

**APA**

# Frame it Right!

## Back to Basics for Big Buildings

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



# 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!

## Back to Basics for Big Buildings

### Learning Objectives:

- Identify common pitfall 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
  - Woods Strength
  - Walls
  - Floors
  - Roofs
  - Special topics
- Q&A

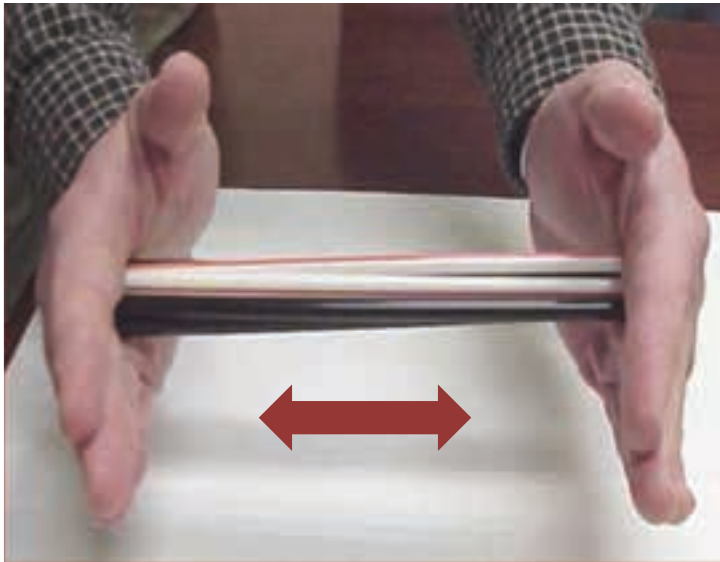




# Wood's Strength Direction

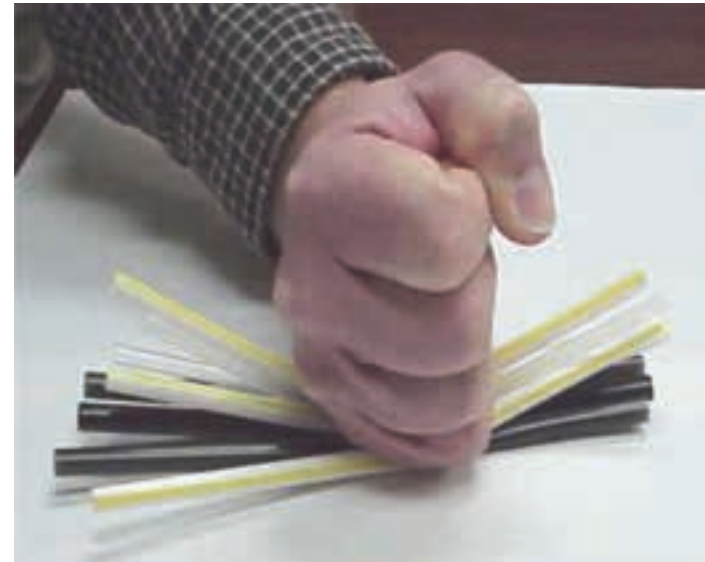
