

Frame it Right: Optimizing Size and Framing Efficiency in Mid-Rise Wood Buildings

September 24, 2025

Presented by

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Image: Stella, DesignARC, Taylor and Syfan, Photo Lawrence Anderson/Esto

Course Description

Increasingly, building designers and developers are looking to mid-rise light-frame wood construction as a cost-effective and sustainable solution for commercial and multi-family buildings. This presentation will review the allowable construction types, with an emphasis on the opportunities and advantages of using light-frame wood in Types III and V. Today's speakers will cover design considerations associated with these types of projects, including how to maximize height and area through the use of sprinklers, open frontage, sloping sites, podiums, and mezzanines. Common framing methods will also be discussed in the context of ensuring that projects are designed to be structurally sound, constructable, and code compliant.

Learning Objectives

1. Discuss how mid-rise, light-frame wood construction meets the need for additional commercial space and multi-family housing while contributing to vibrant and sustainable communities.
2. Review allowable construction types, occupancies, and building heights and areas for mid-rise light-frame wood construction under the 2022 California Building Code (CBC).
3. Explore potential modifications to the CBC's base tabular heights and areas based on building frontage, sprinklers, sloping sites, podiums, and mezzanines.
4. Understand how to design for standard framing practices to avoid costly construction errors and ensure the resulting building is structurally sound and code compliant.



Mid-Rise Design: Optimizing Size, Maximizing Value



INTRODUCTION TO HEIGHTS AND AREAS
FOR MID-RISE MULTI-FAMILY LIGHT-FRAME
WOOD BUILDINGS

September 24, 2025

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Mike Romanowski, SE
Senior Regional Director | CA-South, AZ, NM

Outline

- » Context for Mid-Rise Construction (Urban Densification)
- » Mid-Rise Building Configurations
- » Maximizing Height & Area
- » Case Studies



Landing Apartments, Russell Scott Steedle & Capione Architects, photo Gregory Folkins

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1430 Q, The HR Group Architects, Buehler Engineering, Greg Folkins Photography

Global Population Boom

Global Population

7.9 billion in 2022

9.7 billion by 2050

23% increase

Urban Population

6.4 billion by 2050

40% increase

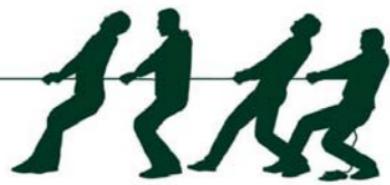


Source: United Nations Department of Economic and Social Affairs

Need for Sustainable Multi-Family & Mixed-Use Structures



Economically Meet our
Urban Housing Needs



Increased Environmental
Responsibility

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

Mid-Rise Construction

Where **wood** is a viable option,
it's likely the most appropriate choice.

- » Senior Living
- » Apartments/Condos
- » Mixed-Use
- » Student Housing
- » Affordable Housing
- » Hotels



The Gibson, Hummel Architects, KPFF Consulting Engineers, photo Leo A. Geis

Why Wood?

- Using wood helps reduce environmental impact
- Wood products play a significant role in the modern economy

Wood Costs Less

Wood is Versatile

Wood Meets Code

Wood is Durable

Wood is Renewable

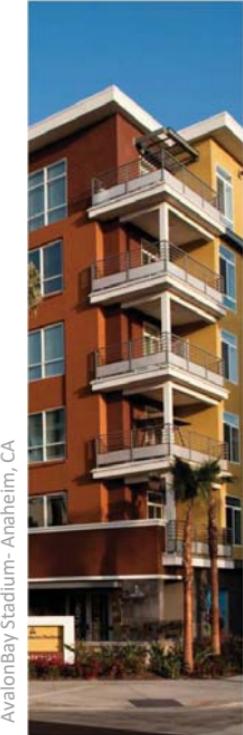


Photo courtesy OFRI



The Gibson, Hummel Architects, KPFF Consulting Engineers, photo Leo A. Geis

Carbon Footprint | High Density Housing



Sustainability Advantage

AvalonBay Stadium-Anaheim, CA



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 CO₂



Avoided greenhouse gas emissions:

8,440 metric tons of CO₂



TOTAL POTENTIAL CARBON BENEFIT:

12,410 metric tons of CO₂

EQUIVALENT TO:

Source: US EPA



2,370 cars off the road for a year



Energy to operate a home for 1,050 years

For information on the calculations in this chart, visit woodworks.org
Note: CO₂ on this chart refers to CO₂ equivalent.

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1430 Q, The HR Group Architects, Buehler Engineering, Greg Folkins Photography

Mid-Rise Wood Construction

How many stories
can be wood framed
in the CBC?

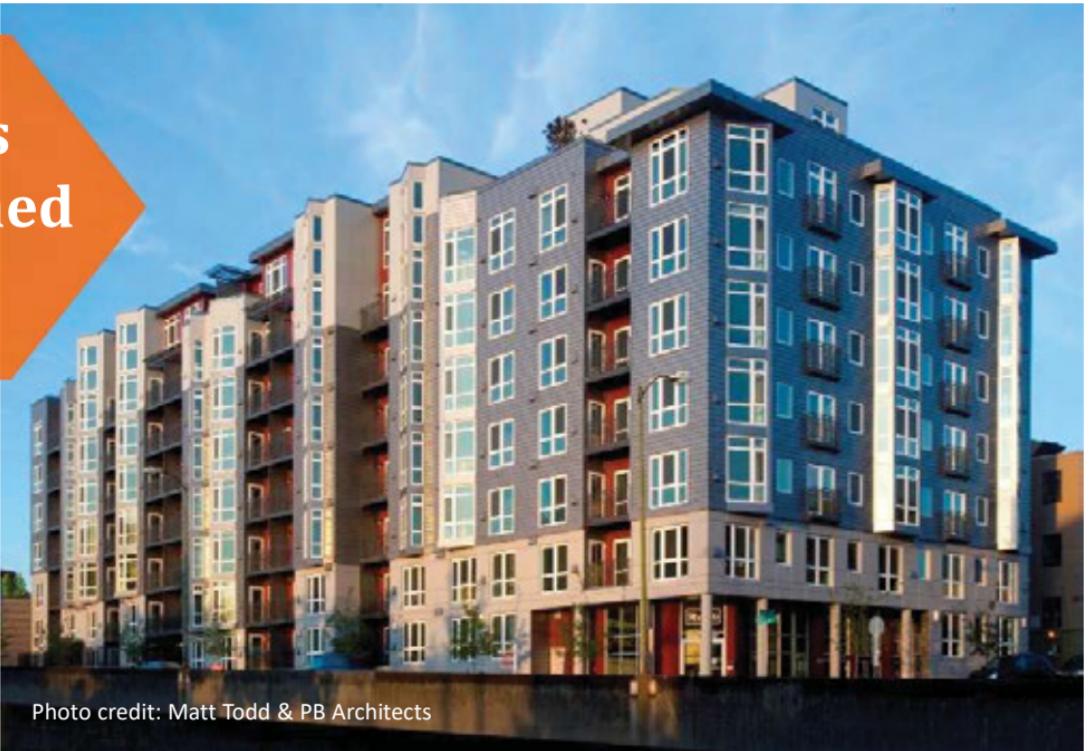


Photo credit: Matt Todd & PB Architects

Mid-Rise Wood Construction

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



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 (20-35 units/acre)



Wrap-Around (aka the Texas Donut)

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-stories yields 60-80 units/acre



Podium (not a code-defined term)

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



4 Over 1 Podium

**4 wood stories of residential
over 1-story (parking or
retail) podium**

» 80–100 units/acre

Inman Park Condos, Atlanta, GA
Davis & Church



5 Over 1 Podium

5 wood stories of residential over 1-story (parking or retail) podium

» 100–120 units/acre

AvalonBay Stadium, Anaheim, CA
VanDorpe Chou Associates



Inman Park Condos, Atlanta, GA
Davis & Church

5 Over 1 Podium

5 wood stories of residential over 1-story (residential) podium

» 120–140 units/acre

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



Outline

- » Context for Mid-Rise Construction (Urban Densification)
- » Mid-Rise Building Configurations
- Maximizing Height & Area
 - 1. Construction Types
 - 2. Tabulated Heights & Areas
 - 3. Measuring Height
 - 4. Sprinkler Systems
 - 5. Frontage
 - 6. Calculating Allowable Building Area
 - 7. Basements, Mezzanines & Special Design Provisions
- » Case Studies



1430 Q, The HR Group Architects, Buehler Engineering, Greg Folkins Photography

Construction Types – Section 602

Type V

- » All building elements can be any material allowed by code
- » Subdivided into **V-A** (protected) and **V-B** (unprotected)

Type IV (Heavy/Mass Timber)

- » Minimum prescriptive sizes per CBC Section 2304.11
- » Exterior walls must be noncombustible or MT (may be FRTW in **IV-HT**)
- » Interior building elements must be noncombustible or MT (may be light-frame wood in **IV-HT** if fire rated)
- » Subdivided into **IV-A**, **IV-B**, **IV-C** and **IV-HT**, each with different levels of protection

Type III

- » Exterior walls must be noncombustible (may be FRTW in most cases)
- » Interior building elements can be any material allowed by code
- » Subdivided into **III-A** (protected) and **III-B** (unprotected)

Tabulated Heights & Areas

TABLE 504.3
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE ^{a, f}

OCCUPANCY CLASSIFICATION	See Footnotes	TYPE OF CONSTRUCTION										
		Type I		Type II		Type III		Type IV				
		A	B	A	B	A	B	A	B	C	HT	
B, F, M, S, U	NS ^b	UL	160	65	55	65	55	65	65	65	50	40
	S	UL	180	85	75	85	75	270	180	85	70	60
R-2 ^b	NS ^d	UL	160	65	55	65	55	65	65	65	50	40
	S13R	60	60	60	55	60	55	60	60	60	50	40
	S (without area increase)	UL	180	85	75	85	75	270	180	85	70	60
	S (with area increase)	UL	160	65	55	65	55	250	160	65	60 ^j	40

TABLE 504.4
ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE ^{a, b, f}

OCCUPANCY CLASSIFICATION	See Footnotes	TYPE OF CONSTRUCTION										
		Type I		Type II		Type III		Type IV				
		A	B	A	B	A	B	A	B	C	HT	
B	NS	UL	11	5	3	5	3	5	5	5	3	2
	S	UL	12	6	4	6	4	18	12	9	4	3
R-2 ^b	NS ^d	UL	11	4	4	4	4	4	4	4	3	2
	S13R	4	4	4	4	4	4	4	4	4	4	3
	S (without area increase)	UL	12	5	5	5	5	18	12	8	4	3
	S (with area increase)	UL	11	4	4	4	4	17	11	7	4	2

Tabulated Heights & Areas

TABLE 506.2
ALLOWABLE AREA FACTOR (A_r = NS, S1, S13R, S13D or SM, as applicable) IN SQUARE FEET^{a, b, c}

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION											
		Type I		Type II		Type III		Type IV					
		A	B	A	B	A	B	A	B	C	HT	A	B
B	NS	UL	UL	37,500	23,000	28,500	19,000	108,000	72,000	45,000	36,000	18,000	9,000
	S1	UL	UL	150,000	92,000	114,000	76,000	432,000	288,000	180,000	144,000	72,000	36,000
	SM	UL	UL	112,500	69,000	85,500	57,000	324,000	216,000	135,000	108,000	54,000	27,000
R-2 ^b	NS ^d	UL	UL	24,000	16,000	24,000	16,000	61,500	41,000	25,625	20,500	12,000	7,000
	S13R			96,000	64,000	96,000	64,000	246,000	164,000	102,500	82,000	48,000	28,000
	S1	UL	UL	72,000	48,000	72,000	48,000	184,500	123,000	76,875	61,500	36,000	21,000
	SM (without height increase)	UL	UL	24,000	16,000	24,000	16,000	61,500	41,000	25,625	20,500	12,000	7,000
	SM (with height increase)	UL	UL	24,000	16,000	24,000	16,000	61,500	41,000	25,625	20,500	12,000	7,000
R-2 Type VA construction ^e	NS ^f	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	12,000	NP
	S13R	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	12,000	NP
	S1	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	48,000	NP
	SM (without height increase)	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	36,000	NP
	SM (with height increase)	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	36,000 ^g	NP

NS = Buildings not equipped throughout with an automatic sprinkler system

S1 = Buildings a maximum of one story above grade plane equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1 (NFPA 13)

SM = Buildings two or more stories above grade plane equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1 (NFPA 13)

S13R = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.2 (NFPA 13R)

Measuring Height – Chapter 2 Definitions

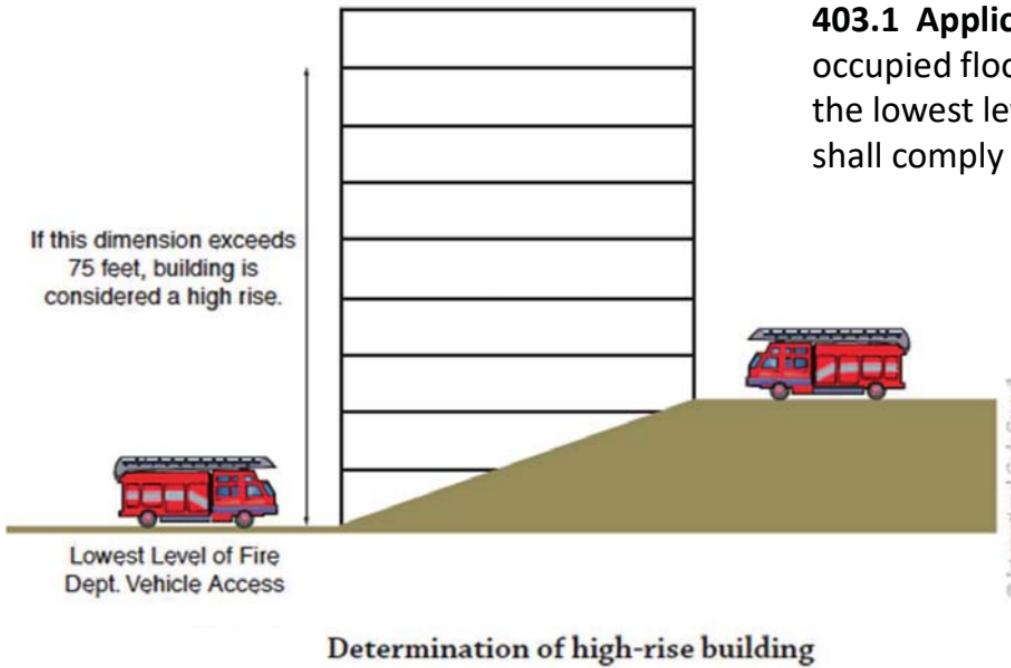
HEIGHT, BUILDING. The vertical distance from *grade plane* to the average height of the highest roof surface.

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 from the building, between the building and a point 6 feet from the building.



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

Measuring Height – Section 403



403.1 Applicability. New high-rise buildings having occupied floors located more than 75 feet above the lowest level of fire department vehicle access shall comply with Sections 403.2 through 403.7.

Sprinkler Systems

In many cases, sprinklers are required by code depending on occupancy per Section 903.2

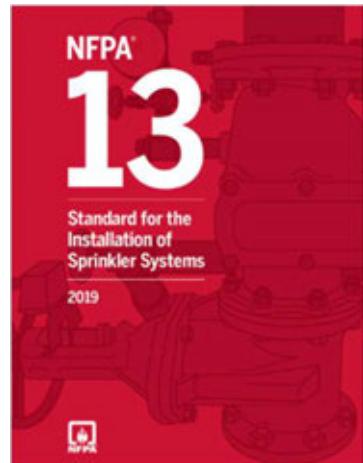
- » Most new Group R fire areas
- » Group A, E, M or S fire areas exceeding 1k-48k sf



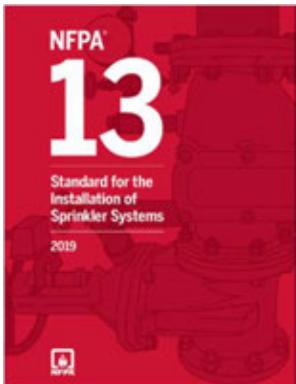
Stella Apartments, DesignARC, Taylor and Syfan, photo Lawrence Anderson

Sprinkler Systems

- » NFPA 13
Standard for Commercial Occupancies per CBC Section 903.3.1.1
- » NFPA 13R
Standard for Low-Rise Residential Occupancies per CBC Section 903.3.1.2
- » NFPA 13D
Standard for One and Two-Family Residences per CBC Section 903.3.1.3



Sprinkler Systems – NFPA 13 vs. NFPA 13R



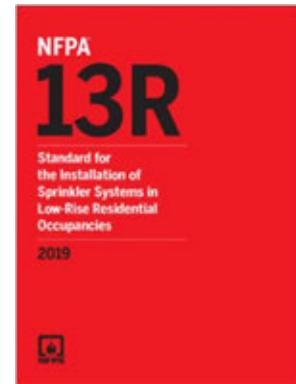
NFPA 13

Goal: Provide life safety and property protection

Fully sprinklered system throughout entire building even in unoccupied spaces (closets, attics)

Can cost more

Permitted for many occupancies, buildings of many sizes, allows greater building size increases



NFPA 13R

Goal: Provide life safety only

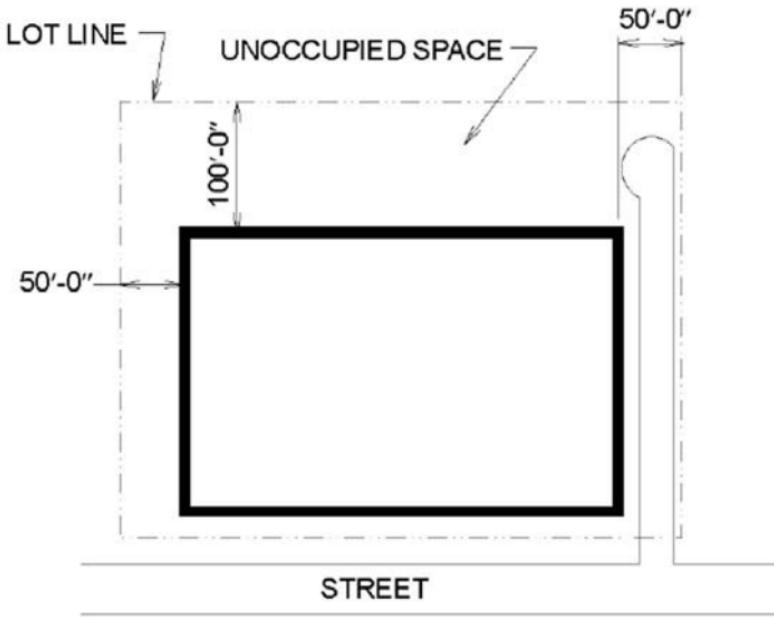
Partially sprinklered system; unoccupied spaces often don't require sprinklers

Lower levels of water discharge, shorter water supply time can result in smaller pipe sizes, reduce need for storage & pumps

Limited applications, mainly for multi-family up to 4 stories, 60 feet

Frontage – Section 506.3

The allowable area of a building is permitted to be increased when it has a certain amount of frontage on streets (public ways) or open spaces, since this provides access to the structure by fire service personnel, a temporary refuge area for occupants as they leave the building in a fire emergency and a reduced fire exposure to and from adjacent structures.



