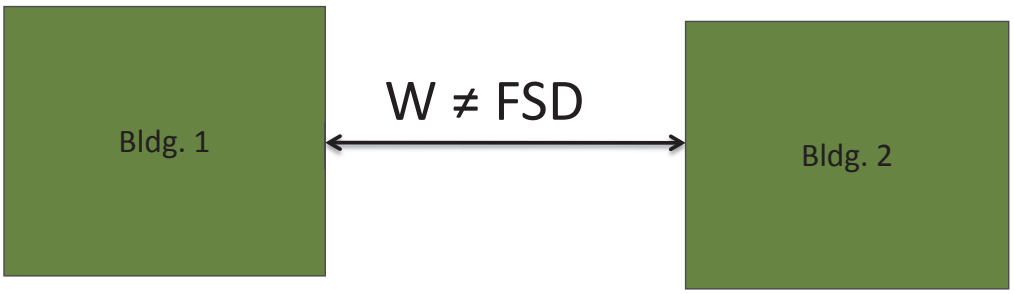
(IBC 506.2) $I_{f\,max} = .75$

I_s = Area increase factor due to sprinkler protection

(IBC 506.3) I_s=3 for 1 story, I_s=2 for > 1 story

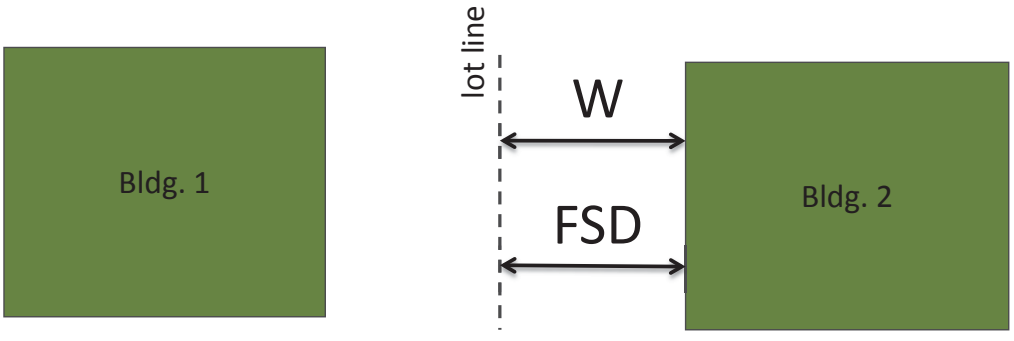
Frontage Increases – IBC 506.2.1

In 2012 code, there is further clarification between "W" for area increases and Fire Separation Distance for purposes of fire resistance ratings of walls and openings



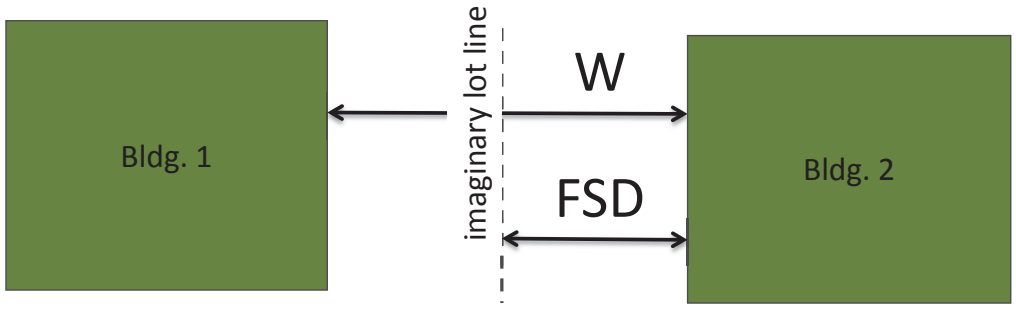
Frontage Increases – IBC 506.2.1

For two buildings on DIFFERENT lots



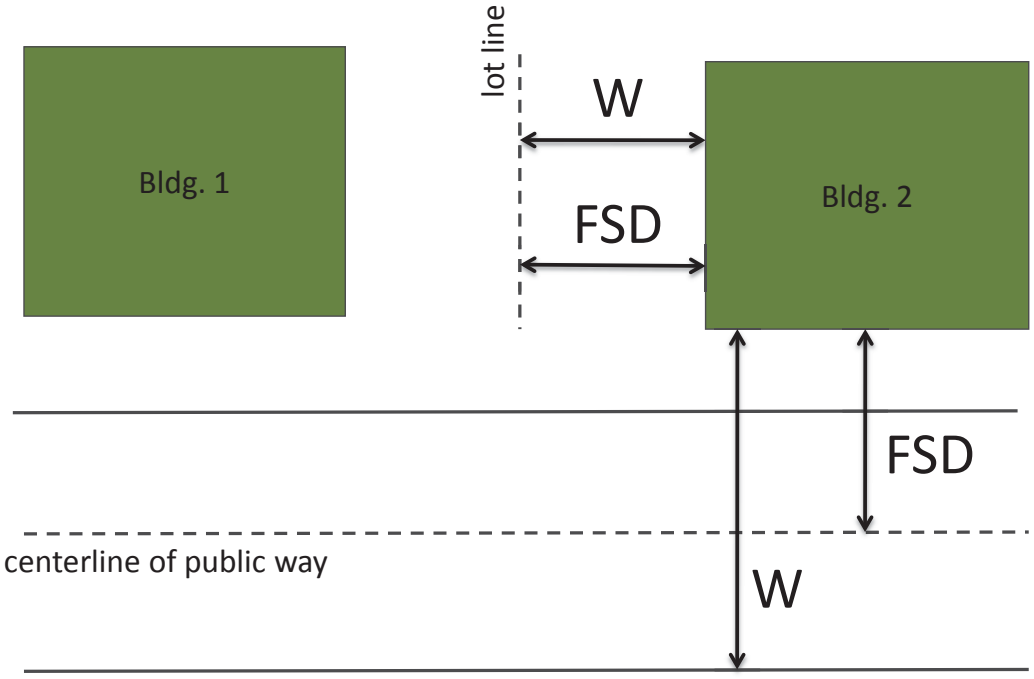
Frontage Increases – IBC 506.2.1

For two buildings on the SAME lot



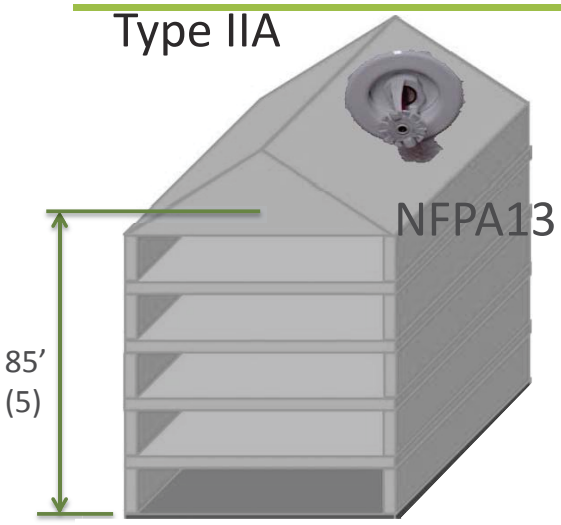
Frontage Increases – IBC 506.2.1

Buildings near public right of ways:

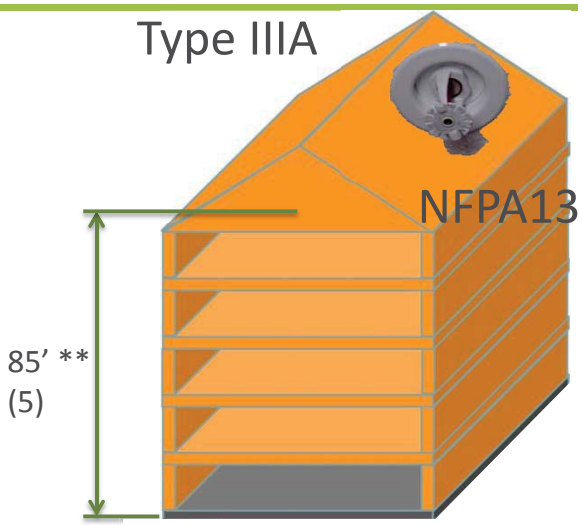


Step 2 – Increased Height & Story Area

Type IIA



Type IIIA

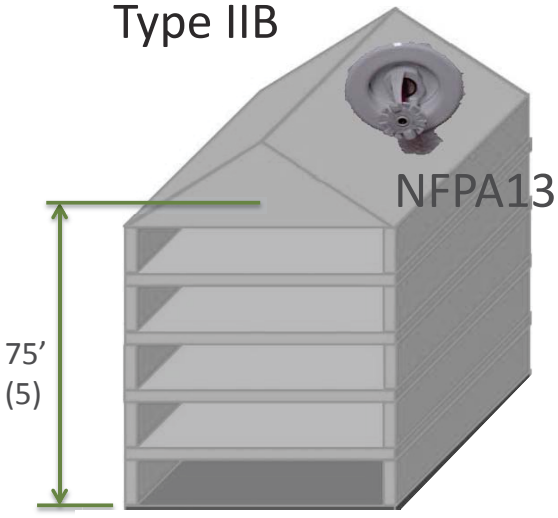


Occupancy	IIA (ft^2)*	IIIA (ft^2)*
R-1	72,000 +18,000 (max frontage)	72,000 +18,000 (max frontage)
R-2	72,000 +18,000 (max frontage)	72,000 +18,000 (max frontage)

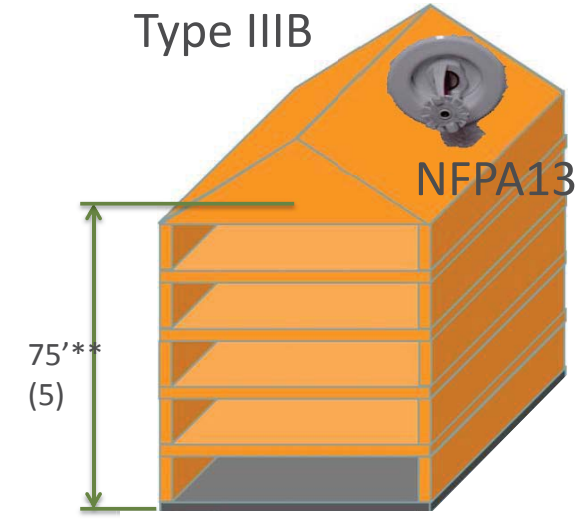
*Areas reflect PER STORY max. Total building max may limit area further.
**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height in SDC D,E,F

Step 2 – Increased Height & Story Area

Type IIB



Type IIIB



Occupancy	IIB (ft^2)*	IIIB (ft^2)*
R-1	48,000 +12,000(max frontage)	48,000 +12,000(max frontage)
R-2	48,000 +12,000(max frontage)	48,000 +12,000(max frontage)

*Areas reflect PER STORY max. Total building max may limit area further.
**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height in SDC D,E,F

Type IIIB for R Occupancy

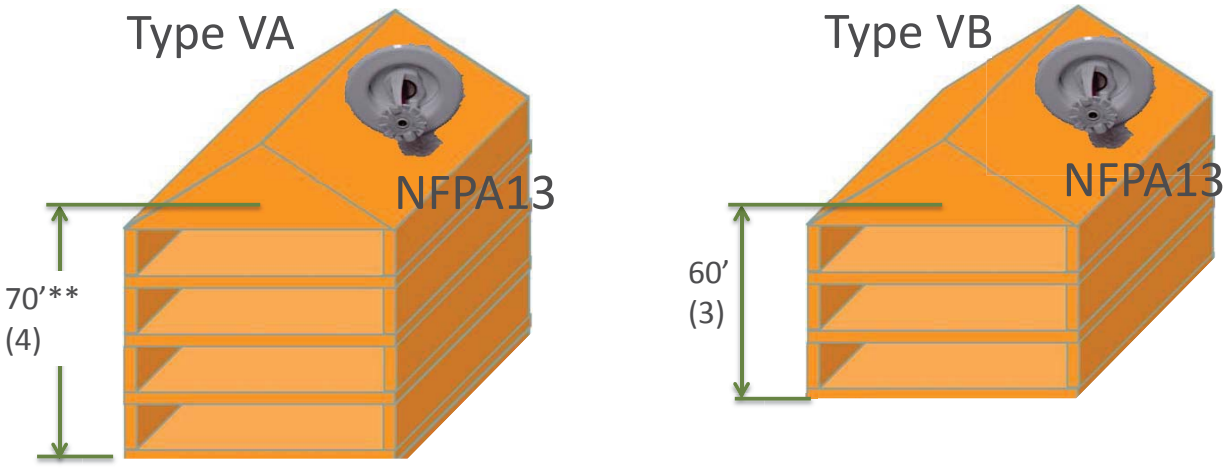
711.3

… Horizontal assemblies separating dwelling units in the same building and horizontal assemblies separating sleeping units in the same building shall be a minimum of 1-hour fire-resistance-rated construction.

EXCEPTION

Dwelling unit and sleeping unit separations in buildings of Type IIB, IIIB and VB construction shall have fire-resistance ratings of not less than 1 /2 hour in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1.

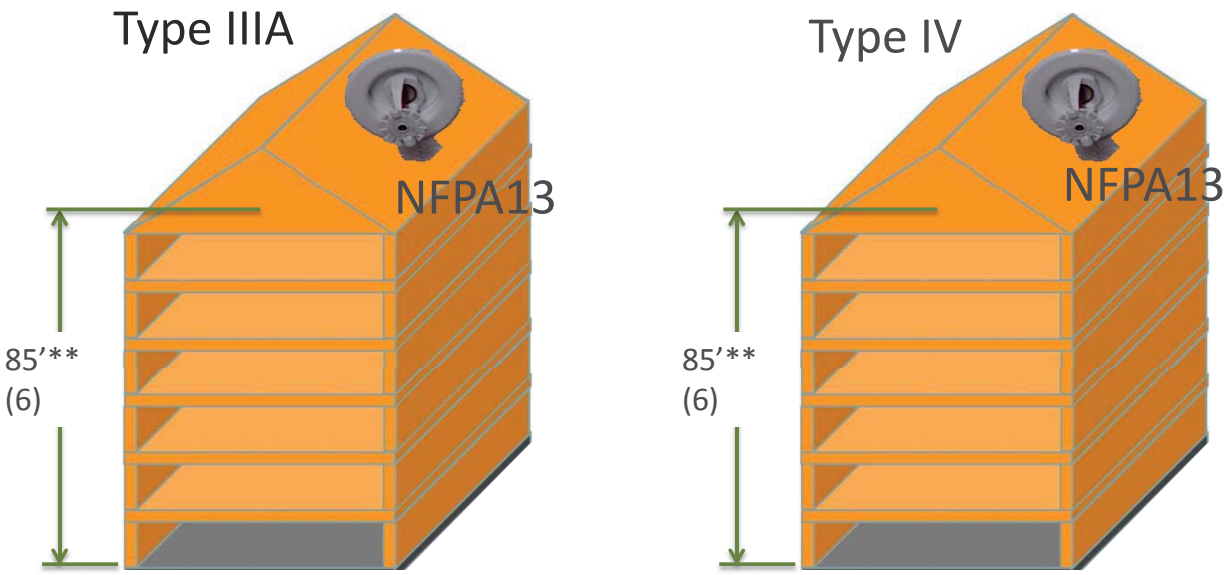
Step 2 – Increased Height & Story Area



Occupancy	VA (ft^2)*	VB (ft^2)
R-1	36,000 +9,000(max frontage)	21,000 +5,250(max frontage)
R-2	36,000 +9,000(max frontage)	21,000 +5,250(max frontage)

*Areas reflect PER STORY max. Total building max may limit area further.
**ASCE7 12.2-1 limits wood shear wall seismic systems to 65' in height in SDC D,E,F

Opportunity for Office Occupancy (B)



Occupancy	IIIA (ft^2)*	IV (ft^2)*
B	85,500 +21,375(max frontage)	108,000 +27,000(max frontage)

*Areas reflect PER STORY max. Total building max may limit area further.
**ASCE7 12.2-1 limits wood shear wall seismic systems to 65' in height in SDC D,E,F

Summary of Building Heights

Building Heights and Stories by Building Type With NFPA 13 Sprinklers				
	IIIA	IIIB	VA	VB
Occupancy	85 ft	75 ft	70 ft	60 ft
R-1/R-2/R-4	5	5	4	3
A-2/A-3	4	3	3	2
B	6	4	4	3
M	5	3	4	2
S-2	5	4	5	3
S-1	4	3	4	2

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65' in height in SDC D,E,F

Maximum Building Area – 506.4

Single Occupancy Area determination

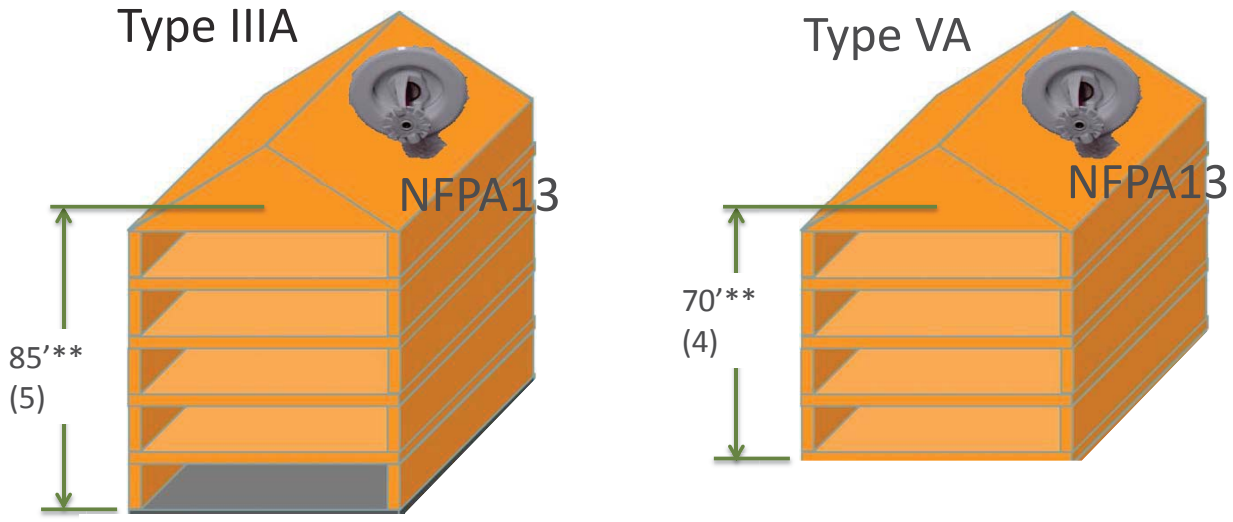
- Two stories above grade:
  - Maximum Building Area = A_a x 2
- Three stories or more above grade:
  - Maximum Building Area = A_a x 3
- No Story shall exceed A_a

Exceptions

- Unlimited area buildings
- Buildings with NFPA 13R sprinkler system

A_a – Allowable Area PER STORY

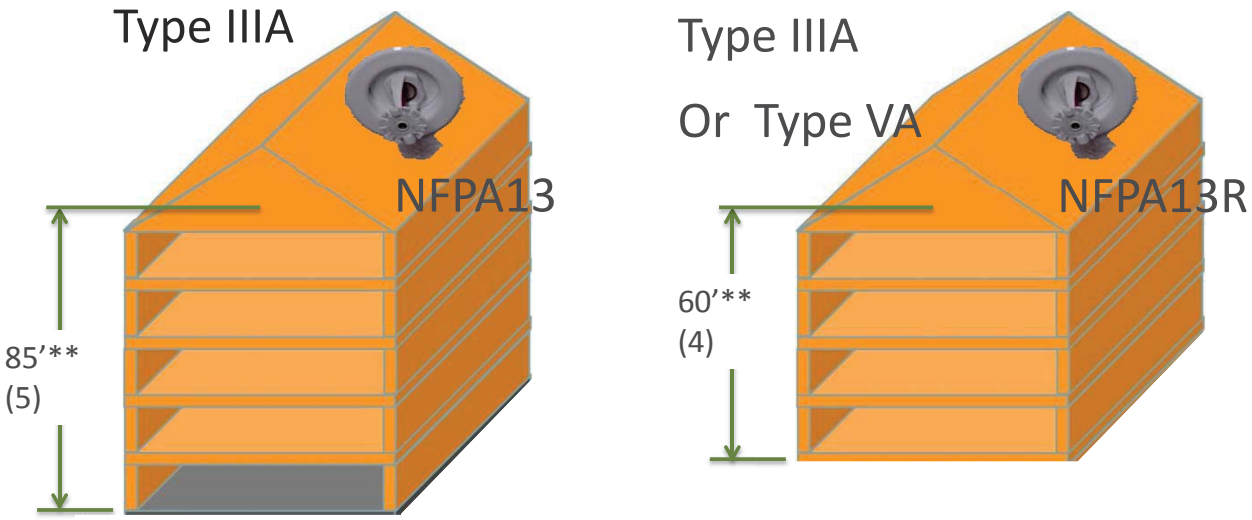
Step 3 – Max Building vs. Story Areas



Occupancy	IIIA	VA
Story Area	72,000 +18,000 (max frontage)	36,000 +9,000(max frontage)
Building Area	216,000 +54,000 (max frontage)	108,000 +27,000 (max frontage)

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65' in height in SDC D,E,F

Step 3 – Max Building vs. Story Areas



Occupancy	IIIA (NFPA 13)	IIIA (NFPA 13R)	VA (NFPA 13R)
Story Area	72,000 (3x tabulated)	24,000 (=tabulated)	12,000 (=tabulated)
Building Area	216,000 (3x story)	96,000 (4x story)	48,000 (4x story)

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65' in height in SDC D,E,F

Case Study: Innovations in Wood

Emory Point

Location: Atlanta, GA

3 buildings complete - Luxury Apt., retail, restaurants

- (1) 5 story Type III wood frame over slab on grade
- (2) 4 stories of wood over 1 story concrete podium

35% savings

- $14/sf (wood concept)
- $22/sf (PT conc. Slab and frame)

Architect: Cooper Carry, The Preston Partnership

Engineer: Ellinwood + Machado, Pruitt Eberly Stone

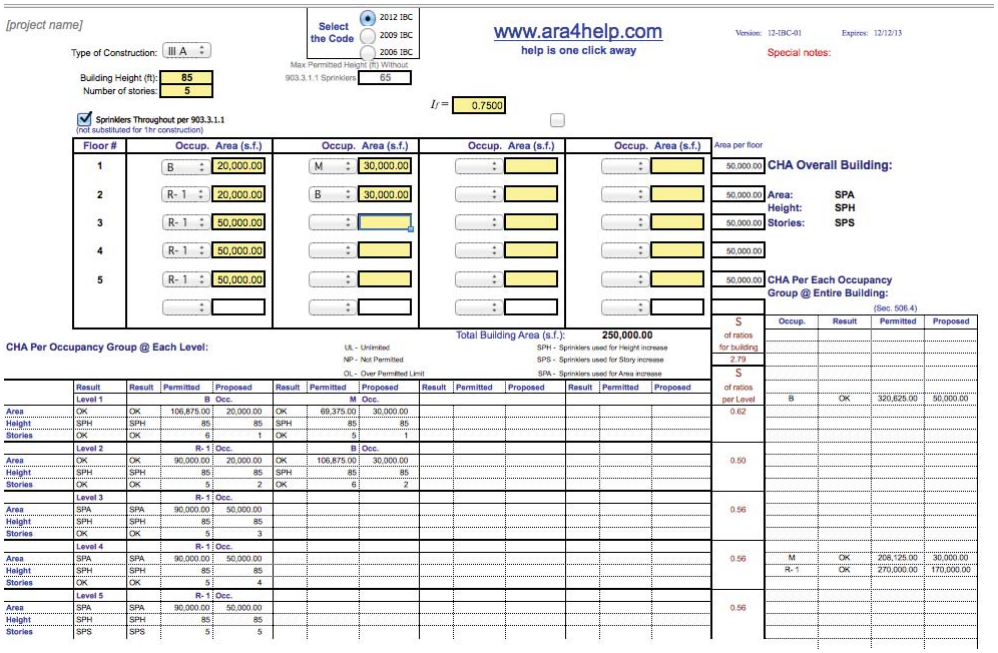
Contractor: Fortune-Johnson Contracting

Completed: 2012

Photo credit: Gables Residential

Mixed Use Occupancy

Located at woodworks.org – design tools – online calculators – Heights and Areas Calculator