## 1. Wood has a strength direction

Load parallel  
to grain



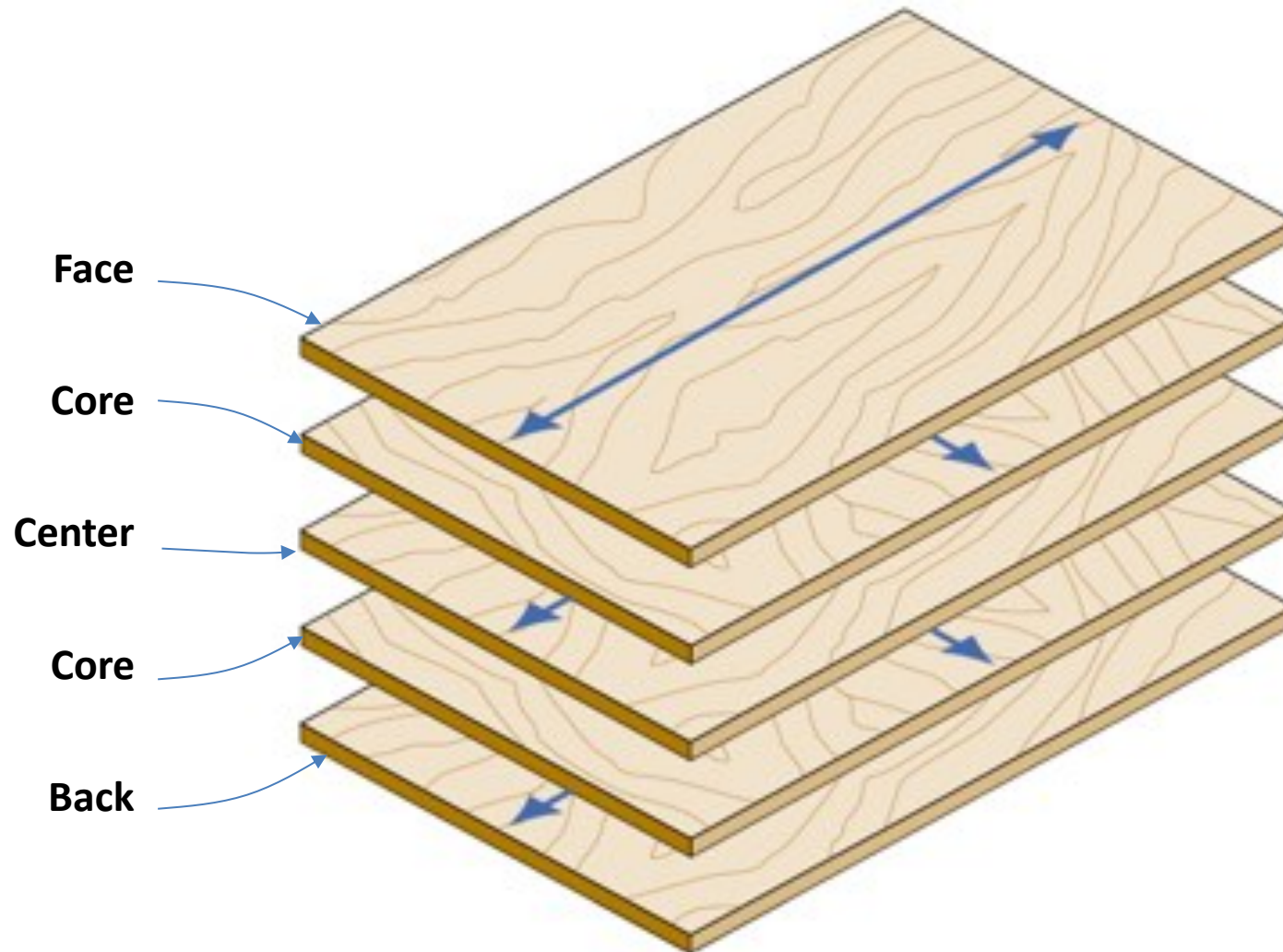
**Stronger**

Load perpendicular  
to grain



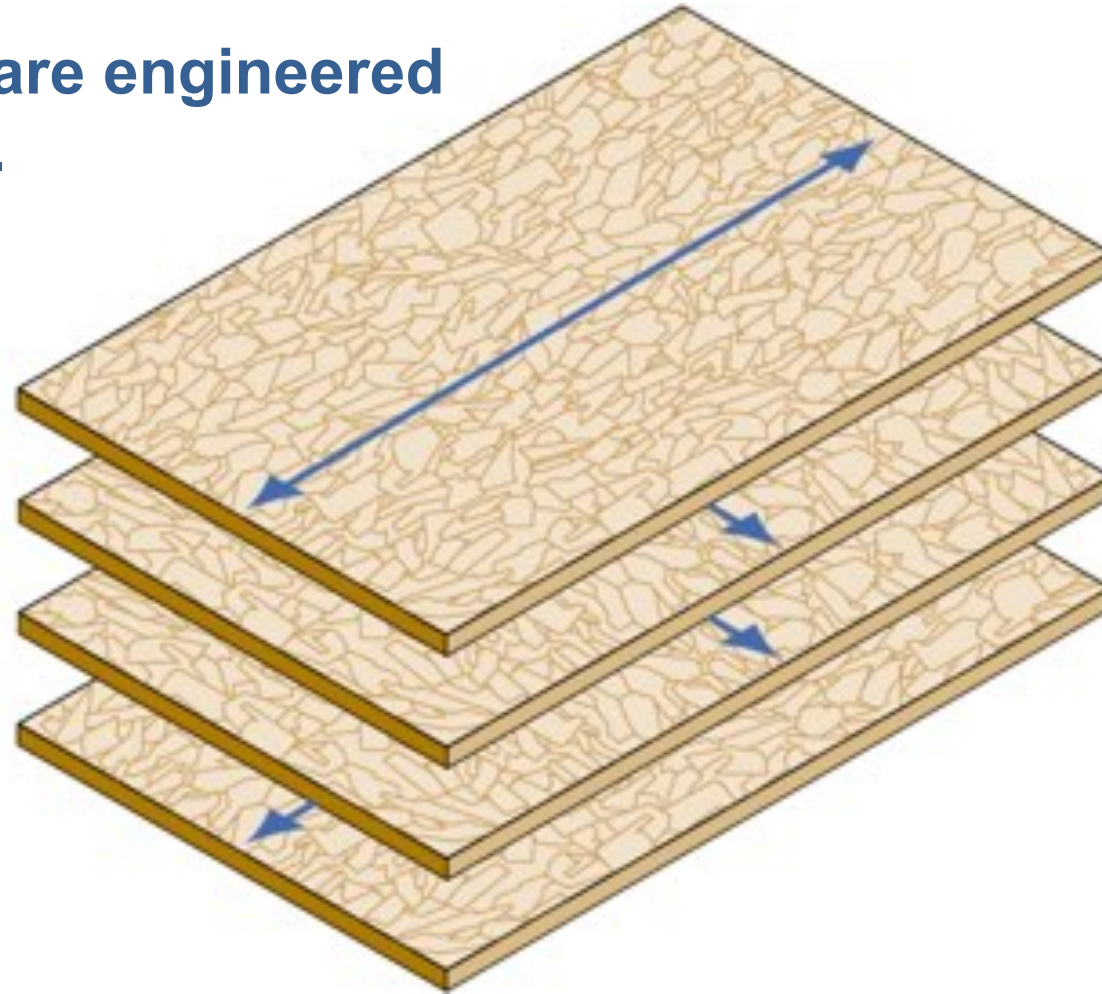
**Weaker**

# Wood's Strength Direction



# Structural Panels

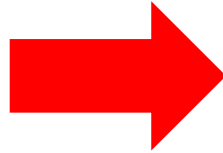
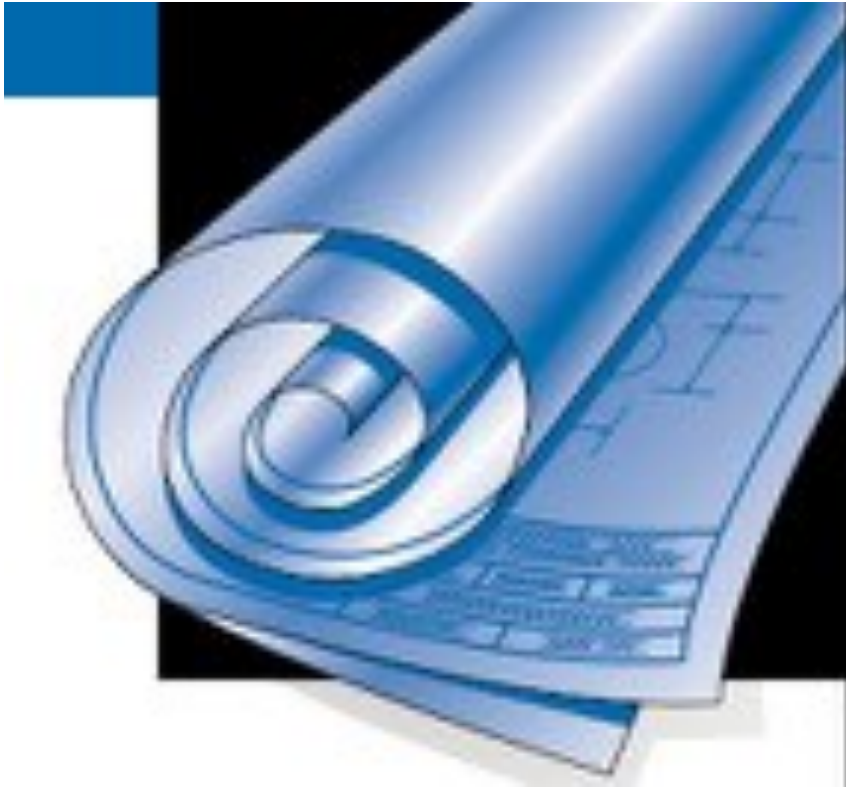
**OSB layers are engineered for strength.**





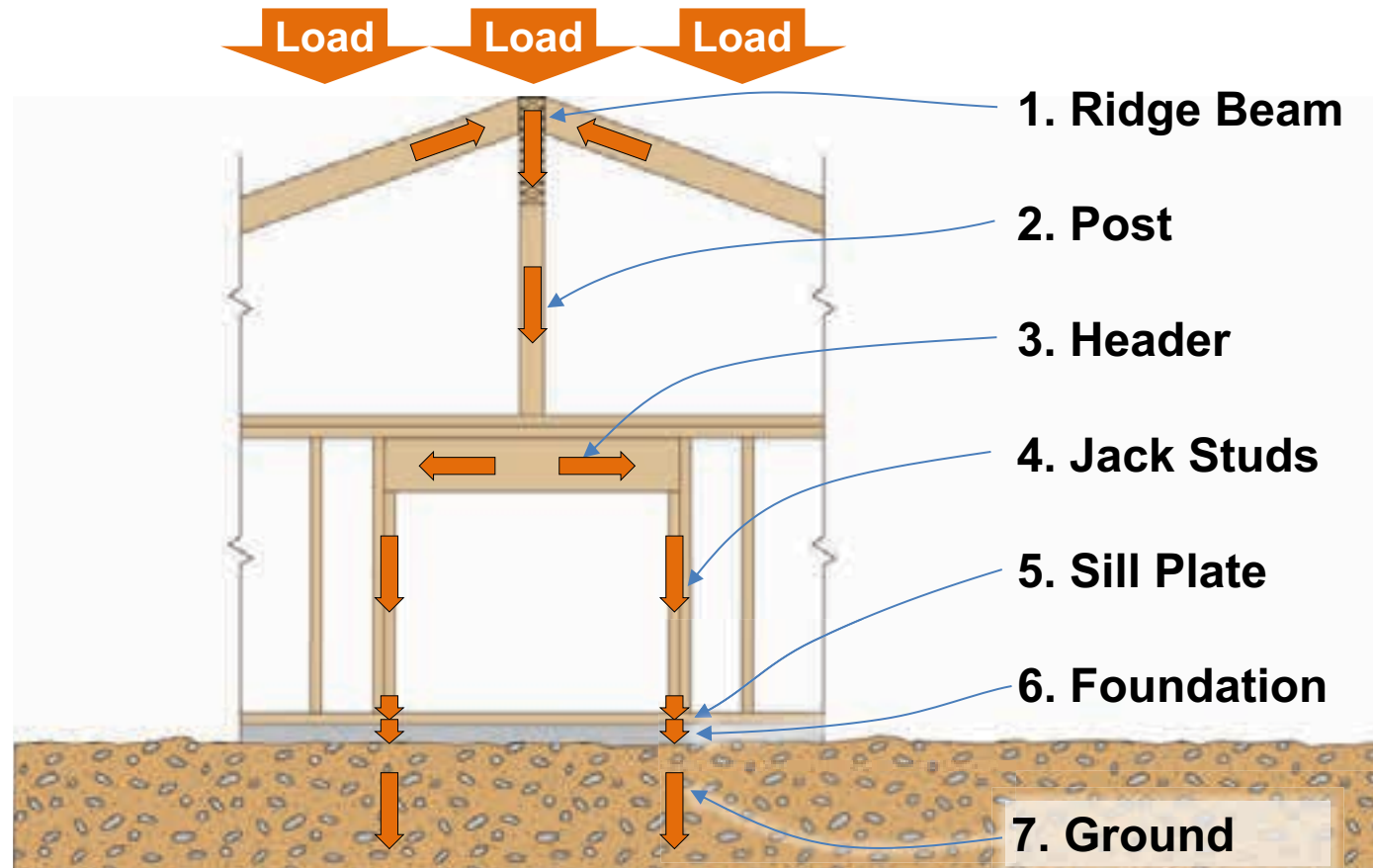
# Frame it Right!