Frontage – Sections 506.3.1 & 506.3.2

MINIMUM QUALIFICATIONS

25% min. of the building perimeter is on a public way or open space 20' min. distance from the building face to:

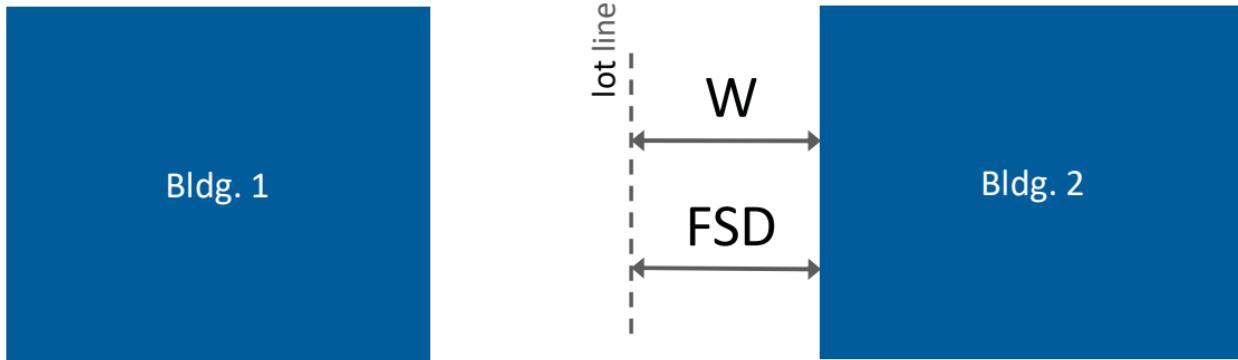
- » The closest interior lot line
- » The entire width of a street, alley or public way
- » The exterior face of an adjacent building on the same property

Frontage

The width “W” of public way or open space is NOT always the same as fire separation distance (FSD) used for purposes of determining fire resistance ratings of exterior walls and openings

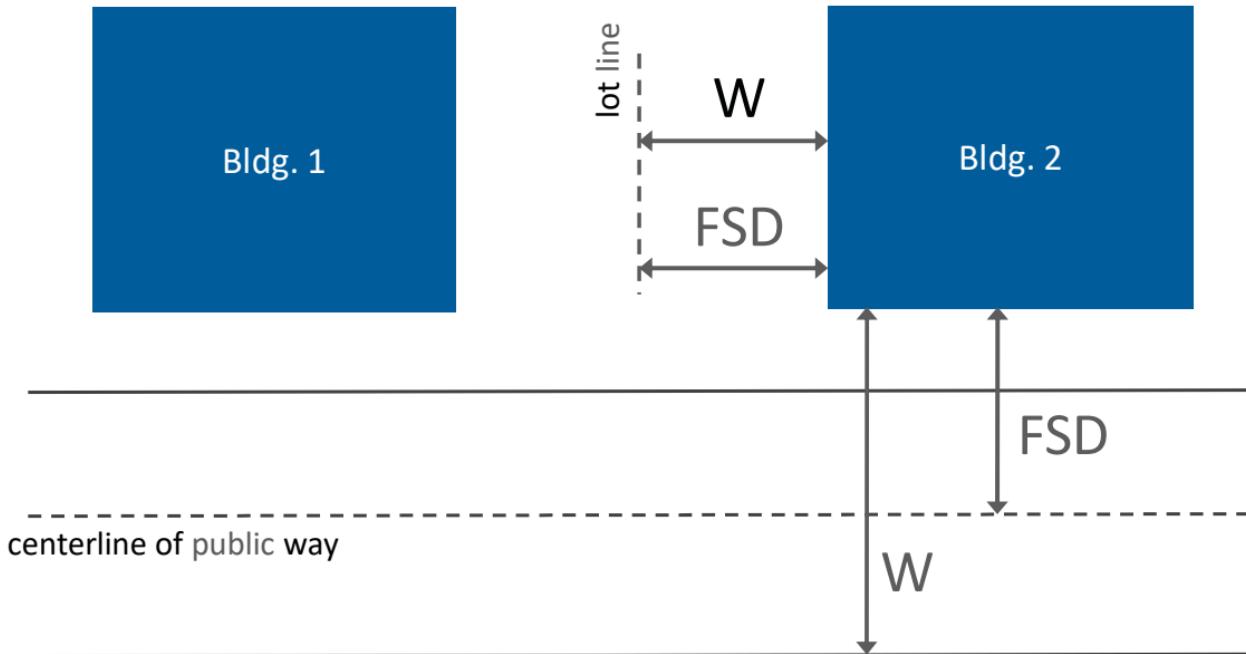
Frontage – Section 506.3.2

For two buildings on DIFFERENT lots



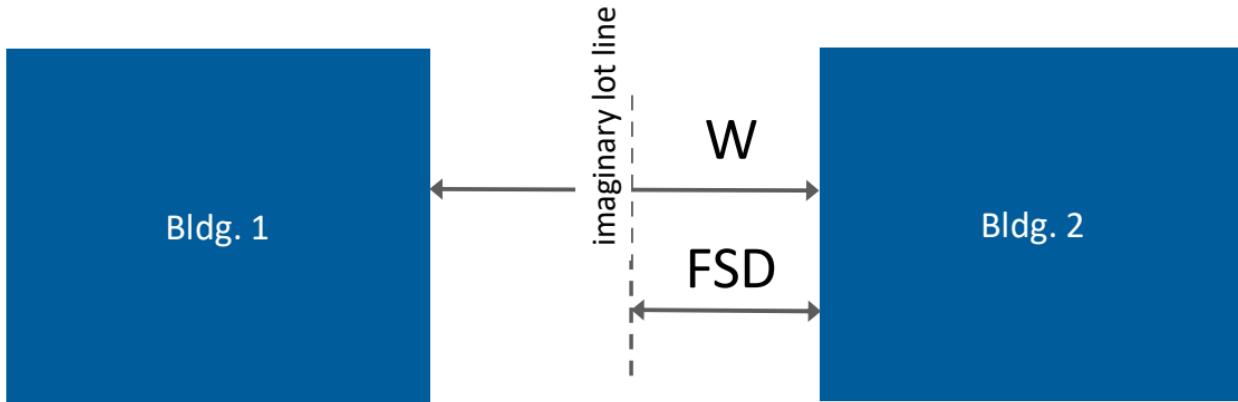
Frontage – Section 506.3.2

For buildings near public right of ways:



Frontage – Section 506.3.2

For two buildings on the SAME lot



Frontage – 2019 CBC Section 506.3.2

$$W = [(L_1 \times w_1) + (L_2 \times w_2) + (L_3 \times w_3) \dots] / F$$

(Equation 5-4)

WHERE:

W = Calculated width (weighted average) of public way or open space (feet)

L_n = Length of a portion of the exterior perimeter wall

w_n = Width (≥ 20 feet) of public way or open space associated with that portion of the exterior perimeter wall

F = Building perimeter that fronts on a public way or open space having a width of 20 feet or more

Frontage – 2019 CBC Section 506.3.3

$$I_f = [F/P - 0.25] W/30$$

(Equation 5-5)

Where:

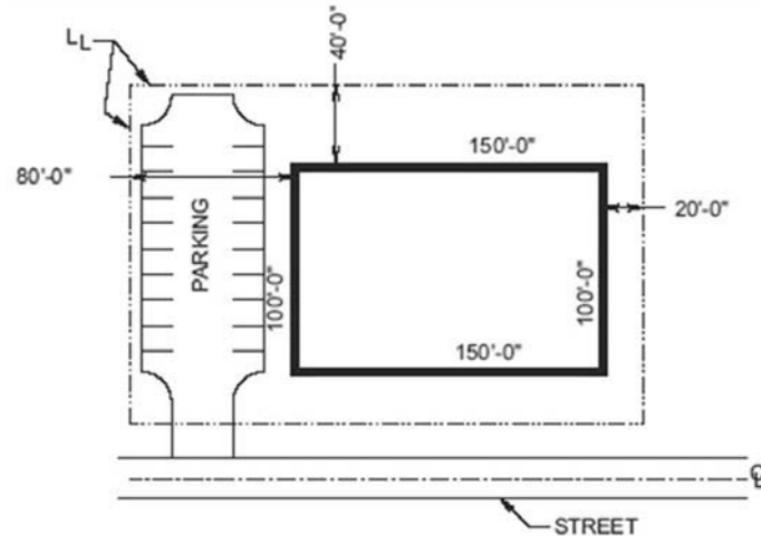
I_f = Area factor increase due to frontage ($I_{f\max.} = 0.75$)

F = Building perimeter that fronts on a public way or open space having a minimum distance of 20 feet

P = Perimeter of entire building (feet)*

W = Width of public way or open space (feet) in accordance with Section 506.3.2 (30 feet max.)

* Fire walls must be treated like a perimeter wall with zero frontage



SITE PLAN

Frontage – 2022 CBC Section 506.3.3

506.3.3 Amount of increase. The area factor increase based on frontage shall be determined in accordance with Table 506.3.3.

TABLE 506.3.3
FRONTAGE INCREASE FACTOR*

PERCENTAGE OF BUILDING PERIMETER	OPEN SPACE (feet)			
	0 to less than 20	20 to less than 25	25 to less than 30	30 or greater
0 to less than 25	0	0	0	0
25 to less than 50	0	0.17	0.21	0.25
50 to less than 75	0	0.33	0.42	0.50
75 to 100	0	0.50	0.63	0.75

Calculating Allowable Building Area (Single-Occupancy Building 3** Stories or Less) – Section 506.2.1

$$A_a = A_t + (NS \times I_f)$$

(Equation 5-1)

A_a = Allowable area of each story (sq. ft.)

A_t = Tabular allowable area factor (**NS**, **S1** or **S13R**) per Table 506.2*

NS = Tabular allowable area factor per Table 506.2 for nonsprinklered building (sprinklered or not)

I_f = Area factor increase due to frontage (percent) per Section 506.3

* Code error; **SM** should have been included

** Code error; for A, E, H, I, L and R occupancies, Equation 5-1 should apply to buildings 2 stories or less

Calculating Allowable Building Area (Single-Occupancy Building More Than 3* Stories) – Section 506.2.1

$$A_a = [A_t + (NS \times I_f)] \times S_a$$

(Equation 5-2)

A_a = Allowable area (sq. ft.)

A_t = Tabular allowable area factor (NS, S13R or SM) per Table 506.2

NS = Tabular allowable area factor per Table 506.2 for nonsprinklered building (sprinklered or not)

I_f = Area factor increase due to frontage (percent) per Section 506.3

S_a = Except for A, E, H, I, L and R occupancies, actual number of stories above grade plane, not to exceed 3. For A, E, H, I, L and R occupancies, actual number of stories above grade plane, not to exceed 2.

* Code error; for A, E, H, I, L and R occupancies, Equation 5-2 should apply to buildings more than 2 stories

Basements on Sloping Sites- Section 506.1.3

Basements need not be included in the total allowable floor area of a building provided the total area of such basements does not exceed the area permitted for a one-story above grade plane building.

A “basement” is defined as “A story that is not a story above grade plane” such that the finished surface of the floor next above is:

- No more than 6 feet above grade plane; and
- No more than 12 feet above the finished ground level at any point



Fashion Valley, CA
AvalonBay Communities

Mezzanines – Section 505.2

Mezzanines are considered a portion of the story below and are not counted toward building area* or number of stories if:

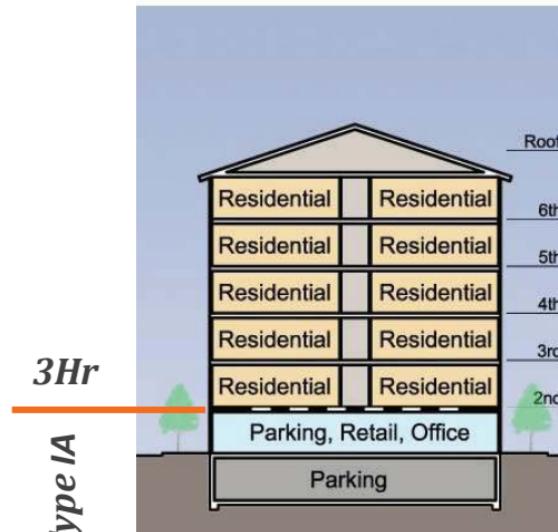
- » Maximum 1/3 the floor area of a *room* or *space* where located (1/2 the floor area within dwelling units located in buildings equipped throughout with NFPA 13 or NFPA 13R sprinkler systems)
- » Special egress provisions apply
- » Must be open and unobstructed to room in which it's located (walls \leq 42" allowed)
 - » Several exceptions
- » Slightly different for equipment platforms

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

Special Design Provisions (Podiums) – Section 510.2



5-story Type III building



5-story Type III building
on top of a Type I-A podium

Increases total allowable stories...not allowable building height

Special Design Provisions (Podiums) – Section 510.2

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

- » Overall height is still limited to min. of either building
- » 3-hr rated horizontal assembly
- » Building below is Type I-A with sprinklers
- » Enclosures penetrating horizontal assembly are 2-hr rated
- » Occupancy above is A (occupant load <300), B, M, R or S
- » Occupancy below is anything except H
- » Fire walls (if req'd), can terminate at podium level

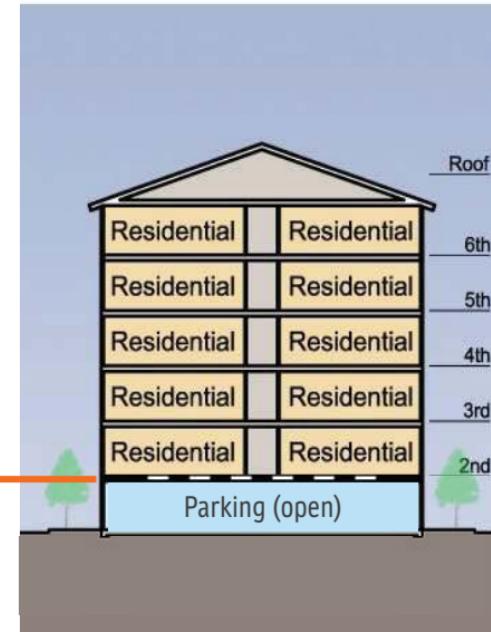
The Flats at ISU, Normal, IL
OKW Architects
Precision Builders & Associates



Special Design Provisions (Wood Podiums) - Section 510.4

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

- » Occupancy above is R and below is S-2
- » Parking garage is open Type IV parking with grade entrance
- » Horizontal assembly between 1st and 2nd floor shall be:
 - » Type IV
 - » Have 1-hr fire rating when sprinklered
 - » Have 2-hr fire rating when not sprinklered
- » Overall height from grade is still limited by the R occupancy



<http://www.woodworks.org/experttip/can-parking-incorporated-mixed-use-wood-frame-buildings-construction-type-perspective/>

Parking beneath Group R

Wood Podiums

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' Multi-family 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 gypsum (or light weight concrete) topping over wood structural panels supported by I-joints 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 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



Multi-Story Wood Construction

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

Sponsored by reThinking Wood and WoodWorks

Photo: Lawrence Anderson, www.woodworks.org

Stella Marina del Rey, California
Architect: DesignARC

Photo: Lawrence Anderson, www.woodworks.org

CONTINUING EDUCATION

EARN ONE AIA/CES HSW
LEARNING UNIT (LU)

EARN ONE GBC CE HOUR FOR LEED
CREDENTIALED MAINTENANCE

Learning Objectives

- Identify the sustainability and economic benefits of using wood construction for mid-rise buildings.
- Summarize building code requirements and provisions for mid-rise multi-family

CONTINUING EDUCATION

Outline

- » Context for Mid-Rise Construction (Urban Densification)
- » Mid-Rise Building Configurations
- » Maximizing Height & Area
- » Case Studies



1430 Q, The HR Group Architects, Buehler Engineering, Greg Folkins Photography

Case Study – Wood Buildings Aim High

Inman Park Condominiums

Atlanta, GA

Architect: Brown Doane Architects

Engineer: Davis & Church



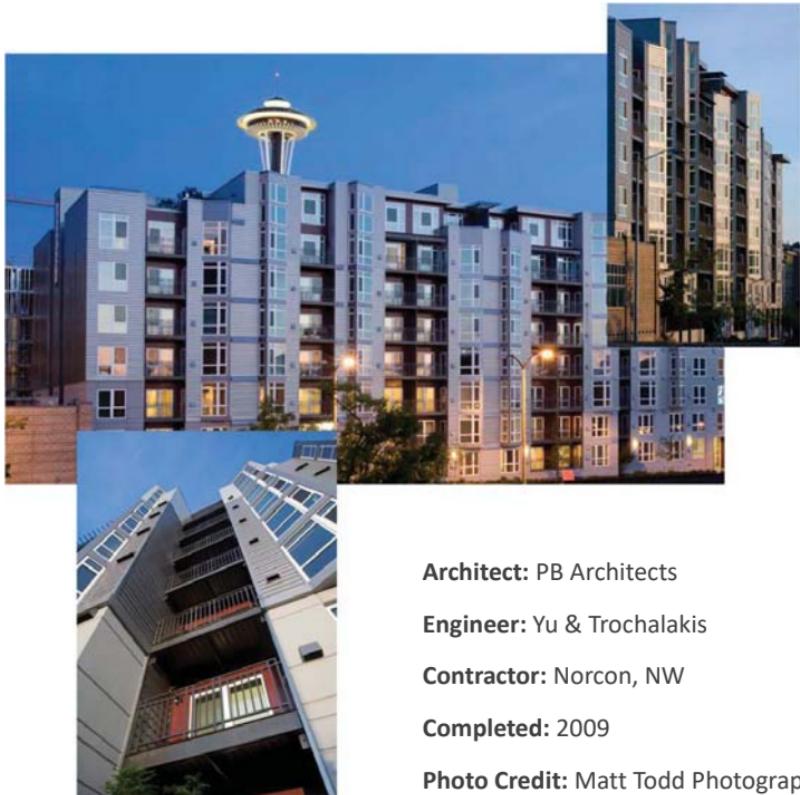
4 stories of wood over 1 story of concrete parking
Floor joists selected to maximize headroom and not exceed building height (10' ceilings)
Drop ceilings for MEP at perimeter of some rooms

Case Study - Maximizing View and Value With Wood

Marselle Condominiums

Seattle, WA

- » Type III-A condo complex
- » 5-1/2 stories of wood over 2 stories of concrete
- » Mezzanines added \$250 in cost, but \$1M in value
- » 30% cost saving over concrete
- » Time savings over steel



Architect: PB Architects

Engineer: Yu & Trochalakis

Contractor: Norcon, NW

Completed: 2009

Photo Credit: Matt Todd Photography

Case Study – Innovations in Wood

Emory Point Atlanta, GA

- » 3 mixed-use buildings completed – Luxury apt.'s, retail and restaurants
- » (1) 5-story building of Type III-A wood over slab on grade
- » (2) 4-story buildings of Type V-A wood over 1-story concrete podium

35% Structure Savings

- » \$14/sf (wood floor structure)
- » \$22/sf (concrete floor structure)



Architect: Cooper Carry, The Preston Partnership

Engineer: Ellinwood + Machado, Pruitt Eberly Stone

Contractor: Fortune-John

Photo credit: Gables Residential

Frame it Right! Back to Basics for Big Buildings

Lindsey Kuster, PE
Engineered Wood Specialist



APA – The Engineered Wood Association



1933: Douglas Fir Plywood Association

1994: APA—The Engineered Wood Association



APA – The Engineered Wood Associate



APA's 42,000 square-foot research center

Introduction

- **Structural Engineering Background**
- **Southwest Representative**
 - California
 - Arizona
 - Nevada
 - New Mexico
- **Based in San Diego**



lindsey.kuster@apawood.org

Frame it Right! Back to Basics for Big Buildings

Course Description:

The demand for commercial and multifamily construction is soaring, and the framing industry is expanding to meet this demand.

APA – The Engineered Wood Association has walked hundreds of job sites and identified the most common wood construction framing errors found in today's nonresidential buildings.

This session examines the consequences of these framing mistakes from the ground up providing practical solutions for avoiding typical issues using APA resources as a guide.

Frame it Right!

Learning Objectives:

- **Identify common pitfalls in the construction of low-rise wood buildings.**
- **Understand how the loads on a nonresidential wood building influence framing and mitigate negative effects of loading.**
- **Understand how engineered wood products (EWP) may be used and how to choose EWP products that meet those needs.**
- **Learn how to navigate technical resources to address the challenges with nonresidential wood buildings framers.**

Agenda

Why is Training Needed?

Building from the ground up

- Wood Strength
- Walls
- Floors
- Roofs
- Special Topics
- Q&A



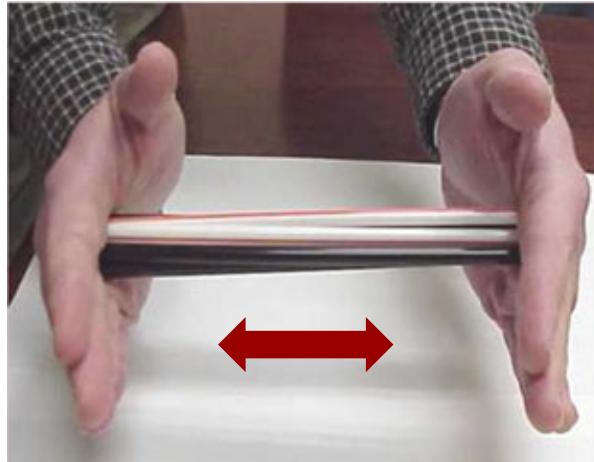
Engineered Wood Products (EWP)



- ✓ **Plywood**
- ✓ **OSB** – Oriented Strand Board
- ✓ **I-joist and Rim Board**
- ✓ **Glulam** – Glued Laminated Timber
- ✓ **LVL** – Laminated Veneer Lumber
- ✓ **LSL** – Laminated Strand Lumber
- ✓ **OSL** – Oriented Strand Lumber
- ✓ **CLT** – Cross Laminated Timber
- ✓ **MPP** – Mass Plywood Panels