[project name]

Select the Code: 2012 IBC / 2009 IBC / 2006 IBC

www.ara4help.com
help is one click away

Version: 12-IBC-01 Expires: 12/12/13

Special notes:

Type of Construction: III A

Building Height (ft): 85
Number of stories: 5

Max Permitted Height (ft) Without 903.3.1.1 Sprinklers: 85

I_f = 0.7500

Sprinklers Throughout per 903.3.1.1 (not substituted for 1hr construction)

Floor #	Occup.	Area (s.f.)	Occup.	Area (s.f.)	Occup.	Area (s.f.)	Occup.	Area (s.f.)	Area per floor
1	B	20,000.00	M	30,000.00					50,000.00
2	R-1	20,000.00	B	30,000.00					50,000.00
3	R-1	50,000.00							50,000.00
4	R-1	50,000.00							50,000.00
5	R-1	50,000.00							50,000.00

CHA Overall Building:
Area: SPA
Height: SPH
Stories: SPS

CHA Per Each Occupancy Group @ Entire Building: (Sec. 506.4)

Occup.	Result	Permitted	Proposed
B	OK	320,625.00	50,000.00
M	OK	208,125.00	30,000.00
R-1	OK	270,000.00	170,000.00

Total Building Area (s.f.): 250,000.00

S of ratios for building: 2.79

CHA Per Occupancy Group @ Each Level:

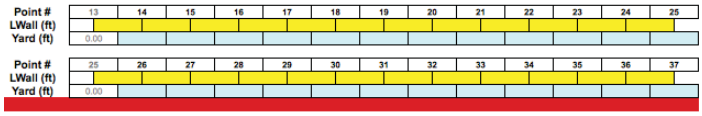
UL - Unlimited
NP - Not Permitted
OL - Over Permitted Limit

SPH - Sprinklers used for Height increase
SPS - Sprinklers used for Story increase
SPA - Sprinklers used for Area increase

	Result	Result	Permitted	Proposed	Result	Permitted	Proposed	Result	Permitted	Proposed	Result	Permitted	Proposed	S of ratios per Level
	Level 1		B	Occ.		M	Occ.							
Area	OK	OK	106,875.00	20,000.00	OK	69,375.00	30,000.00							0.62
Height	SPH	SPH	85	85	SPH	85	85							
Stories	OK	OK	6	1	OK	5	1							
	Level 2		R-1	Occ.		B	Occ.							
Area	OK	OK	90,000.00	20,000.00	OK	106,875.00	30,000.00							0.50
Height	SPH	SPH	85	85	SPH	85	85							
Stories	OK	OK	5	2	OK	6	2							
	Level 3		R-1	Occ.										
Area	SPA	SPA	90,000.00	50,000.00										0.56
Height	SPH	SPH	85	85										
Stories	OK	OK	5	3										
	Level 4		R-1	Occ.										
Area	SPA	SPA	90,000.00	50,000.00										0.56
Height	SPH	SPH	85	85										
Stories	OK	OK	5	4										
	Level 5		R-1	Occ.										
Area	SPA	SPA	90,000.00	50,000.00										0.56
Height	SPH	SPH	85	85										
Stories	SPS	SPS	5	5										

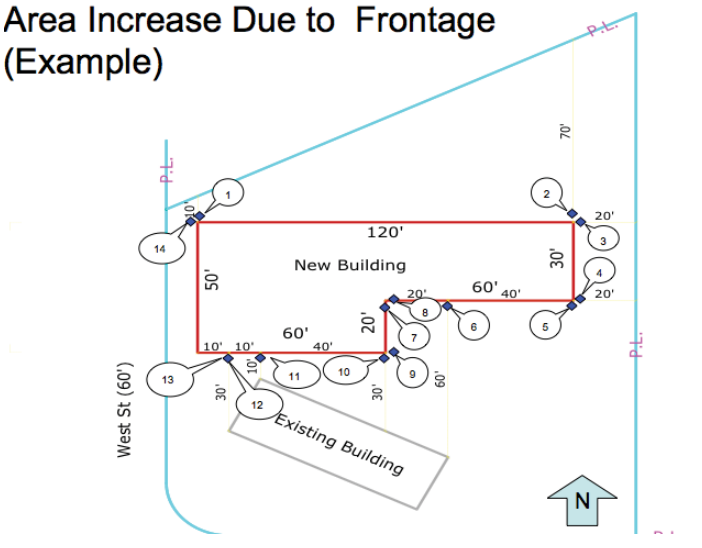
Mixed Use Occupancy

Located at woodworks.org – design tools – online calculators – Heights and Areas Calculator



Point #	13	14	15	16	17	18	19	20	21	22	23	24	25
LWall (ft)													
Yard (ft)	0.00												

Point #	25	26	27	28	29	30	31	32	33	34	35	36	37
LWall (ft)													
Yard (ft)	0.00												

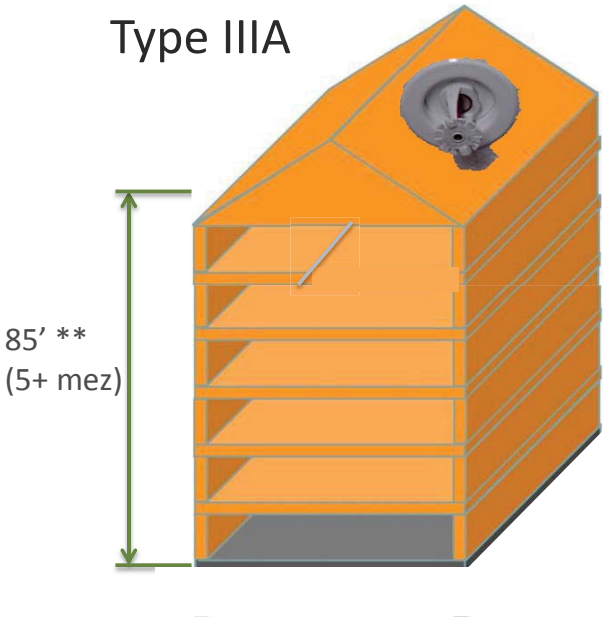


Step 4–Addition of Mezzanine

An intermediate level or levels between the floor and ceiling of any story and in accordance with *IBC* Section 505.

Occupancy	IIIA (NFPA 13)
Story Area	72,000* (3x tabulated)
Building Area	216,000 (3x story area)

*Areas reflect PER STORY max. Total building max may limit area further.
**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height in SDC D,E,F



Mezzanines – IBC 505

Not counted toward building area or height if:**

- Maximum 1/3 floor area of *room* or *space* where located
- Special egress provisions apply
- Must be open and unobstructed to room in which it’s located (walls ≤ 42” allowed)
  - Several exceptions
- Slightly different for equipment platforms

**Does count toward fire area with regard to fire protection in Chapter 9

Case Study: Maximizing View and Value With Wood

Marselle Condominiums

Location: Seattle WA

Type IIIA condo complex

5 -1/2 stories of wood over 2 stories of concrete

mezzanine added $250K cost but $1M in value

30% cost savings over concrete

Time savings over steel

Architect: PB Architects

Engineer: Yu & Trochalakis

Contractor: Norcon, NW

Completed: 2009

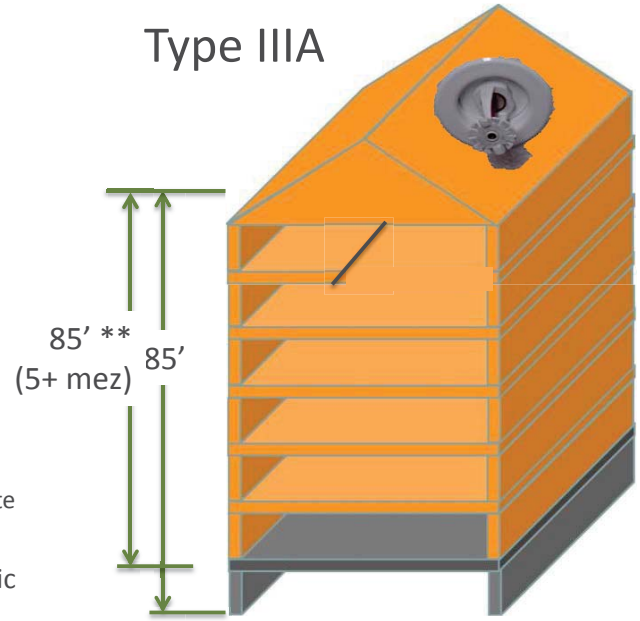
Photo Credit: Matt Todd Photography

Step 4-Horizontal Building Separation

Horizontal Assembly = a fire-resistance-rated floor or roof assembly of materials designed to restrict the spread of fire in which continuity is maintained

Drs Jullian and Raye Richardson Apts.
San Francisco, CA
David Baker Architect, Photo Credits: Bruce Damonte

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height in SDC D,E,F



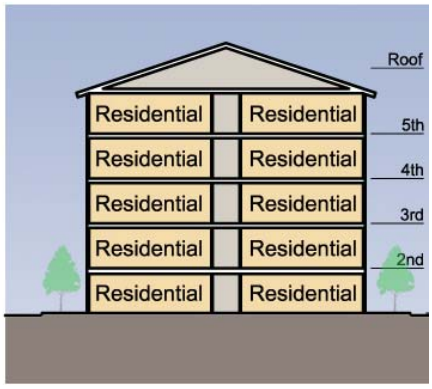
Horizontal Building Separation – 510.2

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

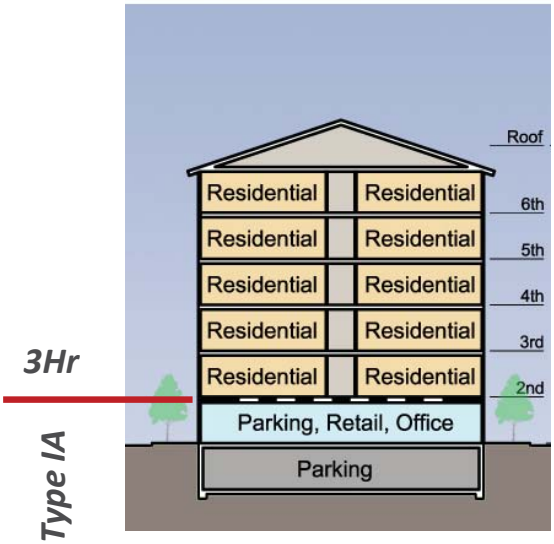
- overall height is still limited to min of either building
- 3hr rated horizontal assembly
- Building below is one story above grade
- Building below is Type 1A with sprinklers
- Enclosures penetrating horizontal assembly are 2hr rated
- occupancy above is A, B, M, R or S
- occupancy below is A, B, M, R or S-2

The Flats at ISU, Normal, IL
OKW Architects
Precision Builders & Associates

IBC Podium Provisions



5 story Type III Building



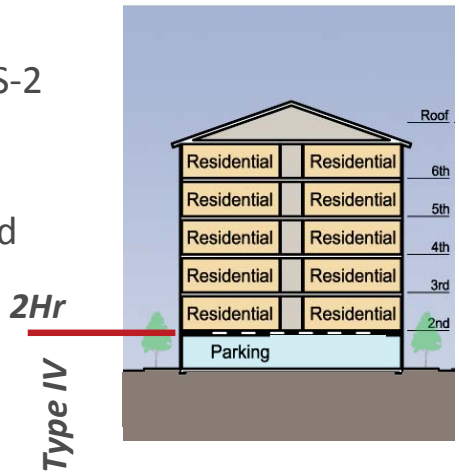
5 story Type III Building
On Top of a Type IA Podium

Special Provisions for Podiums in IBC 2012 510.2
Increases allowable stories… not allowable building height

Parking Beneath Group R – IBC 510.4

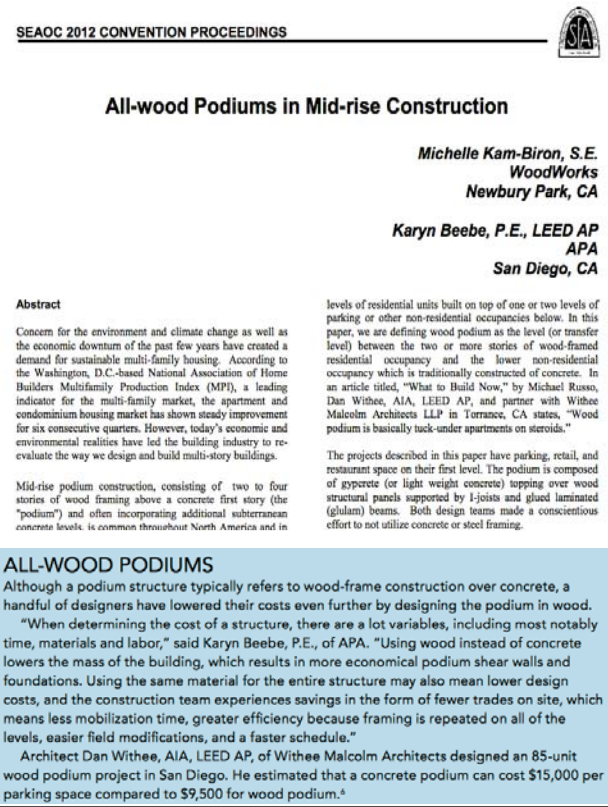
Possibility of a Type IV podium where number of stories starts above parking when:

- Occupancy above is R and below is S-2
- Lower floor is open Type IV parking with grade entrance
- Horizontal assembly between 1st and 2nd floor shall be
  - Type IV
  - Have 1 hr fire resistance rating when sprinklered
  - Have 2 hr fire resistance rating when not sprinklered
- Overall height is still limited to occupancy



5 story Type III Building On Top of a Type IV

Horizontal Separation



SEAOC 2012 CONVENTION PROCEEDINGS

All-wood Podiums in Mid-rise Construction

Michelle Kam-Biron, S.E.
WoodWorks
Newbury Park, CA

Karyn Beebe, P.E., LEED AP
APA
San Diego, CA

Abstract

Concern for the environment and climate change as well as the economic downturn of the past few years have created a demand for sustainable multi-family housing. According to the Washington, D.C.-based National Association of Home Builders Multifamily Production Index (MPI), a leading indicator for the multi-family market, the apartment and condominium housing market has shown steady improvement for six consecutive quarters. However, today's economic and environmental realities have led the building industry to re-evaluate the way we design and build multi-story buildings.

Mid-rise podium construction, consisting of two to four stories of wood framing above a concrete first story (the "podium") and often incorporating additional subterranean concrete levels, is common throughout North America and in levels of residential units built on top of one or two levels of parking or other non-residential occupancies below. In this paper, we are defining wood podium as the level (or transfer level) between the two or more stories of wood-framed residential occupancy and the lower non-residential occupancy which is traditionally constructed of concrete. In an article titled, "What to Build Now," by Michael Russo, Dan Withee, AIA, LEED AP, and partner with Withee Malcolm Architects LLP in Torrance, CA states, "Wood podium is basically tuck-under apartments on steroids."

The projects described in this paper have parking, retail, and restaurant space on their first level. The podium is composed of gypcrete (or light weight concrete) topping over wood structural panels supported by I-joists and glued laminated (glulam) beams. Both design teams made a conscientious effort to not utilize concrete or steel framing.

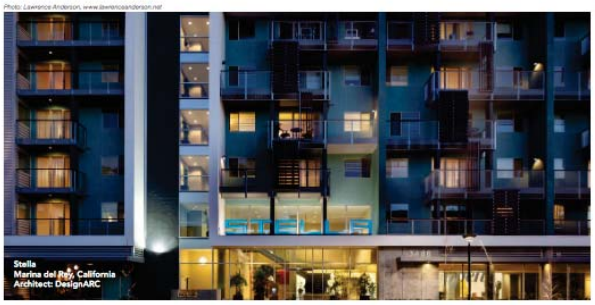
ALL-WOOD PODIUMS

Although a podium structure typically refers to wood-frame construction over concrete, a handful of designers have lowered their costs even further by designing the podium in wood.

"When determining the cost of a structure, there are a lot variables, including most notably time, materials and labor," said Karyn Beebe, P.E., of APA. "Using wood instead of concrete lowers the mass of the building, which results in more economical podium shear walls and foundations. Using the same material for the entire structure may also mean lower design costs, and the construction team experiences savings in the form of fewer trades on site, which means less mobilization time, greater efficiency because framing is repeated on all of the levels, easier field modifications, and a faster schedule."

Architect Dan Withee, AIA, LEED AP, of Withee Malcolm Architects designed an 85-unit wood podium project in San Diego. He estimated that a concrete podium can cost $15,000 per parking space compared to $9,500 for wood podium.[6]

- **Horizontal Wood Assemblies are effectively used to transition from Residential units above to Retail/Parking below**



CONTINUING EDUCATION

Multi-Story Wood Construction

A cost-effective and sustainable solution for today's changing housing market

Sponsored by reThink Wood and WoodWorks

Cost-effective, code-compliant and sustainable, mid-rise wood construction is gaining the attention of design professionals nationwide, who see it as a way to achieve higher density housing at lower cost—while reducing the carbon footprint of their projects. Yet, many familiar with wood construction for two- to four-story residential structures are not aware that the International Building Code (IBC) allows wood-frame but its benefits are equally applicable to other occupancy types."

Among their benefits, wood buildings typically offer faster construction and reduced installation costs. For example, after completing the first phase of a developer-funded five-story student housing project using steel construction, OKW Architects in Chicago switched to wood. "The 12-gauge steel panels were expensive, very heavy and difficult to install; and welding

CONTINUING EDUCATION

EARN ONE AIA/CES HSW LEARNING UNIT (LU)

EARN ONE GBCI CE HOUR FOR LEED CREDENTIAL MAINTENANCE

Learning Objectives

After reading this article, you should be able to:

Case Study: Horizontal Separation

Galt Place Apartments

Location: Galt, CA

Mixed Use Residential over Retail and Parking

Architect: Applied Architecture

Sloped Sites

Fashion Valley, CA
AvalonBay Communities

Seattle, WA
PB Architects

Fashion Valley, CA
AvalonBay Communities

Sloped Sites

HEIGHT, BUILDING. The vertical distance from *grade plane* to the average height of the highest roof surface.

GRADE PLANE. A reference plane representing the average of finished ground level adjoining the building at *exterior walls*. Where the finished ground level slopes away from the *exterior walls*, the reference plane shall be established by the lowest points within the area between the building and the *lot line* or, where the *lot line* is more than 6 feet (1829 mm) from the building, between the building and a point 6 feet (1829 mm) from the building.

626 Dekalb Avenue, Atlanta, GA
Matt Church - Davis Church Structural Engineers

2012 Code Conforming Wood

Table of Contents

Available for Free Download: www.awc.org

Outline

- Need for Mid-rise Construction (Urban Densification)
- Mid-rise Building Types/Configurations
- Maximizing Height & Area
- Fire Ratings & Requirements
  - Overview
  - Exterior Walls
  - Fire Walls
  - Fire Barriers
  - Fire Partitions
  - Shaft Walls
  - Corridors
  - Balconies

Fire Resistance Ratings

Key Differences in Fire Ratings for Construction Types			
	IIIA	IIIB	VA
Exterior (bearing) wall framing	FRT	FRT	non-FRT
Exterior wall fire rating	2 hr	2 hr	1 hr
Floor assembly fire rating	1 hr	0 hr	1 hr
Fire wall rating	3 hr	3 hr	2 hr

IBC Tables 601 & 706.4

Note: FRT = Fire Retardant Treated

Fire Performance

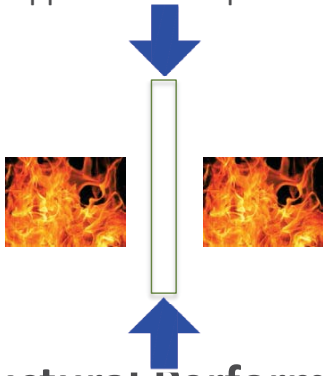
Fire-Resistance Rated Wall Assemblies

Fire-Resistance Rating: The period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests, prescribed in Section 703.

Tested under a standardized test fire exposure for a given duration to:

1. Prevent the passage of flame and temperature rise from one side to the other
2. Continue to provide vertical structural support when exposed to fire and elevated temperatures

Fire Confinement



Structural Performance

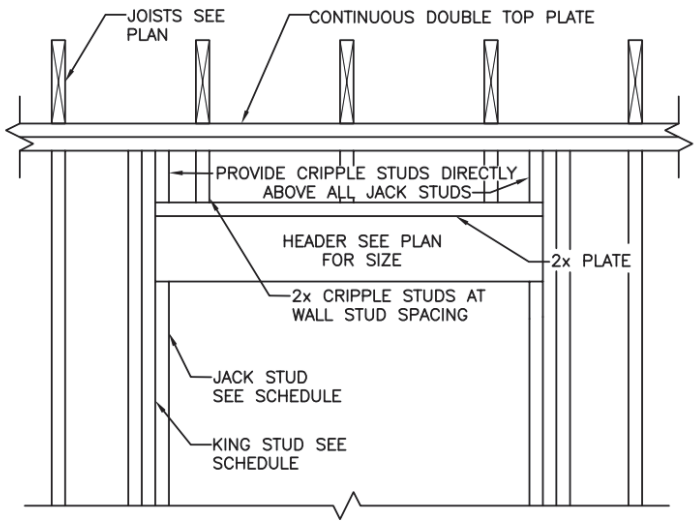
Fire-Resistance Rated Wall Assemblies

There are five basic types of fire-resistance rated wall assemblies:

- Light Frame Bearing Walls (IBC 704.4.1)
- Exterior Walls (IBC 705)
- Fire Wall or Party Wall (IBC 706)
- Fire Barrier (IBC 707)
- Fire Partition (IBC 708)

Light Frame Bearing Walls (IBC 704.4.1)

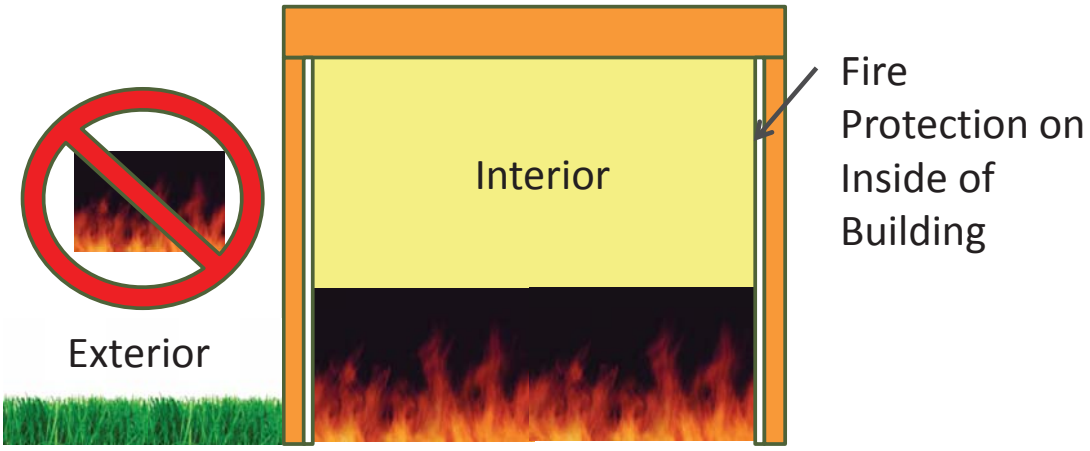
King studs, jack studs, and boundary elements may have fire-resistance rating provided by membrane in load bearing wall



Typ. Bearing Wall Opening Framing

Exterior Walls - FSD

Basic assumption is that fires begin at the interior and rated wall assemblies are not required *from* the exterior unless close to another structure.