**Does this match?**

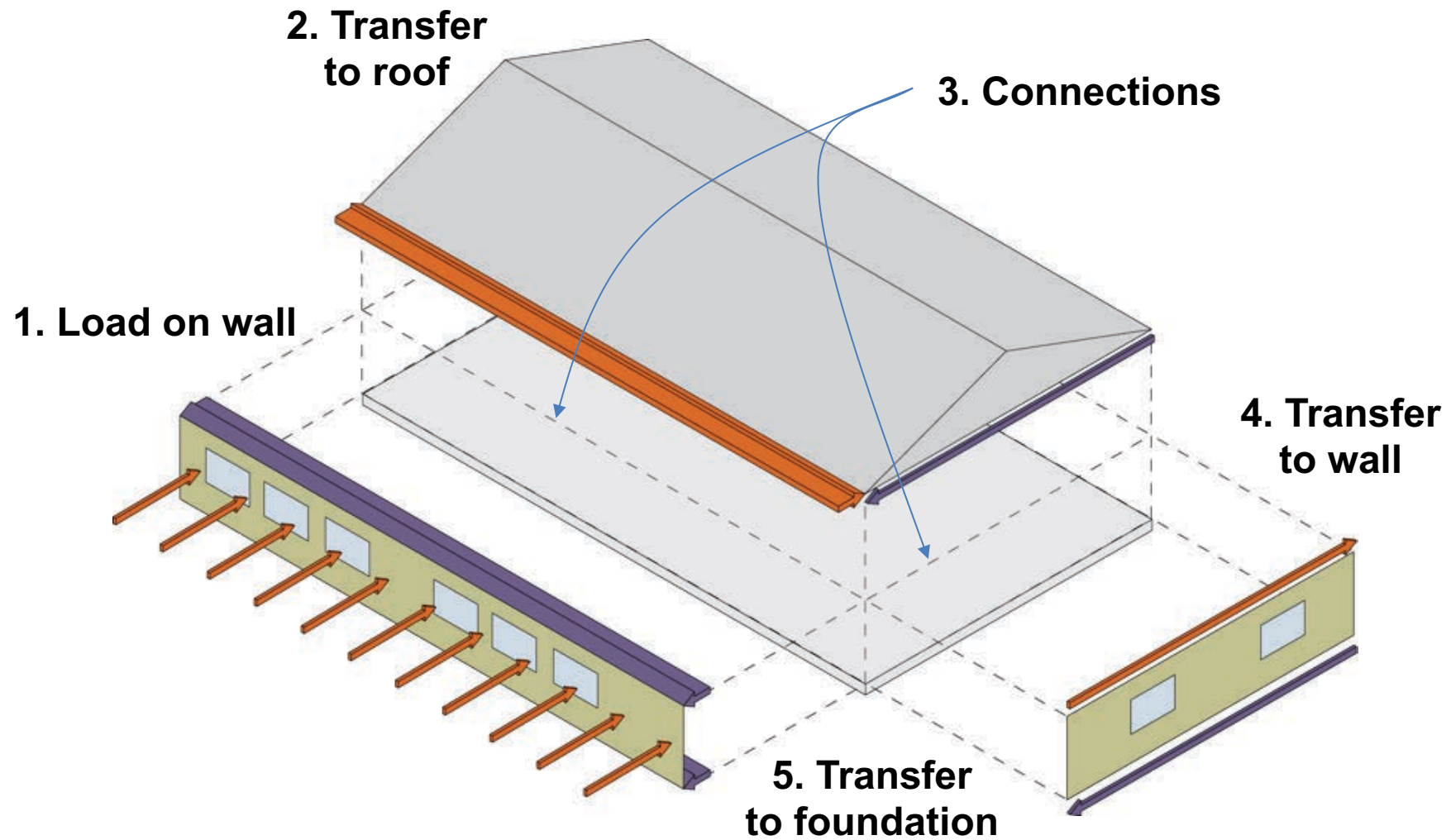


# Load Path

## Vertical (Gravity) Load Path



# Load Path

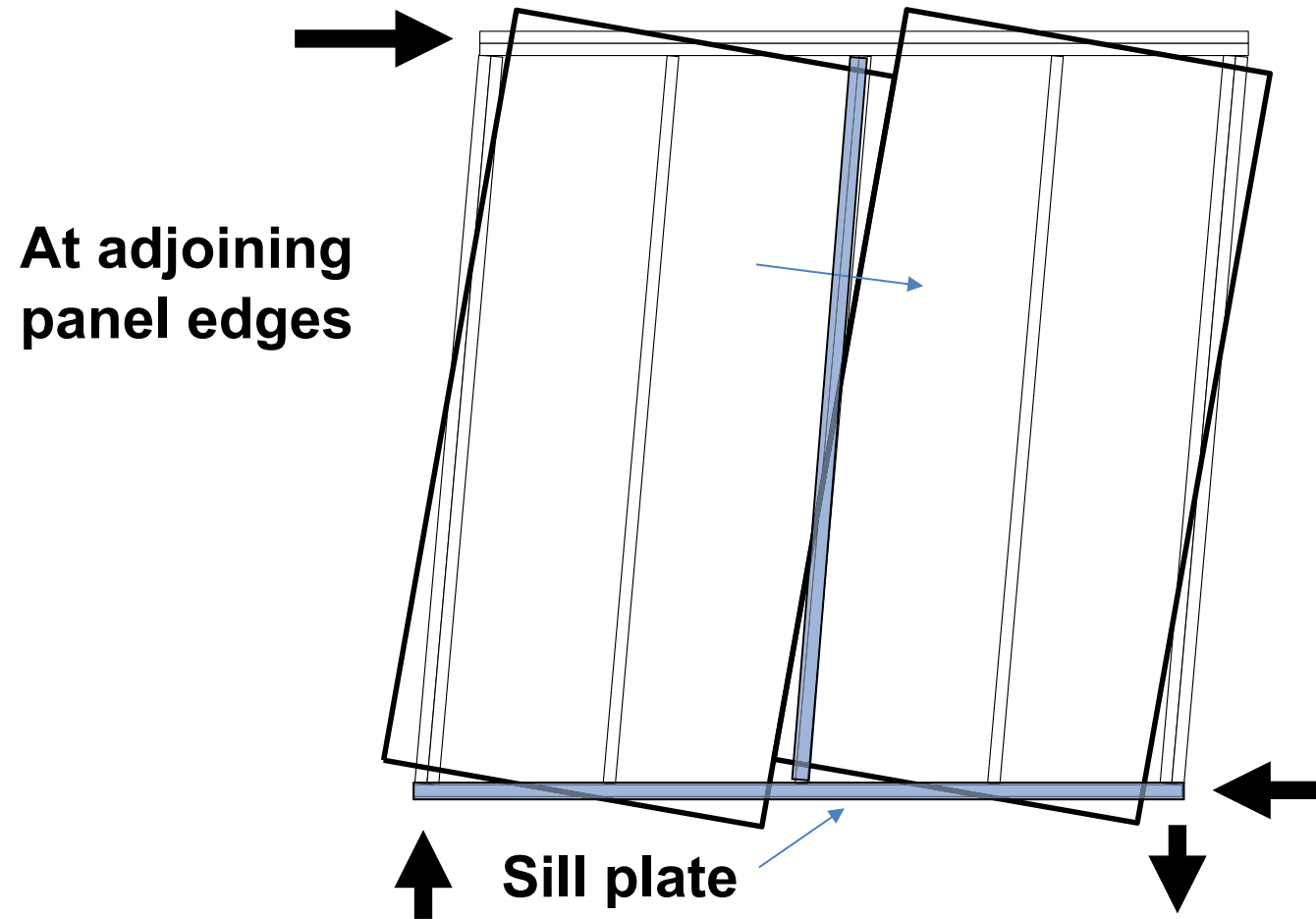


# Building From the Ground Up: **Walls**





# Building From the Ground Up: Walls



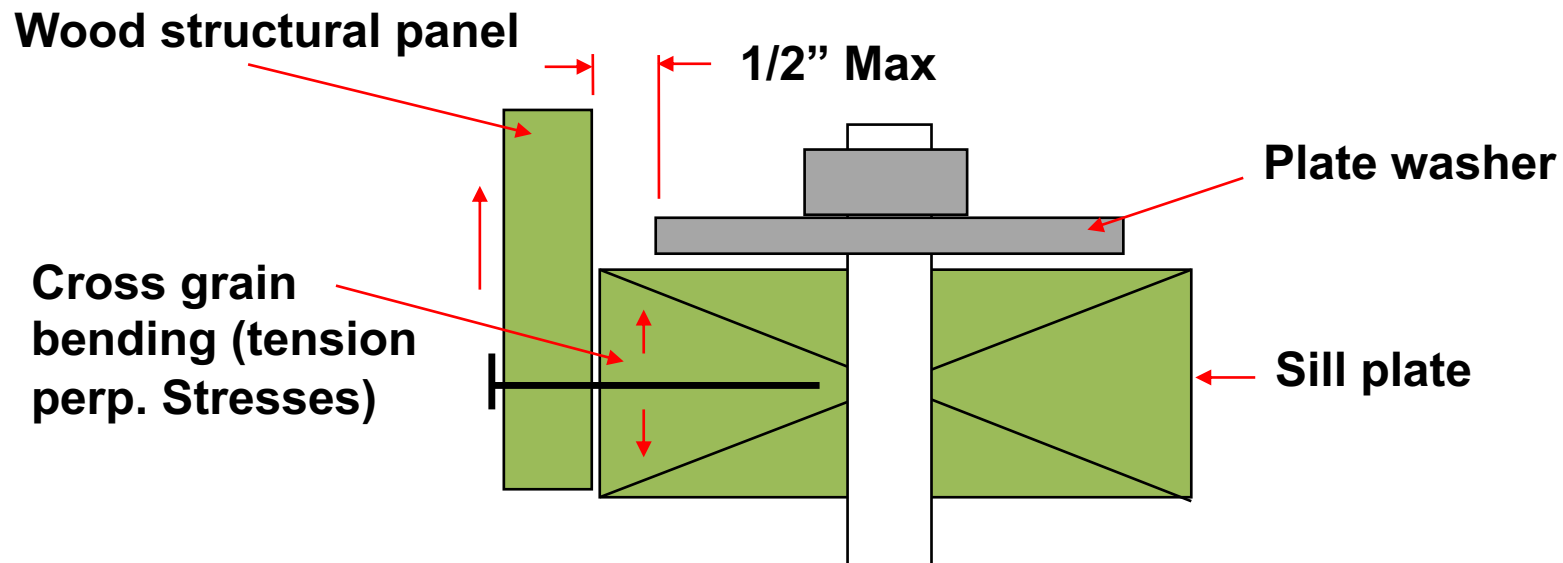
# Building From the Ground Up: Walls

**Anchor Bolts are not Hold Downs**



# Anchor Bolts

- Size and spacing per engineer
- Large plate washers (3"x3"x0.229") prevent cross grain bending-splitting of sill plate (Required in Seismic Zones D and E, IBC 2308.3.1) APA recommends for High Wind Applications