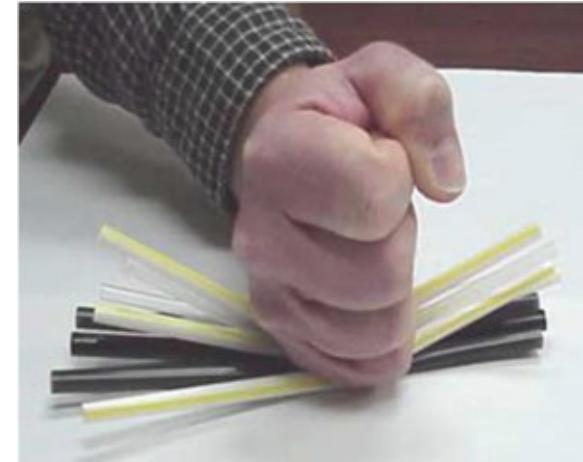
Wood has a Stronger Direction

Load parallel
to grain



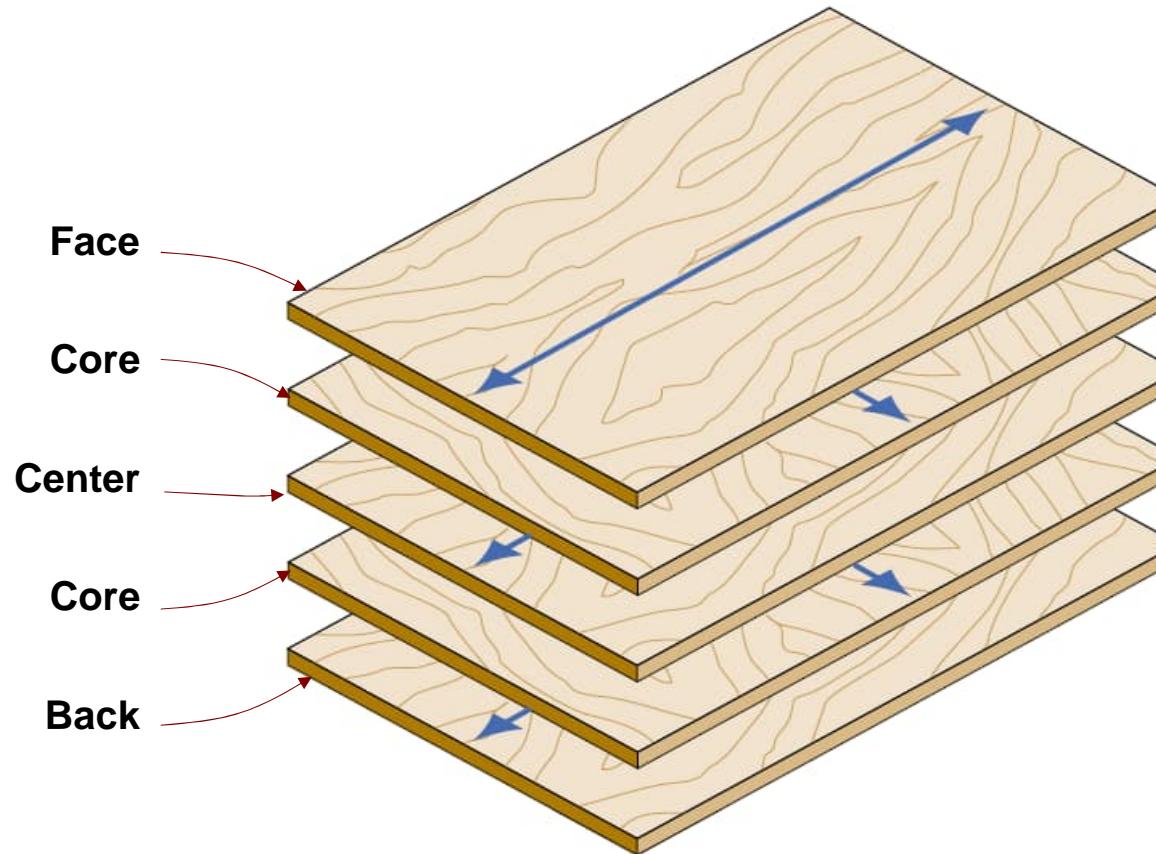
Stronger

Load perpendicular
to grain

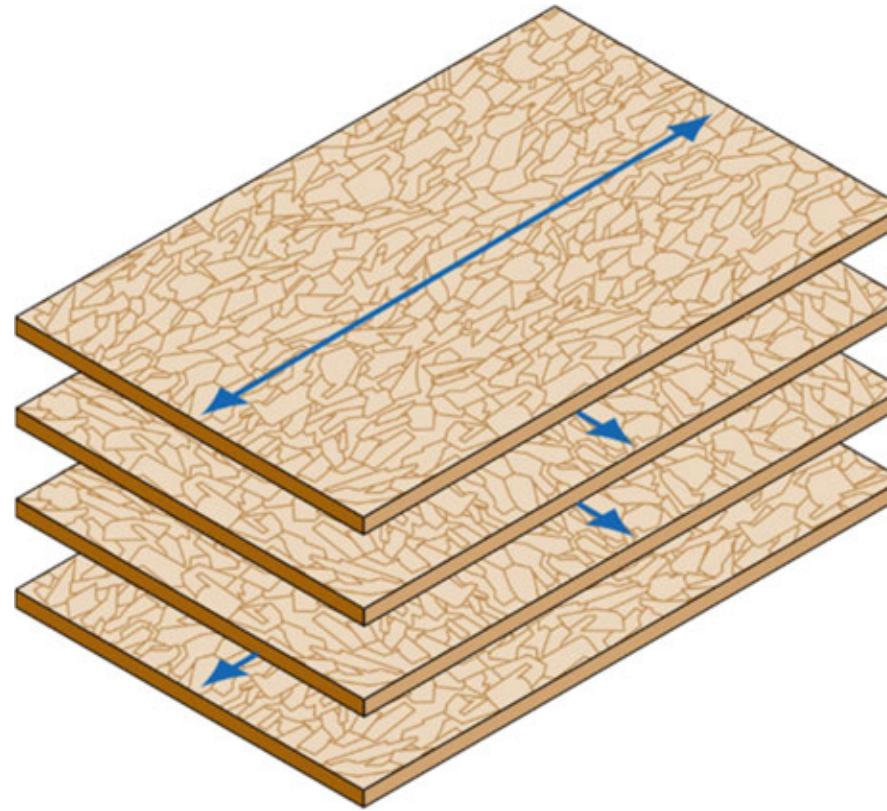


Weaker

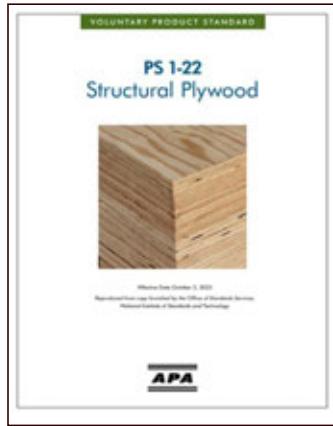
Plywood Layup



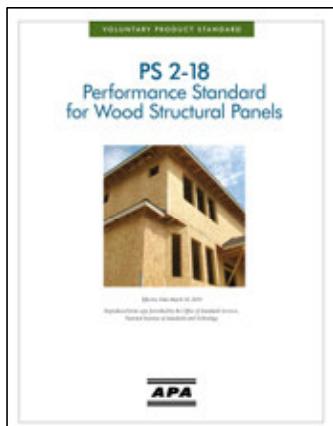
Oriented Strand Board (OSB) Layup



Manufacturing Standards



PS 1: Voluntary Product Standard
PRESCRIPTIVE Standard (revised 2022)



PS 2: Voluntary Product Standard
PERFORMANCE Standard (revised 2019)



APA Stamp in the Field



APA Panel Certification Marks

APA panel grade

Span rating

(Bond classification)

Exposure 1

Applications where construction delays are expected prior to providing protection, not intended for permanent exposure to the weather



SIZED FOR SPACING

Mill number

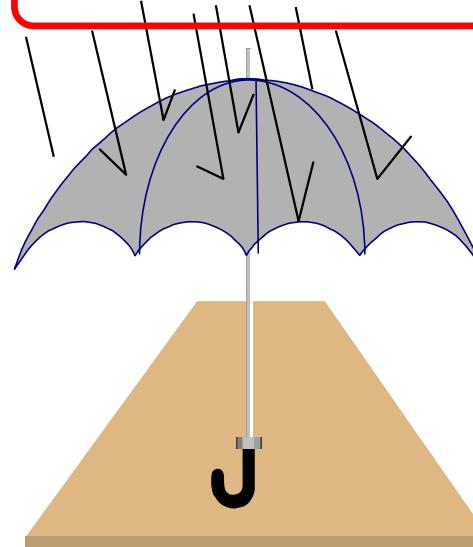
Performance-rated panel standard

Performance category



Bond Classification

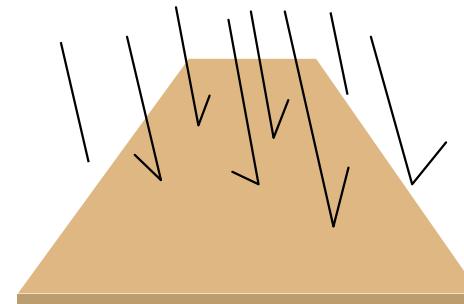
EXPOSURE 1



Exposure due to
construction delays

EXTERIOR

OR



Long term weather
exposure

APA Panel Certification Marks

Out-of-Date Specifications

- **1/2" CDX – C & D veneers, with exterior glue
(when panels were made with interior & exterior glue)**

Previous Specifications

- **15/32" APA Rated Sheathing, 32/16, Exposure 1**

New Terminology

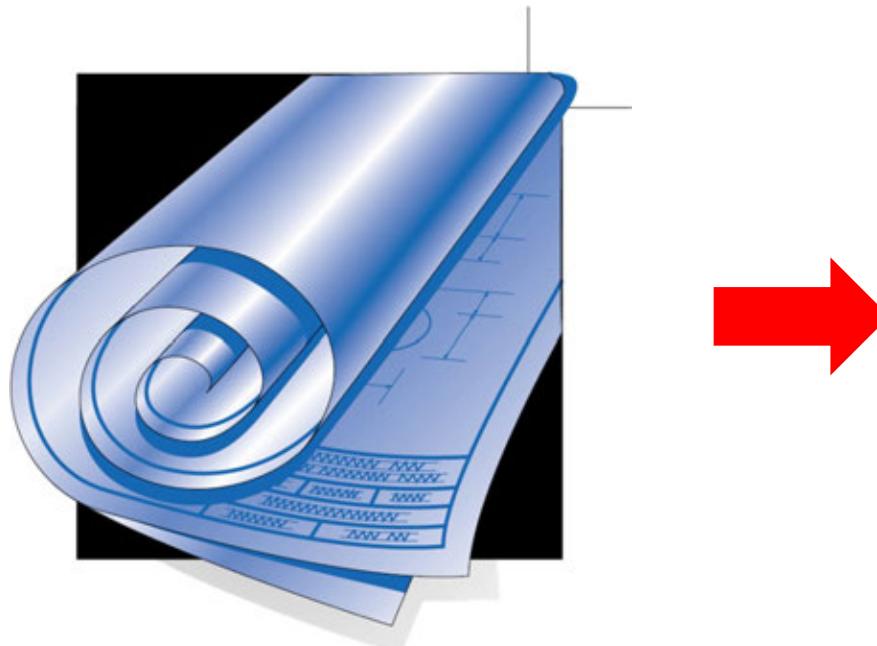
- **15/32 Performance Category, APA Rated Sheathing, 32/16,
Exposure 1, Square edge (or T&G)**

<https://www.apawood.org/apa-trademark>

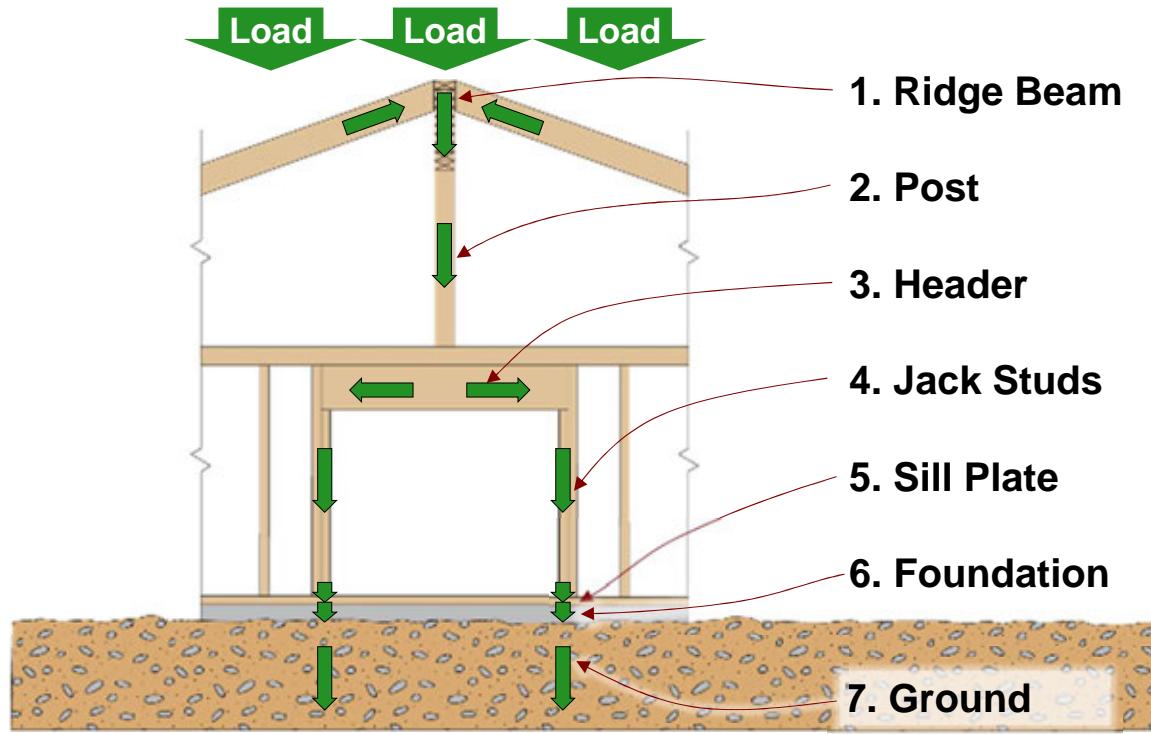


Frame it Right!

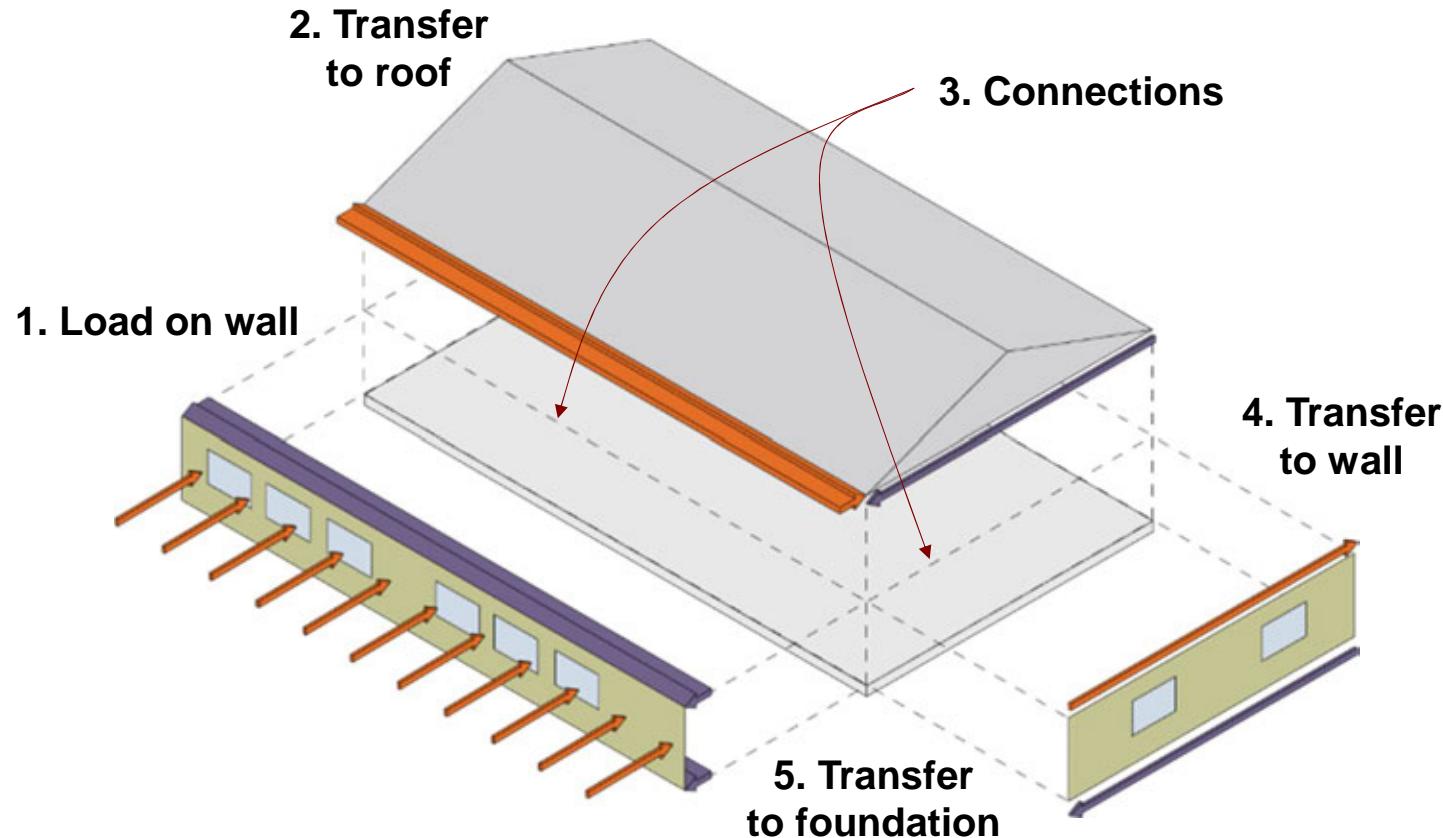
Does this match?



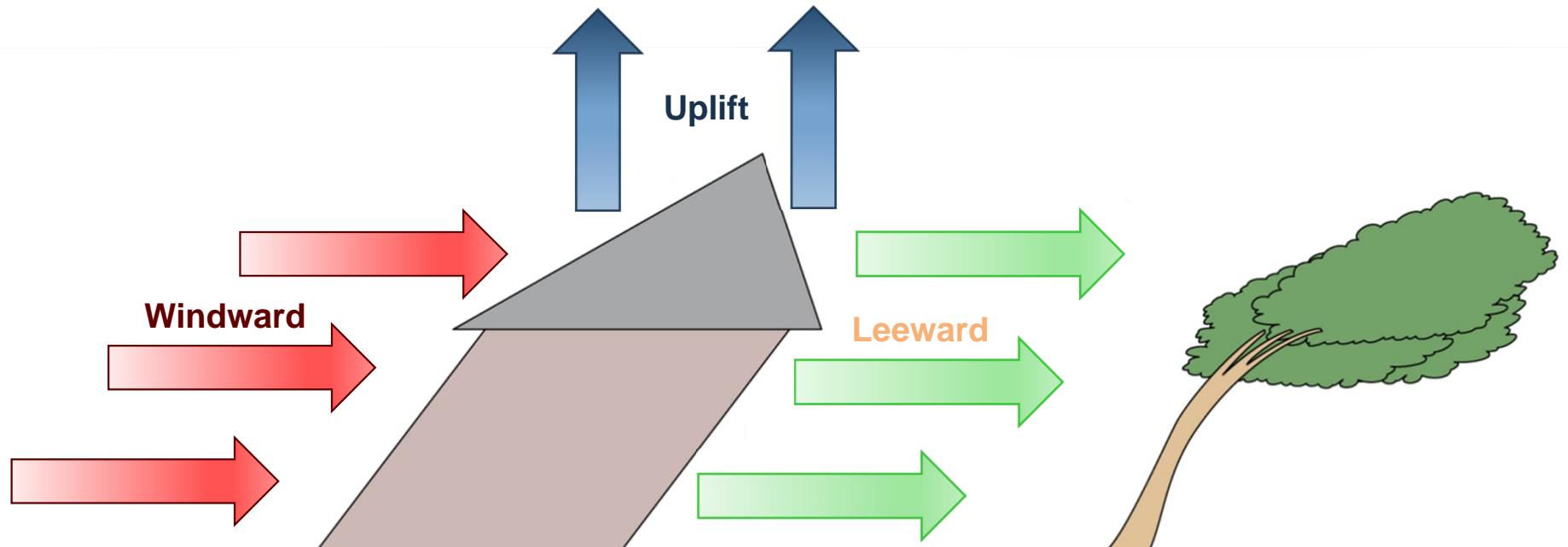
Vertical (Gravity) Load Path



Lateral Load Path



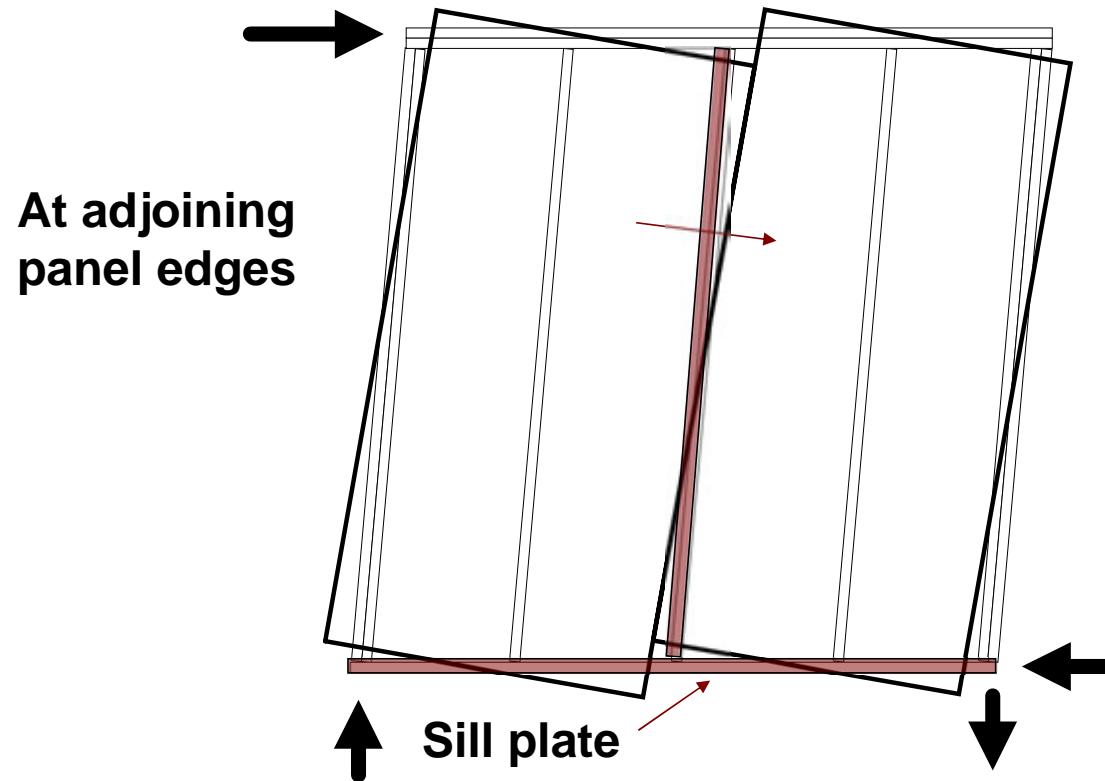
Lateral Load Path



Building From the Ground Up: Walls



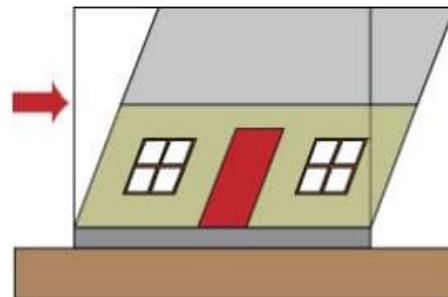
Building From the Ground Up: Walls



Lateral Forces

Modes of Failure

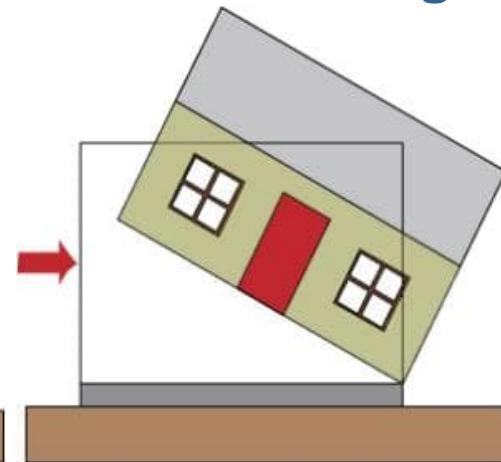
Racking



Sliding



Overspinning



Resisted by Bracing

Resisted by Anchors

Resisted by Hold-
Downs & Dead Load

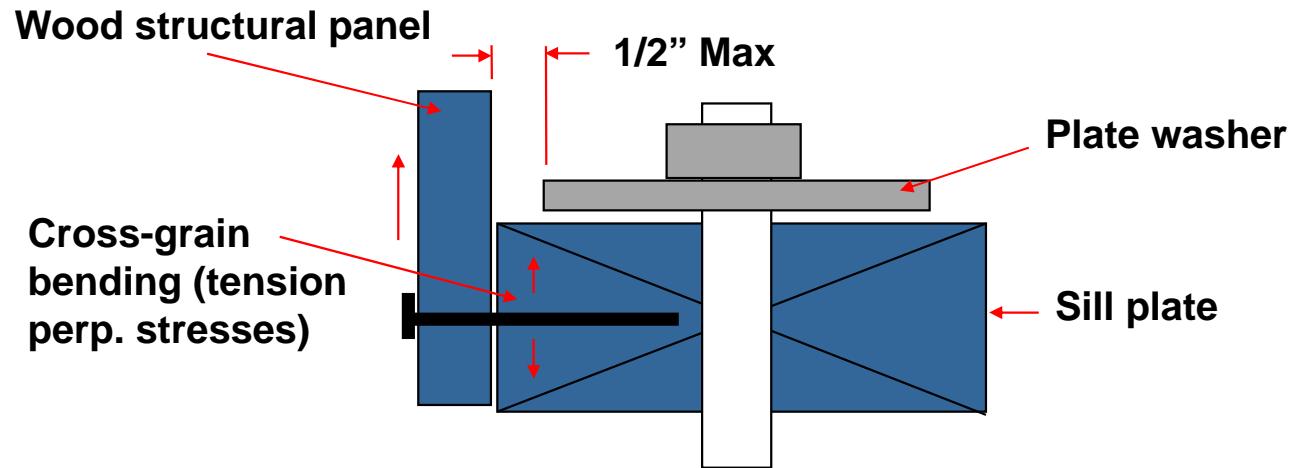
Building From the Ground Up: Walls

Missing washer



Anchor Bolts

- **Size and spacing per engineer.**
- **Large plate washers (3" x 3" x 0.229") prevent cross- grain bending/splitting of sill plate (required in Seismic Zones D and E, CBC 2308.3.1). APA recommends these for high wind applications.**