Exterior Walls (IBC 705)

705.5 Fire Resistance Ratings: Exterior walls shall be fire-resistance rated in accordance with Tables 601 and 602 and this section. The required fire-resistance rating of exterior walls with a fire separation distance of greater than 10 feet (3048 mm) shall be rated for exposure to fire from the inside. The required fire-resistance rating of exterior walls with a fire separation distance of less than or equal to 10 feet (3048 mm) shall be rated for exposure to fire from both sides.

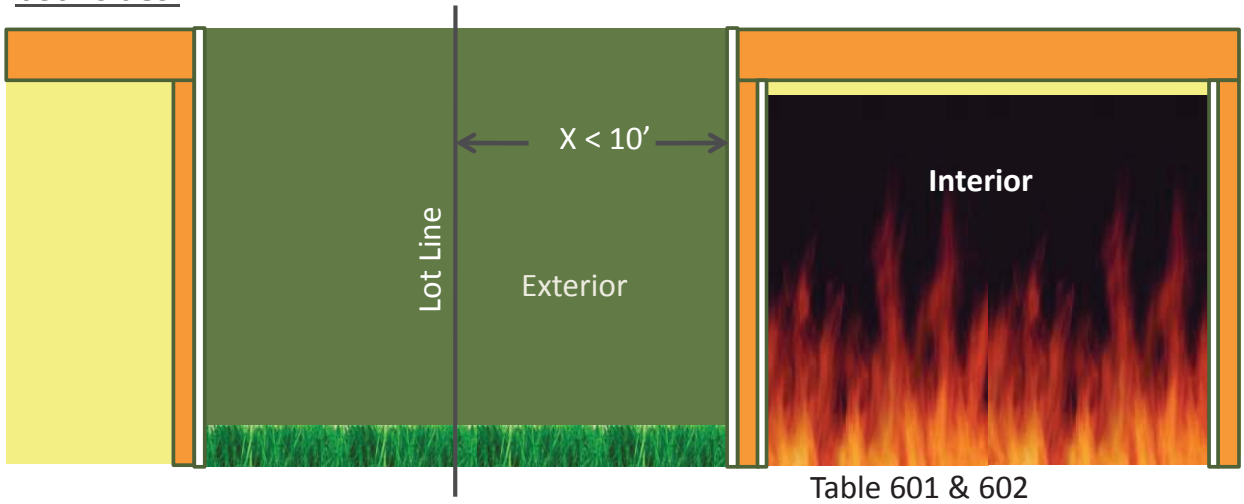
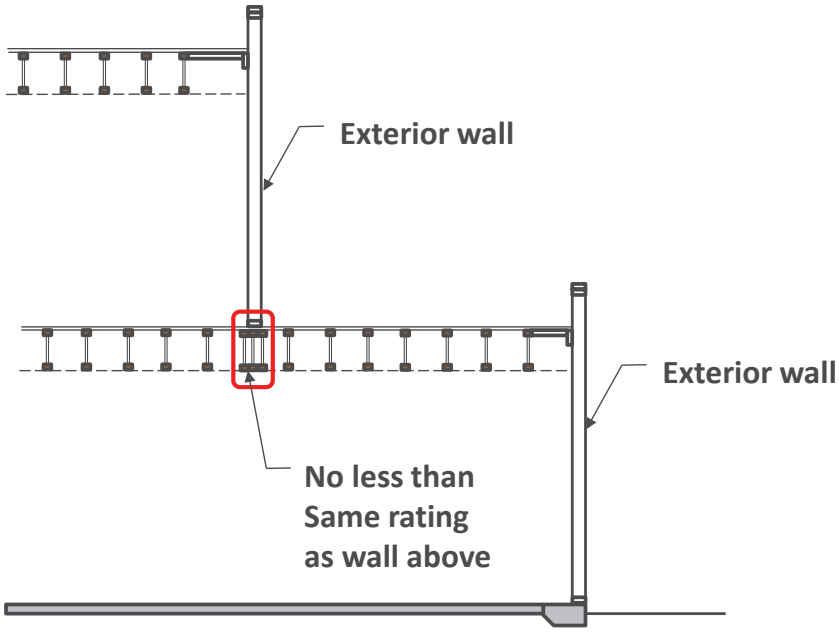


Table 601 & 602

Exterior Walls – Vertical Offsets

There is no requirement for an exterior wall to extend to the foundation in a stepped building.

Posts, beams or walls, that support a rated exterior wall must be fire – resistance rated not less than the rating of the supported wall (IBC 704.1)



Exterior Walls - Asymmetry

S MAT GYPSUM
SHEATHING AT EXTERIOR CONDITIONS

Common issues with tested assemblies:

- Assembly Asymmetry- separate assemblies for each side

Exterior Walls – Using FRT Studs

ONLINE CERTIFICATIONS DIRECTORY Home Quick Guide Contact Us UL.com

BXUV.GuideInfo
Fire Resistance Ratings - ANSI/UL 263

View Listings Page Bottom

Guide Information

The Design Inform

I. INTRODU

II. GENERA

III. FLOOR-

IV. BEAMS

V. COLUMNS

VI. WALLS AND PARTITIONS

"Wood stud walls may contain fire-retardant-treated studs as well as untreated wood studs. The use of fire-retardant-treated plywood (wood structural panels) may be used in Designs that contain use of untreated plywood when all other specified attributes are equivalent to the wood structural panel used in the Design."

Exterior Walls – Addition of WSP

4.7 Fire-resistive Construction:

As an alternate to plywood of the same thickness, structural-use panels may be used in one-hour fire-resistive floor-ceiling or roof-ceiling assemblies permitted by the applicable code. In lieu of $^{15}/_{32}$-inch-thick (11.9 mm) or $^{1}/_{2}$-inch-thick (12.7 mm) plywood, two-layer assemblies are permitted to be constructed with $^{7}/_{16}$-inch-thick (11.1 mm), nonveneer rated sheathing (span-rated 24/16).

The $1^{3}/_{32}$-inch- or $1^{1}/_{8}$-inch-thick (27.8 mm or 28.6 mm) Sturd-I-Floor (rated 48 oc) panels may be substituted for the double-wood floor for one-hour wood-floor construction.

Structural-use panels may be installed between the fire protection and the wood studs on either the interior or exterior side of fire-resistance-rated wood frame wall and partition assemblies described in the applicable code, provided the length of fasteners is adjusted for the added thickness of the panel.

Tongue-and-groove structural-use panels that are either $1^{3}/_{32}$ inch or $1^{1}/_{8}$ inch (27.8 mm or 28.6 mm) thick, with exterior glue, may be substituted for the plywood permitted in the code for heavy timber roof decks in Type IV construction.

Common issue with tested assemblies:

- Inclusion of wood structural panel – ESR2586 & AWC's DCA4 OR Gypsum Association Manual Guidelines

Component Additive Method (CAM) for Calculating and Demonstrating Assembly Fire Resistance

Wood-frame walls and floors offer designers a unique opportunity to provide structures with economy as well as proven energy performance. Where these assemblies are required by the building codes to achieve a minimum fire resistance rating, a wide range of options for design exists.

veloped from conducting a series of fire resistance tests. The Component Additive Method (CAM) provides for calculating the fire resistance of load bearing and non-load bearing floor, wall, ceiling and roof assemblies. The calculated fire resistance provisions within Section 722.6 of the *International Building Code®* (*IBC*) were developed using CAM.

Building Code Requirements

Fire Wall, Barrier, Partition

Fire wall (IBC 706)

- Divides structure into separate buildings
- Continuous from foundation (or top of three hour podium) to or through roof
- Structural stability required to allow collapse on either side from fire without causing collapse of fire wall
- Special requirements at roof and intersection with exterior walls , at horizontal projecting elements and between stepped buildings
- Required to be of non-combustible construction except in type V construction
- 2 to 4 hour rated (Table 706.4)

Fire Barrier (IBC 707)

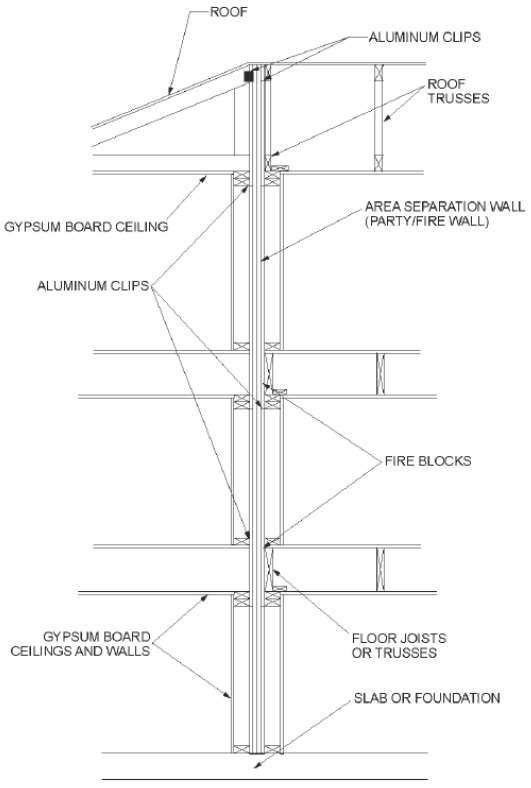
- Designed to restrict the spread of fire with continuity through the building
- Divides structure into fire areas, and fire barriers are required for various purposes such as shaft enclosures, exit enclosures, atrium separation, occupancy separations, and control or incidental use areas.
- Supported by construction of equal fire resistance-rating (except for incidental use areas in type IIB, IIIB and VB construction)
- 1 to 4 hour rated (table 707.3.10)

Fire Partition (IBC 708)

- Separates dwelling units, sleeping areas, corridors, and tenant spaces.
- May terminate at the lower side of a fire –resistance rated floor/ceiling/roof assembly
- In most instances fire partitions are not required to be supported by fire resistance-rated construction in type IIB, IIIB and VB construction (section 708.4)
- Rated 1 hour or less (IBC section 708.3)

Fire Walls – Structural Stability

706.2 Structural Stability:
Fire walls shall have sufficient structural stability under fire conditions to allow collapse of construction on either side without collapse of the wall for the duration of time indicated by the required fire-resistance rating or shall be constructed as double fire walls in accordance with NFPA 221.



Fire Walls – Ratings & Materials

TABLE 706.4
FIRE WALL FIRE-RESISTANCE RATINGS

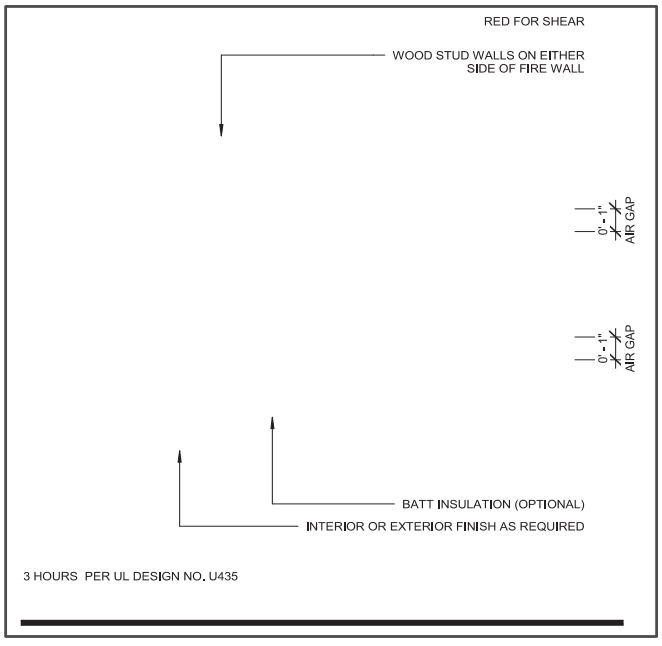
GROUP	FIRE-RESISTANCE RATING (hours)
A, B, E, H-4, I, R-1, R-2, U	3[a]
F-1, H-3[b], H-5, M, S-1	3
H-1, H-2	4[b]
F-2, S-2, R-3, R-4	2

a. In Type II or V construction, walls shall be permitted to have a 2-hour fire-resistance rating.
b. For Group H-1, H-2 or H-3 buildings, also see Sections 415.6 and 415.7.

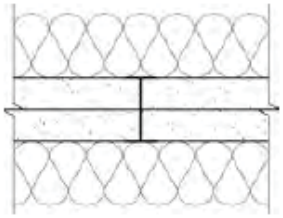
IBC 706.3 – Fire walls shall be of any approved non-combustible materials.

Exception: Buildings of Type V construction

Fire Wall - Assembly

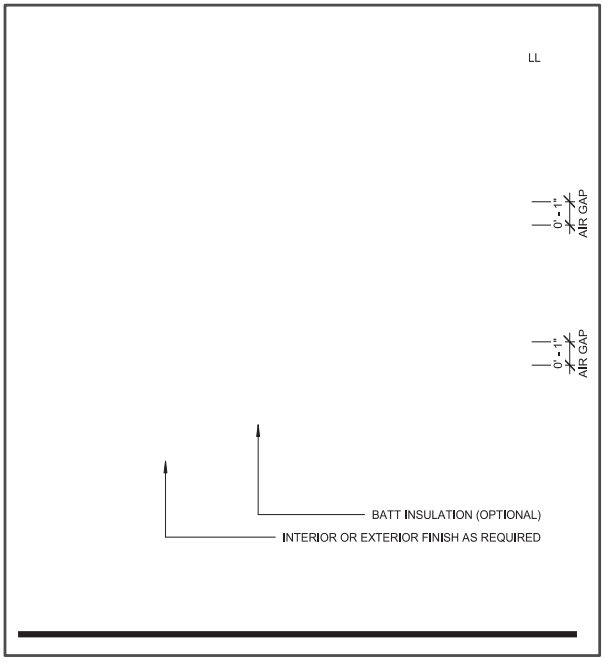


3 HOUR FIRE

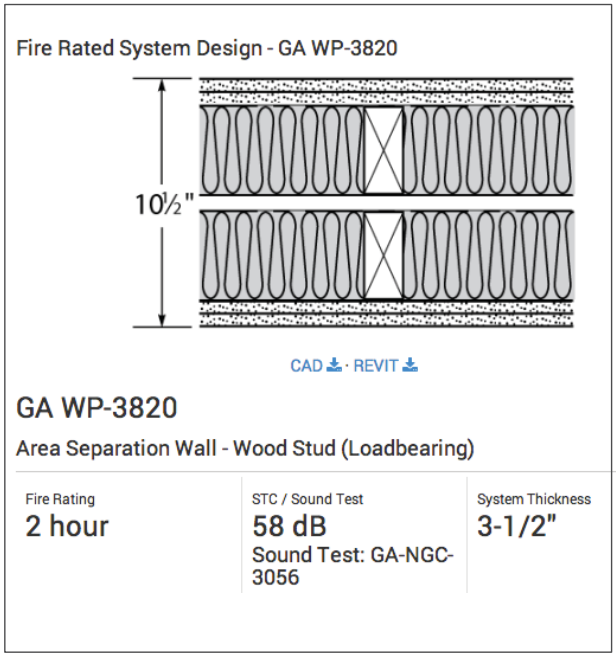


- (2) 1” Type X Gypsum
- 2” H Studs
- 2” mineral fiber insulation

2 HR Fire Wall– Type V

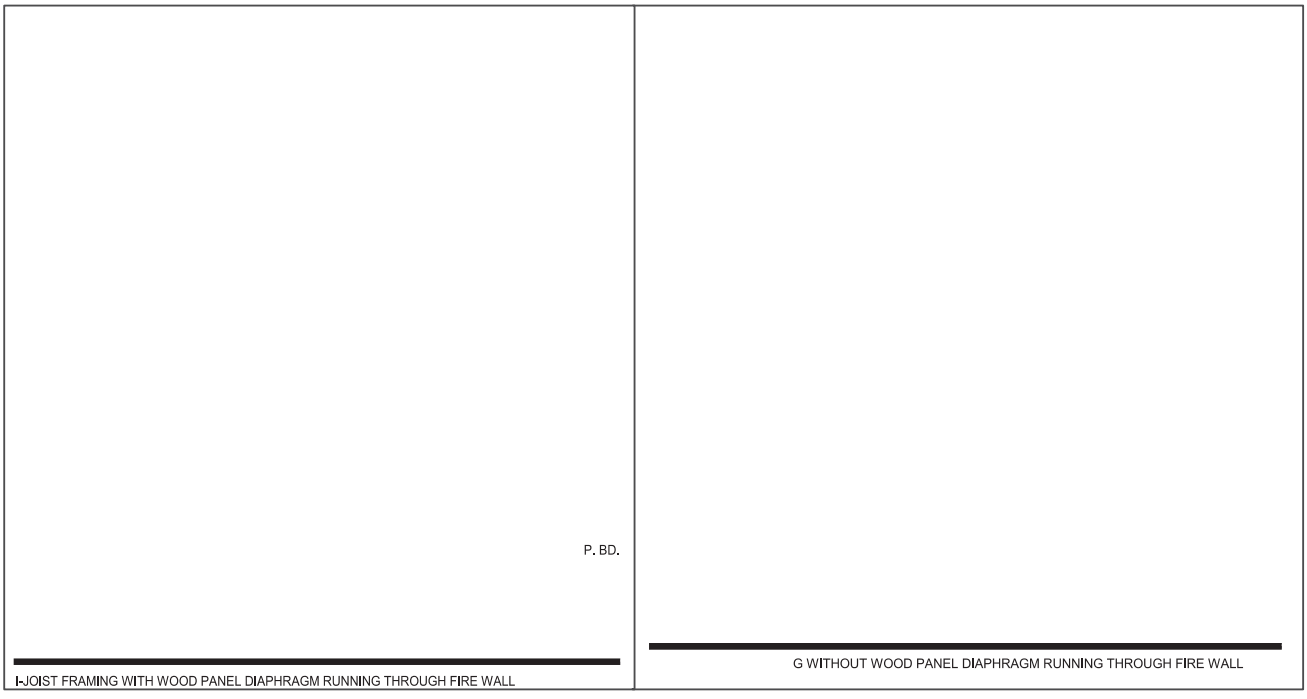


CAD & Revit Details: www.woodworks.org



http://www.usgdesignstudio.com/wall-selector.asp?framingType=18708&bldgSystem=18620

Fire Walls – Diaphragm Continuity



CAD & Revit Details: www.woodworks.org

Fire Walls – Diaphragm Continuity

SEAOSC

SEAoSC LIGHT-FRAMING CONSTRUCTION COMMITTEE
STRUCTURAL ENGINEERS ASSOCIATION OF SOUTHERN CALIFORNIA
SEISMOLOGY OPINION

DATE: **March 21, 2008**

Continuity of Plywood Diaphragm Sheathing in 2 hr and 3hr Fire Walls:

Opinion: The continuity of plywood diaphragm sheathing should be maintained across the air gap commonly encountered in double stud Firewalls of 2 or 3 hour construction. The intent is to ensure that structural continuity is not significantly reduced in the roof and floor diaphragms.

Commentary:

This opinion is prepared to address the issue of diaphragm continuity as it relates to recent changes in 2007 CBC and 2006 IBC model code. Specifically the outgoing UBC provisions for Area-Separation walls have more or less been replaced by the Fire wall provisions of the IBC. Such walls are encountered in light-frame multifamily or mixed-use construction and are often constructed as a double studwall when occurring at partywall locations. The double stud walls are typically separated by an airspace of a one to four inches.