# Building From the Ground Up: Walls

**Missing washer**



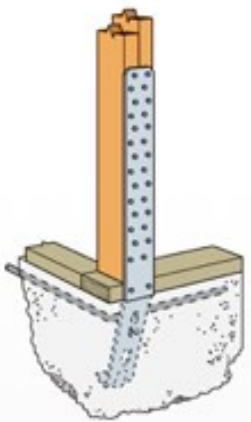


# Building From the Ground Up: Walls

## Hold-down hardware



# Building From the Ground Up: **Walls**



# Building From the Ground Up: Walls





# Building From the Ground Up: **Walls**

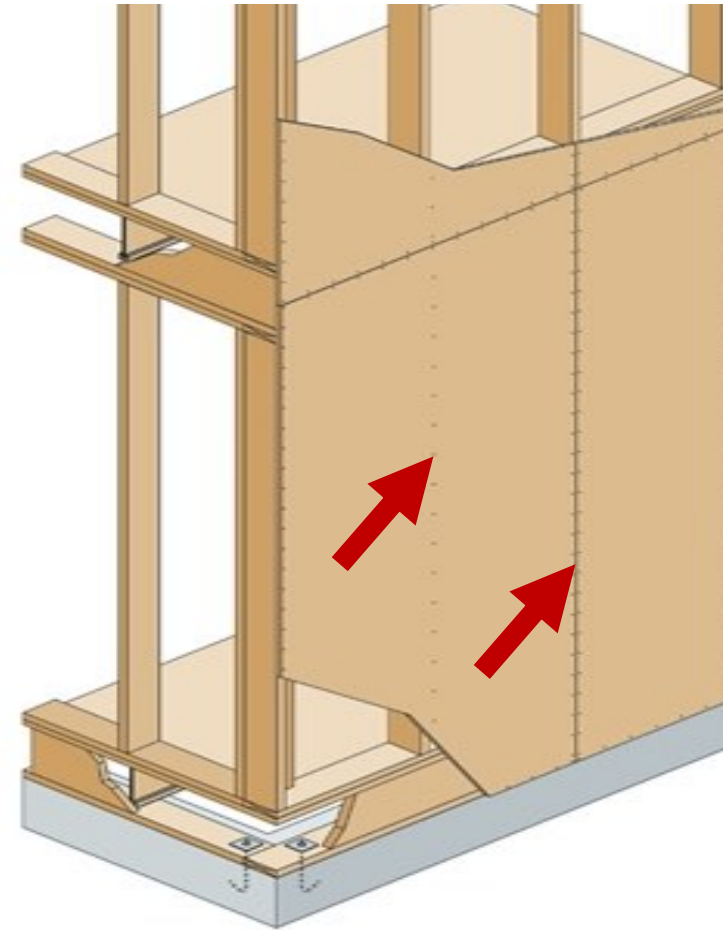




# Building From the Ground Up: Walls

## Wall Sheathing

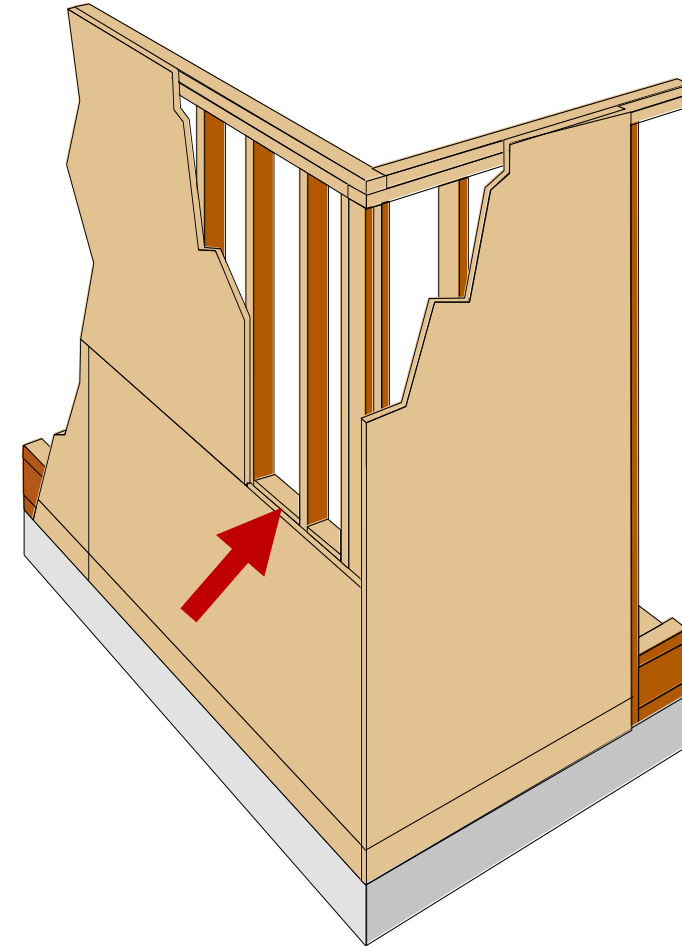
- Racking/shear resistance
- Wind pressure resistance
- Nonstructural benefits
- Installation:
  - Per engineer's design
  - Min. fastening: 8d nails @ 6" o.c. perimeter and 12" o.c. in the field min.