Building From the Ground Up: Walls



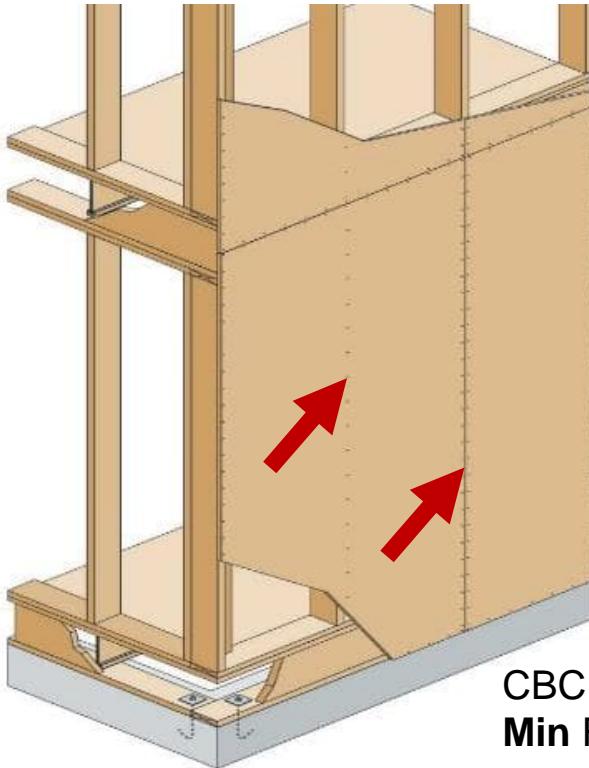
Building From the Ground Up: Walls



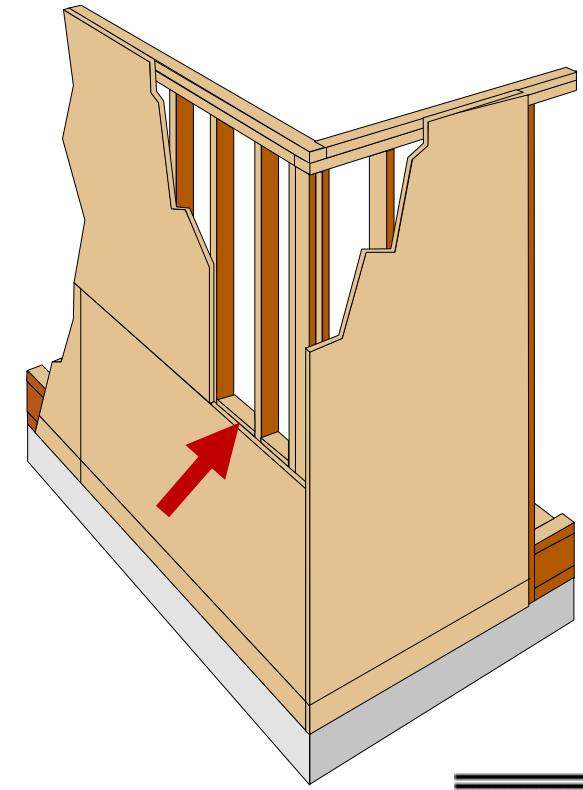
Building From the Ground Up: Walls



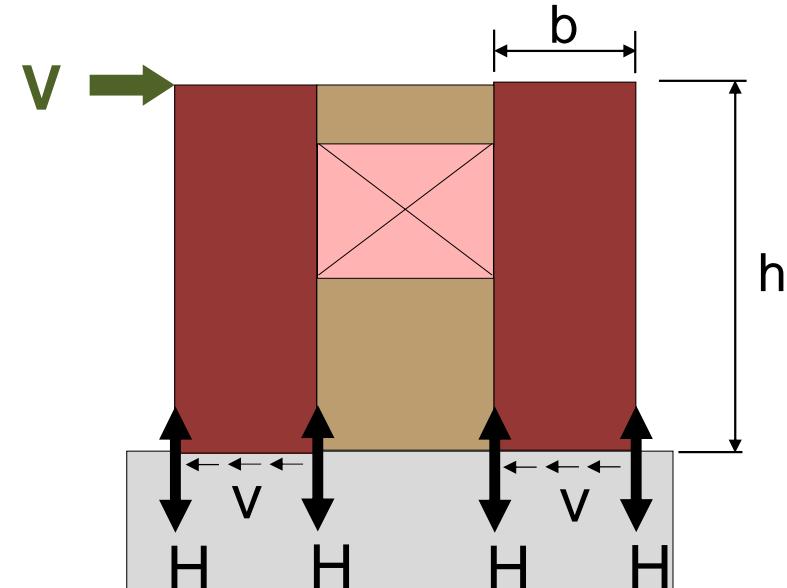
Building From the Ground Up: Walls



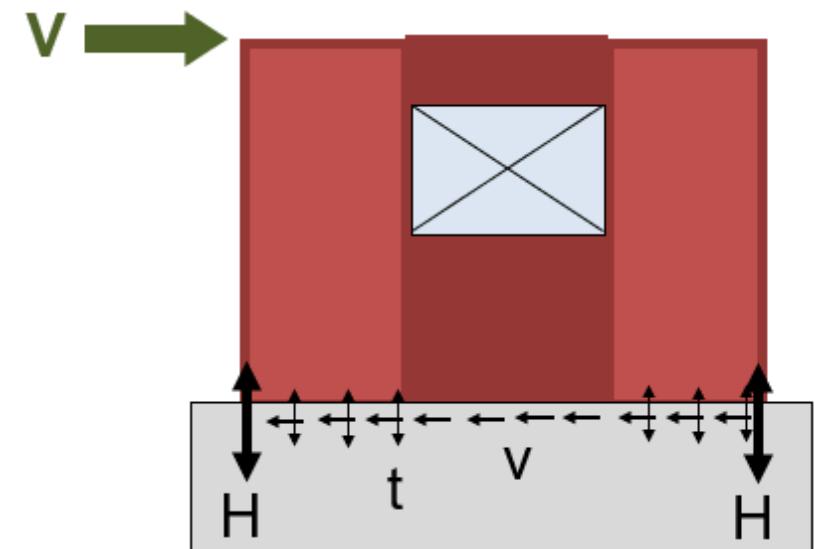
CBC Table 2304.10.2
Min Fastener Requirements



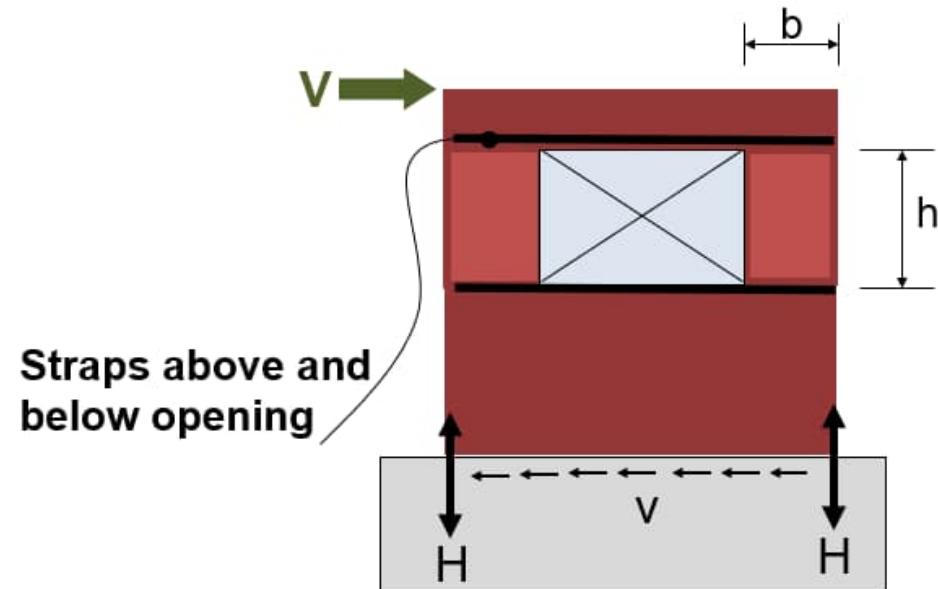
Segmented Shear Walls



Perforated Shear Walls



Force Transfer Around Openings (FTAO) Shear Walls

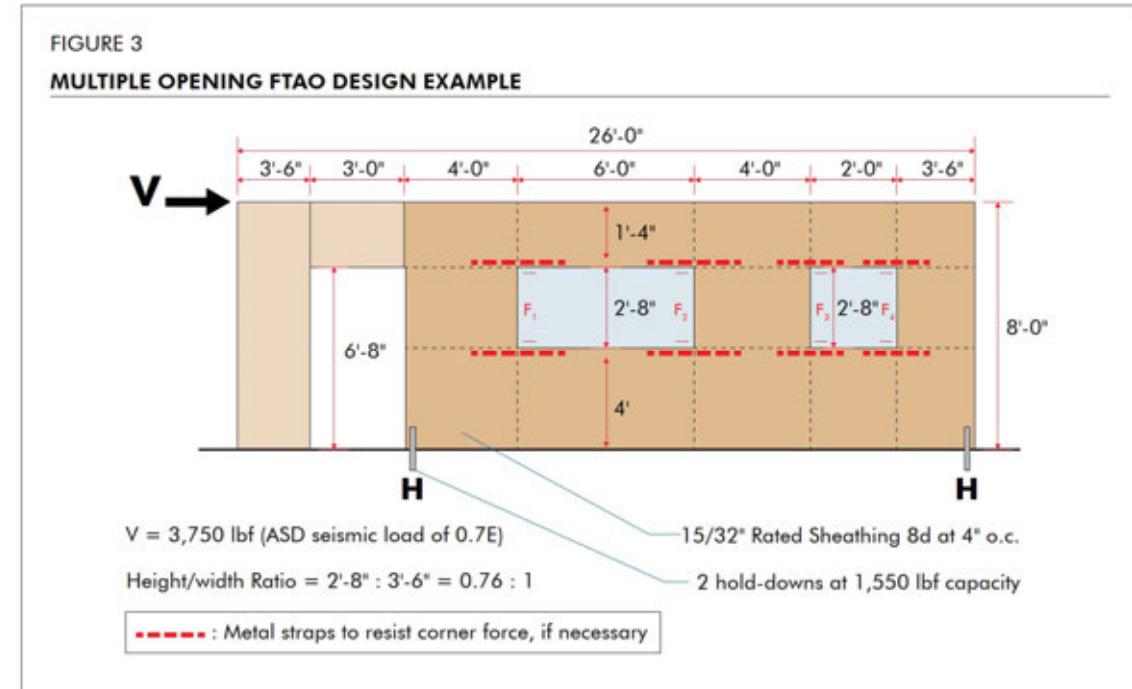


FTAO Technical Note - Form T555

Provides a design example
for FTAO wall with two
window openings

FTAO Calculator: Companion
to Technical Note

www.apawood.org/ftao



APA FTAO Calculator

Excel-based tool released January 2018

Based on design methodology developed by Diekmann

Calculates:

Max hold-down force for uplift resistance

Required horizontal strap force above and below openings

Max shear force for sheathing attachments

Max deflection

**Design example
corresponds with FTAO
Technical Note, Form T555**



APA Force Transfer Around Openings Calculator

This calculator is an Excel-based tool for professional designers that uses FTAO methodology to calculate maximum hold-down force for uplift resistance, the required horizontal strap force for the tension straps above and below openings, the maximum shear force to determine sheathing attachment, and the maximum deflection of the wall system. The calculator includes worksheets for shear walls with openings and a design example.

DOWNLOAD

High Load Shear Walls



Rated Sheathing

versus

Structural I

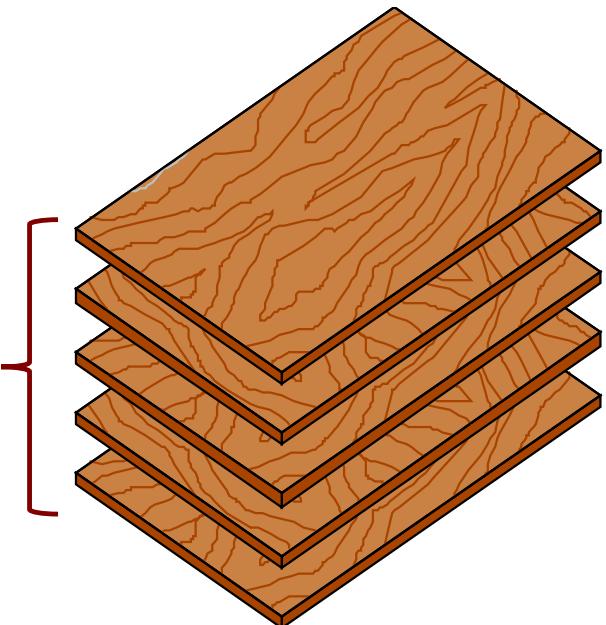


Structural I Panels

- Increased shear capacity
- Increased stiffness, especially across the panel
- Plywood & OSB (performance tested)
- Before specifying, check local availability