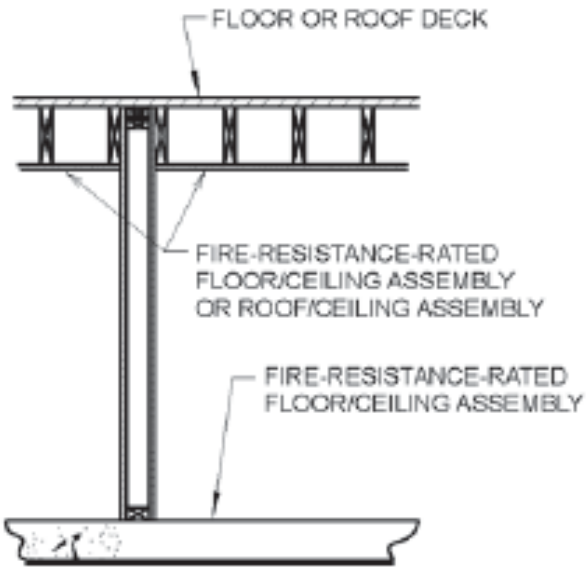
The IBC has introduced language [IBC 705.4] that states fire walls must have "sufficient structural stability" under fire conditions to allow collapse of either side. Previous commentary to the UBC topic of Area Separation

Fire Barriers – IBC 707

Supported by assembly of equal or greater fire resistance (with exceptions when required for separating incidental use areas in type IIB, IIIB and VB construction)

Commonly used in:

- Shaft enclosures
- Interior exit stairway
- Exit stairway enclosures
- Exit passageways
- Incidental uses (IBC 509)
- Occupancy separations
- Atriums
- Creating separate fire areas



Shaft Walls

705.5: Continuity:

- Extend and attach to foundation to floor/roof
- Through concealed spaces
- Joints and voids shall comply with sections 707.8 and 707.9

713.4 Fire-Resistance Rating:

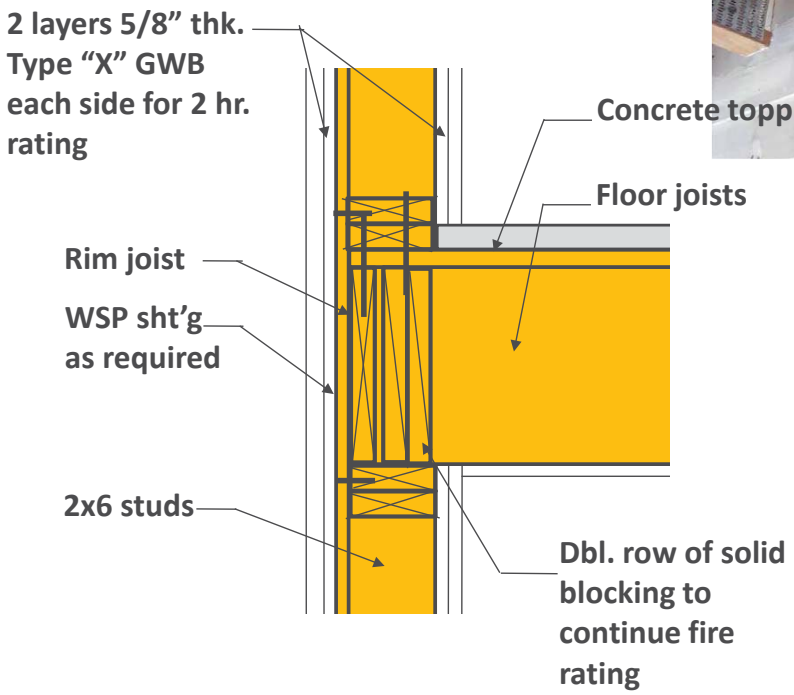
- Not less than 2 hours (4 stories or more)
- 1 hour (less than 4 stories)
- Number of connected stories includes basement but not mezzanine
- Fire rating shall not be less than floor assembly penetrated, but need not exceed 2 hours

Wood Framed Shaft Walls

Using wood framed shaft walls can:

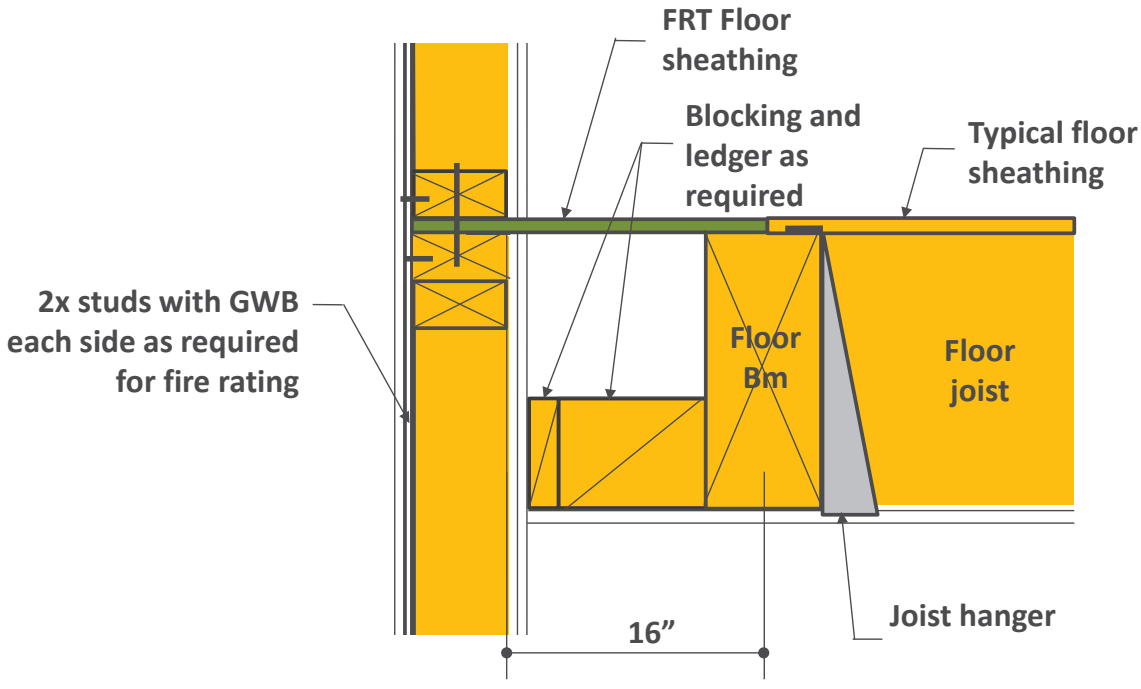
- Eliminate lateral load considerations associated with attaching wood diaphragms to concrete or masonry shaft walls (SDPWS 4.1.5)
- Eliminate differential shrinkage at floor to wall transition
- Eliminate different construction trades in building during construction
- Reduce costs
- Improve schedule

Shaft Wall Details

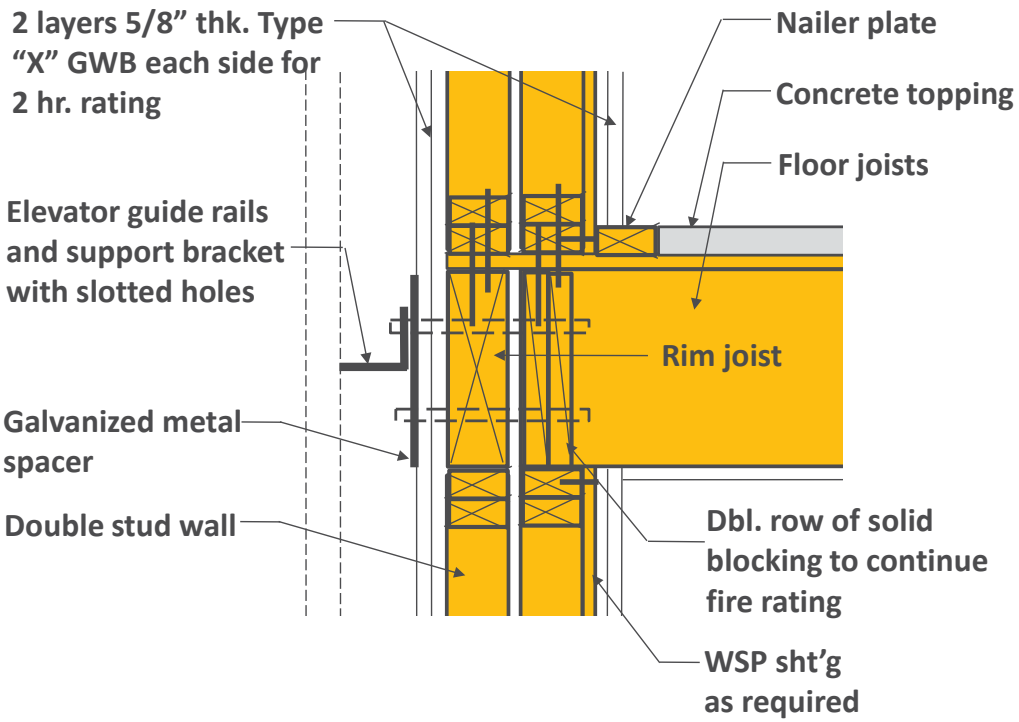


Wood Design Focus: Volume 22, Issue 3 by Smith

Shaft Wall Details

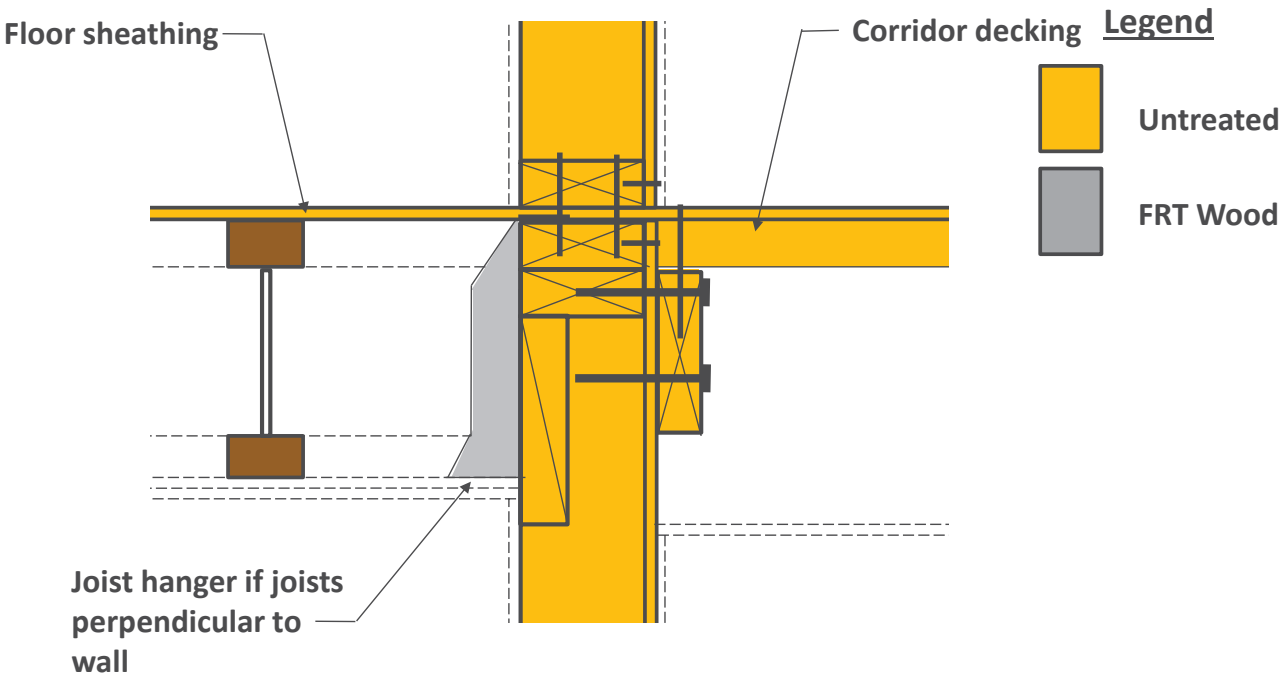


Elevator Shaft Wall



Wood Design Focus: Volume 22, Issue 3 by Smith

Corridors - 1hr Floor



Choosing Fire Rated Assemblies

Tested assemblies (ASTM E119) per IBC 703.2:

- UL Listings
- Gypsum Catalog
- Proprietary Manufacturer Tests
- Industry Documents: such as AWC's DCA3

Alternate Methods per IBC 703.3

- Prescriptive designs per IBC 721.1
- Calculated Fire Resistance per IBC 722
- Fire-resistance designs documented in sources
- Engineering analysis based on a comparison
- Fire-resistance designs certified by an approved agency

Balconies – IBC 1406.3

Balconies of combustible construction and not FRT shall be:

- Rated in accordance w/ Table 601 for floors
- Or be of Type IV
- And shall not exceed 50% of bldg perimeter

Exceptions

- Balconies in Type III, IV and V can be of type V const and shall not have fire resistance rating if sprinkler protection provided
- Untreated wood is permitted for rails and guardrails

Balconies – IBC 1406.3

So….

For Type III or V balcony options are:

1. Non-combustible – no sprinklers/no fire rating
2. FRT – no fire sprinklers/no fire rating
3. Type IV– no fire sprinklers/no fire rating
4. Non treated – fire sprinkler/no fire rating
5. Non treated – fire rated per 601 & 602/ no sprinkler

Outline

- Mid-Rise Construction Types & Life Safety Review
- Structural Design & Detailing Considerations
- Shrinkage Considerations & Detailing
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

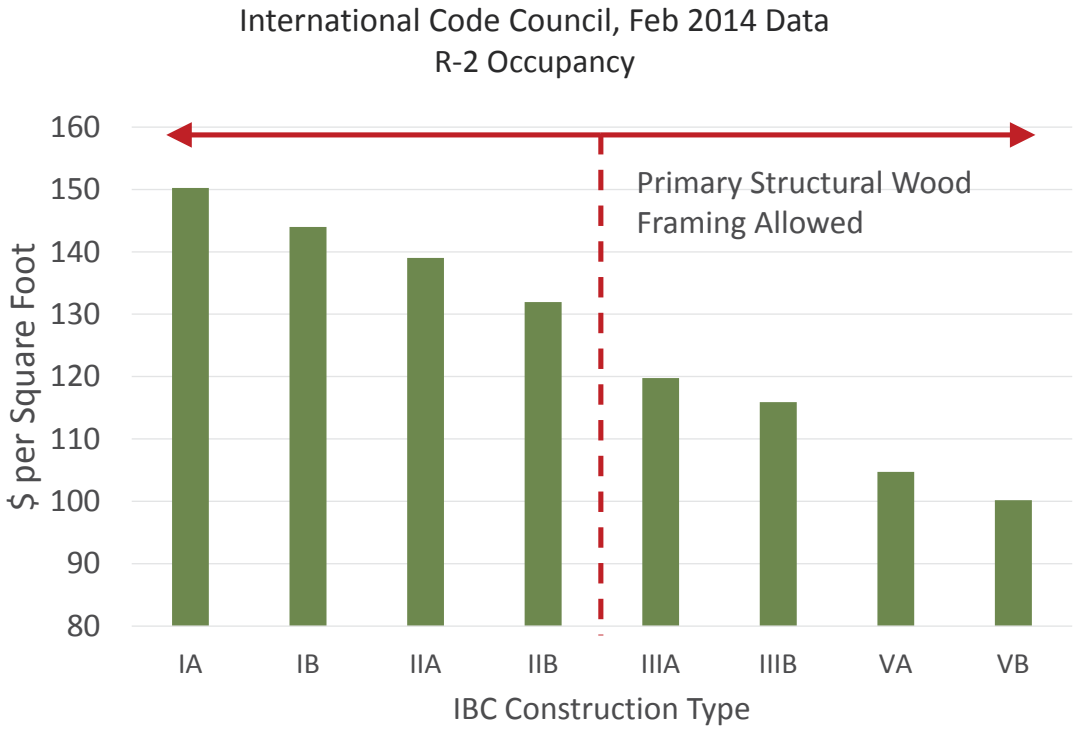
Outline

- Mid-Rise Construction Types & Life Safety Review
- Structural Design & Detailing Considerations
- Shrinkage Considerations & Detailing
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

Mid-Rise Construction Types

Materials	Protected Elements	Less Protected Elements	Unprotected Elements
Non-Combustible	IA, IIA	IB	IIB
Combustible	-	-	-
Mixed Systems	IIIA	IIIB	-
Heavy Timber	-	IV	-
Any Materials	VA	-	VB

IBC Building Valuation Data



IBC Building Size Limits

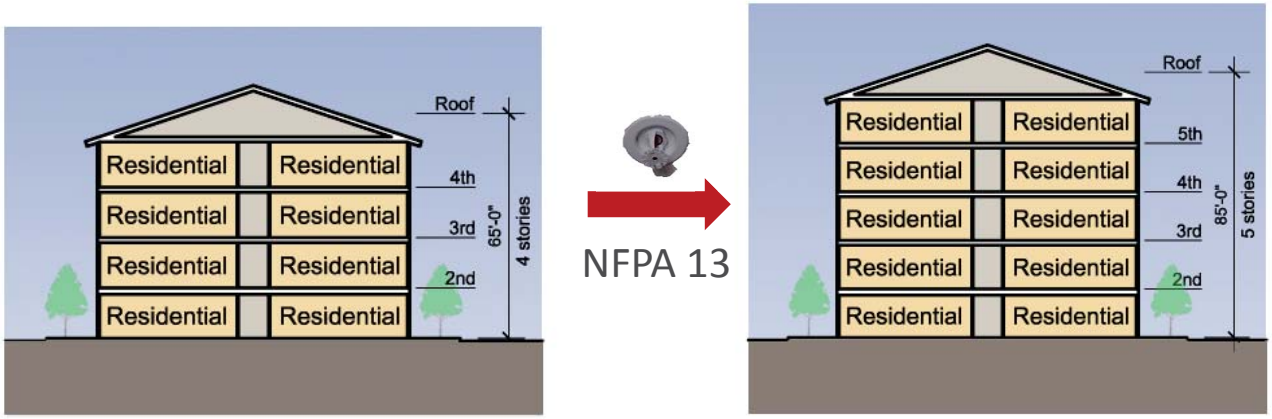
Residential (R1, R2, and R4) Occupancies

Construction Type Allowable Limit	IIIA	IIIB	VA	VB
Stories	4	4	3	2
Height (ft)	65	55	50	40
Building Area/Story (ft^2)	24k	16k	12k	7k
Total Building Area* (ft^2)	72k	48k	36k	14k

* Assuming max stories built

IBC 2012 Table 503 Tabular Values

IBC Building Size Limits



IIIA Tabular Height Limits **Increased Limits**

With NFPA 13 Sprinklers:

IBC gives an allowable Heights and Area Increase

IBC Building Size Limits with Sprinkler

Residential (R1, R2, and R4) Occupancies

Type IIIA Construction Allowable Limit	Table 503	NPFA 13	NPFA 13	Frontage ?
Stories	4	**5**	**5**	**5**
Height (ft)	65	**85**	**85**	**85**
Building Area/Story (ft^2)	24k	24k	**72k**	**90k**
Total Building Area* (ft^2)	72k	72k	**216k**	**270k**
IBC 2012 Section	503	504.2	506.3	506.2

* Assuming max stories built per IBC 506.4

? Maximum frontage increase possible

Case Study: Stella Apartments

Architect: Design ARC. Los Angeles, CA
Photos: Lawrence Anderson, www.lawrenceanderson.net

Stella Apartments

Location: Marina Del Ray, CA

244 Apts., 650K sf total (2 bldgs)

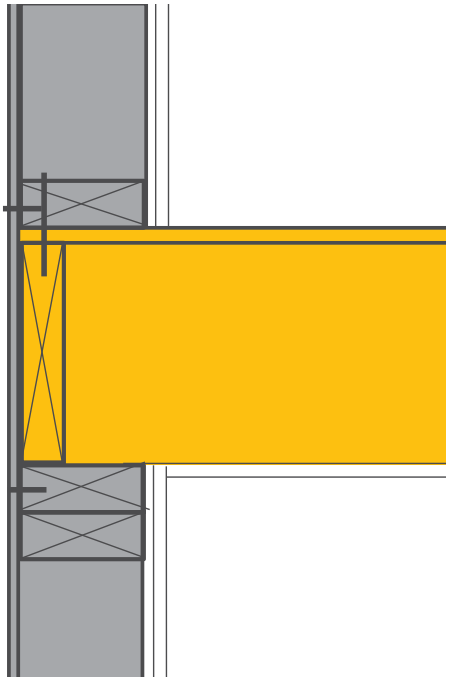
Type IIIA and VA construction

Panelized wood framing saved 1-2 months construction time and $200,000

Outline

- Mid-Rise Construction Types & Life Safety Review
- Structural Design & Detailing Considerations
- Shrinkage Considerations & Detailing
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

Platform Framing



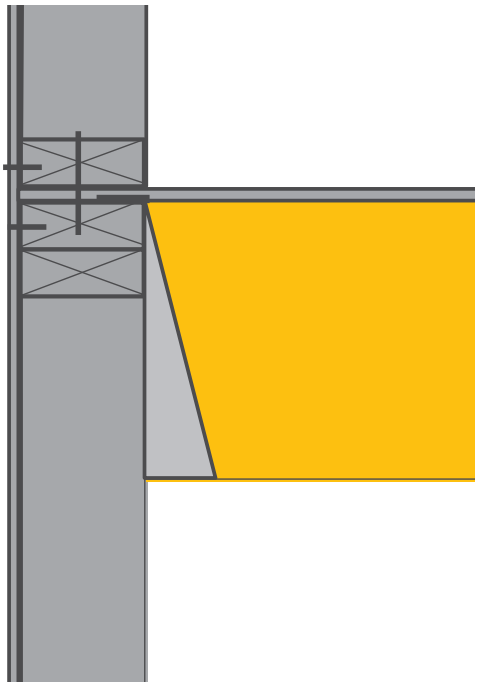
Structural

- Direct bearing/ no add'l hardware
- May require load transfer blocking for concentrated loads from above
- Wall sole plate and floor sheathing crushing may need to be considered

Constructability

- Framing can be completed before drywall and insulation are installed
- Common length studs

Semi-balloon Framing



Structural

- Additional hardware/no direct bearing
- No load transfer blocking req'd

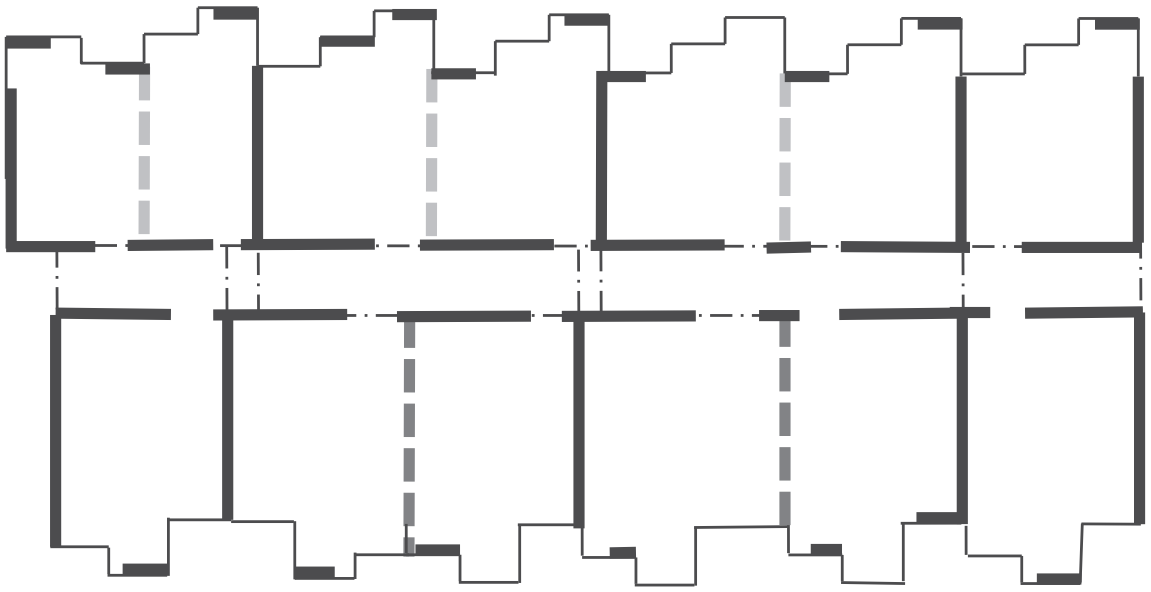
Rated Assemblies

- May accommodate continuity in exterior walls in Type III construction

Constructability

- Framing can be completed before drywall and insulation are installed
- Custom length studs
- Can help minimize building shrinkage

Shear Wall Framing Considerations

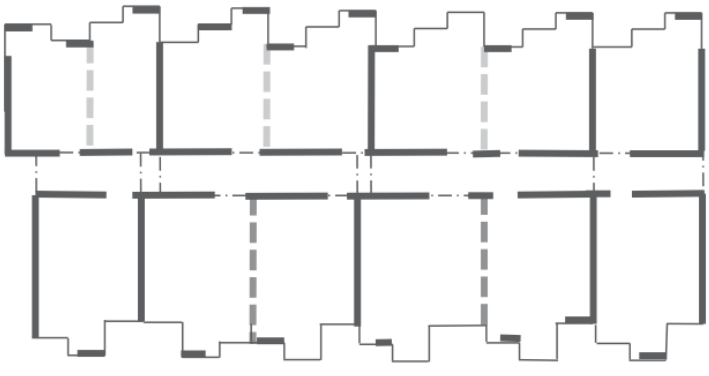


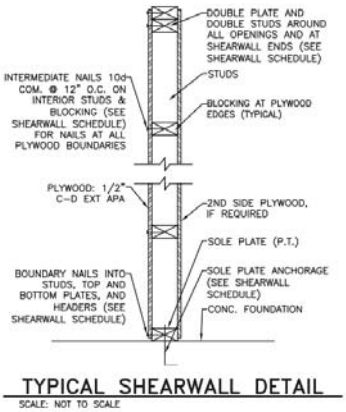
Typical Floor Plan Shear Wall Layout

Indicates wood sheathed shear wall

Shear Wall Framing Considerations

- Typical floor plan results in shorter solid wall sections, offset walls, need for more collectors, struts
- Shorter walls = higher concentrated loads
- Higher concentrated loads = tighter nailing, larger hold downs & end posts, possibly double sided sheathing
- Code requirements for wall height to width ratios must be met
- Accumulated loads further concentrate forces in lower level walls