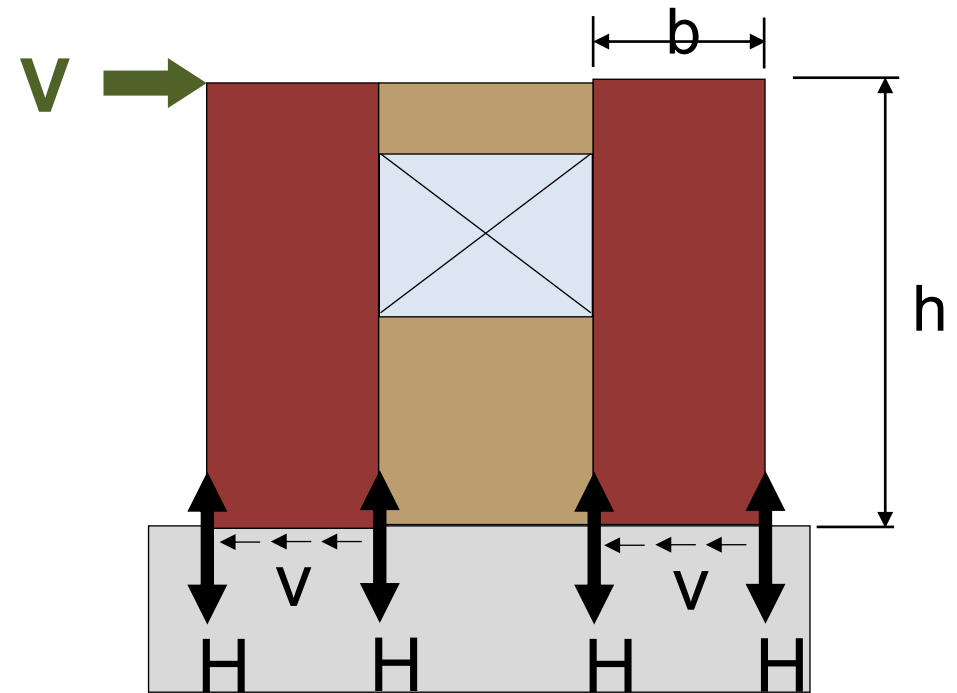
# Building From the Ground Up: Walls

- **Wall sheathing**

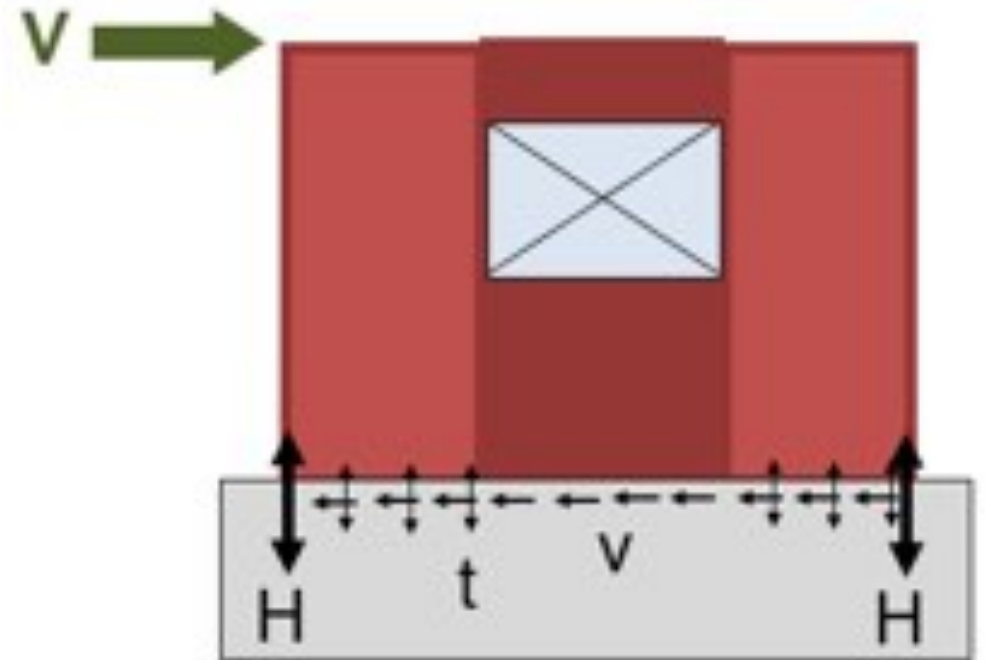
- Plywood or OSB
- Orientation



# Segmented Shear Walls

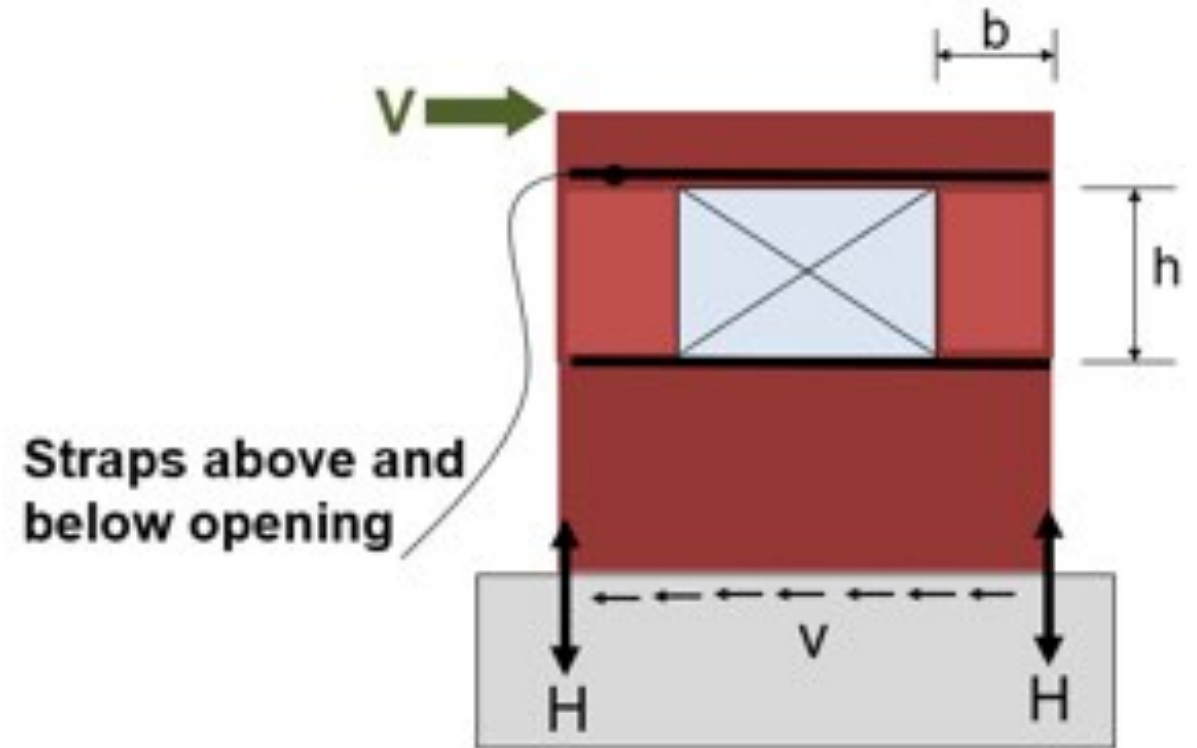


# Perforated Shear Walls





# Force Transfer Around Openings (FTAO) Shear Walls



# High Load Shear Walls



**Rated Sheathing**



versus



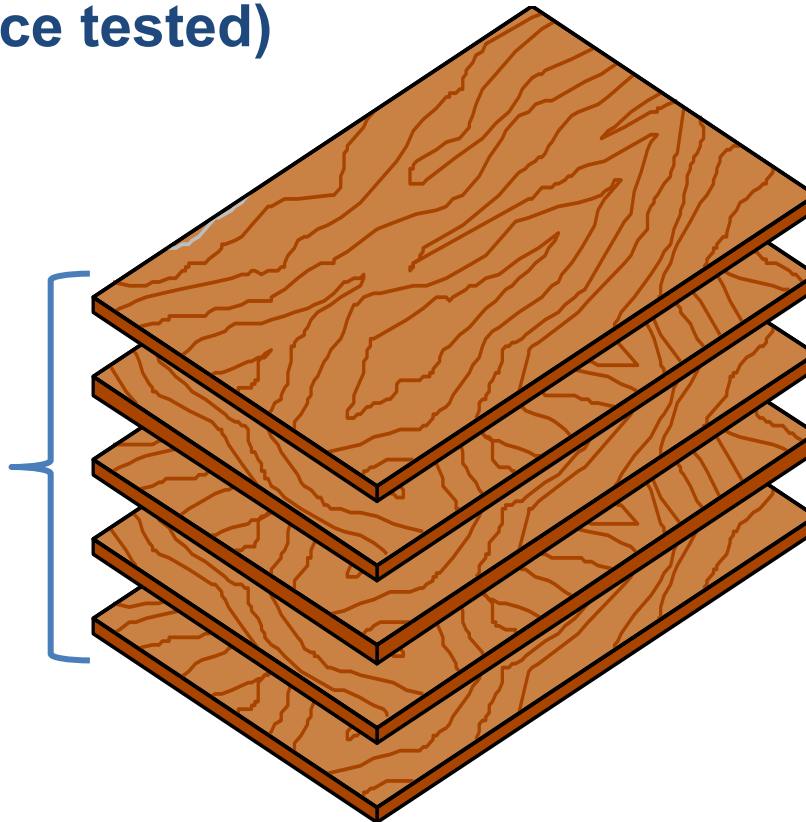
**Structural I**

# Structural I Panels

- Increased shear capacity
- Increased stiffness, especially across the panel