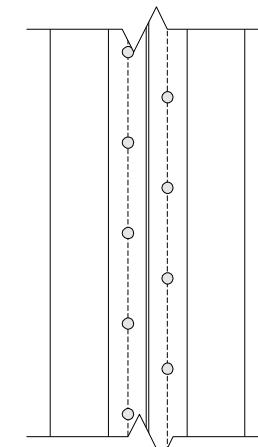


Group 1 Species

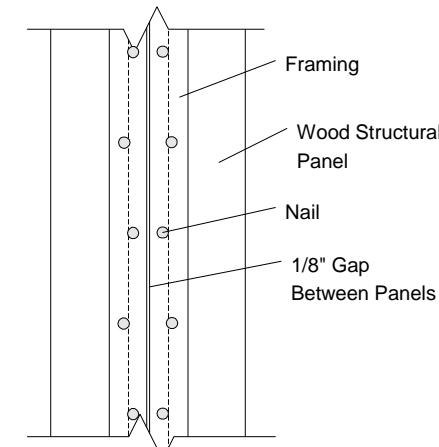


Building From the Ground Up: Walls

**Staggered nailing in
tightly nailed shear wall
helps prevent splitting
of framing**

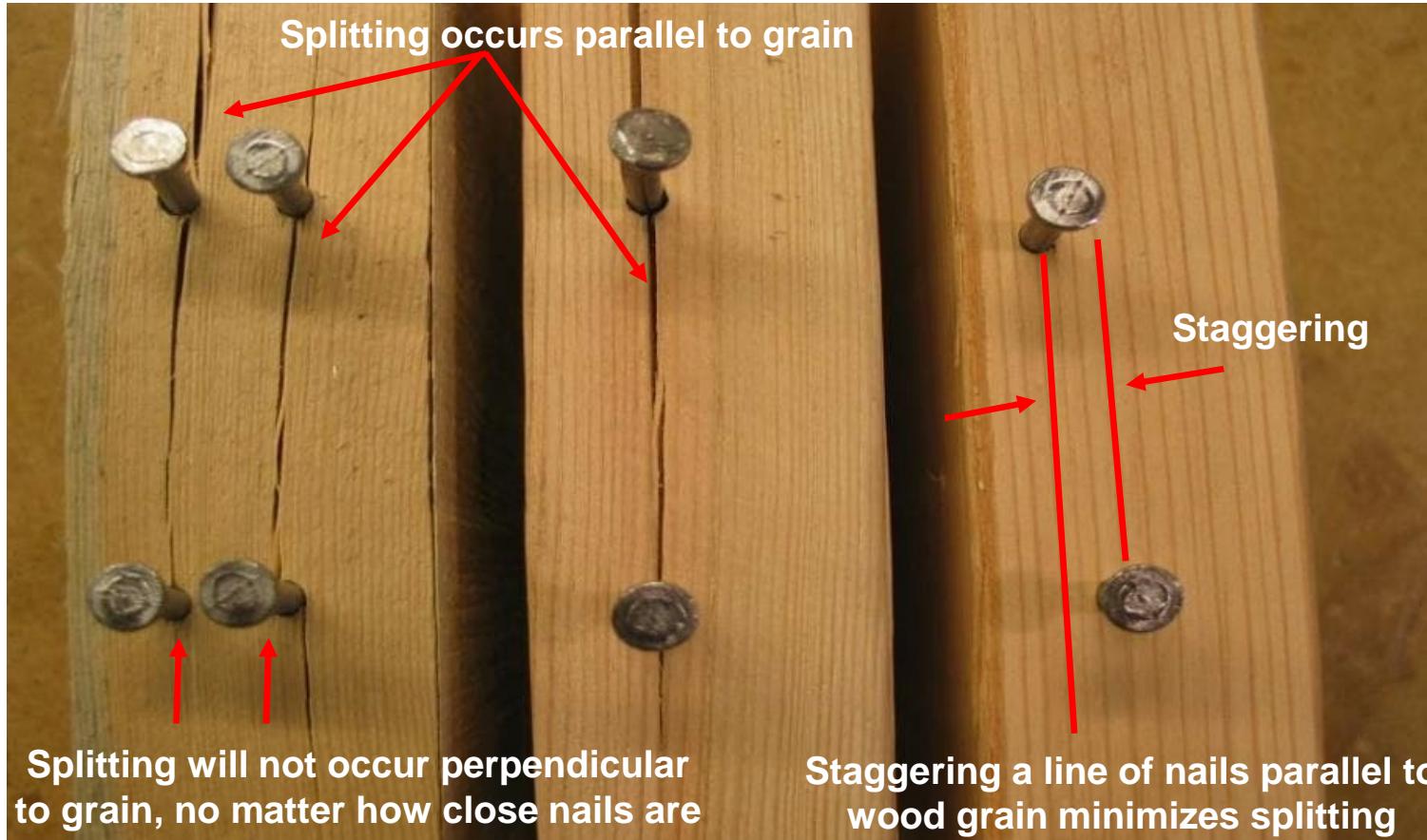


Nailing not staggered



Nailing staggered

Staggered Fastening



Walls: Floor to Floor Load Transfer

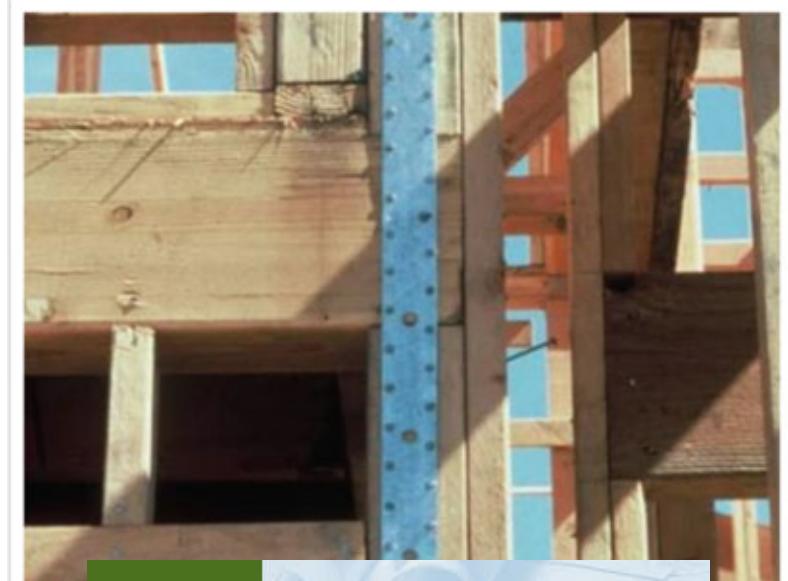


TECHNICAL NOTE

Using Wood Structural Panels for
Combined Uplift and Shear Resistance

Number E510 • February 2008

APA Technical Note E510



System Report

SR-101C

FEBRUARY 2015

Design for Combined Shear and Uplift from Wind

APA System Report SR-101



Building From the Ground Up: Walls

Wall Sheathing
Nail-base sheathing

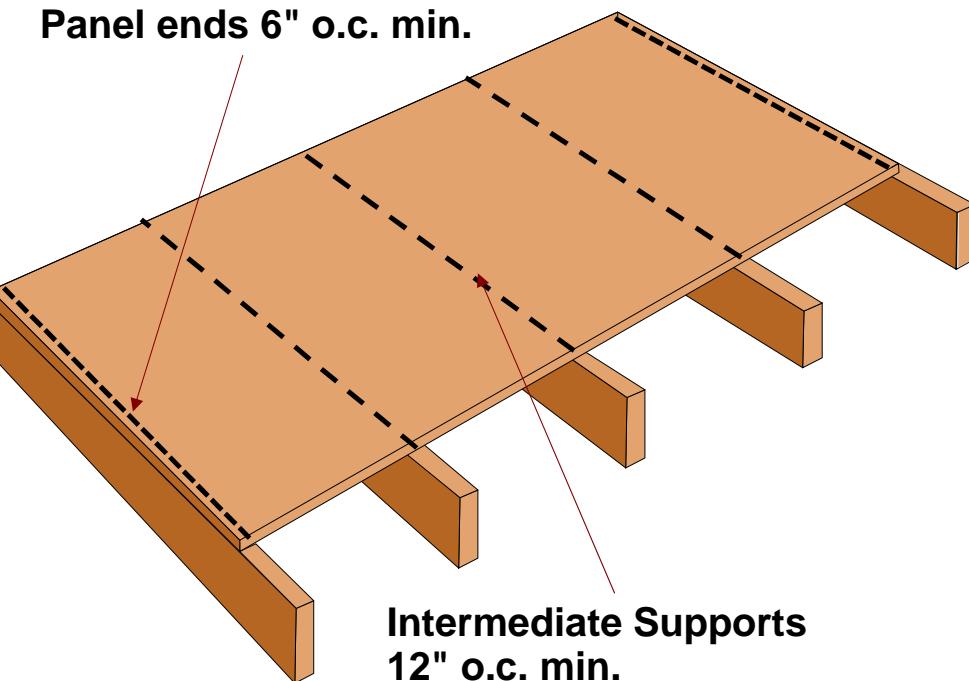
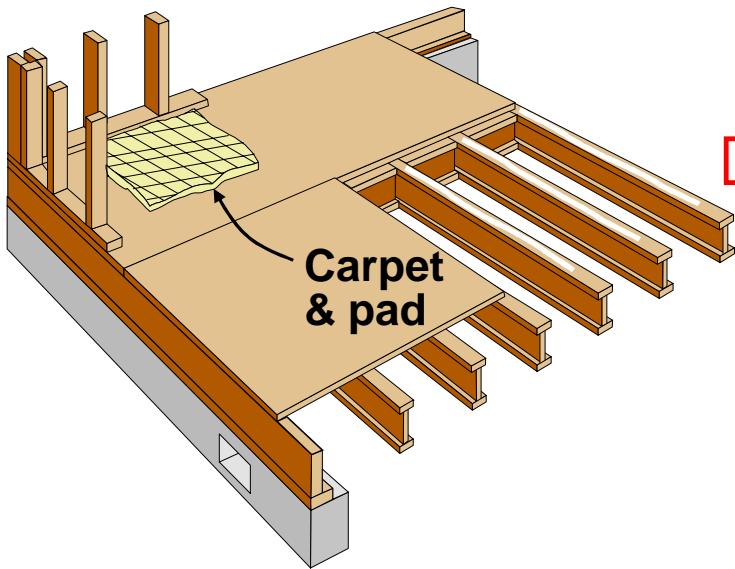


Resource: APA Construction Guide: *Nail-Base Sheathing for Siding and Trim Attachment*, Form Q250

Building From the Ground Up: Floors

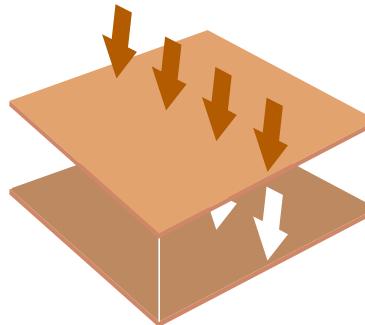


Building From the Ground Up: Floors



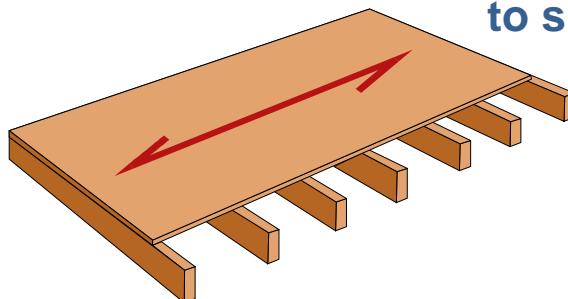
CBC Table 2304.10.2 **Min** Fastener Requirements

Building From the Ground Up: Floors



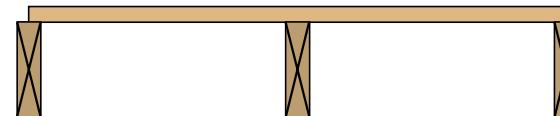
Roof Span L/240
30 PSF live
10 PSF dead

Floor Span L/360
100 PSF live
10 PSF dead



**Strength axis perpendicular
to supports**

**Continuous Span
(2 spans or 3 supports min.)**



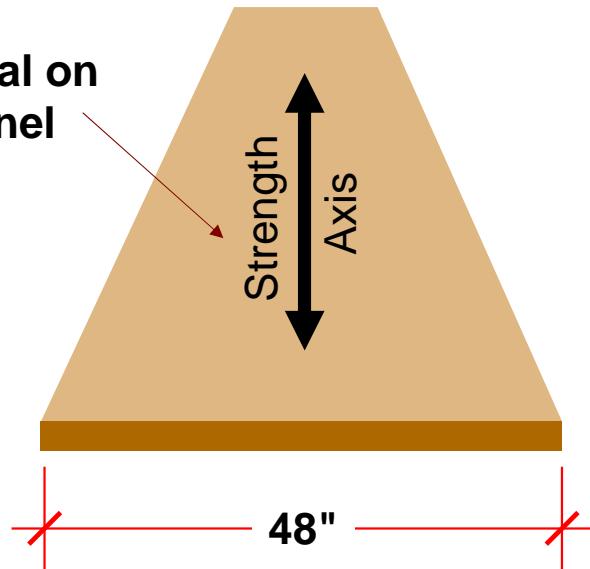
No simple spans



Building From the Ground Up: Floors

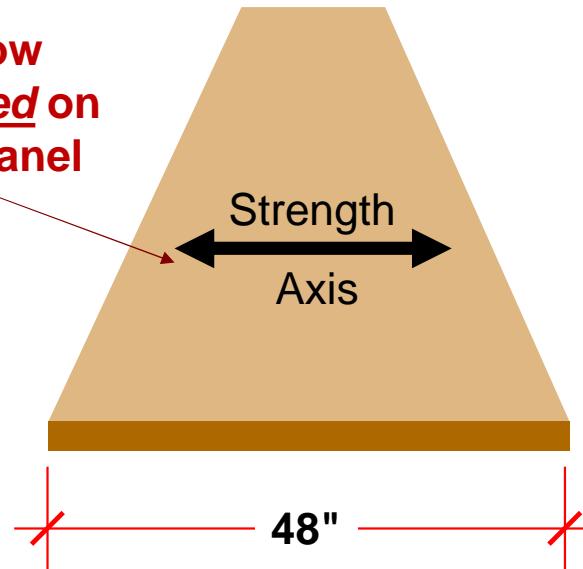
Strength Axis

Arrow
optional on
the panel



Common

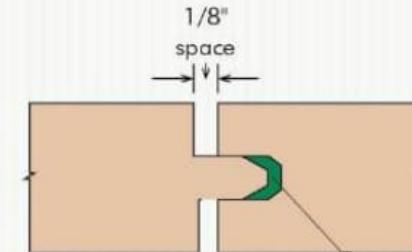
Arrow
required on
this panel



Not Common



RECOMMENDED TONGUE-AND-GROOVE JOINT SPACING



AFG-01 or ASTM D3498 when
glued floor system is used



Resource: APA Technical Note: *Floor Squeaks – Causes, Solutions and Prevention, Form C468*

Fully Fasten with Clamping Force



Resource: *Subfloor Preparation to Receive Finished Flooring, Form V440*

APA
American Plywood Association

Frame it Right!

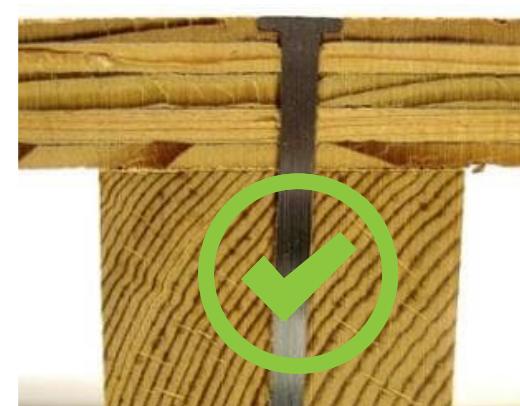


APA

Building From the Ground Up: Floors

Nail installation

Overdriving reduces performance APA recommends adding one for every two overdriven



Overdriven Nails

To Maintain Shear Capacity (APA Technical Topic TT-012)

Overdriven Fasteners	Overdriven Distance	Action
$\leq 20\%$ Perimeter	$< 1/8"$	None
$> 20\%$ Perimeter	$> 1/16"$	Add 1 nail for every 2 overdriven
Any	$> 1/8"$	

APA **Technical Topics**
TT-012 | DECEMBER 2011

Effect of Overdriven Fasteners on Shear Capacity

The following is a suggested procedure for determining if overdriven fasteners will affect the shear capacity of diaphragm or shear wall connections.

- If any case described below is met, then no reduction in shear capacity needs to be taken.
- If all nails are overdriven into panels by no greater than $1/16$ inch during construction under dry conditions (moisture content less than 10 percent):
 - If no more than 20 percent of the fasteners around the perimeter of panels are overdriven by no greater than $1/8$ inch, no reduction in shear capacity needs to be taken.
 - If all fasteners around the perimeter of panels appear to be overdriven by the same amount, and it appears that panels have been faced during construction, it can be assumed that the fastener overdriven is due to panel thickness swelling. This can be verified by measuring the thickness of panels where fasteners appear to be overdriven, and comparing to measurements where panels have been punched from the woodies, or to the original source panel thickness which is indicated in the APA redi-rect.
 - If faced panels used in construction are thicker than the required minimum nominal panel thickness upon which the design shear capacity is based, and the overdriven is less than or equal to the difference between the two panel thicknesses. For example, if design shear for the construction requires a $1/32$ inch minimum nominal panel thickness and the actual sheathing is $1/32$ inch with all fasteners overdriven $1/8$ inch, the net result is a $1/32$ inch panel that meets the design shear requirement.
- If more than 20 percent of the fasteners around the perimeter of panels are overdriven by over $1/16$ inch, or if any are overdriven by more than $1/8$ inch, additional fasteners must be driven to maintain the required shear capacity. For every two fasteners introduced, one additional fastener must be driven. If nails were used in the original installation, and are spaced too close to allow the placement of additional nails, then approved staples should be used for the additional fasteners required to reduce the potential for splitting the fastener.

Reference Documents: A.I. and L.J. Smith, 1994, "Effect of Overdriven Nails on Shear Walls," APA Report No. TT-0-9, Portland, OR; APA, 2007, "Effect of Overdriven Nails on Shear Capacity of Panels and Sheathing," APA Report TT-002, Portland, OR.

DISCLAIMER: The information contained herein is based on APA - The Engineered Wood Association's continuing education seminar, "Effect of Overdriven Nails on Shear Capacity of Panels and Sheathing," which is intended to educate industry professionals and officials on issues they may encounter in assessing any legal liability or responsibility for the use, application, and interpretation of this information. This document is not a substitute for engineering judgment or professional advice. It is the responsibility of the individual practitioner or design professional to ensure compliance with local, state, and federal codes and regulations. The use of this document does not imply that the information contained herein is the only correct or valid information. It is the responsibility of the individual practitioner or design professional to determine what information is actually necessary.

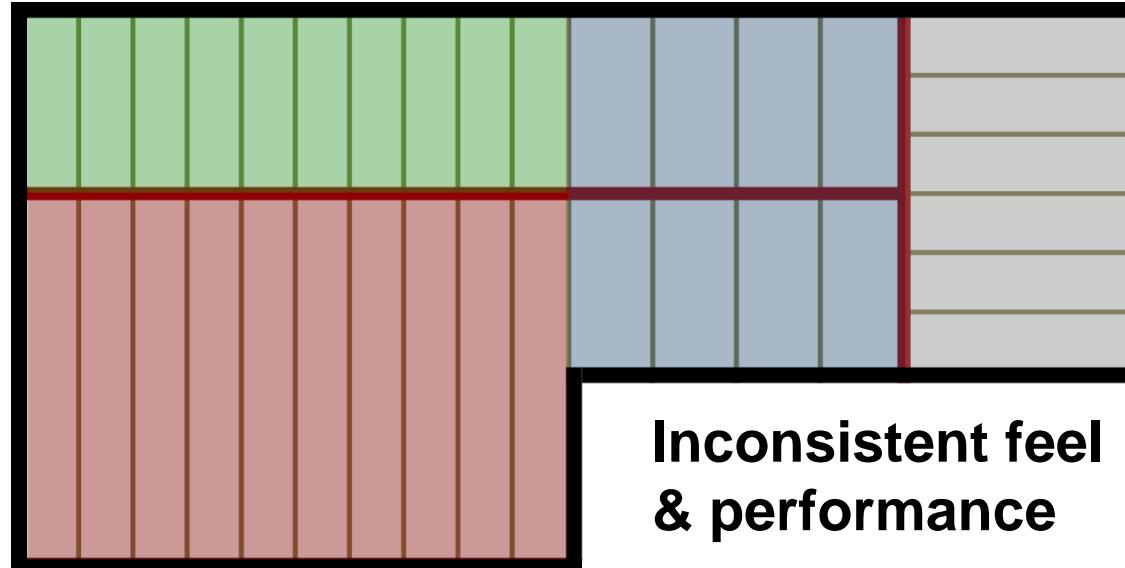
© 2011 APA - The Engineered Wood Association

Building From the Ground Up: Floors



Floor Joist Layout — Consistency Counts

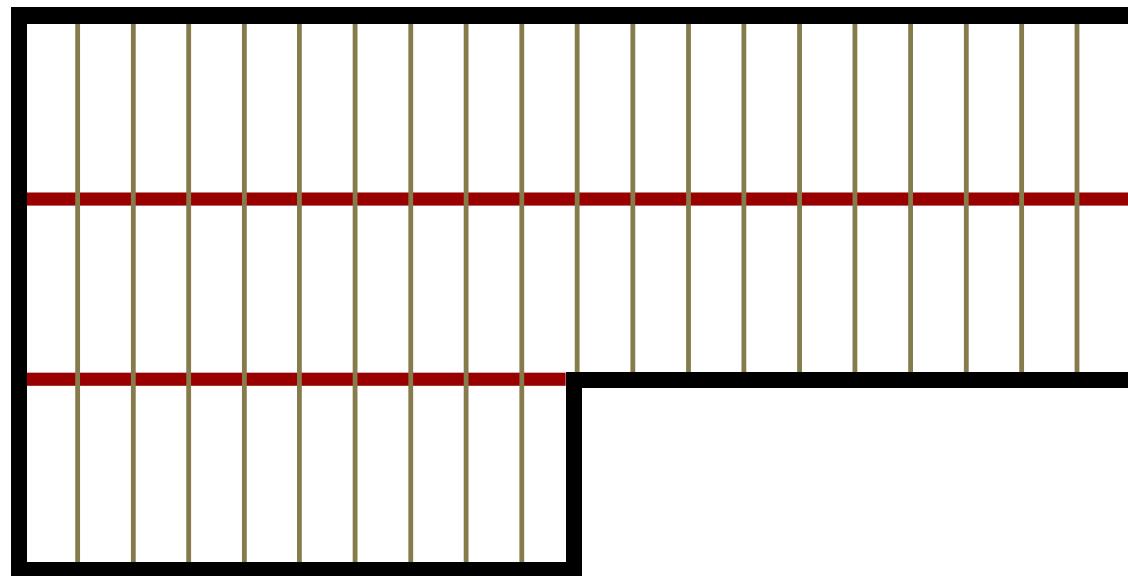
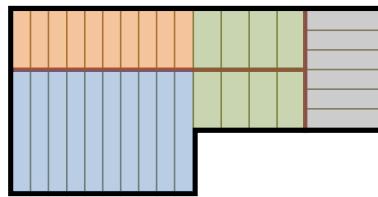
Inconsistent spacing & span



Floor Joist Layout — Consistency Counts

Consistent Spacing & Span

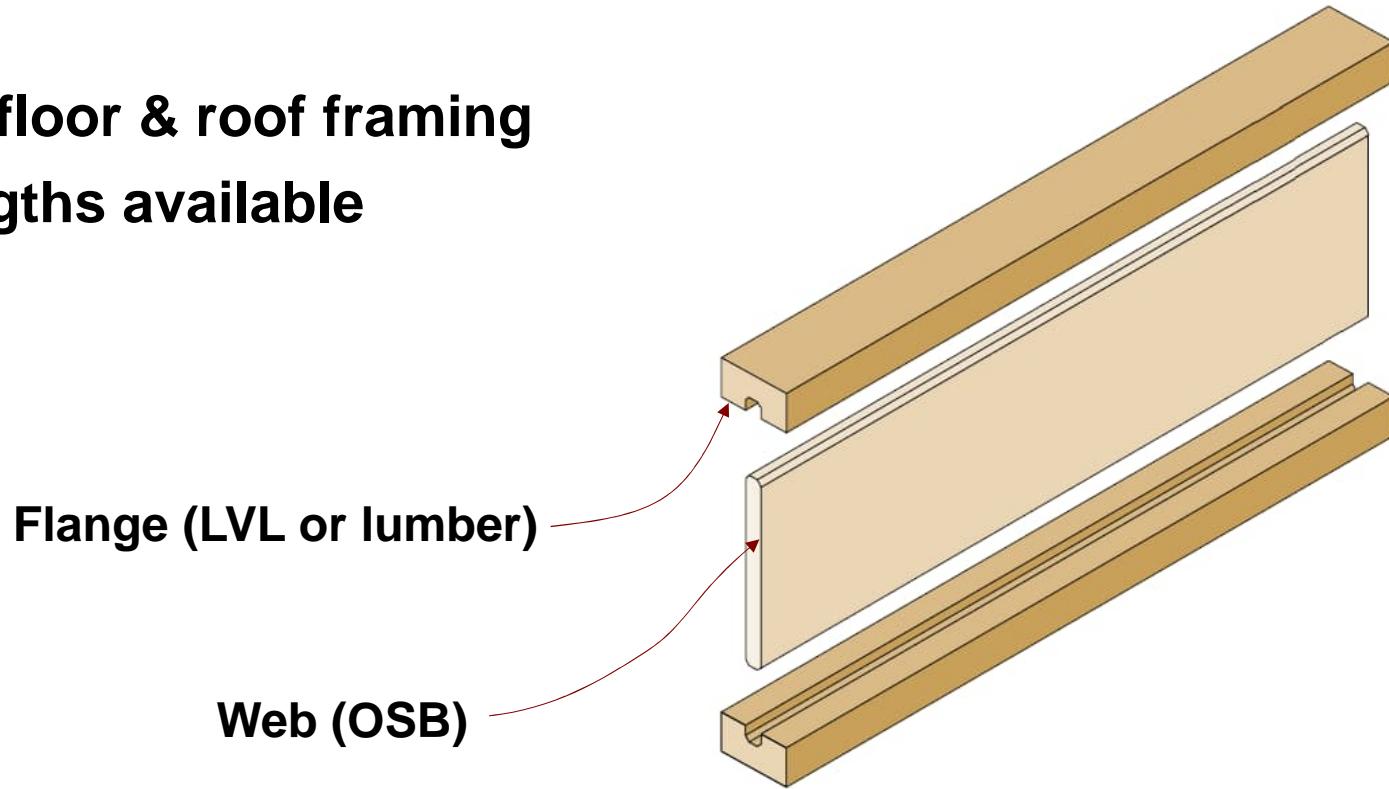
Before



Use Wood's Strength Direction

I-joist

- Used for floor & roof framing
- Long lengths available



Sustainability

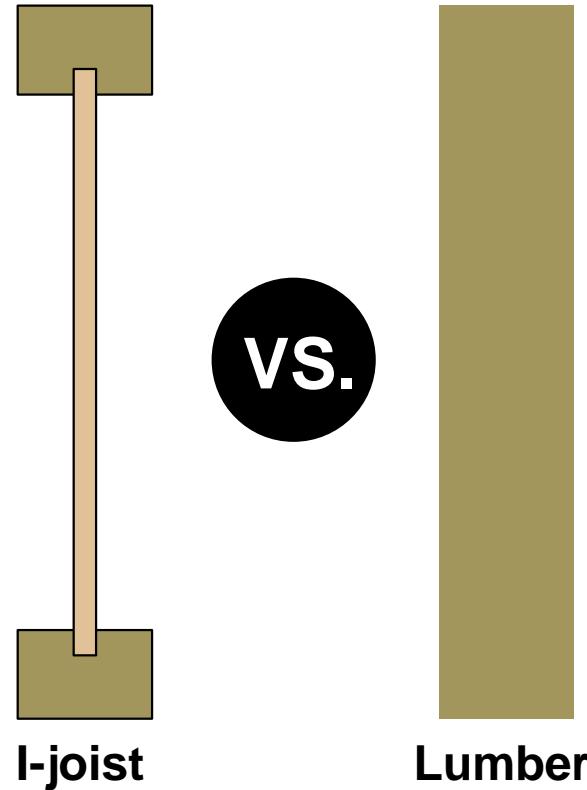
I-joist vs. Lumber

Both at 16" o.c.