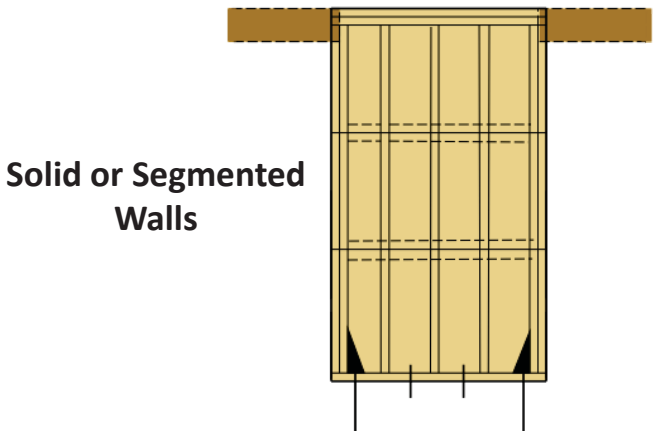




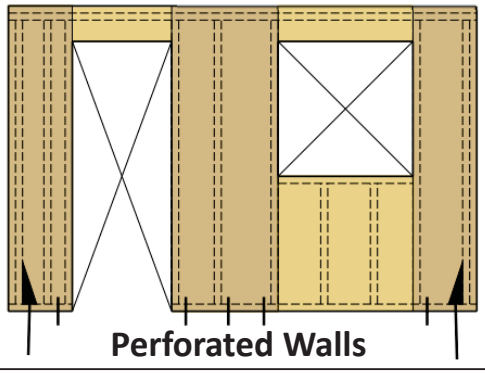
Shear Wall Framing Considerations

- Shear wall components can affect other building features
- End Posts: More wood in wall = less insulation
- Sheathing on interior walls affect wall finishes, acoustics
- Hold downs, end posts, blocking can affect in-wall utilities
- Openings in walls for MEP can affect shear wall strength

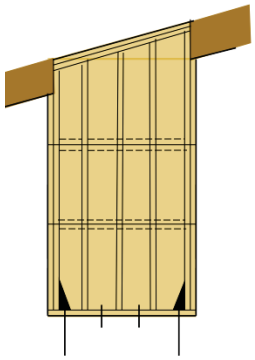
Shear Wall Configuration Options

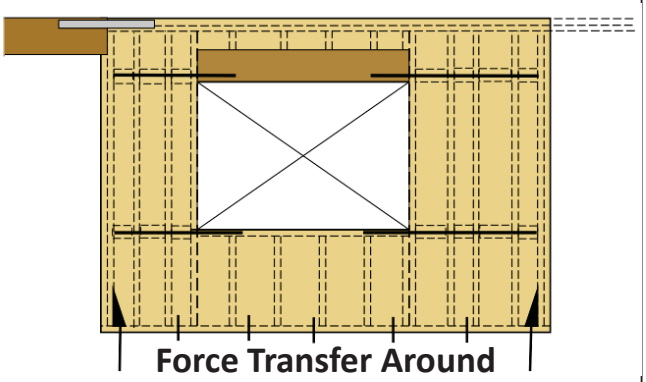


Solid or Segmented Walls



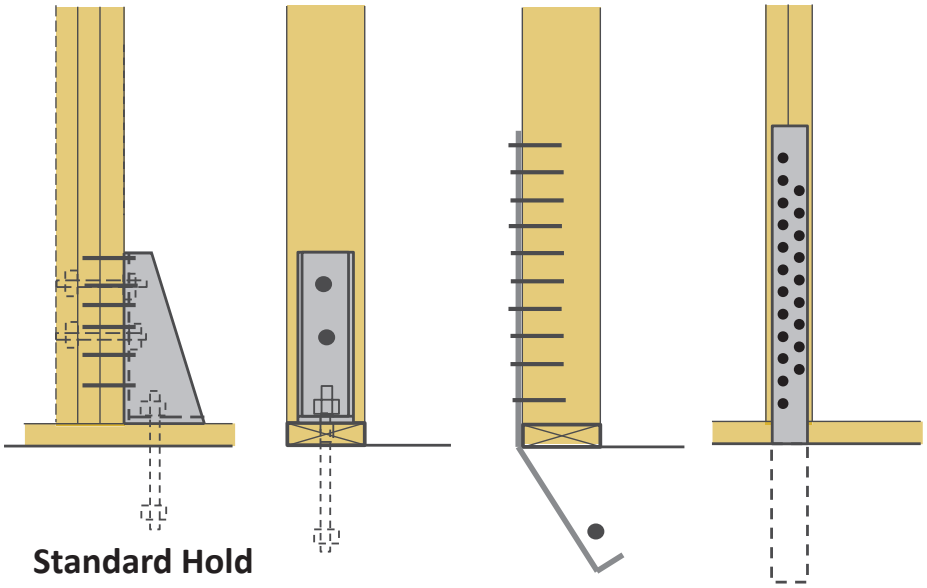
Perforated Walls





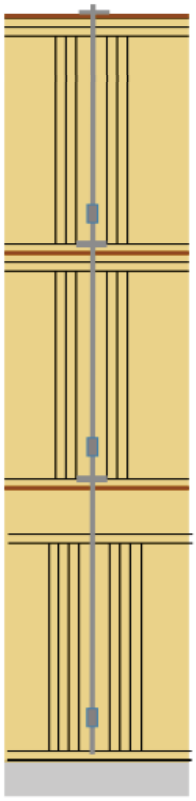
Force Transfer Around Openings Walls

Shear Wall Hold Down Options



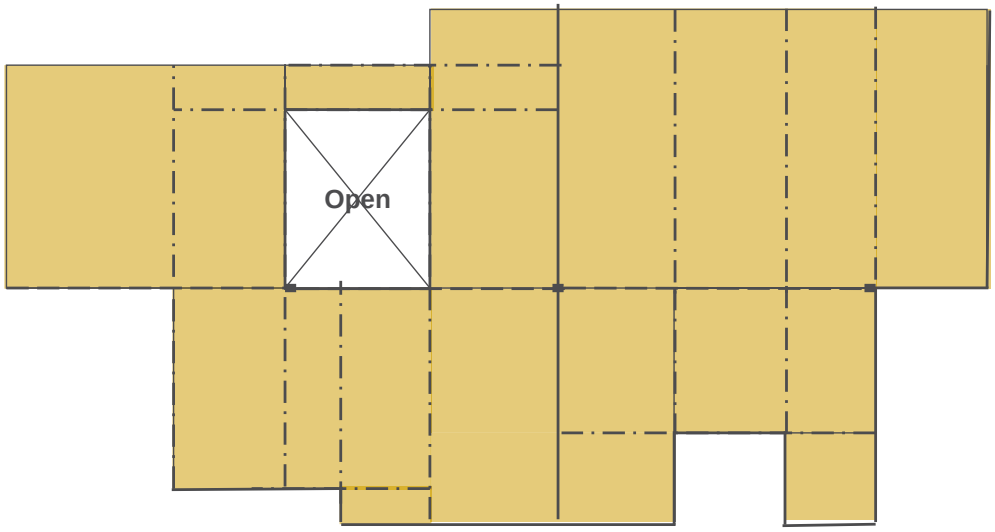
Standard Hold Down Installation

Strap Hold Down Installation



Continuous Rod - Automatic Tensioning Systems

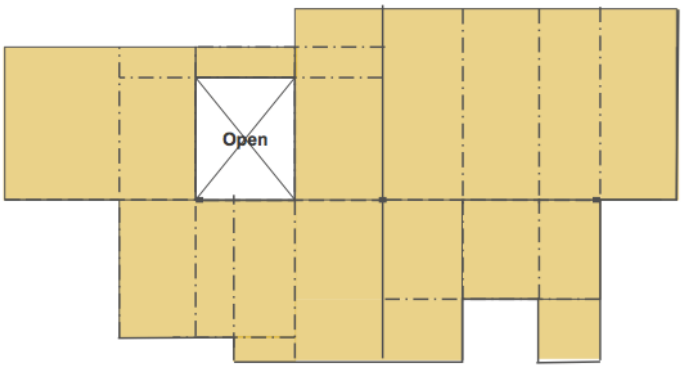
Diaphragm Considerations



Typical Floor Plan Diaphragm Layout

Diaphragm Considerations

- Typical floor plan results in diaphragm offsets, re-entrant corners, discontinuities, openings
- Diaphragm openings, discontinuities = higher concentrated, localized loads
- Higher concentrated loads = tighter nailing, larger chord & strut loads, may require blocked diaphragm
- Code requirements for diaphragm length to width ratios must be met



Shear Wall to Podium Slab Interface

- Amplification of seismic forces is required for elements supporting discontinuous walls per ASCE 7-10 12.3.3.3
- Overstrength factor of 3 (may be reduced to 2.5 per footnote g of Table 12.2-1) is required
- Attachment to concrete slab must also conform to ACI 318 Appendix D
- Typically will be transitioning from ASD for wood design to LRFD for concrete design
- Hold down attachments to concrete options: embedded nuts or plates, sleeves through slab, welded studs & reinforcing

PT Sole Plate vs FRT Continuity

In type III construction with FRT studs, what happens where the sole plate is in contact with concrete?

- FRTW is required
- PT wood is required

FRT contains about 10x borate compound found in PT (borate is water soluble)

Can specify a product tested to do both

Outline

- Mid-Rise Construction Types & Life Safety Review
- Structural Design & Detailing Considerations
- Shrinkage Considerations & Detailing
  - Concepts
  - Calculations
  - Recommendations
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

IBC 2012 on Shrinkage

2304.3.3 Shrinkage. Wood walls and bearing partitions shall not support more than two floors and a roof unless an analysis satisfactory to the building official shows that shrinkage of the wood framing will not have adverse effects on the structure or any plumbing, electrical or mechanical systems, or other equipment installed therein due to excessive shrinkage or differential movements caused by shrinkage. The analysis shall also show that the roof drainage system and the foregoing systems or equipment will not be adversely affected or, as an alternative, such systems shall be designed to accommodate the differential shrinkage or movements.

Key Factors Influencing Shrinkage

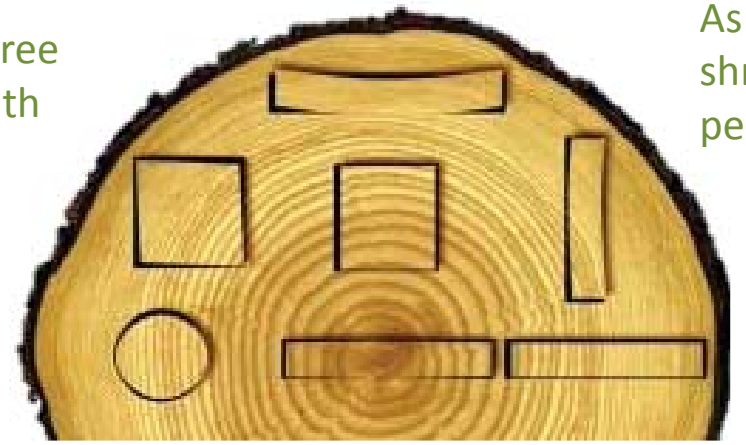
- Pre-construction moisture content (MC)
- In-service equilibrium moisture content (EMC)
- Cumulative thickness of cross-grain wood contributing to shrinkage

Wood species has relatively little impact since most species used in commercial construction have similar shrinkage properties.

Basic Wood Shrinkage Theory

Moisture changes cause dimensional changes perpendicular to grain

Growing tree is filled with water

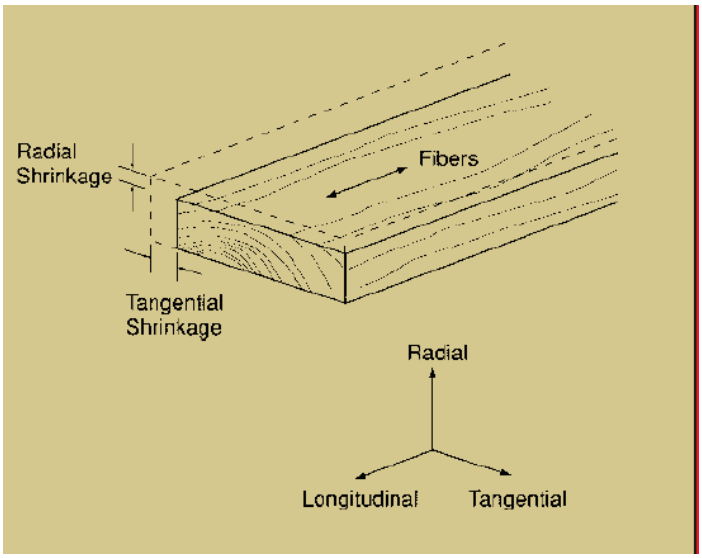


As wood dries, it shrinks perp. to grain

Image: Wood Handbook, Wood as an Engineering Material, USDA Forest Service, Forest Products Laboratory, 2010

Basic Wood Shrinkage Theory

Shrinkage in lumber expected ACROSS the grain.
Longitudinal shrinkage is negligible.



Wider & Thicker --- NOT Taller

Basic Wood Shrinkage Theory

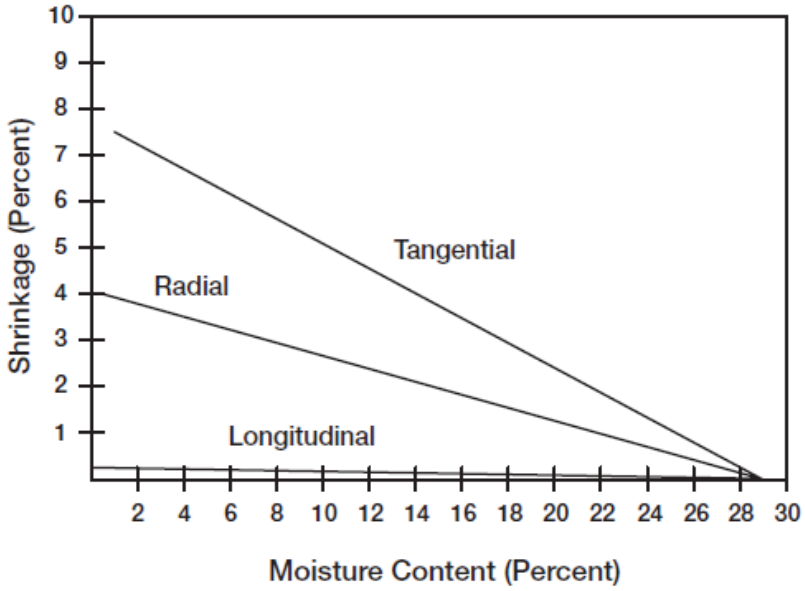


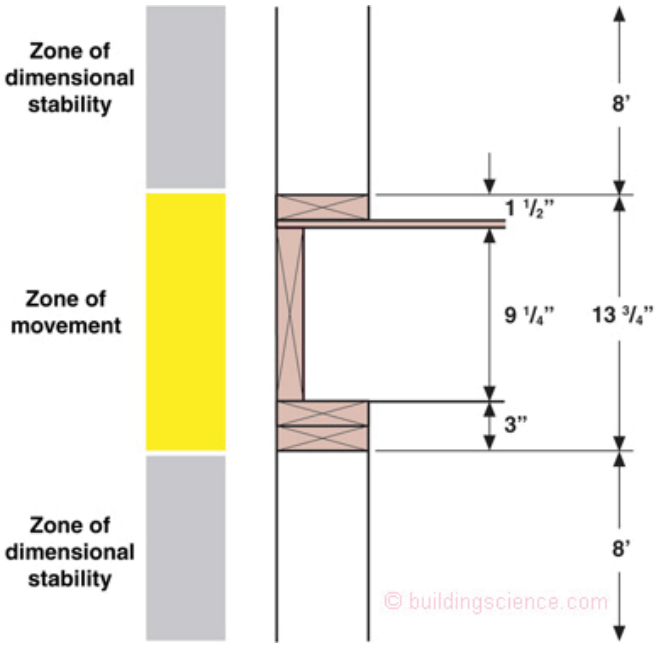
Figure 2. Average shrinkage properties

Zone of Movement

Shrinkage occurs primarily in horizontal members

- Wall plates
- Floor/rim joists

Be aware of cumulative shrinkage.



Pre-Construction Moisture Content

Product	Moisture Content
Lumber – S-Dry	19% or less
Lumber – S-Green	Usually over 19%
Panel products (OSB, plywood)	4-8%
I-Joists	4-16%

→ M_i = 19%

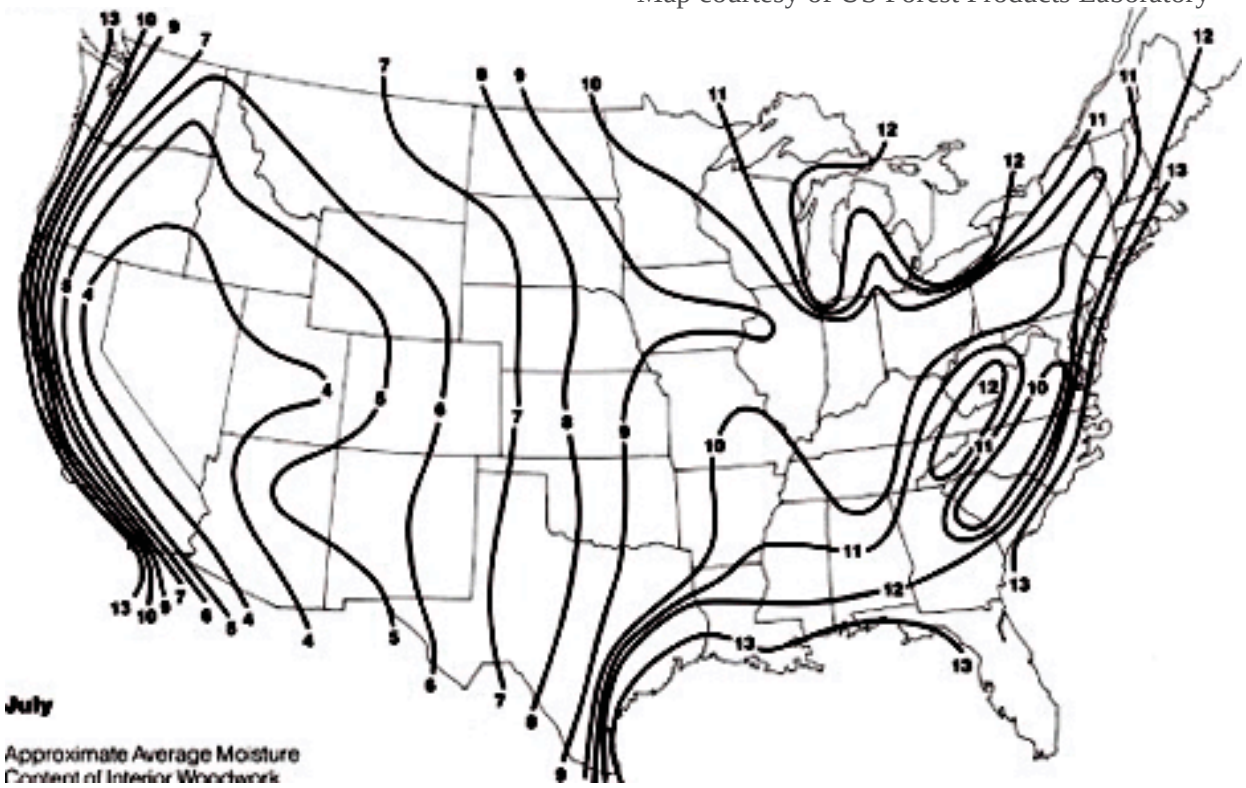
→ M_i = 28%

Minimize Construction Moisture Accumulation

1. Minimize storage of material on site where rain and standing water can increase moisture content.
2. Keep unused framing material covered
3. Inspect pre-built wall panels prior to installation for proper material and quality of mechanical fasteners.
4. “Dry-in” the structure as quickly as possible.
5. Immediately remove any standing water from floor framing after rain showers.

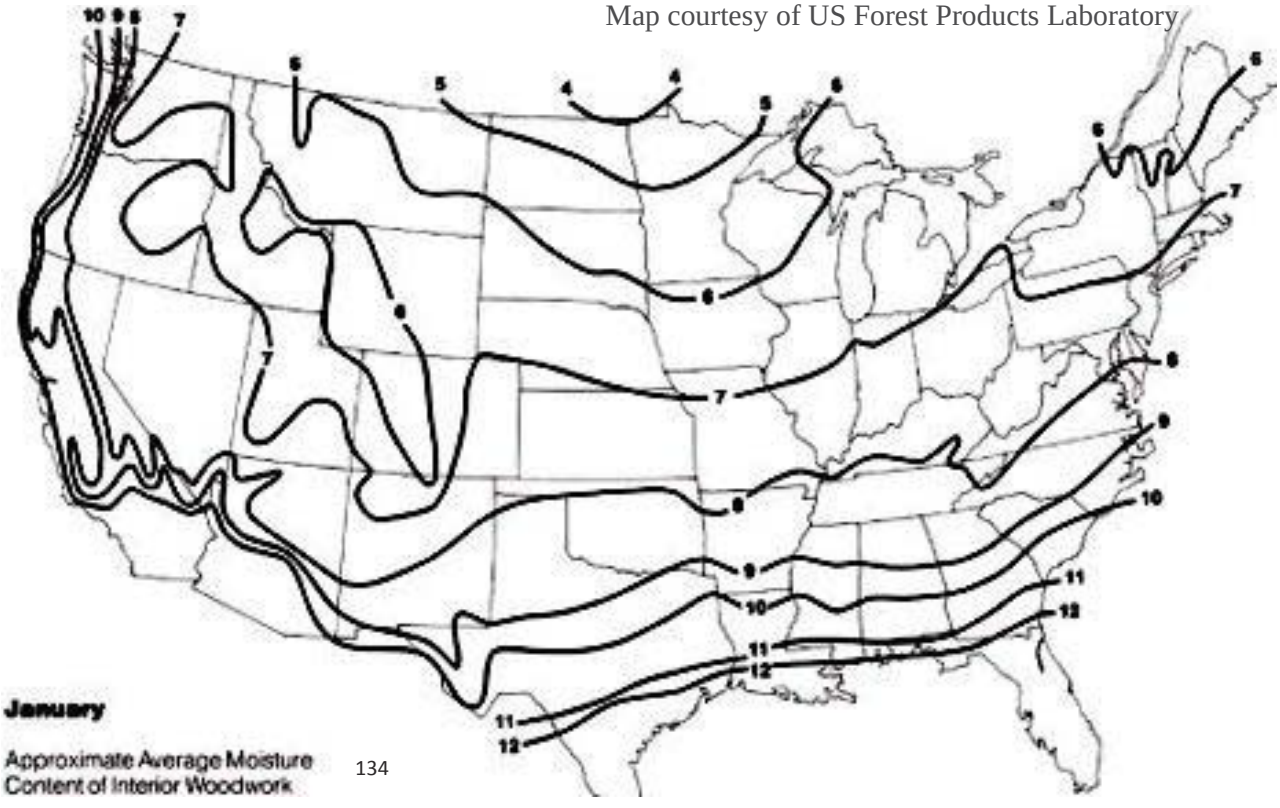
In-service Average EMC in July

Map courtesy of US Forest Products Laboratory



In-service Average EMC in January

Map courtesy of US Forest Products Laboratory



Calculating Shrinkage

For MC **between 6 to 14%** the shrinkage formula is:

$$S = D_i\left[C_T\left(M_F - M_i\right)\right]$$

S = shrinkage (in inches)

D_i = initial dimension (in inches)

C_T / C_R= dimension change coefficient, tangential/radial direction

- C_T = 0.00319 for Douglas Fir-Larch
- C_T = 0.00323 for Hem-Fir
- C_T = 0.00263 for Spruce-Pine-Fir
- C_T = 0.00263 for Southern Pine

M_F = final moisture content (percent)

M_i = initial moisture content (percent)

Calculating Shrinkage

For MC **outside the range of 6 to 14%** :

$$S = \frac{D_i\left(M_F - M_i\right)}{\frac{30(100)}{S_T} - 30 + M_i}$$

S = shrinkage (in inches)

D_i = initial dimension (in inches)

S_T /S_R= tangential/radial shrinkage (%) from green to oven dry

M_F = final moisture content (percent)

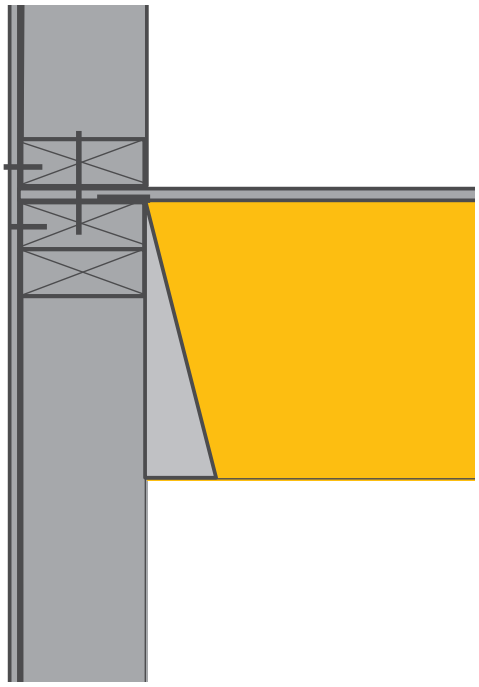
M_i = initial moisture content (percent)

Minimizing Shrinkage

Semi-balloon framing

- incorporates floor framing hanging from top plates
- Eliminates tangential shrinkage in zone of movement
- Floor framing doesn't contribute to overall building shrinkage

Non-standard stud lengths and increased hardware requirements are a result.