- Available in OSB (performance tested)



Group 1  
Species



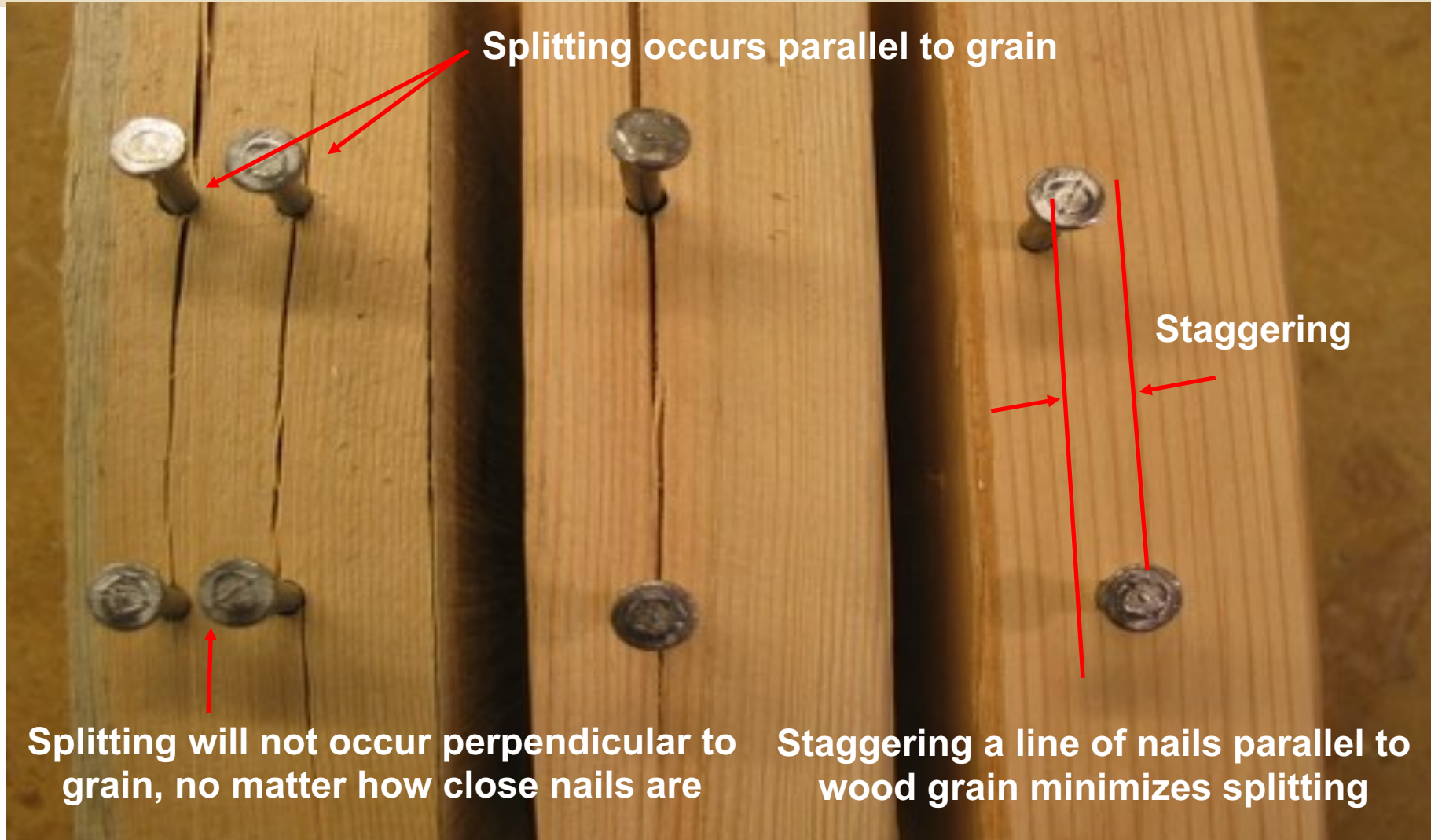
# Building From the Ground Up: Walls

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





# Staggered Fastening



# Building From the Ground Up: Walls

## Framing layouts



**3x studs**



versus



**(2) 2x studs**



# Floor to floor load transfer options



# Building From the Ground Up: Walls

## Wall Sheathing

- Nail-base sheathing





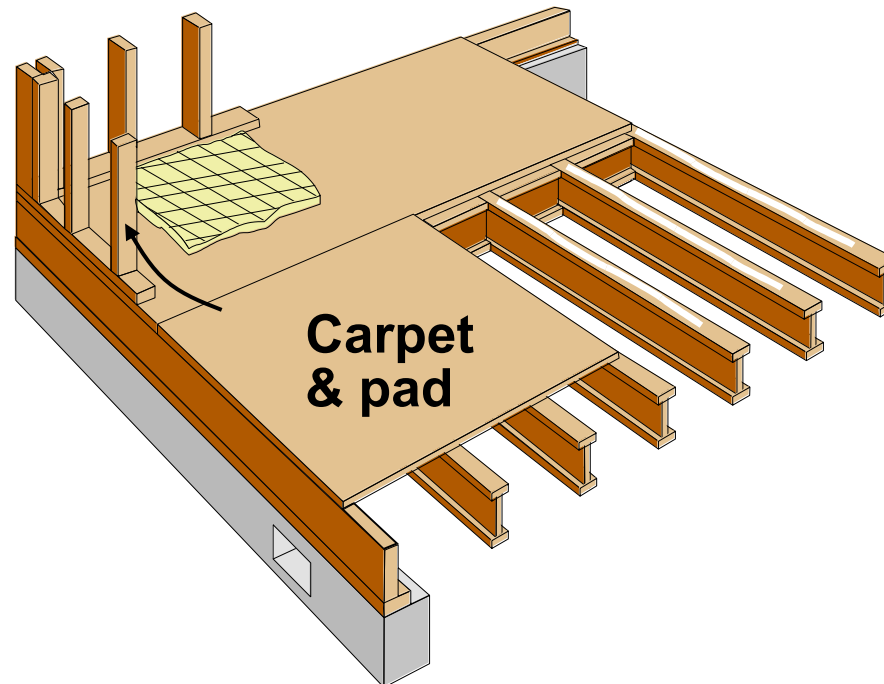
# Building From the Ground Up: **Floors**