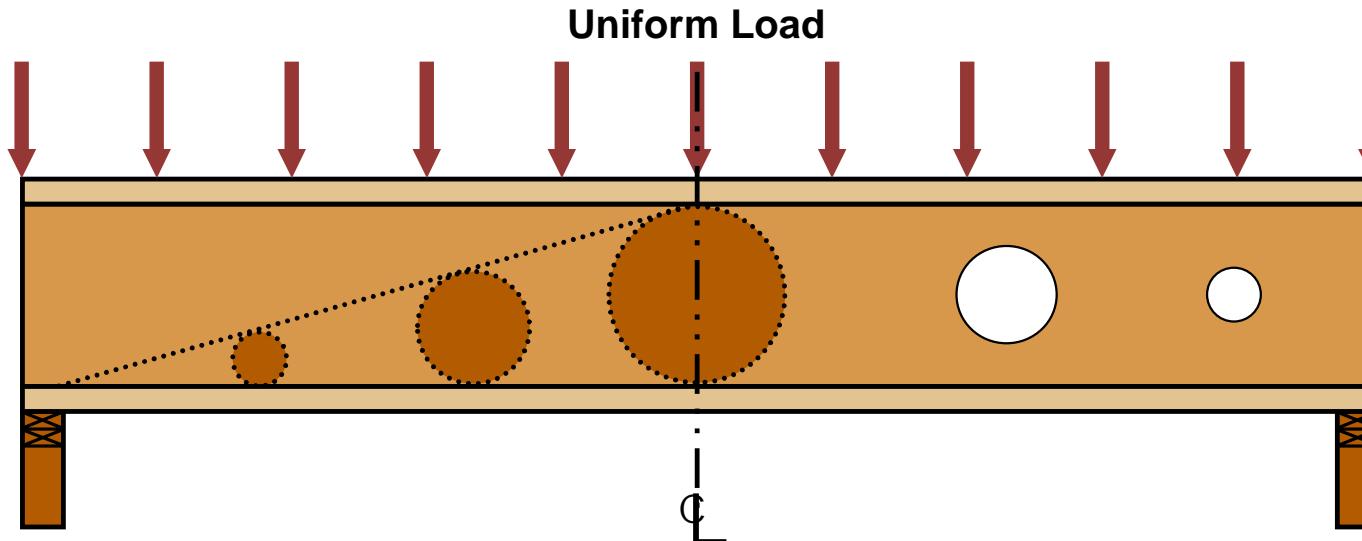
- 36% less wood fiber

I-joist at 19.2" o.c & Lumber at 16" o.c.

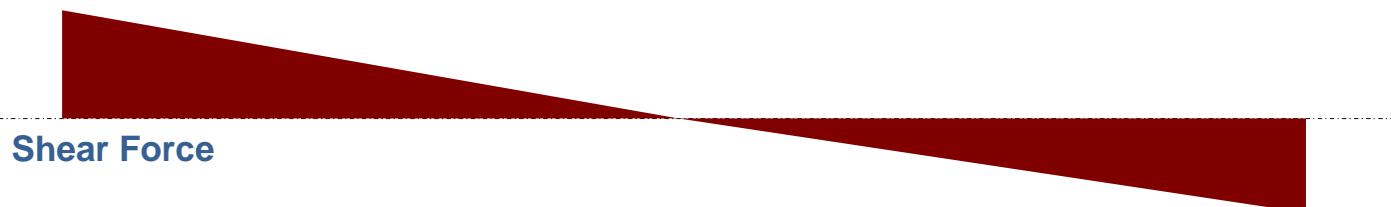
- 46% less wood fiber



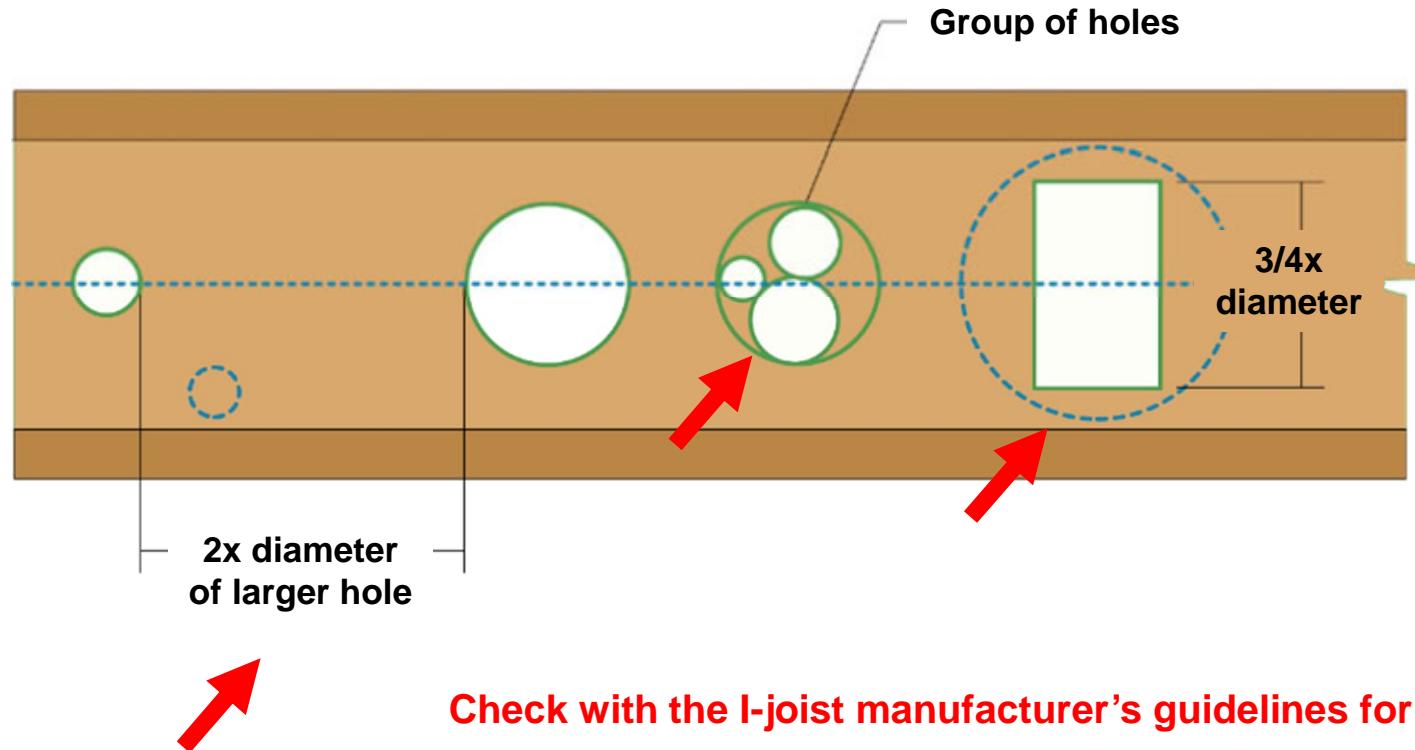
Building From the Ground Up: Floors



Hole Size in Proportion to Shear Force



Building From the Ground Up: Floors



I-Joist “Knockouts”



Frame it Right!



APA

Building From the Ground Up: Floors

Laminated Veneer Lumber (LVL)



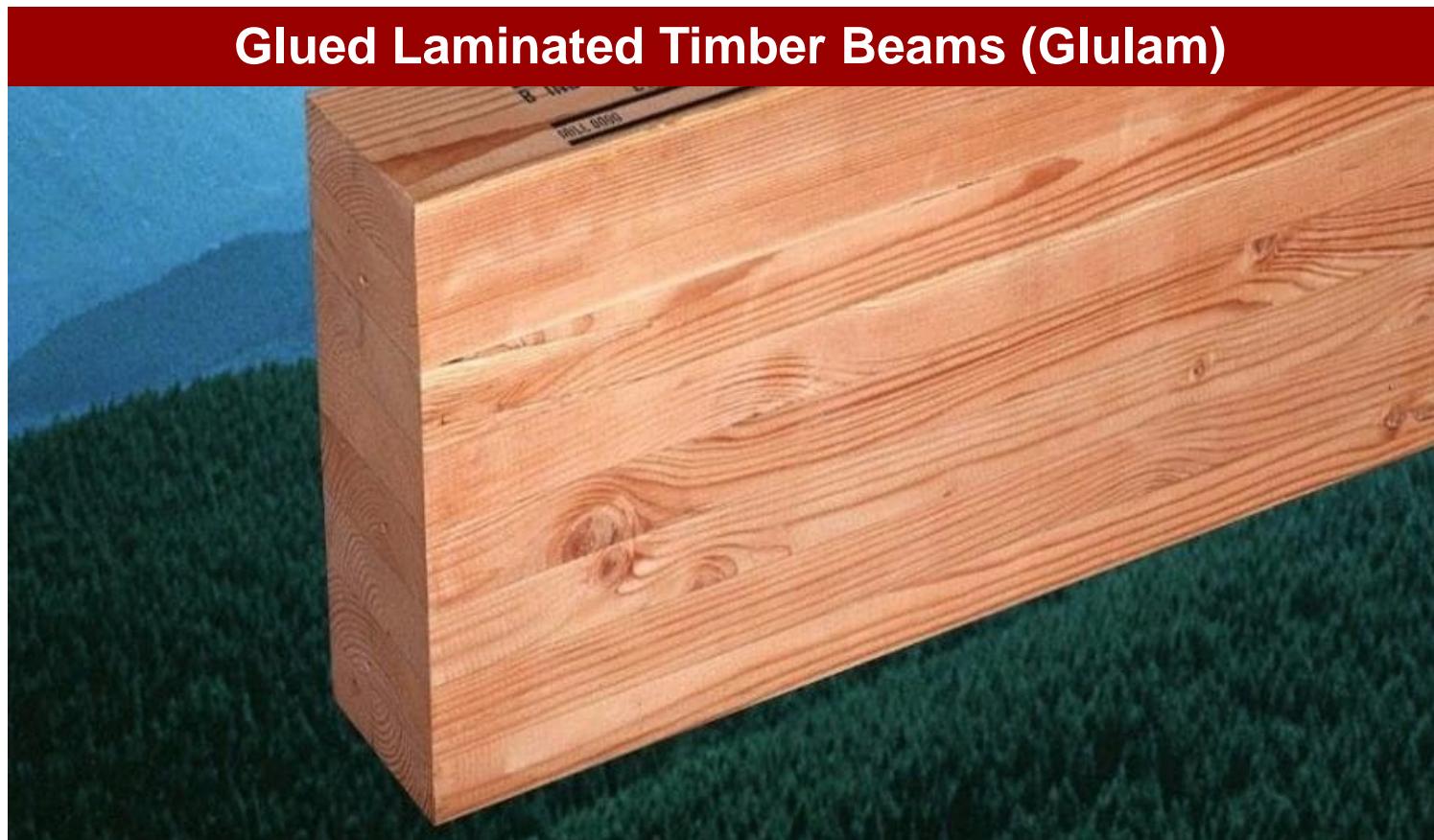
Building From the Ground Up: Floors

Laminated Strand Lumber (LSL)



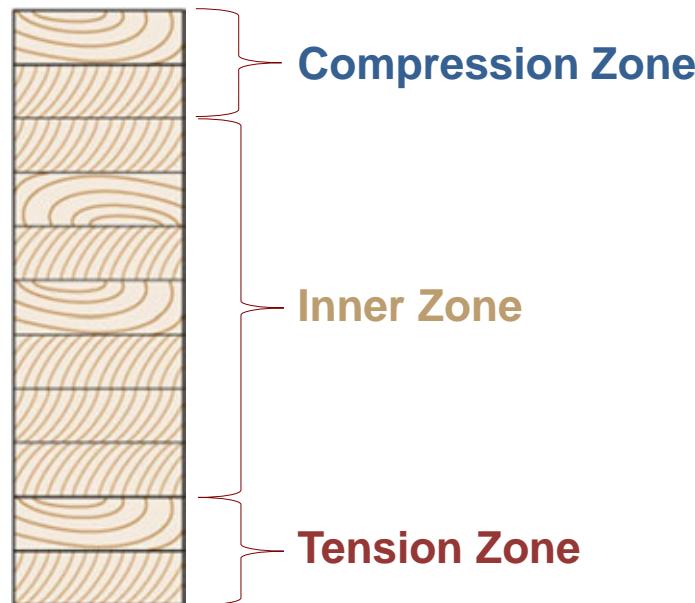
Building From the Ground Up: Floors

Glued Laminated Timber Beams (Glulam)



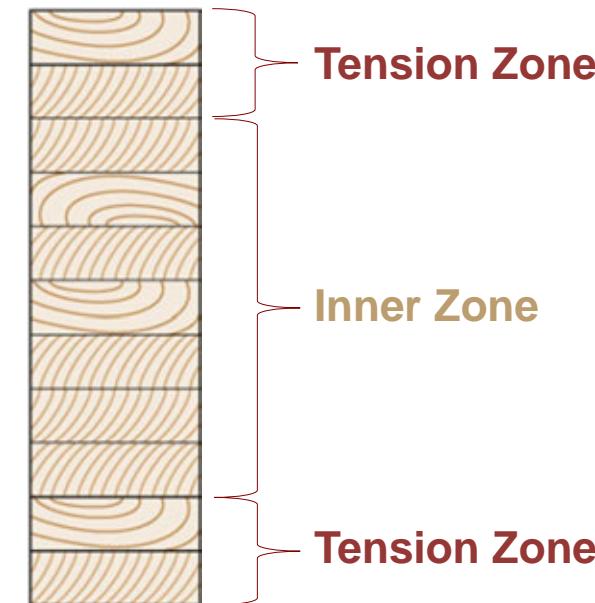
Balanced and Unbalanced Glulam

Unbalanced Beam



24F-V4 Layup

Balanced Beam



24F-V8 Layup

Caution when using Unbalanced Glulams

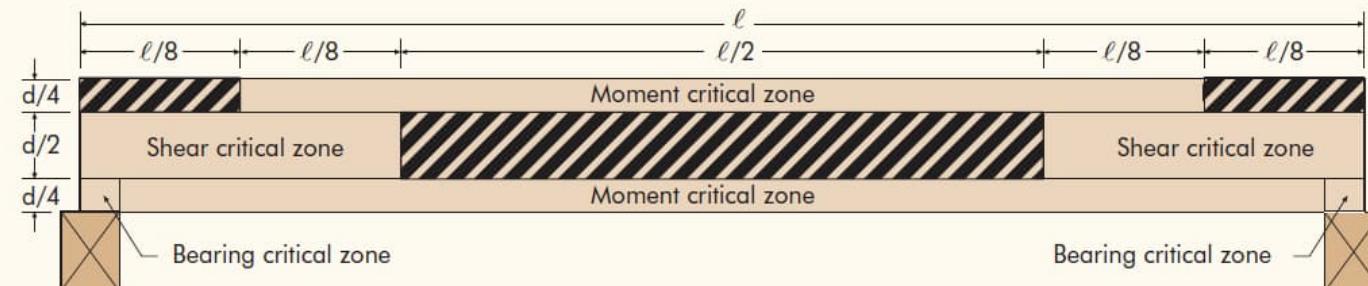


Building From the Ground Up: Floors

APA Tech Note: Field Notching and Drilling Glulam, Form S560

FIGURE 3

ZONES WHERE SMALL HORIZONTAL HOLES ARE PERMITTED IN A UNIFORMLY LOADED, SIMPLY SUPPORTED BEAM

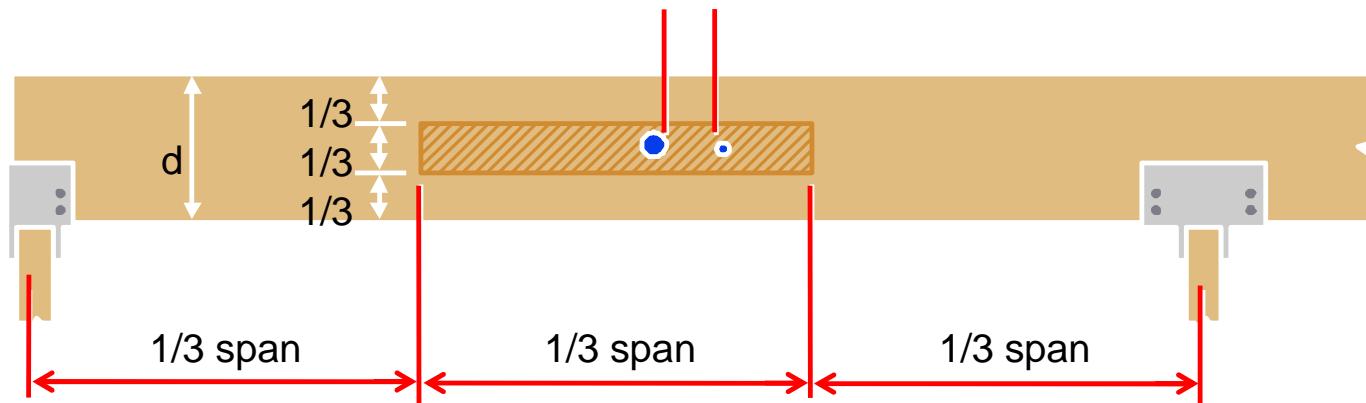


Zone where horizontal holes are permitted for passage of wires, conduit, etc.

Building From the Ground Up: Floors

APA Tech Note: Field Notching and Drilling LVL, Form G535

Minimum amount of spacing = 2 x diameter of the largest hole



 Zone where holes are permitted for passage of wires, conduits, etc.

No holes greater than 2" in diameter. No more than 3 holes per span.

Check with LVL manufacturer's guidelines for holes

Building From the Ground Up: Floors

APA Tech Notes: Effect of Large Diameter Horizontal Holes on Properties of LVL and Glulam Beams, Forms V900 and V700



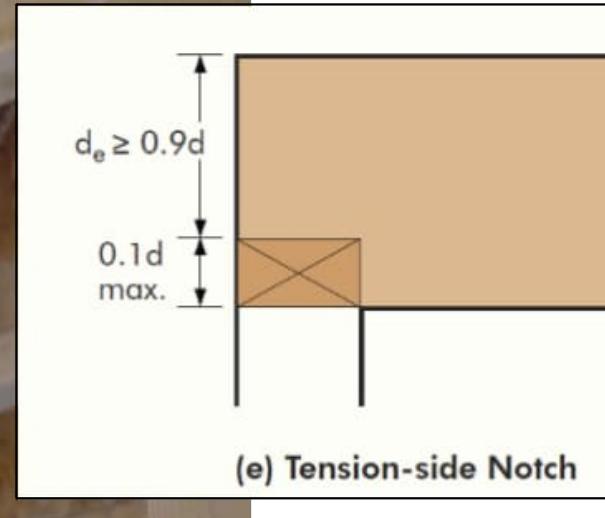
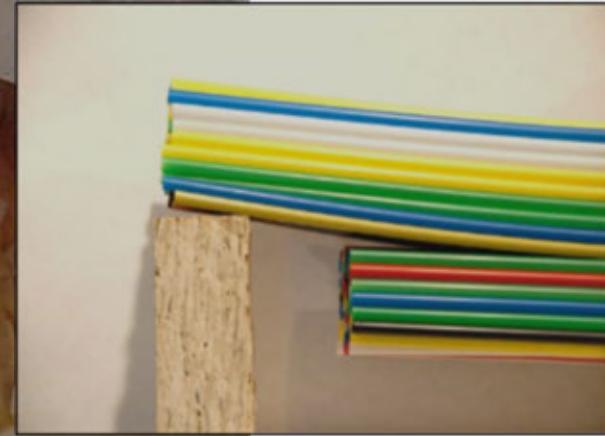
TECHNICAL NOTE

Effect of Large Diameter Horizontal Holes on the Bending and Shear Properties of Laminated Veneer Lumber



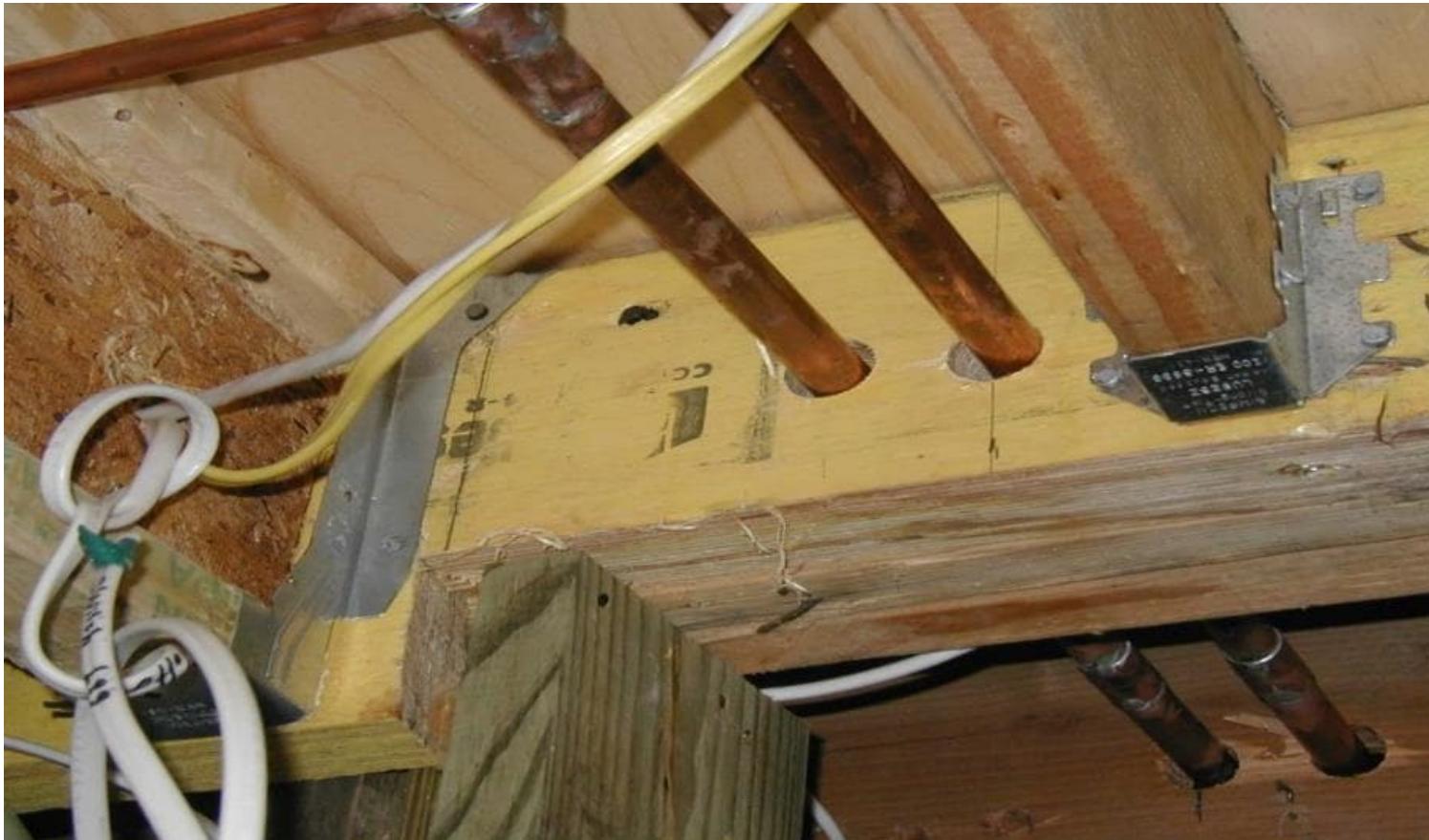
TECHNICAL NOTE

Effect of Large Diameter Horizontal Holes on the Bending and Shear Properties of Structural Glued Laminated Timber