Differential Movement

Movement between wood frame elements and other materials that…

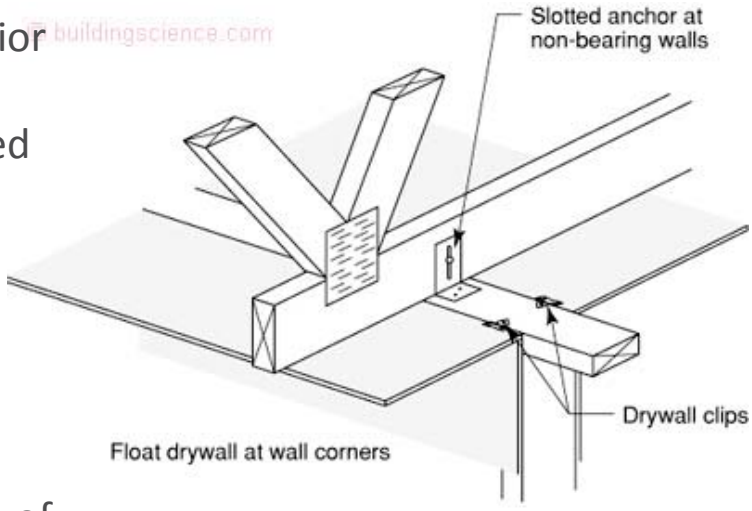
- do not shrink at all
- shrink much less
- expand

Shrinkage & Finish Considerations

Large expanses of interior and exterior drywall, paneling and siding need to be looked at specifically.

Employ expansion joint and slip-type detailing.

Attention to interaction of structural (load-bearing) and non-structural elements is necessary



Shrinkage & MEP Considerations

Fully compress wall framing by completing all dead load potential PRIOR to mechanical installations.

Avoid rigid vertical piping in mechanical and plumbing systems. Flexible members allow for shrinkage between floors.

MEP Considerations

Vertical vent stacks should be installed after completion of framing.

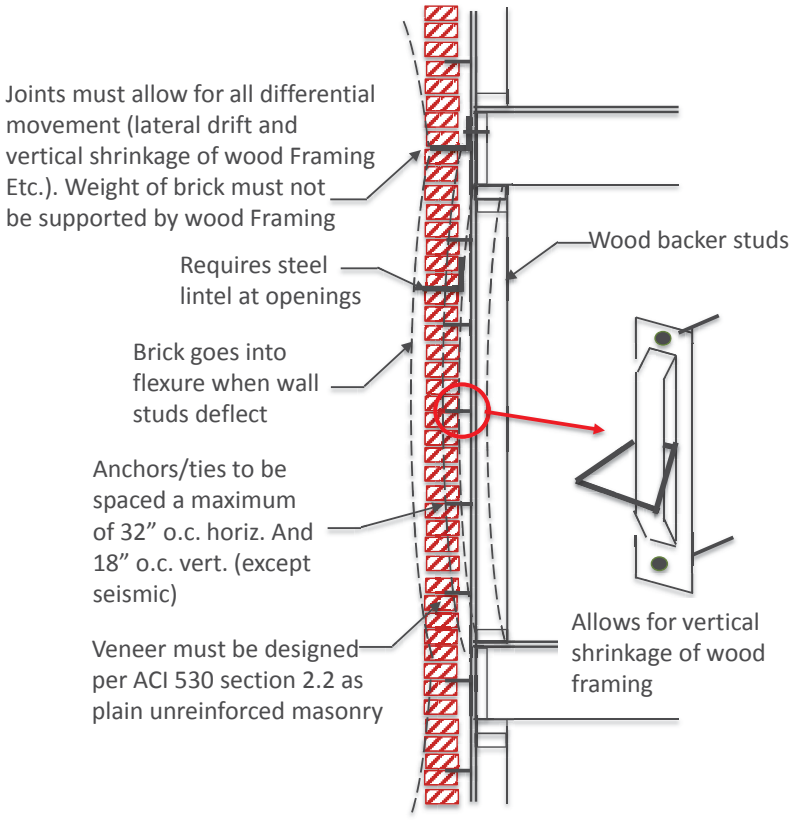
Vent stacks require special attention and must be designed to allow for vertical movement due to shrinkage between floors.

Brick Façade: Solution 1- Plain Unreinforced Brick-h>30’

Design must be in strict conformance with ACI 530 section 6.2.1-Alt. design method (engineered)

Design to section 2.2 (ASD) or 3.2.2 (strength) unreinforced masonry

Brick veneer must be self supporting and not supported off of the wood framing



Façade Considerations - Resources

Brick Industry Association– www.gobrick.com

BRICK INDUSTRY ASSOCIATION | TECHNICAL NOTES on Brick Construction | 28 | November 2012

1850 Centennial Park Drive, Reston, Virginia 20191 | www.gobrick.com | 703-620-0010

Brick Veneer/Wood Stud Walls

Abstract: This *Technical Note* deals with the prescriptive design of anchored brick veneer over wood stud backing in new construction. The properties of the brick veneer/wood stud system are described, which lead to design considerations. Selection of materials, construction details and workmanship techniques are also included.

Key Words: air space, anchors, brick, flashing, foundations,

SUMMARY OF RECOMMENDATIC

Support:
- Provide a noncombustible foundation to support veneer
- Where vertical support is provided by wood construction, provide steel angles properly attached to or supported by wood framing

Veneer Height Limitations:
- For residential construction (*IRC*), do not exceed height listed in Table 1
- For commercial construction (*IBC*) see "Additional Requirements for Buildings Covered by the *IBC*" and the "Wood" chapter of *IBC*

Air Space:
- Maintain a minimum 1 in. (25 mm) air space*
- Where corrugated anchors are used, maintain a maximum 1 in. (25 mm) air space
- Do not exceed 4½ in. (114 mm) between back of brick and sheathing unless anchors are rationally designed
- Completely fill the air space below wall base flashing with grout or mortar
- Where continuous insulation is placed between the veneer and backing, maintain 1 in. (25 mm) between the back of the brick and the face of the insulation

* An air space is allowed to be a 1 in. (25 mm) nominal dimension in the *IRC* and a 1 in. (25 mm) specified dimension in the *IBC* to account for construction tolerances.

Flashing:
- Install above grade at the wall base and extend to or beyond face of brickwork
- Extend base flashing at least 8 in. (203 mm) vertically
- Place at all points where air space is interrupted and at other locations where water removal is desired, such as

BRICK INDUSTRY ASSOCIATION | TECHNICAL NOTES on Brick Construction | 18A | November 2006

1850 Centennial Park Drive, Reston, Virginia 20191 | www.gobrick.com | 703-620-0010

Accommodating Expansion of Brickwork

Abstract: Expansion joints are used in brickwork to accommodate movement and to avoid cracking. This *Technical Note* ...truction and gives guidance regarding their placement. The theory and ...e given showing proper placement of expansion joints to avoid cracking ...act of expansion joints. Also included is information about bond breaks, ... flexible anchorage, movement, sealants.

...TIONS:

Brickwork Without Shelf Angles:
- Accommodate brickwork movement by:
  - placing expansion joints around elements that are rigidly attached to the frame and project into the veneer, such as windows and door frames
  - installing metal caps or copings that allow independent vertical movement of wythes
  - installing jamb receptors that allow independent movement between the brick and window frame
  - installing adjustable anchors or ties

Expansion Joint Sealants:
- Comply with ASTM C 920, Grade NS, Use M
- Class 50 minimum extensibility recommended; Class 25 alternate
- Consult sealant manufacturer's literature for guidance regarding use of primer and backing materials

Bond Breaks:
- Use building paper or flashing to separate brickwork from dissimilar materials, foundations and slabs

Loadbearing Masonry:
- Use reinforcement to accommodate stress concentrations, particularly in parapets, at applied loading points and around openings
- Consider effect of vertical expansion joints on brickwork stability

BRICK INDUSTRY ASSOCIATION | TECHNICAL NOTES on Brick Construction | 18 | October 2008

1850 Centennial Park Drive, Reston, Virginia 20191 | www.gobrick.com | 703-620-0010

Volume Changes - Analysis and Effects of Movement

Abstract: This *Technical Note* describes the various movements that occur within buildings. Movements induced by changes in temperature, moisture, elastic deformations, creep, and other factors develop stresses if the brickwork is restrained. Restraint of these movements may result in cracking of the masonry. Typical crack patterns are shown and their causes identified.

Key Words: corrosion, cracks, creep, differential movement, elastic deformation, expansion.

SUMMARY OF RECOMMENDATIONS:

- Use the following coefficients to calculate movements of brick veneer:
  - Thermal expansion: 4 x 10^{-6} in./in./°F (7.2 x 10^{-6} mm/mm/°C)
  - Moisture expansion: 5 x 10^{-4} in./in. (mm/mm)
  - Creep: 0.7 x 10^{-7} in./in. per psi (0.1 x 10^{-4} mm/mm per MPa)
- Consider coefficients of movements for other materials in contact with brickwork
- Consider elastic deformation and movement of structural elements supporting and connected to brickwork

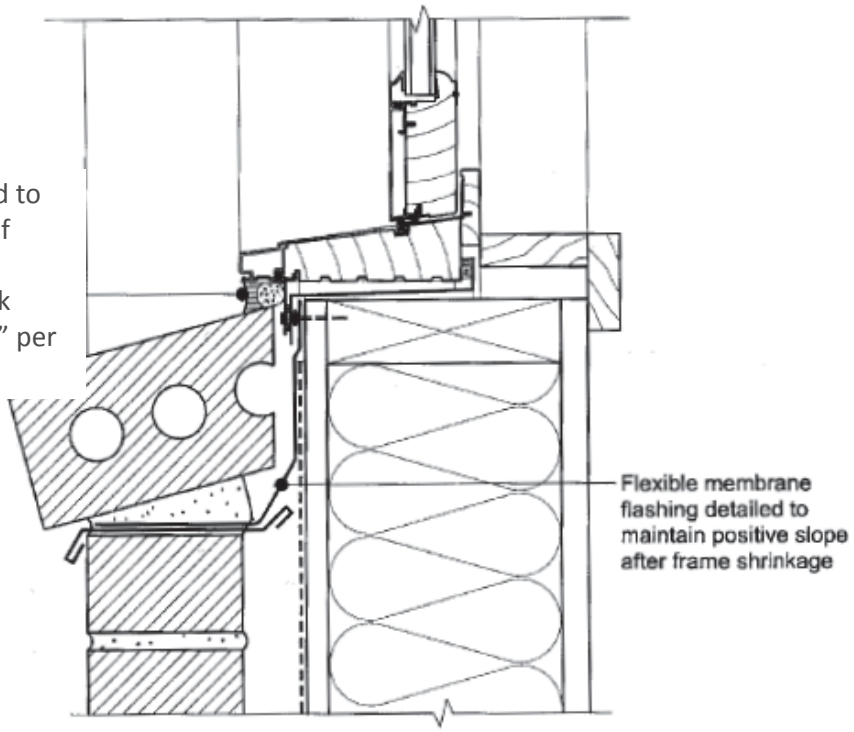
INTRODUCTION

All building materials change in volume in response to changes in temperature or moisture. Changes in volume, elastic deformations due to loads, creep and other factors result in movement. Restraint of these movements may cause stresses within building elements that result in cracks.

To avoid cracks, masonry elements should be designed to minimize movement or accommodate differential movement between materials and assemblies. A system of movement joints can reduce the potential for cracks and the problems they cause. Movement joints can be designed by estimating the magnitude of the different movements

Door and Window Considerations

Sealant joint sized to allow shrinkage of wood frame and expansion of brick (typically ¼" to ½" per floor)

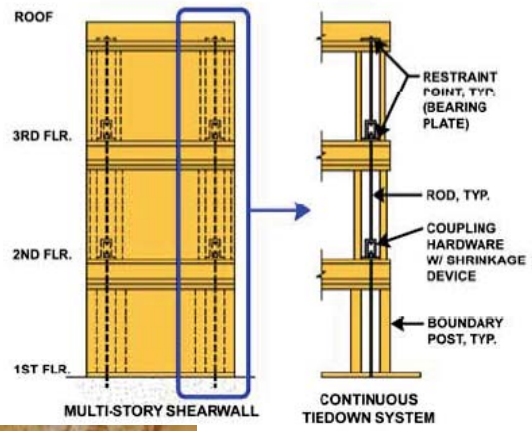


Shrinkage Effects on Structural Components

Strap hold downs can buckle with too much accumulated movement.

Anchor type holdowns should re-tightened before installing finishes.

Threaded rod holdowns with shrinkage compensating devices work well for 4 stories and above with stacking units.



Shrinkage & Deck Considerations

Table 1. Summary of measured deck slopes.

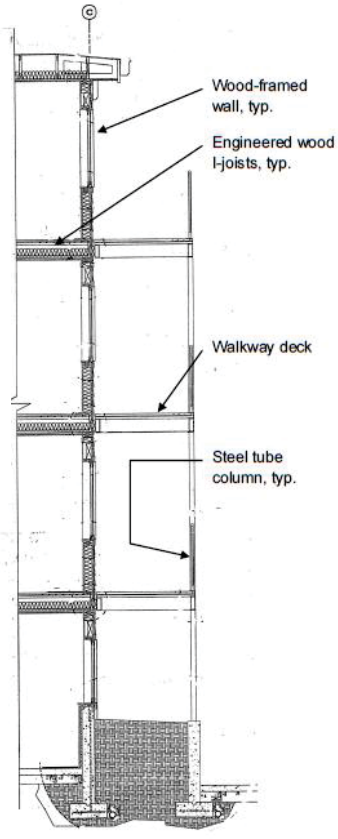
Summary of Deck Slopes for:	Story	Measured Locations	Deck Slope (%)		
			Average	Minimum	Maximum
Free Ledger Condition	4	23	-2.38	-0.70	-2.50
	3	23	-1.22	-0.50	-2.20
	2	23	-0.81	-0.20	-1.60
Fixed Ledger Condition	4	24	-0.26	0.70	-0.90
	3	24	-0.19	1.00	-1.10
	2	24	-0.27	1.20	-1.60

Note: Negative slopes drain to building wall; positive slopes drain away from building wall.

White Paper:

Multi-Story Wood-Frame Shrinkage Effects on Exterior Deck Drainage: A Case Study by Zeno Martin, Wood Design Focus Fall 2010

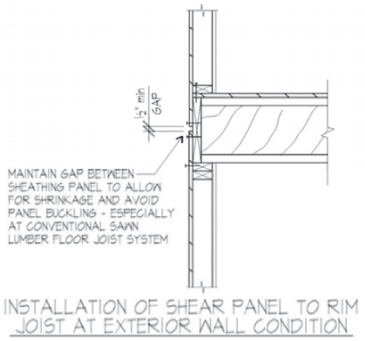
Figure 1. Section of wood-framed wall system showing deck framing with steel deck support columns.



Shrinkage Mitigating Detailing Tips

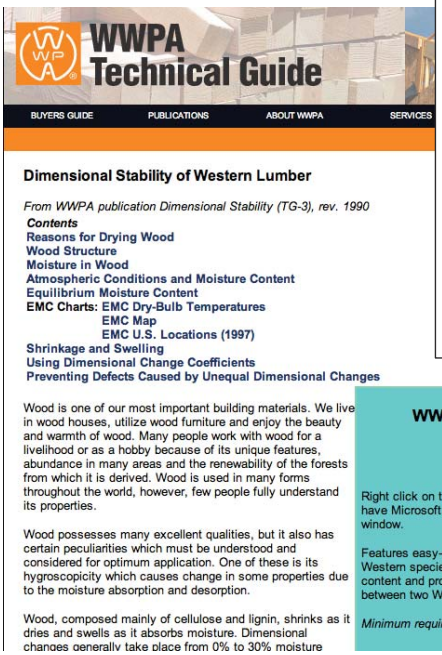
Best practices to mitigate distress to finishes arising from cumulative differential movement:

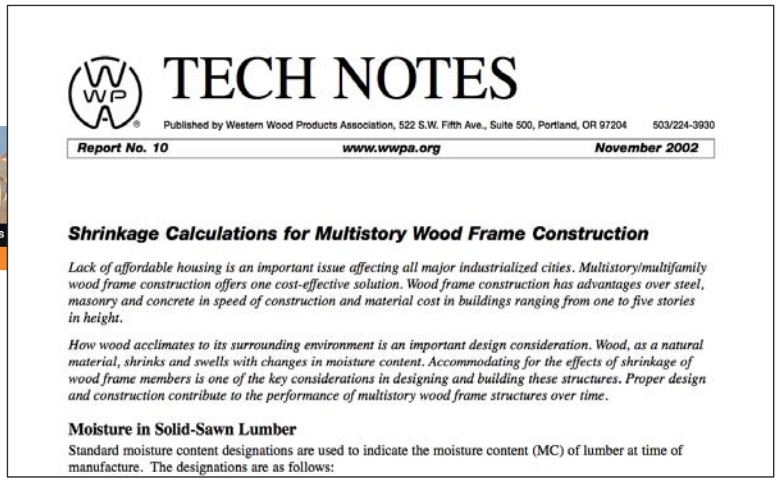
- Be acutely aware of the fact that there will be differential movement
- Address it in detailing and specifications
- Consider where distress will occur
- Provide details to relieve or avoid it

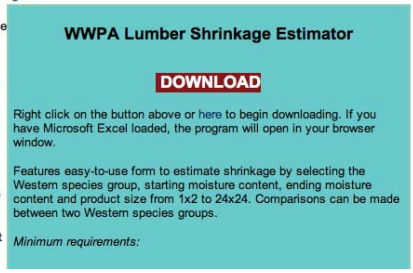


Architects: Cooper Carry & The Preston Partnership
Photo: Aerial Photography Inc.