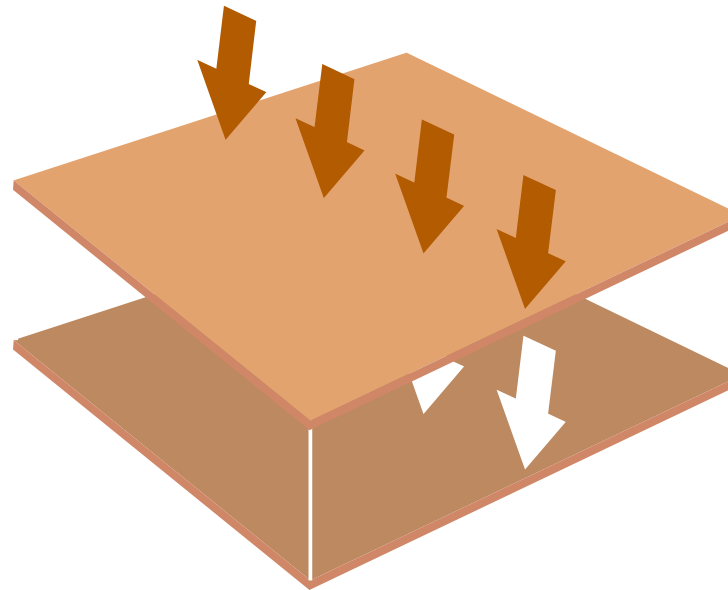
# Building From the Ground Up: Floors

## ■ Sturd-I-Floor

- Combined subfloor & underlayment
- Resistant to concentrated & impact loads
- Plywood or OSB



# Building From the Ground Up: Floors



**Roof Span  $L/240$**

**30 PSF live**

**10 PSF dead**

**Floor Span  $L/360$**

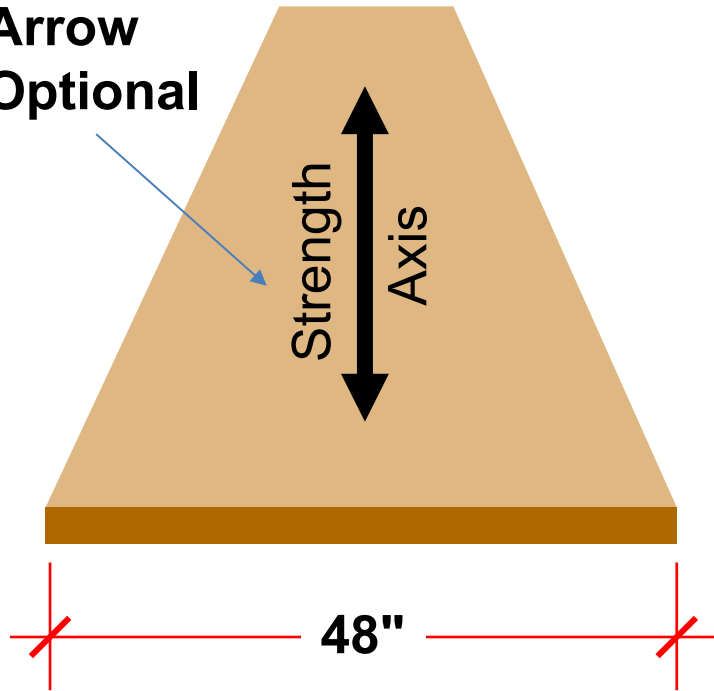
**100 PSF live**

**10 PSF dead**

# Building From the Ground Up: Floors

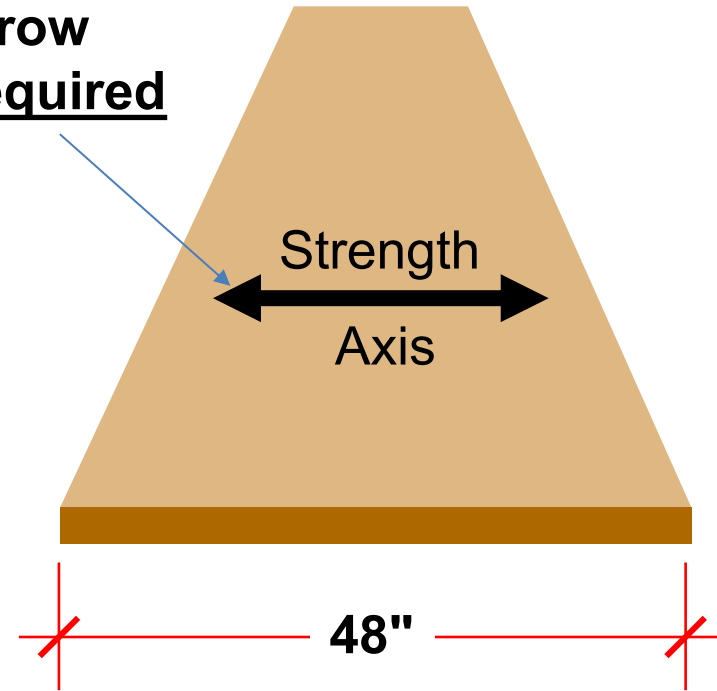
## Strength Axis

Arrow  
Optional



Common

Arrow  
Required

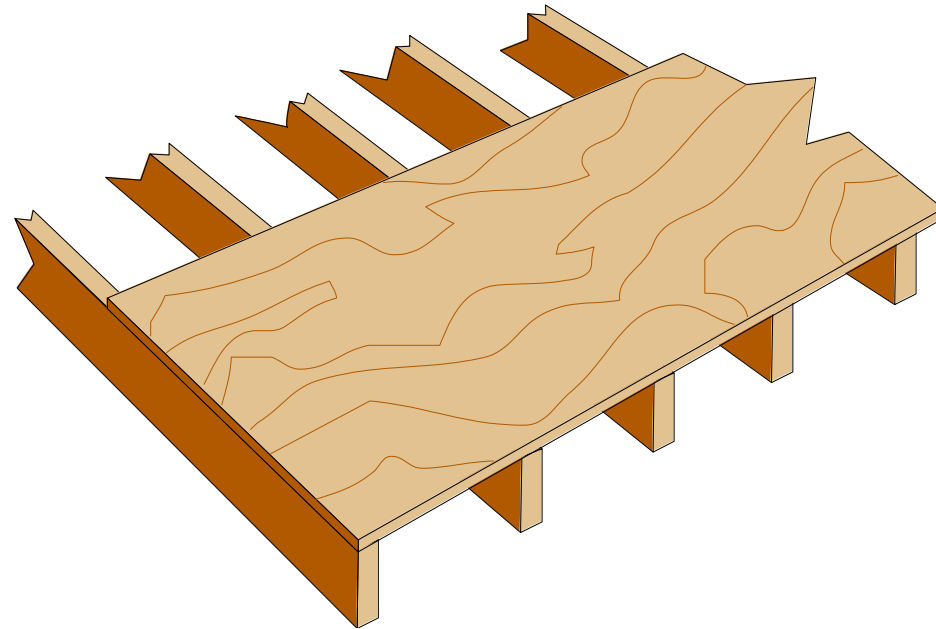
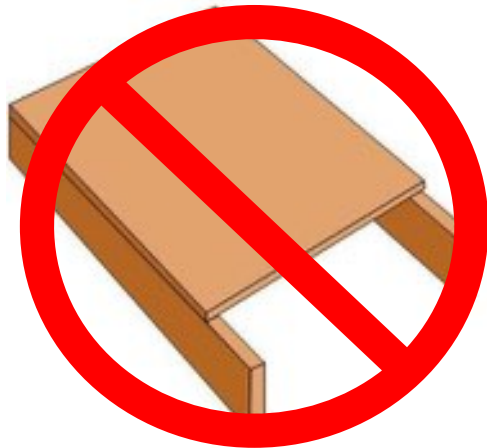


Not Common

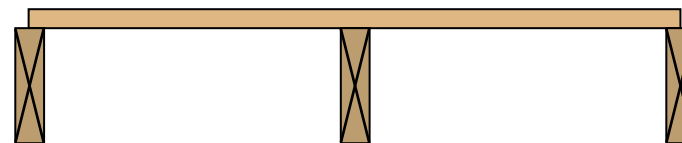


# Building From the Ground Up: Floors

- **Panel installation requirements:**
  - Two spans or 3 supports minimum
  - No simple spans