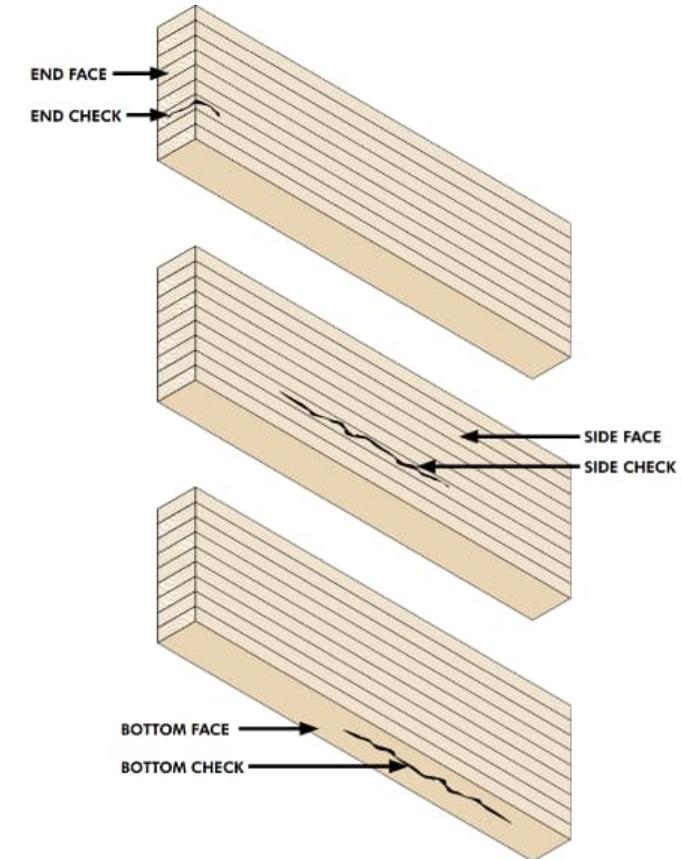
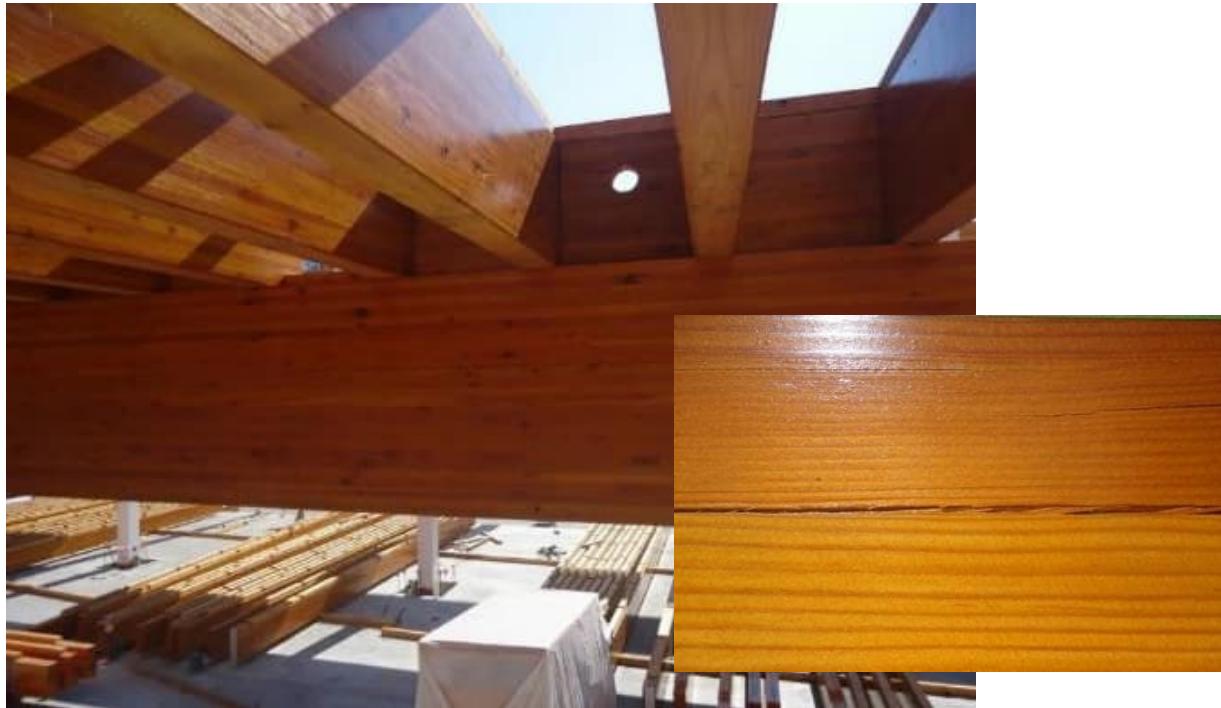
(e) Tension-side Notch

Building From the Ground Up: Floors



Building From the Ground Up: Floors

Seasoning checks in glulams



Wood Properties



- Guidelines established for what size checks are okay without an engineering analysis
- Published in Owner's Guide to Understanding Checks in Glued Laminated Timber, Form F450

Also see APA Technical Note: *Evaluation of Check Size in Glued Laminated Timber Beams*, Form R475

IS MY GLULAM OK?

Is the span of the glulam beam greater than 10 times the depth?

Example: Depth is 12", span is greater than 10'

YES

NO

Where do the checks appear?

BOTTOM FACE

Is the check parallel to the grain of wood?

YES

NO

SIDE FACE

Is the depth of the check less than one-third the width of the beam, and is the length less than one-third the length of the beam?

YES

NO

END FACE

Is the length of the check or split less than one-half the depth of the member?

YES

NO

NO STRUCTURAL CONCERN

If the checks on your building's glulam pose no structural problems, engineering analysis is not required. These recommendations apply to both simple span beams and multiple span beams under uniform loads.

CONSULT DESIGN PROFESSIONAL

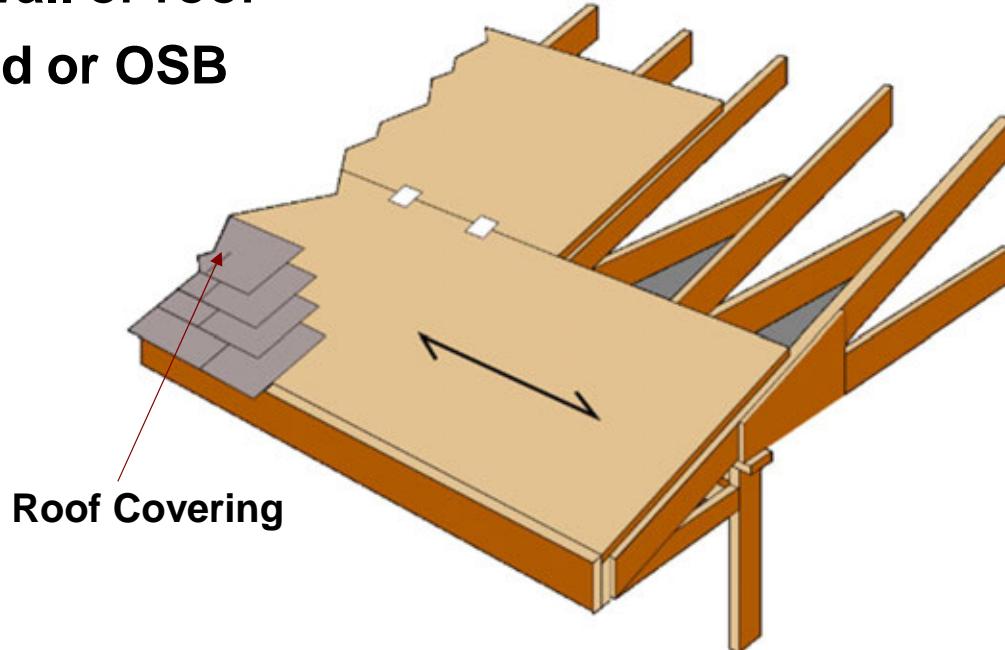
If checks in glulam exceed these sizes and situations, a qualified design professional should evaluate the effect of the checks.

Building From the Ground Up: Roof

Rated Sheathing

Floor, wall or roof

Plywood or OSB



Building From the Ground Up: Roof

APA Engineered Wood Construction Guide, Form E30, Table 34

TABLE 34

RECOMMENDED UNIFORM ROOF LIVE LOADS FOR APA RATED SHEATHING^a AND
APA RATED STURD-I-FLOOR WITH STRENGTH AXIS PERPENDICULAR TO SUPPORTS^b

Panel Span Rating	Minimum Panel Performance Category	Maximum Span (in.)		Allowable Live Loads (psf) ^d						
		With Edge Support ^c	Without Edge Support	12	16	20	24	32	40	48
APA RATED SHEATHING^a										
12/0	3/8	12	12	30						
16/0	3/8	16	16	70	30					
20/0	3/8	19.2	19.2	120	50	30				
24/0	2/8	24	19.2*	190	100	60	30			
24/16	7/16	24	24	190	100	65	40			
32/16	15/32	32	28	300	165	110	65	30		
40/20	19/32	40	32	—	275	195	120	60	30	
48/24	23/32	48	36	—	—	270	175	95	45	30
60/32 ^f	7/8	60	40	—	—	—	305	165	100	70
60/48 ^f	1-1/8	60	48	—	—	—	305	165	100	70

Building From the Ground Up: Roof

APA Engineered Wood Construction Guide, Form E30, Table 37

TABLE 37

RECOMMENDED ROOF LOADS (PSF) FOR APA RATED SHEATHING WITH
STRENGTH AXIS PARALLEL TO SUPPORTS^{a,b} (OSB and 5-ply/5-layer plywood panels unless otherwise noted)

Panel Grade	Panel Performance Category	Span Rating	Maximum Span (in.)	Load at Maximum Span	
				Live	Total
APA STRUCTURAL I RATED SHEATHING	7/16	24/16	24 ^c	15	25
	15/32, 1/2	32/16	24	30 ^d	40 ^d
	19/32, 5/8	40/20	24	70 ^e	80 ^e
	23/32, 3/4	48/24	24	105 ^f	115 ^f
APA RATED SHEATHING	7/16	24/16	16	35	45
	15/32, 1/2	32/16	24 ^c	15 ^g	25 ^g
	19/32, 5/8	40/20	24	40 ^h	50 ^h
	23/32, 3/4	48/24	24	70 ^e	80 ^e

a. For guaranteed or warranted roofs, contact membrane manufacturer for acceptable deck.

b. Provide edge support.

c. Solid blocking recommended at panel ends for 24-inch span.

d. For 4-ply plywood, reduce load by 10 psf.

e. For 4-ply plywood, reduce load by 30 psf.

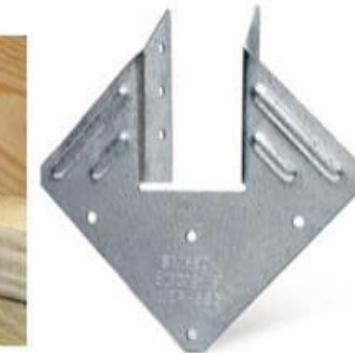
f. For 4-ply plywood, reduce load by 45 psf.

g. For 4-ply plywood, reduce load by 5 psf.

h. For 4-ply plywood, reduce load by 15 psf.

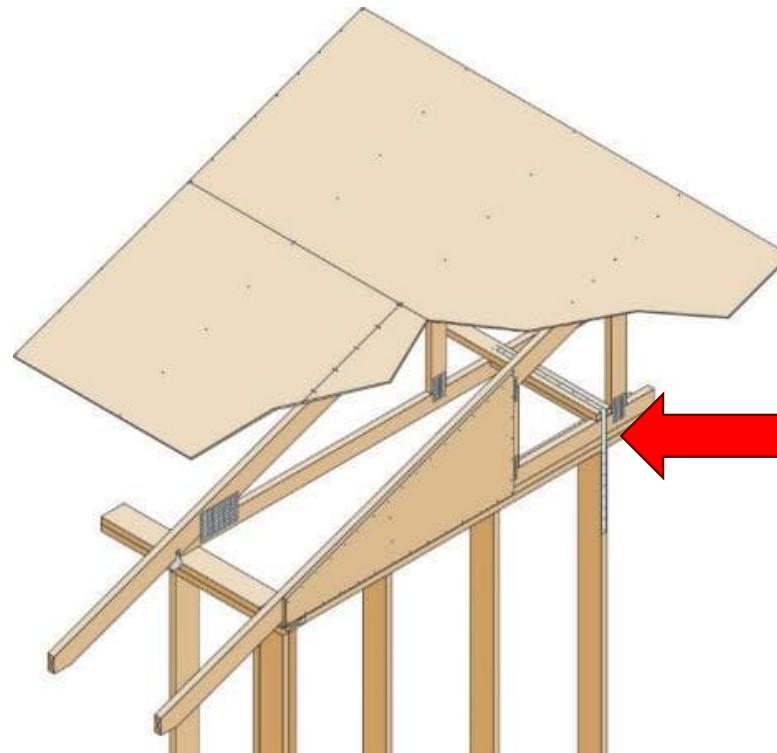
Building From the Ground Up: Roof

3-dimensional metal connectors



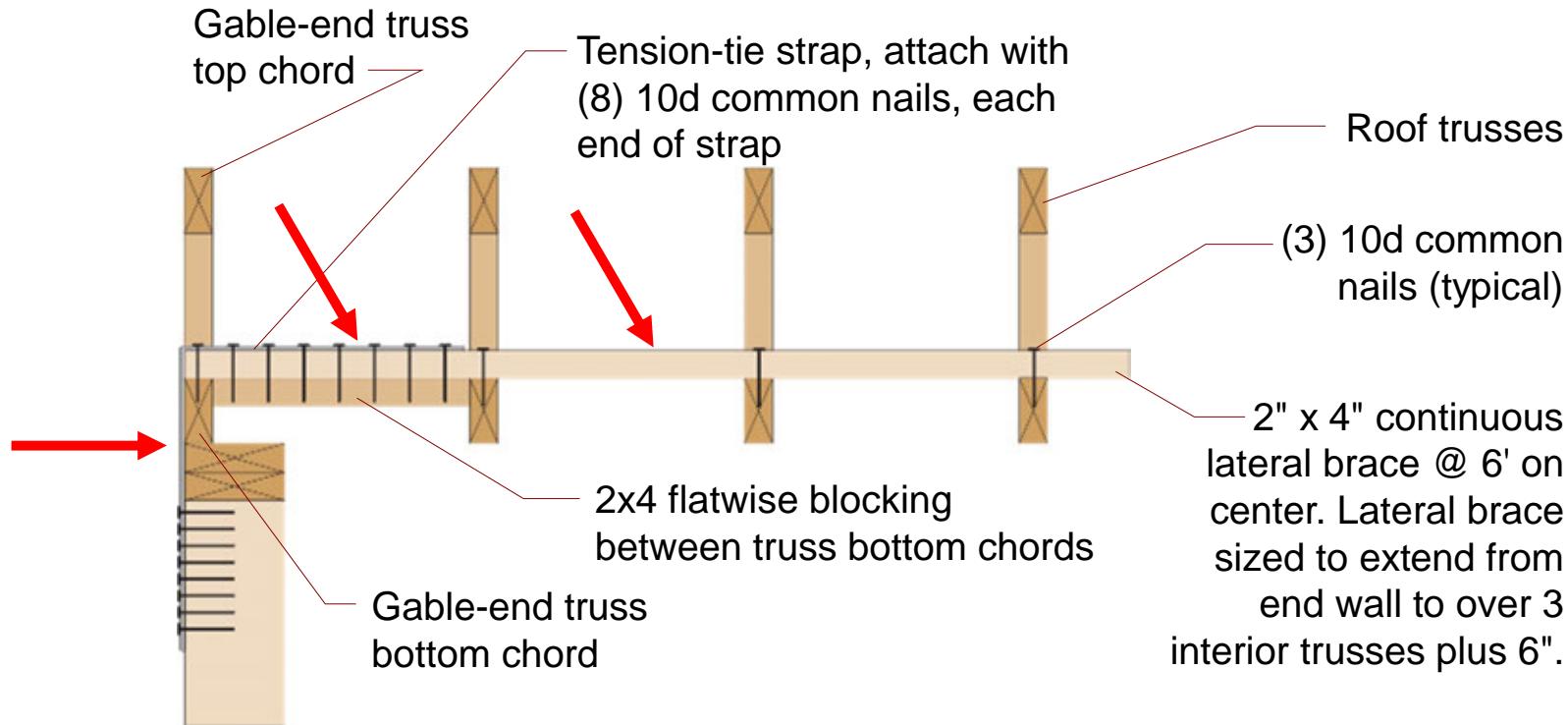
Building From the Ground Up: Roof

Gable ends



Studs-to-Floor/Roof LATERAL LOAD

Tie gable-end walls back to the structure

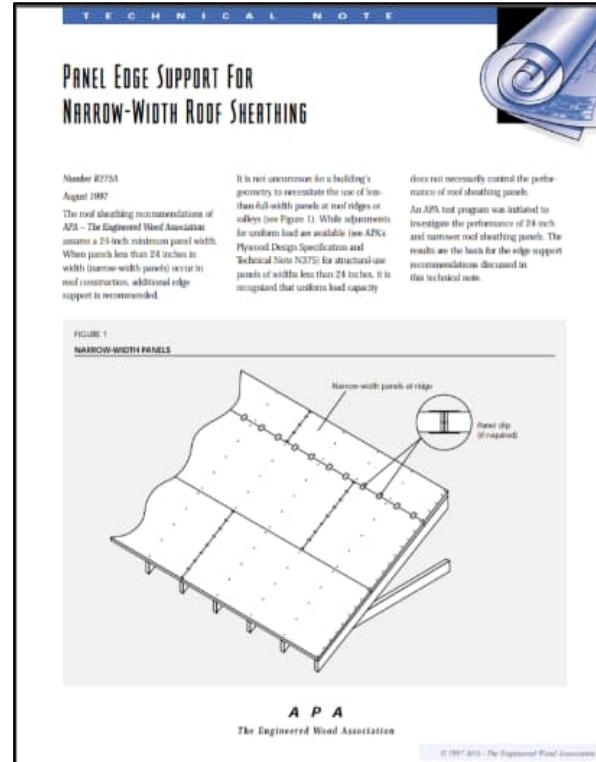


Narrow Width Roof Sheathing

Narrow Roof Sheathing

- **If WSP* is 16" to 24"**
 - 2 clips at lower edge acceptable**
 - Lumber block lower edge**
- **If WSP is 12" to 16"**
 - Lumber block lower edge**
- **If WSP is less than 12"**
 - Lumber block upper and lower edges**

*“WSP” = wood structural panel (plywood or OSB)



APA Technical Note Form R275

Building From the Ground Up: Special Topics

Special topics

- **On-site moisture management**
- **Panel Expansion**
- **Panel Shrinkage**



Building From the Ground Up: Special Topics



Prevent Moisture Intrusion in Subfloors

Drying of Subfloor



Fans

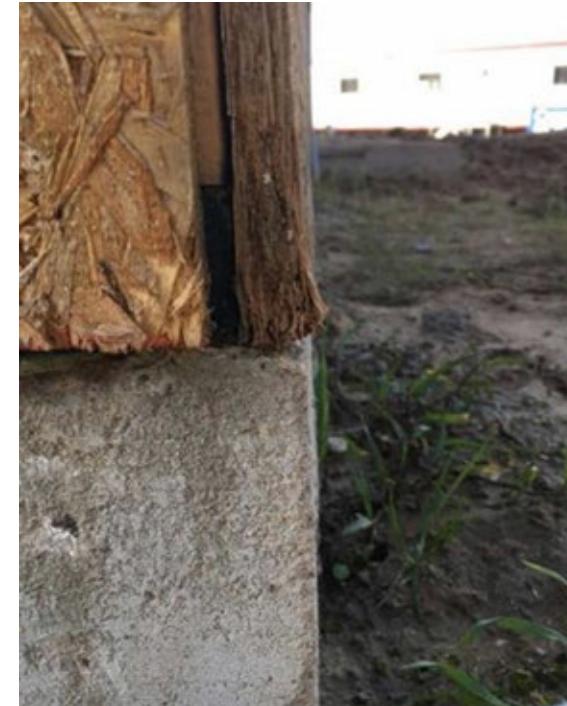


Dehumidification

Building From the Ground Up: Special Topics

Capillary Action

- Is the product touching the foundation rated for concrete contact?
- What are the long-term consequences?