Shrinkage Resources – www.wwpa.com







Outline

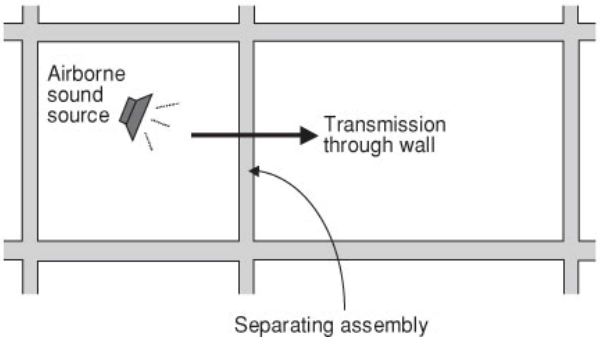
- Mid-Rise Construction Types & Life Safety Review
- Structural Design & Detailing Considerations
- Shrinkage Considerations & Detailing
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

Building Acoustics Overview

Air-borne sound:

- Sound Transmission Class (STC)

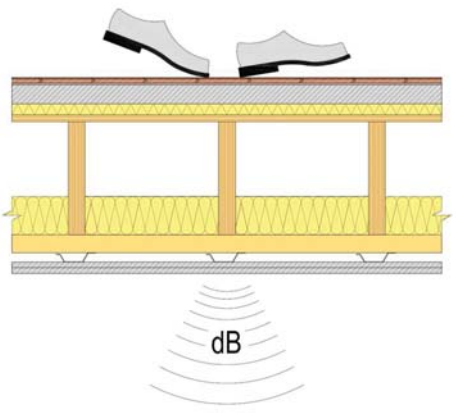
Measures how effectively an assembly isolates air-borne sound and reduces the level that passes from one side to the other



Structure-borne sound:

- Impact Insulation Class (IIC)

Evaluates how effectively an assembly blocks impact sound from passing through it



Acoustical Code Requirements

IBC Section 1207:

Min. STC of 50 (45 if field tested) for:

- All Walls, Partitions, and Floor/Ceiling Assemblies which separate adjacent dwelling units or a dwelling unit from an adjacent public area

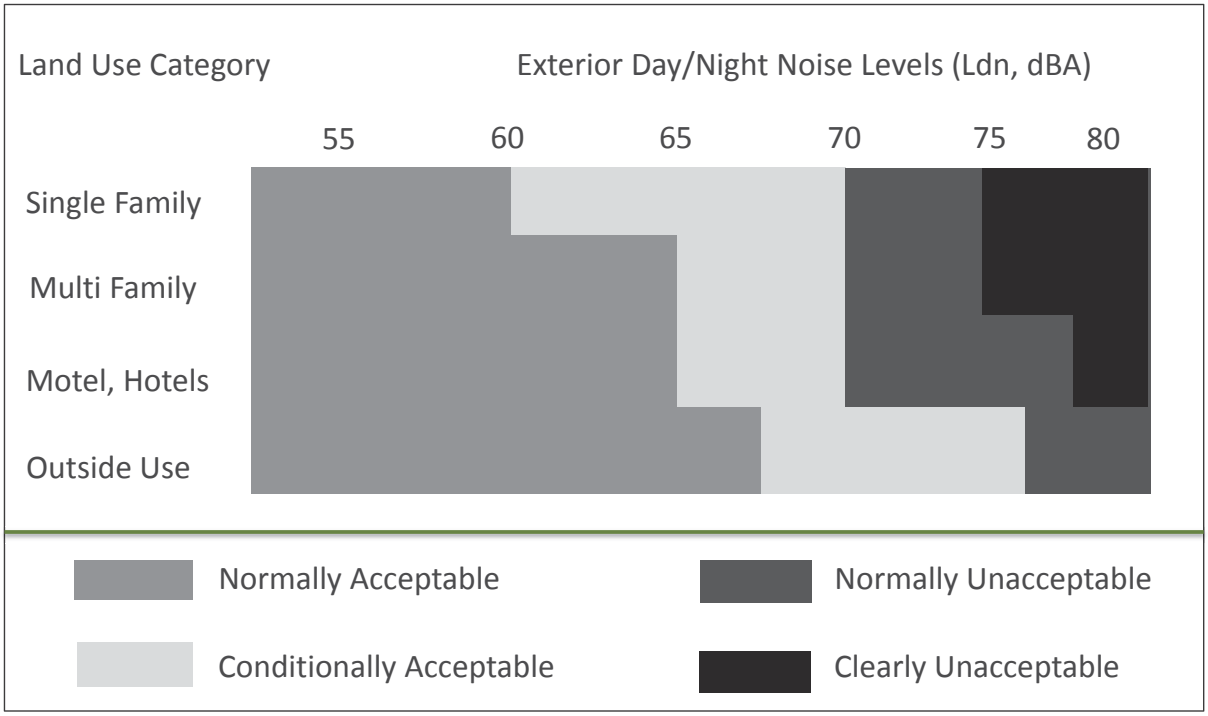
Min. IIC of 50 (45 if field tested) for:

- All Floor/Ceiling Assemblies which separate adjacent dwelling units or a dwelling unit from an adjacent public area

Acoustical Isolation Between Units

Class Designation	Airborne Sound Isolation (STC)	Floor Ceiling Impact Isolation (IIC)
Entry Level	50	50
Market Rate	55	55
Luxury	60	60

Exterior-to-Unit

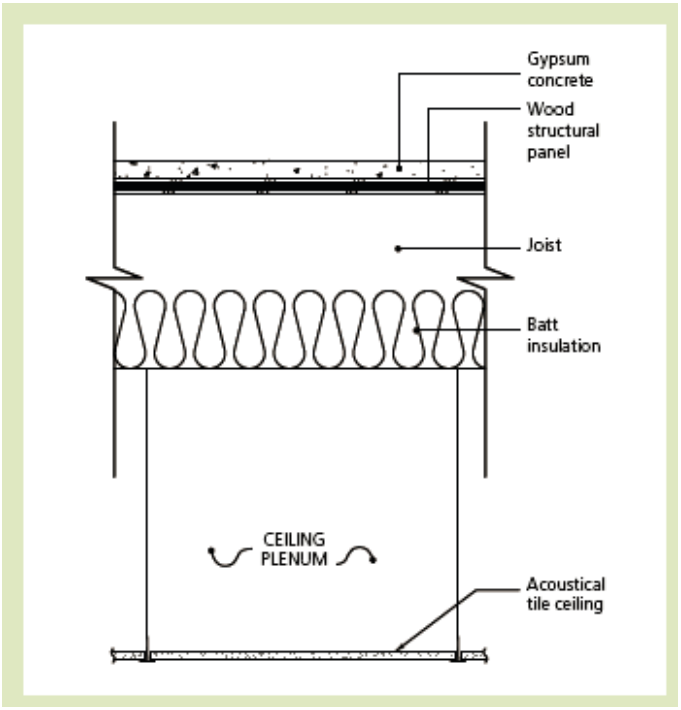


State of California General Plan Guidelines, 1987

Retail-to-Unit

Typical Floor-Ceiling Detail

Although common between restaurants or bars and the apartments above, the configuration shown in this detail may lead to noise complaints by apartment occupants.



Rated Assemblies

WOOD FRAMED WALLS & PARTITIONS

STC	GA FILE NO.
60 - 64	WP 3010
	WP 5450
55 - 59	WP 3110
	WP 3810
	WP 3812
	WP 3820
	WP 3825
	WP 5508
	WP 5509
	WP 5510
	WP 5520
50 - 54	WP 3005
	WP 3239
	WP 3240
	WP 3241
	WP 3242
	WP 3243
	WP 3244
	WP 3245
	WP 3246
	WP 3247
	WP 3251
	WP 3260
	WP 3261
	WP 3910
	WP 5530

SHAFT WALLS

STC	GA FILE NO.
50 - 54	WP 7051
	WP 7052
	WP 7053
	WP 7054
	WP 7054.4
	WP 7056
	WP 7057
	WP 7058
	WP 7059
	WP 7060
	WP 7061
	WP 7062
	WP 7064
	WP 7065.2
	WP 7065.4
	WP 7065.5
	WP 7400
	WP 7422

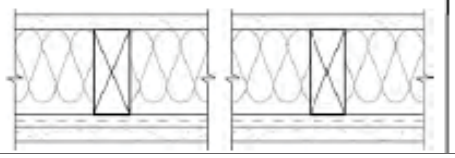
AREA SEPARATION FIRE WALLS

STC	GA FILE NO.
65 - 69	ASW 0800
	ASW 0810
60 - 64	ASW 0980
	ASW 0985
	ASW 0997
	ASW 0998
	ASW 0999
	ASW 1000
	ASW 1003
	ASW 1004
	ASW 1006
50 - 54	ASW 1100
	ASW 1105
	ASW 1111

WOOD FRAMED FLOOR-CEILINGS

STC	GA FILE NO.
60 - 64	FC 5011
	FC 5012
55 - 59	FC 5102
	FC 5103
	FC 5104
	FC 5105
	FC 5107
	FC 5109
50 - 54	FC 5111
	FC 5112
	FC 5115
	FC 5116
	FC 5119
	FC 5120

1 HOUR FIRE	50 to 54 FSTC SOUND

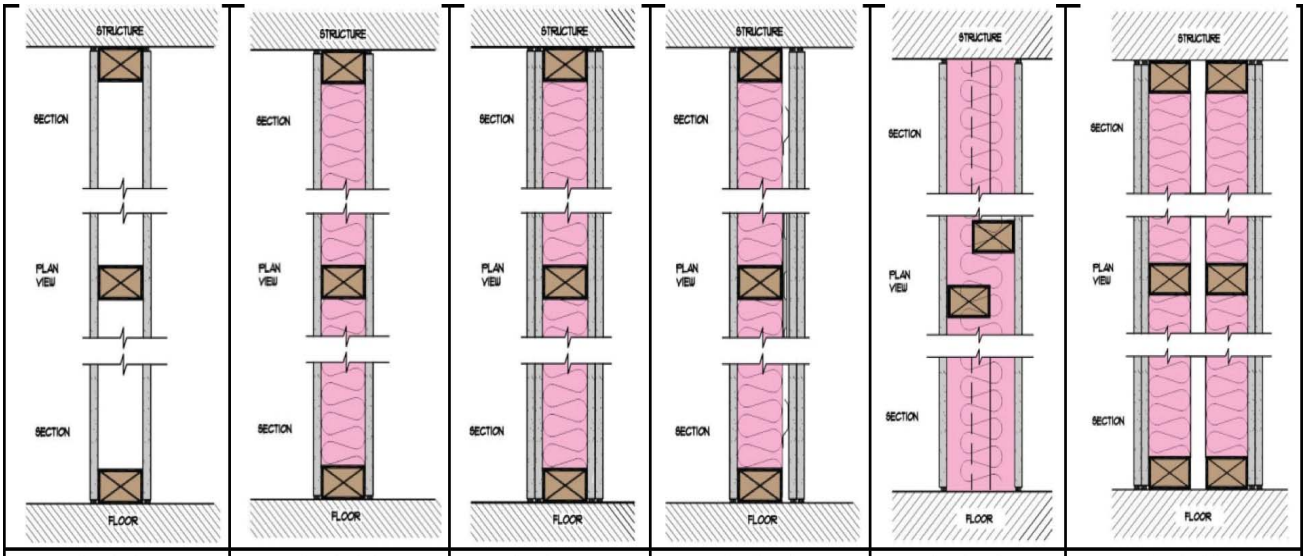


One of Many Performance Goals

University of Washington Student Housing
Seattle, WA
Architect: Mahlum
This five-building project includes a strategic combination of staggered and double stud walls to minimize sound transmission.

Photo: Benjamin Benschneider

Acoustically Rated Assemblies



STC 34	STC 38	STC 45	STC 50	STC 49	STC 63

Figure 1 - Acoustical Progression in Wood Framed Walls

Many available free online STC & IIC rated assembly charts (USG, GP, others)

Acoustically Rated Assemblies

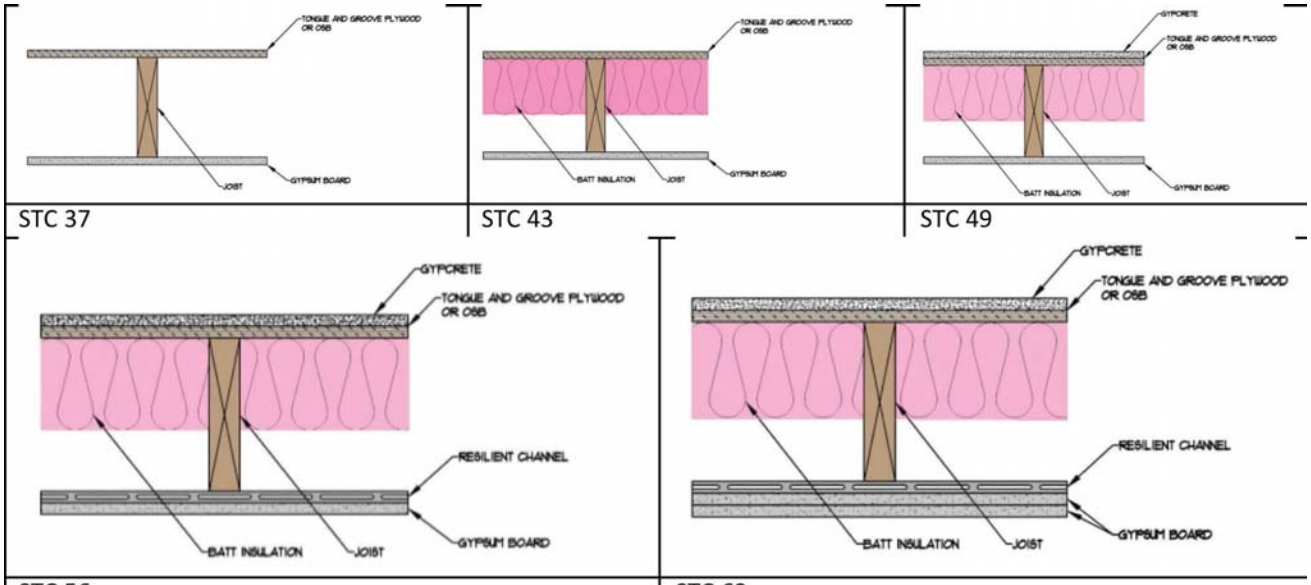
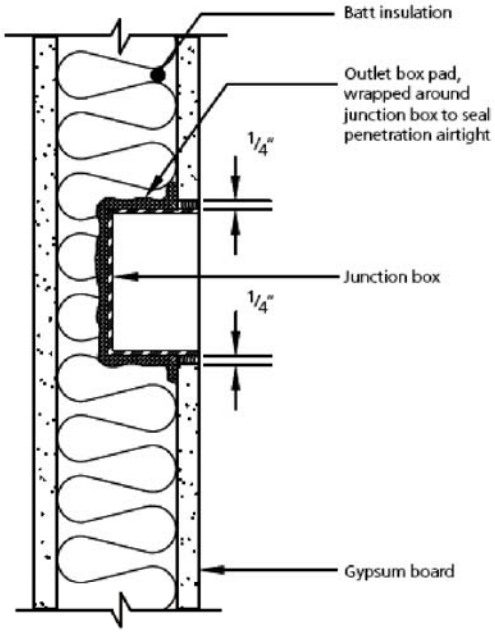


Figure 1 - Acoustical Progression in Wood Framed Floor / Ceilings

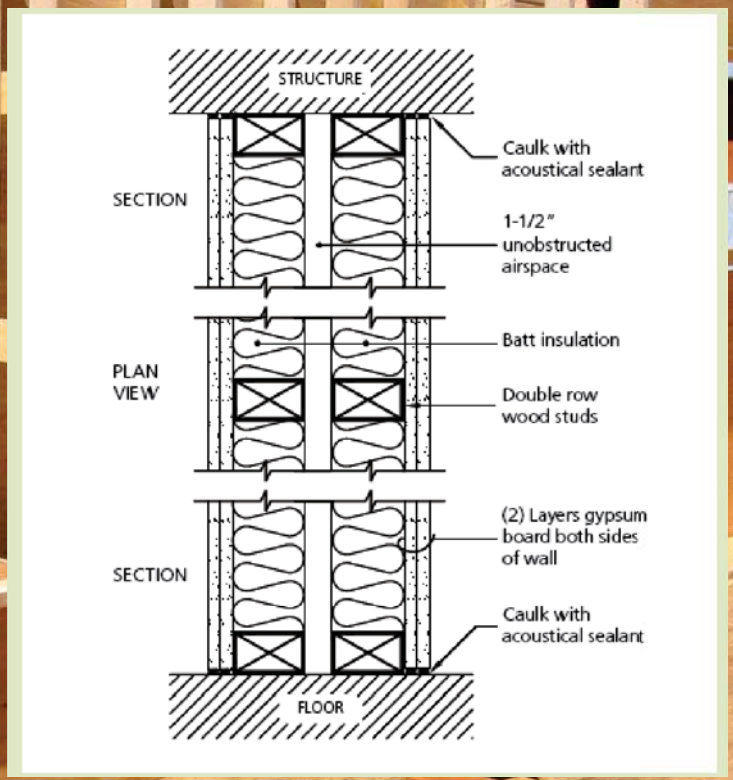
Air Tight and Insulated



Examples of ineffective and effective installation

Photo Dr. Energy Saver

Walls – Double Stud



STC 63 Party Wall

Photo: Econonest Architecture Inc.

Walls – Staggered and Single Stud

After double stud construction, the next best solutions are staggered and single stud.

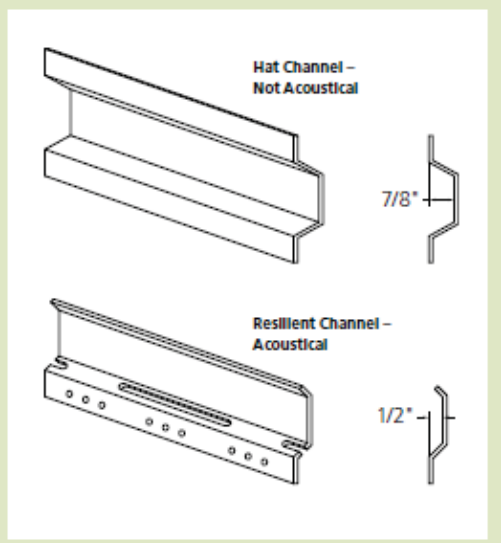
Photos: Root Graphics (l); Arch Wood Protection

Improvement Factor: Insulation

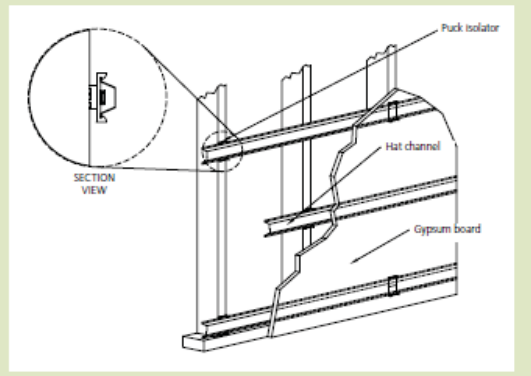
The most cost-effective acoustical improvement to a sound insulation system is the addition of batt insulation or any open cell foam system to the stud or joint cavity.

Photo Dreamstime

Improvement Factor: Resilient Channels

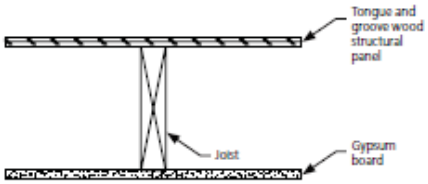


Metal channels found in wood framing

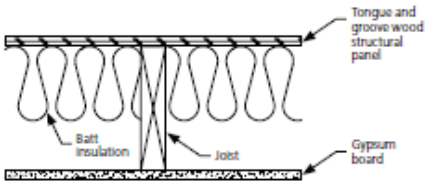


Acoustical 'puck isolator' wall detail (isometric view)

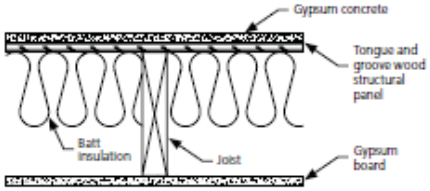
Floor-Ceiling Systems



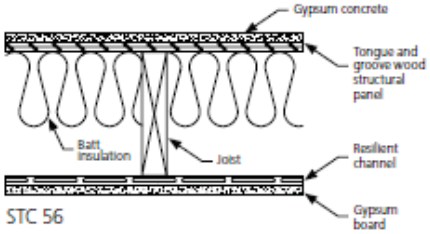
STC 37



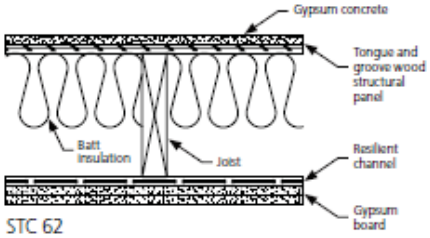
STC 43



STC 49

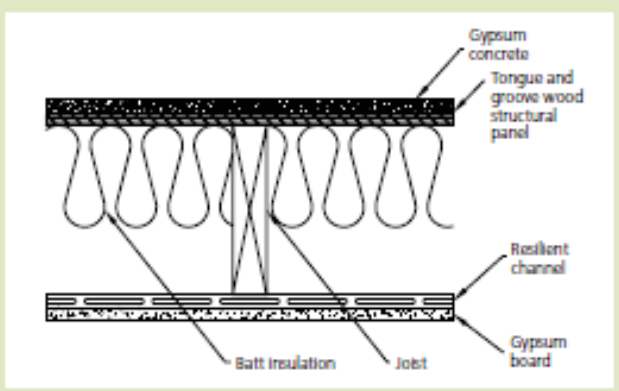


STC 56



STC 62

Acoustical Detailing

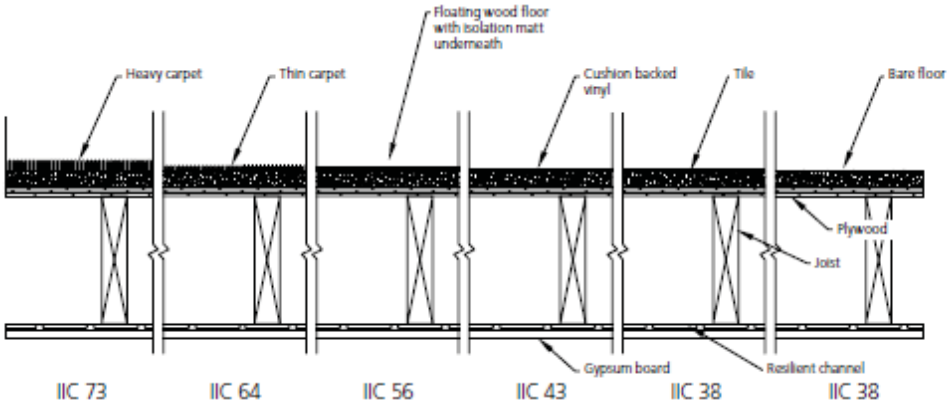


Effective floor-ceiling option includes:

- Gypcrete or light-weight concrete
- Impact isolation matt
- Tongue and groove subfloor (glued and screwed to the joist)
- Joist system (with 6 inches of batt insulation)
- Resilient channel or puck system (resilient system)
- Two layers of 5/8-inch type “X” gypsum board

Impact Isolation

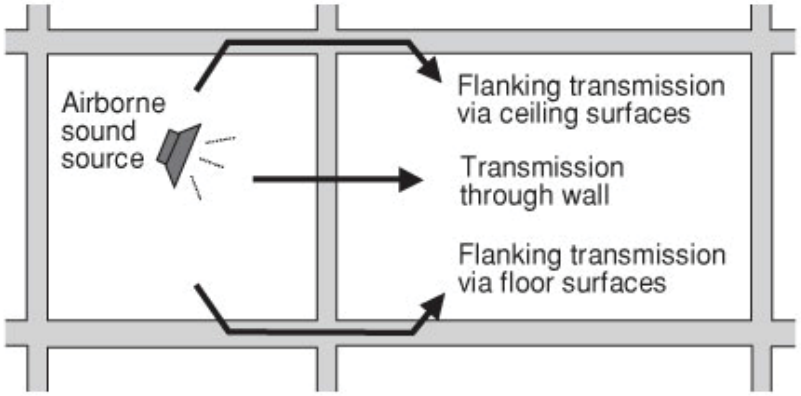
Impact Isolation Progression in Wood-Frame Floors/Ceilings (Section View)



For clarity, batt insulation in the joist cavity is not shown

Additional Acoustics Best Practices

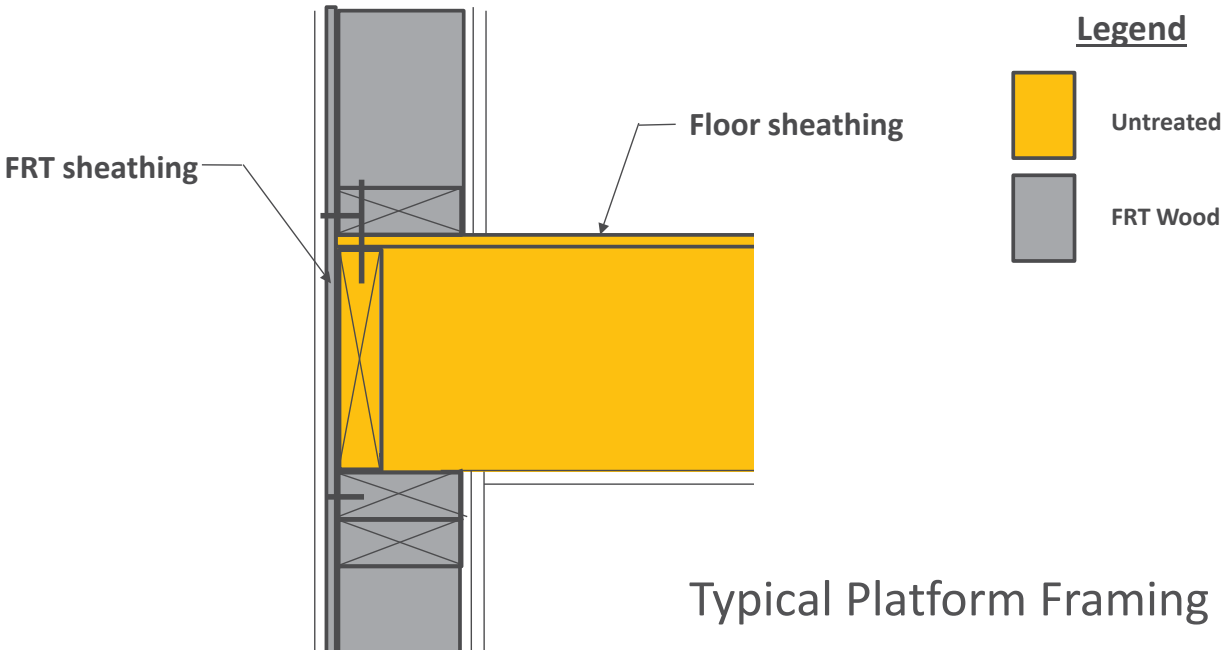
- Avoid creating flanking paths
- Isolate mechanical systems between units
- Seal openings in assemblies (where air flows, sound flows)
- Avoid aligning doors on opposite sides of common hallways