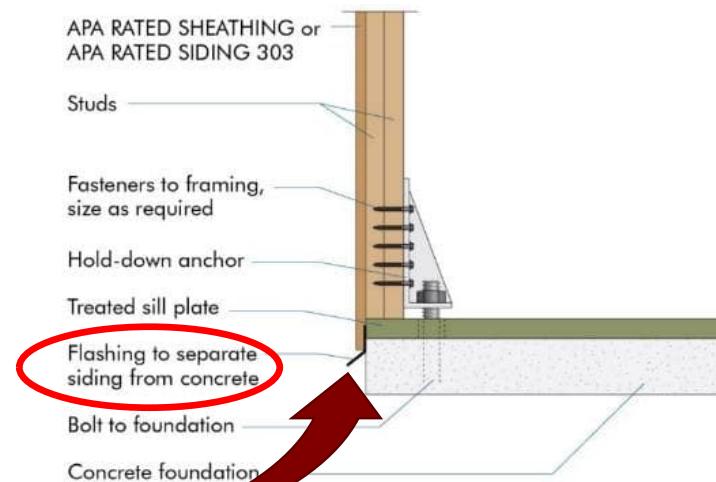
Building From the Ground Up: Special Topics

Use Flashing

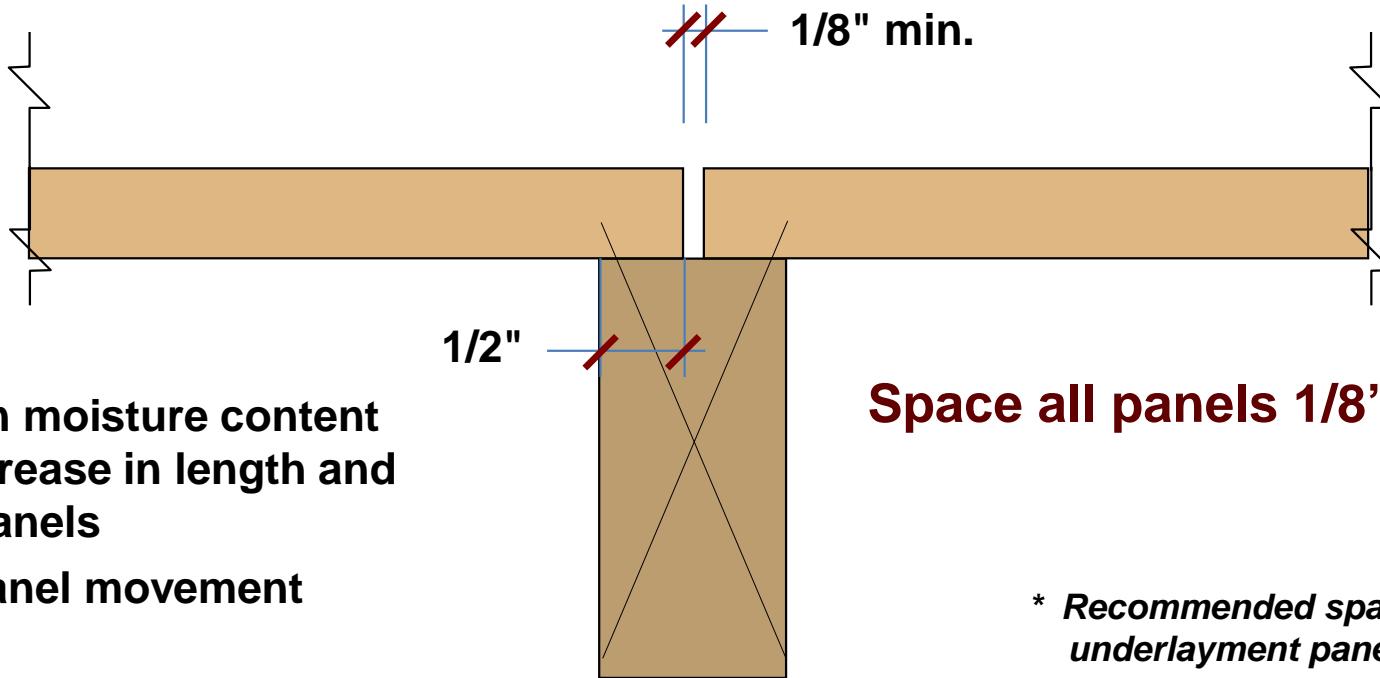
Flashing keeps the panel from contacting the concrete.

SHEAR WALL HOLD-DOWN ANCHOR

Shear wall overturning moments may be transferred by a fabricated steel bracket such as this. Regular foundation bolts may be all that is required in some cases depending on engineering analysis.

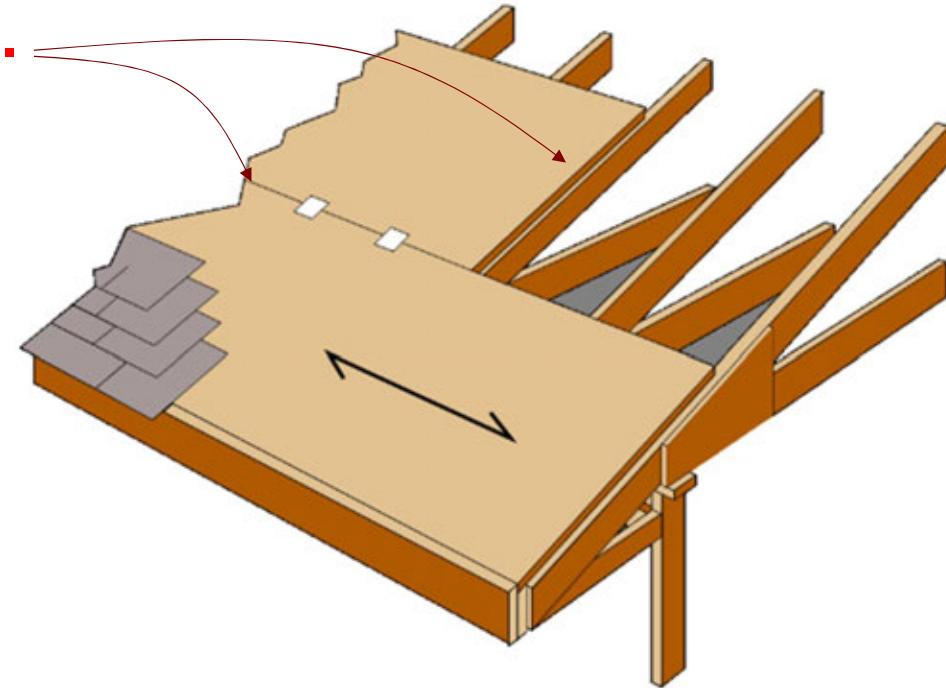


Building From the Ground Up: Special Topics



Building From the Ground Up: Special Topics

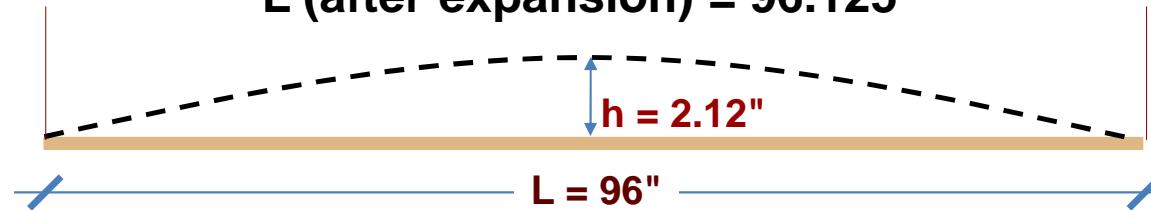
**Space panels 1/8" min.
(ends & edges)**



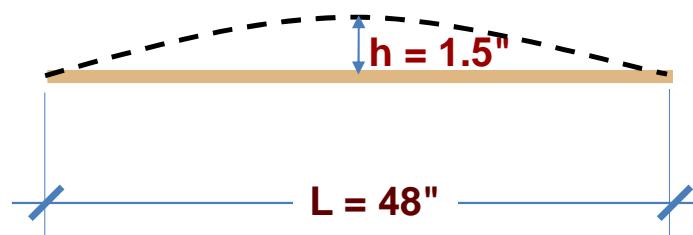
Allow for panel expansion

Building From the Ground Up: Special Topics

L (after expansion) = 96.125"



L (after expansion) = 48.125"



Allow for panel expansion

Building From the Ground Up: Special Topics

What can happen if panels aren't allowed to acclimate?



Building From the Ground Up: Special Topics



Nailing
approx.
3" o.c.

Building From the Ground Up: Special Topics

Buckling — High Risk Applications

- **Panels installed parallel to supports (e.g., walls)**
- **Edge nailing 4" o.c. or closer**
- **Long lasting rainy weather or high humidity**
- **Panels installed within a few days of their manufacture**
- **Others...**



APA Technical Note D481

High risk because the conditions may reduce edge gap's effectiveness in absorbing panel expansion.

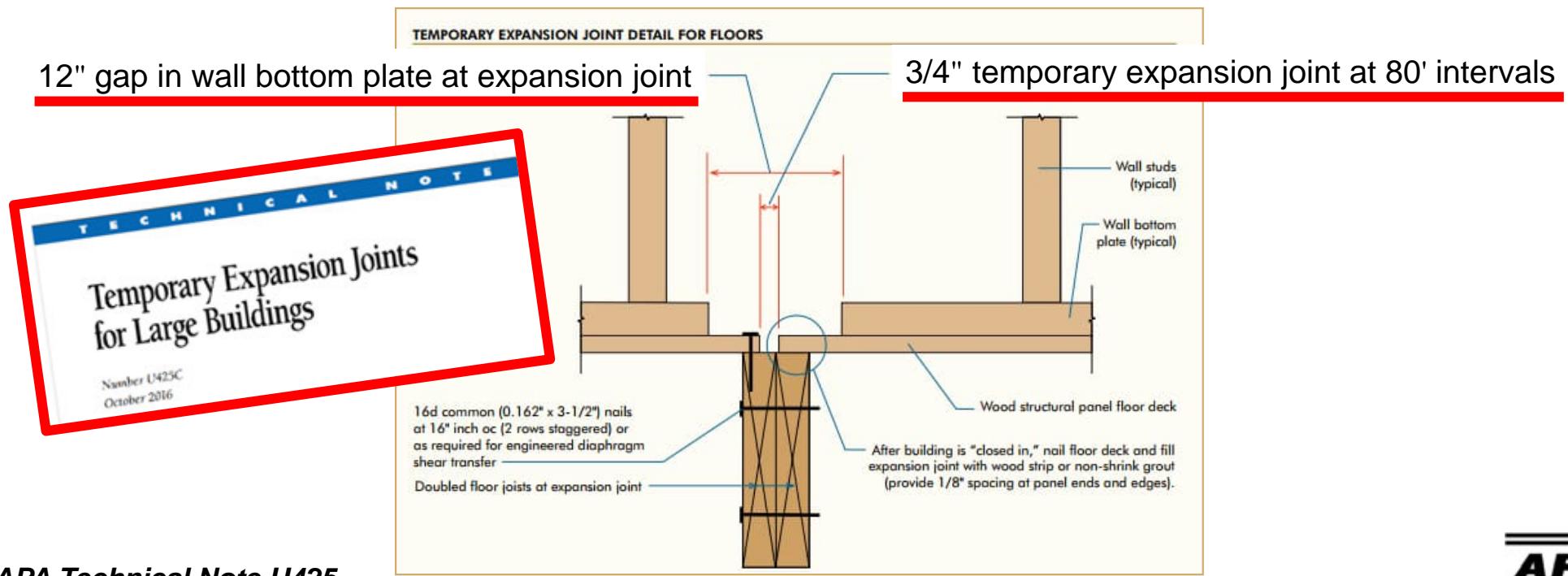
Building From the Ground Up: Special Topics

Panel Expansion of large structures

- **Panel expansion may accumulate through the framing of large, continuous floor or roof decks**
- **Provide temporary expansion joints to minimize displacement when building plan dimension exceeds 80'**



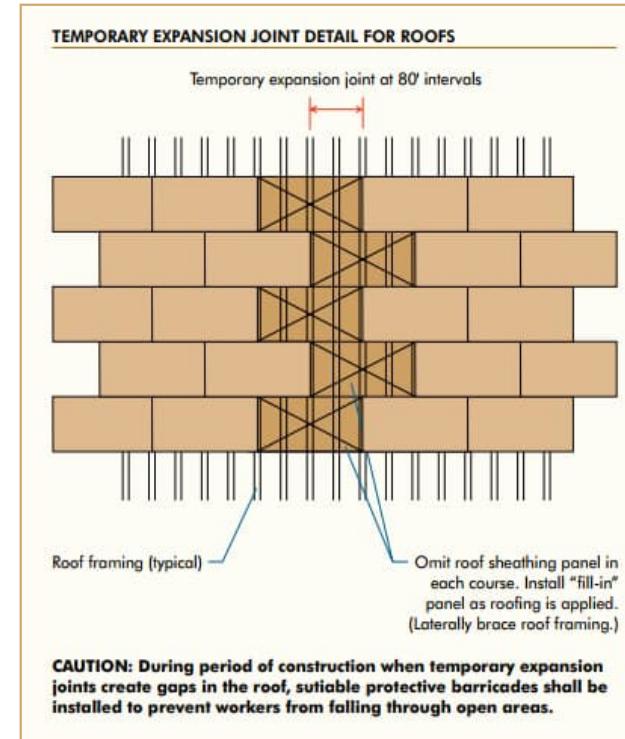
Building From the Ground Up: Special Topics



Building From the Ground Up: Special Topics

Provisions for large structures

- **Sheath 80-foot sections, omitting a roof sheathing panel between sections**
- **Complete installation with fill-in panels immediately before sheathing is covered with roof underlayment**



Building From the Ground Up: Special Topics

Shrinkage occurs primarily in horizontal wood dimensional lumber members such as wall plates and floor joists.



Building From the Ground Up: Special Topics

Wood shrinkage

- Wood mostly shrinks perpendicular to grain. (Shrinkage parallel to grain is approximately 1/40 of the shrinkage perpendicular to grain and can be neglected.)
- The amount of shrinkage (or expansion) in wood is directly proportional to the change in moisture content.
- The higher the moisture content at time of construction, the more shrinkage that can occur in the structure as the structure dries out/acclimates.
- Wood shrinkage must be accounted for in structures > than 2 stories.

Building From the Ground Up: Special Topics

Tips:

- Keep materials dry, dry in as soon as possible
- Load floors ASAP
- Accommodate movement in plumbing and electrical (vertical slip joints, vertical slot holes at horizontal runs, etc.)
- Limit or avoid dissimilar materials.
- Additional information on Accommodating Shrinkage in Wood-Frame Structures can be found on WoodWorks web page, www.woodworks.org

Quick Summary

Simple basics make a big difference:

- Follow the prints and specifications
- Space panels
- Follow fastening guidelines
- Check load paths/stacking
- Control moisture

Assistance is available from APA



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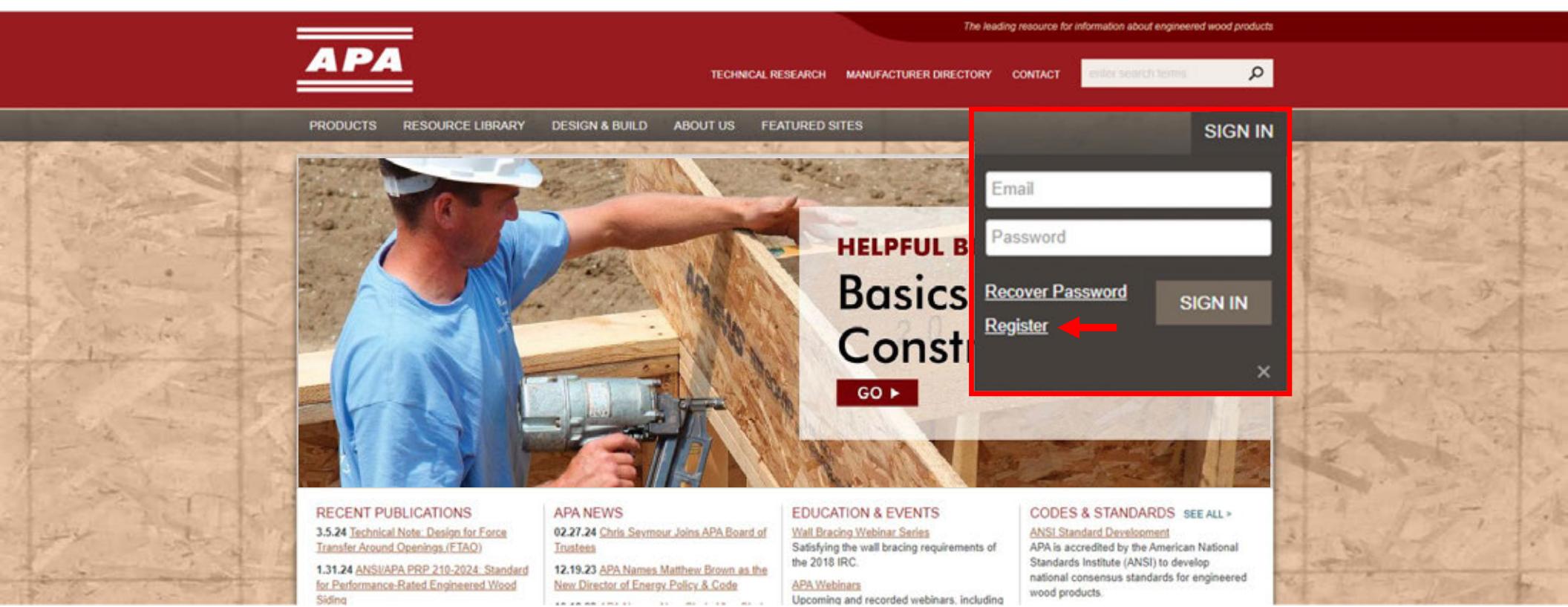
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UPCOMING WEBINAR

Designing Engineered Wood Diaphragm Systems

Wednesday, May 22 | 10-11 a.m. PDT

Diaphragms play a vital role in a building's lateral load path. Whether that lateral load is from seismic activity or wind forces, the diaphragm is responsible for distributing that lateral load to the shear walls. This session provides guidance on the proper design of engineered wood diaphragm



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Representatives available from Monday to Friday, 7:00 AM to 4:00 PM, PST. Please make sure to provide brief details regarding the nature of your inquiry and type of product(s).

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By Contact Form:
Please fill out form as required

Full Name

Profession

Please select.

Company Name

Email

Phone Number (optional)

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Frequently Asked Questions

General

How do I interpret the stamp on APA-trademarked plywood and OSB?

The information contained on the APA trademark is explained in detail on the APA Trademark page. [GO >](#)

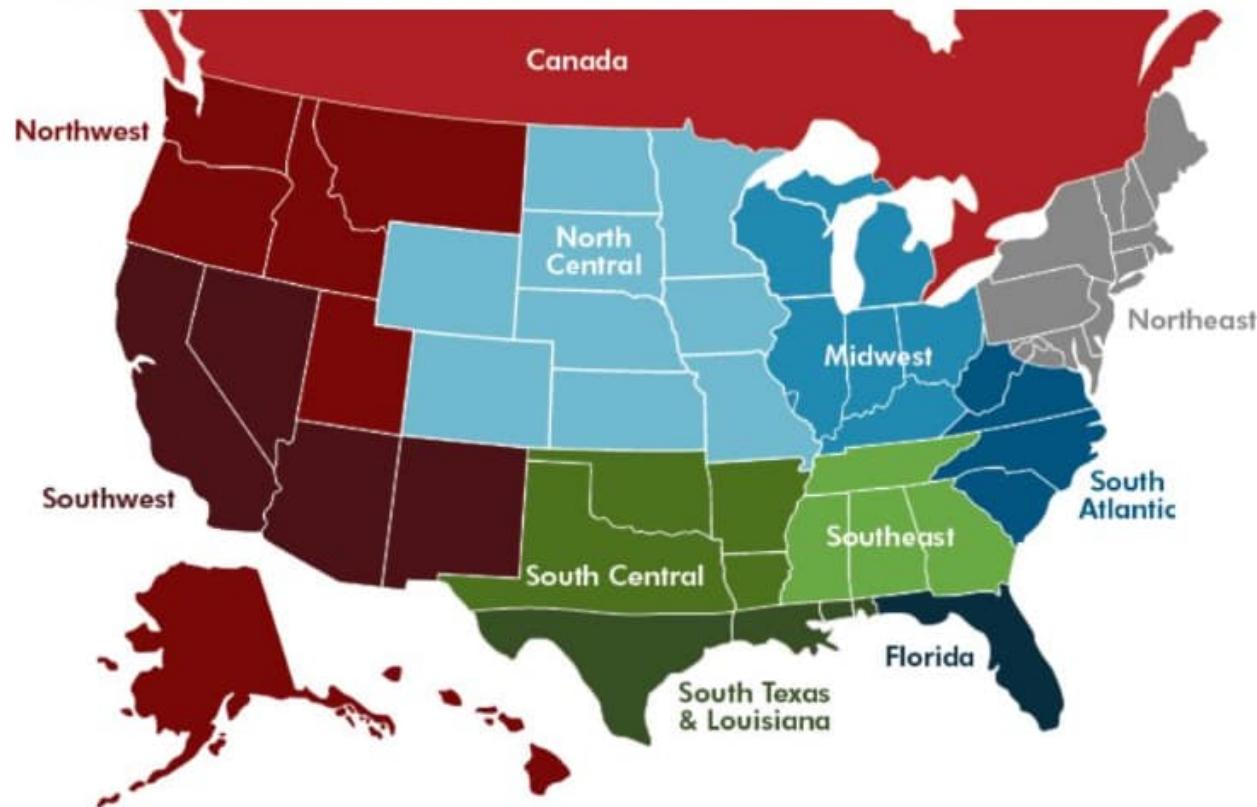
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Questions? Ask us anything.



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