Outline

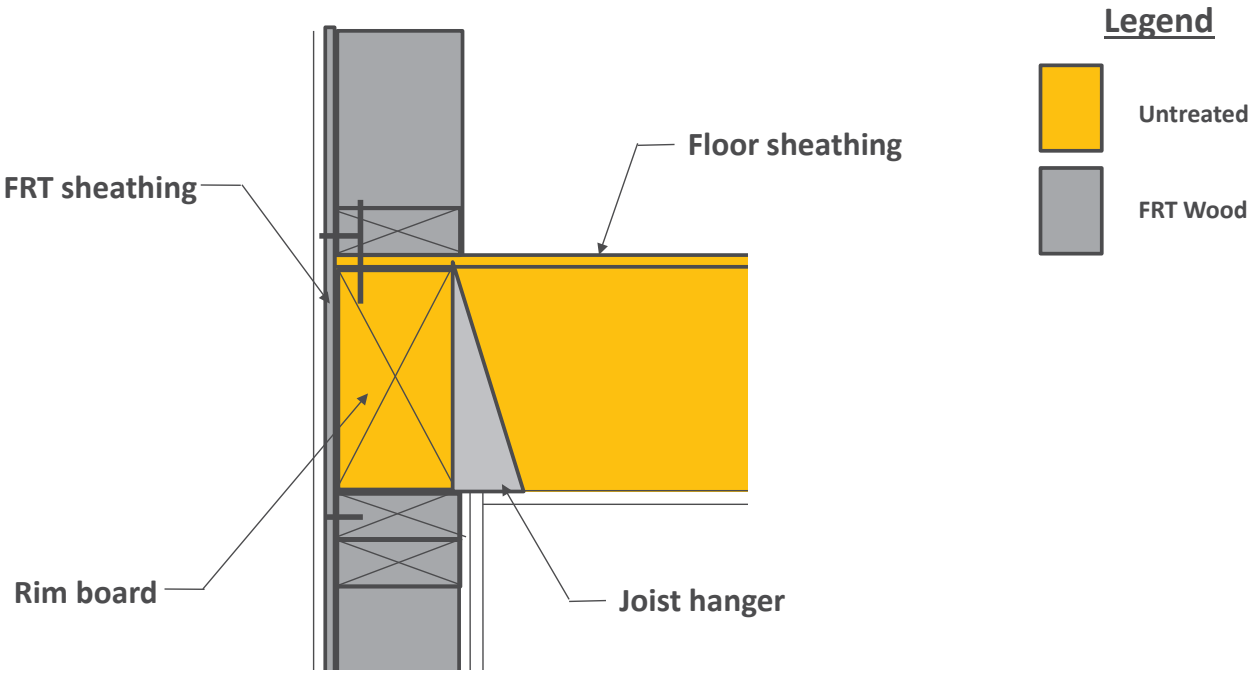
- Mid-Rise Construction Types & Life Safety Review
- Structural Design & Detailing Considerations
- Shrinkage Considerations & Detailing
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

Exterior Walls – Intersecting Floors



Typical Platform Framing

Exterior Walls – Intersecting Floors

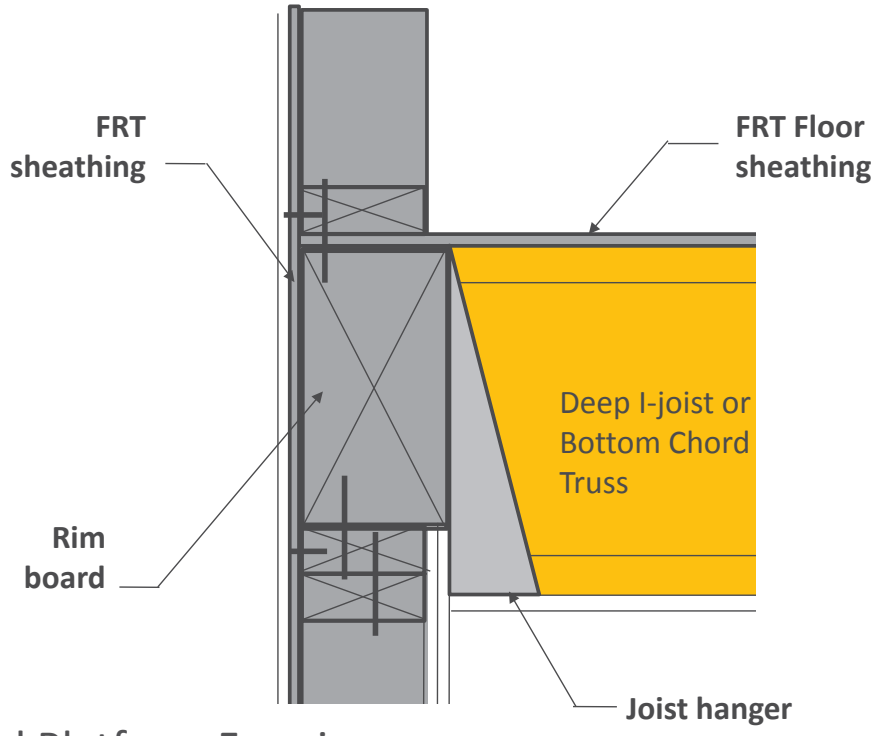


Modified Platform Framing

Fire Resistance of Exposed Members

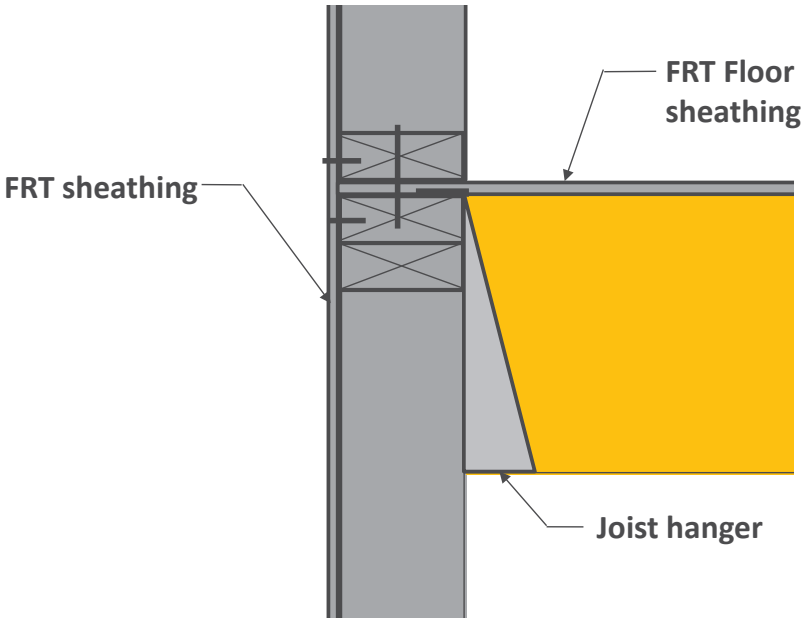
722.1 General. The provisions of this section contain procedures by which the *fire resistance* of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this section and shall not be otherwise used. The calculated *fire resistance* of concrete, concrete masonry and clay masonry assemblies shall be permitted in accordance with ACI 216.1/TMS 0216. The calculated *fire resistance* of steel assemblies shall be permitted in accordance with Chapter 5 of ASCE 29. The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AF&PA *National Design Specification for Wood Construction (NDS).*

Exterior Walls – Intersecting Floors



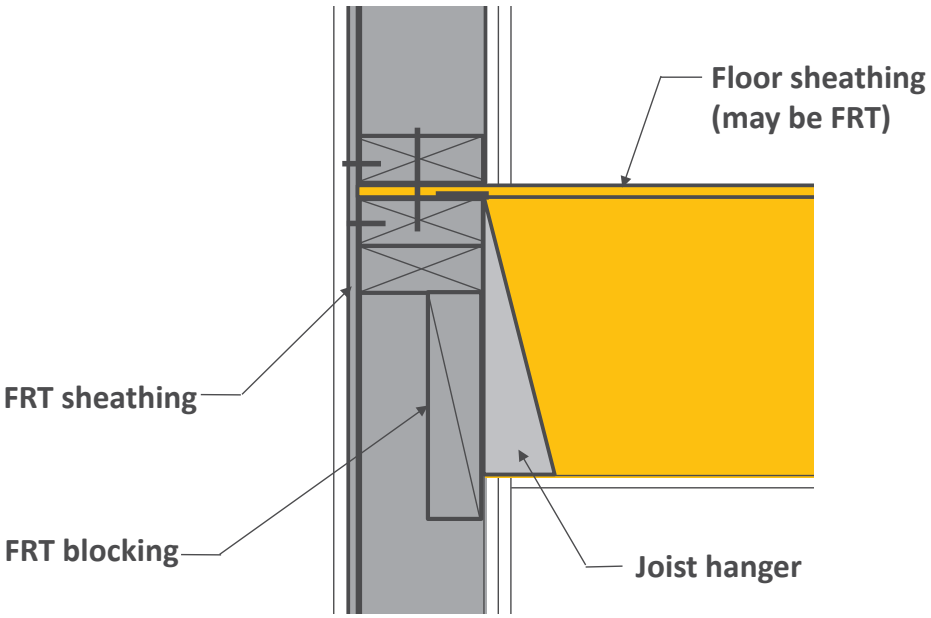
Modified Platform Framing

Exterior Walls – Intersecting Floors



Semi-Balloon Framing

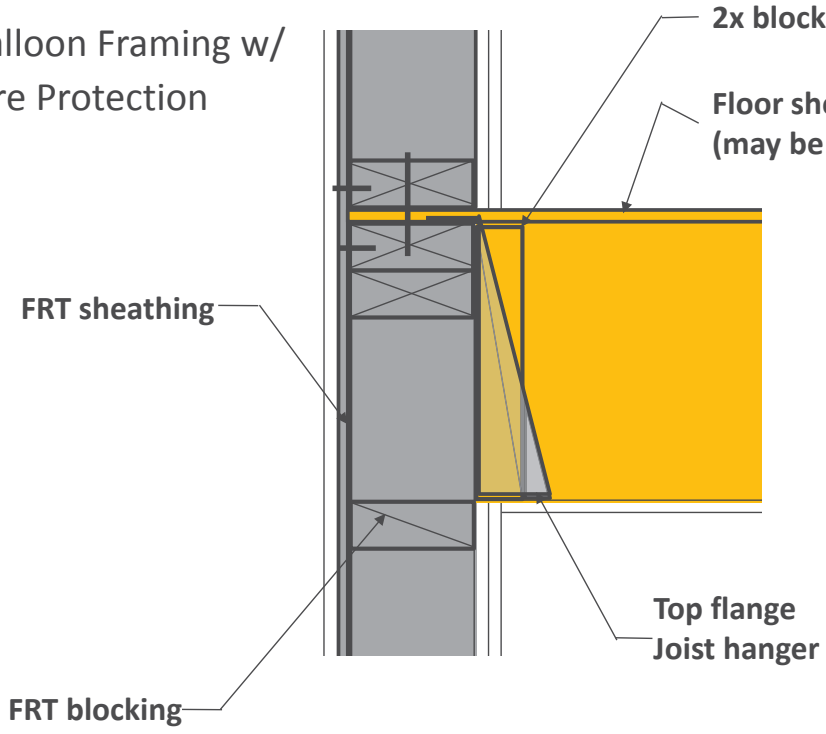
Exterior Walls – Intersecting Floors



Semi-Balloon Framing w/ Add'l Fire Protection

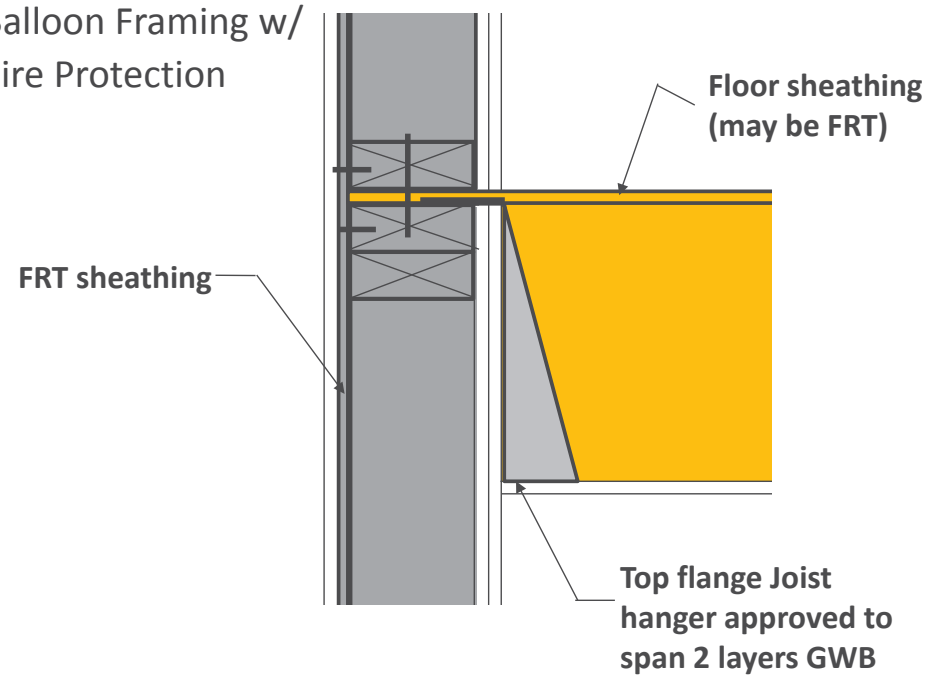
Exterior Walls – Intersecting Floors

Semi-Balloon Framing w/
Add'l Fire Protection

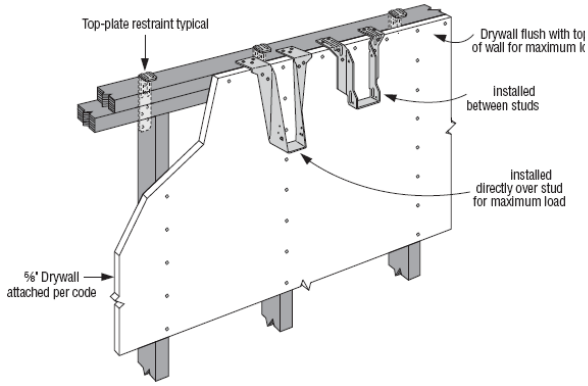


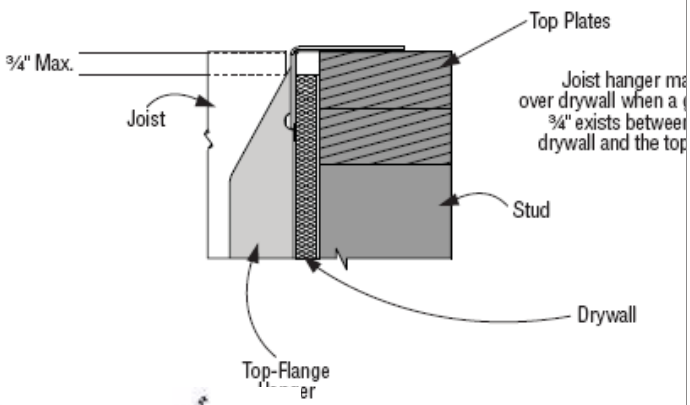
Exterior Walls – Intersecting Floors

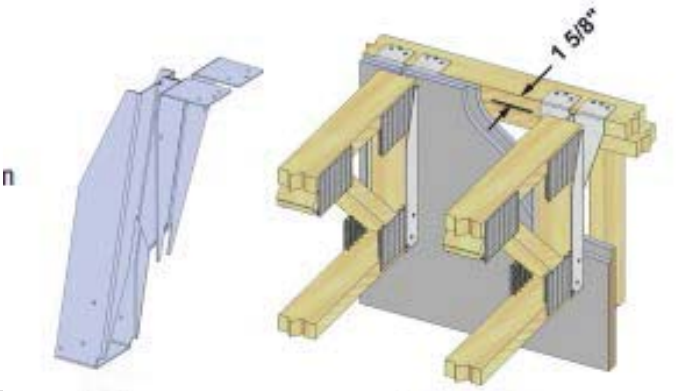
Semi-Balloon Framing w/
Add'l Fire Protection



Over Gypsum Hangers

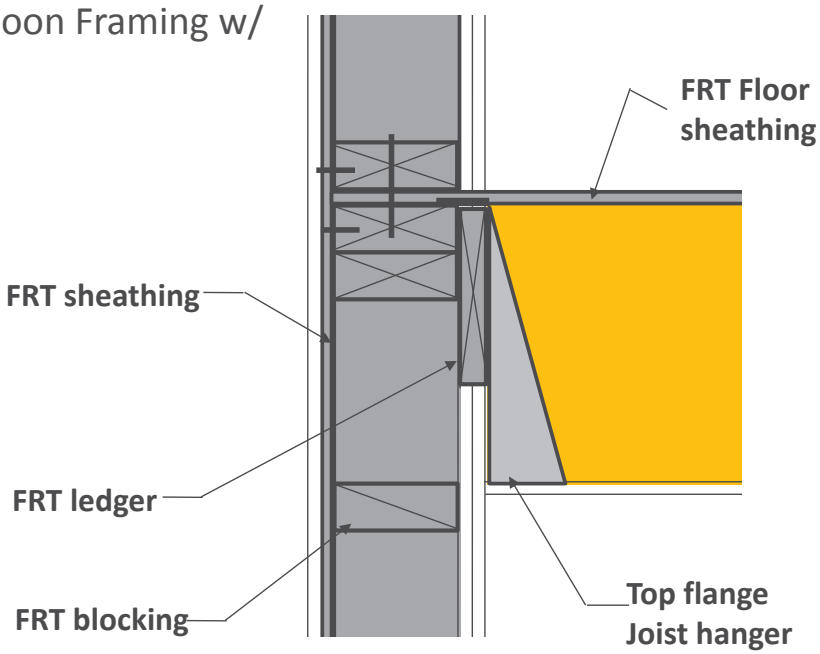






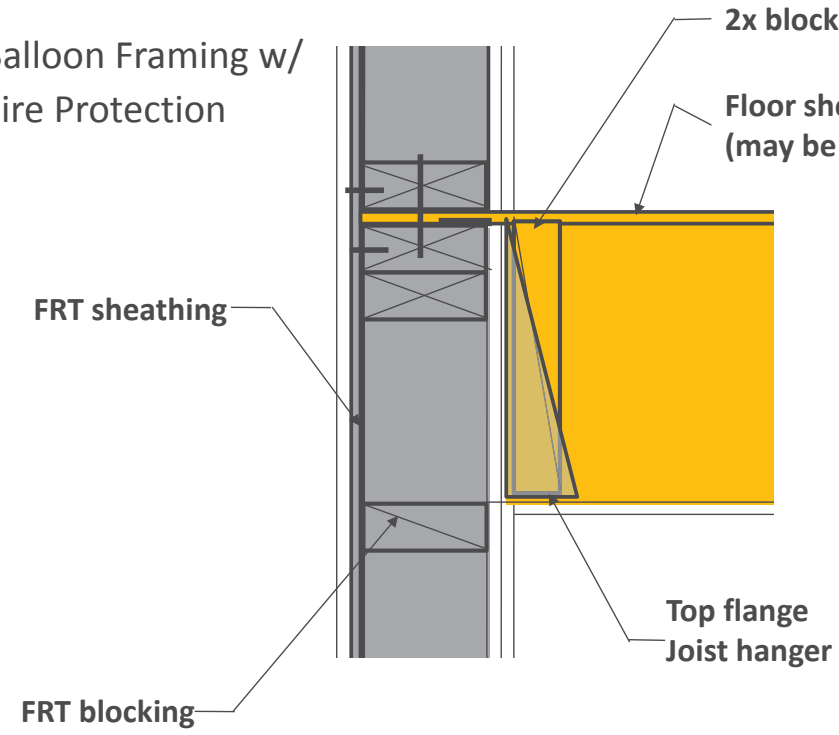
Exterior Walls – Intersecting Floors

Semi-Balloon Framing w/ Ledger



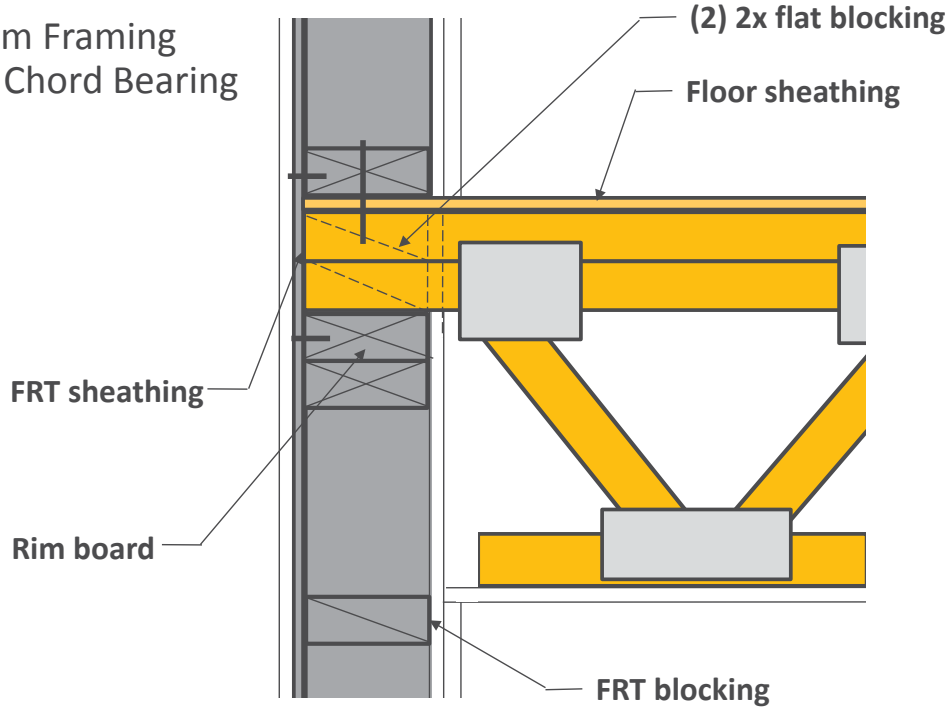
Exterior Walls – Intersecting Floors

Semi-Balloon Framing w/
Add'l Fire Protection



Type III Construction Detail Example

Platform Framing
w/Top Chord Bearing



Type III Construction Detail Examples

What is being enforced in jurisdictions you are working in?

Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

Speaker Name
Speaker organization
Speaker email address