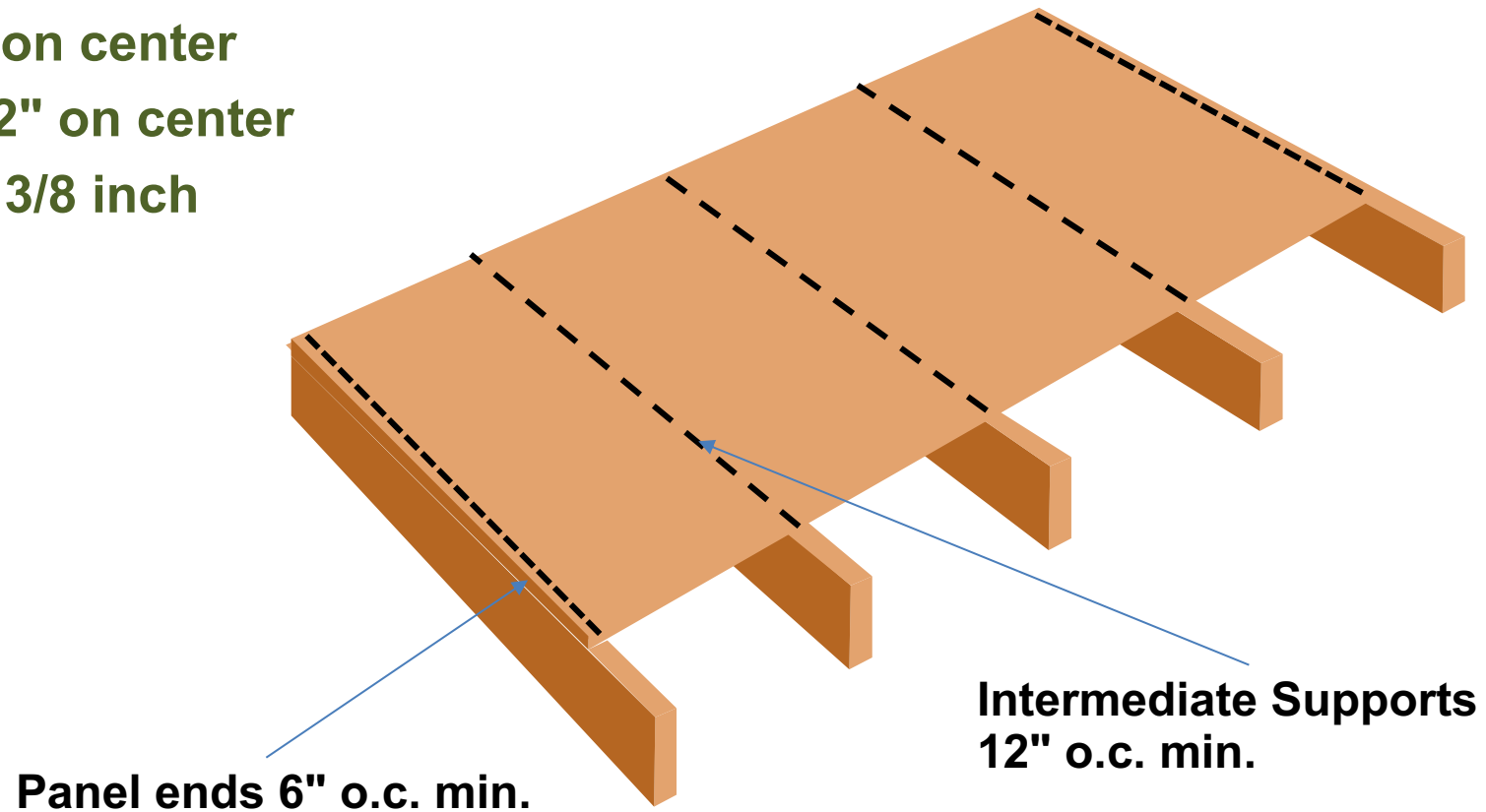
**Continuous Span**  
(2 spans or 3 supports min.)



# Building From the Ground Up: Floors

## ■ IBC Minimum Nailing

- Panel ends - 6" on center
- Intermediate - 12" on center
- Edge distance - 3/8 inch



# Building From the Ground Up: **Floors**



# Building From the Ground Up: **Floors**







# Building From the Ground Up: Floors

## Nail installation

- Overdriving reduces performance
- APA recommends – add one for every two overdriven



Resource: Effect of Overdriven Fasteners on Shear Capacity publication TT-012

# Building From the Ground Up: Floors

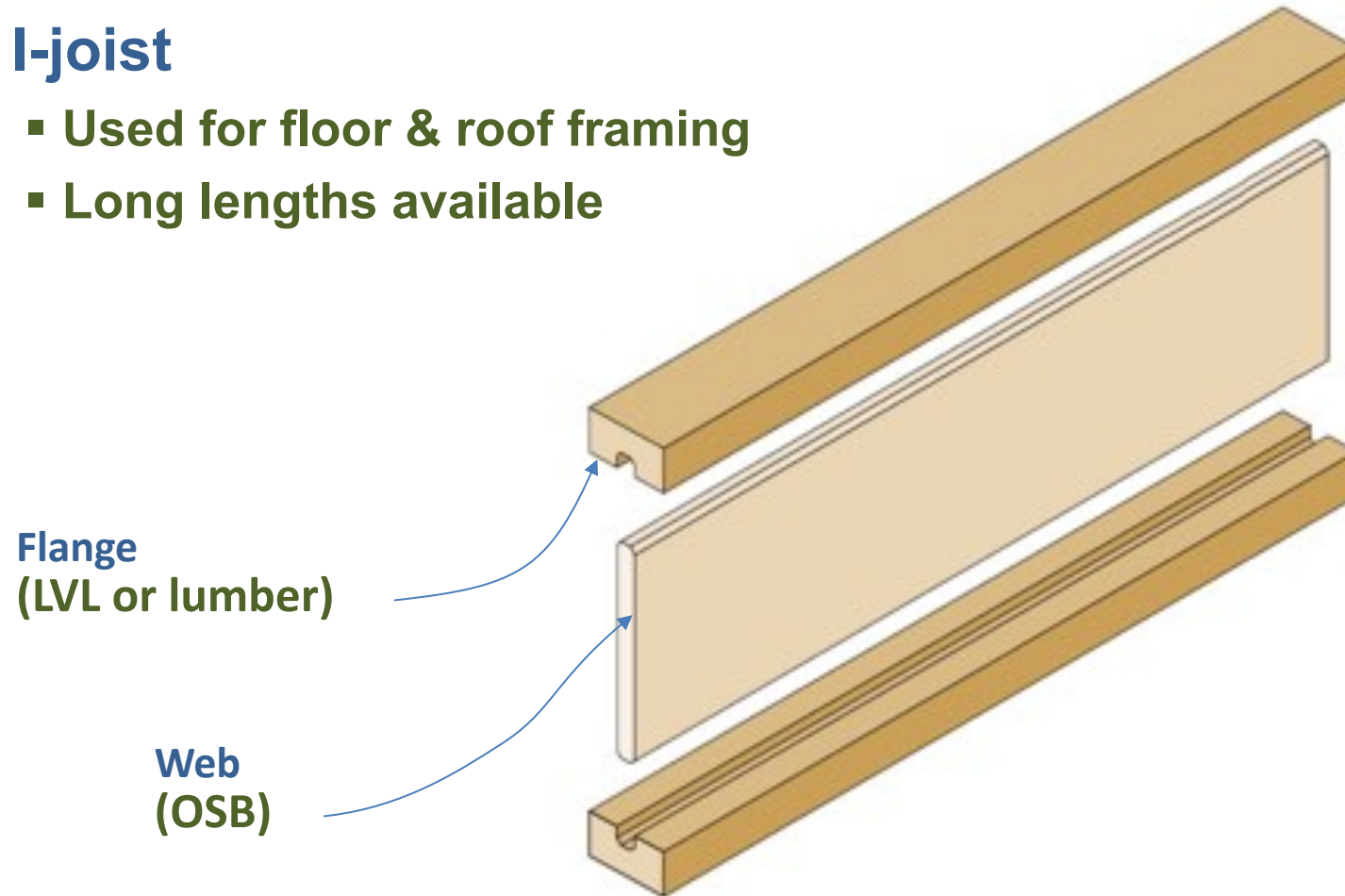
## Overdriven Fasteners

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

# Wood's Strength Direction

- **I-joist**

- Used for floor & roof framing
- Long lengths available

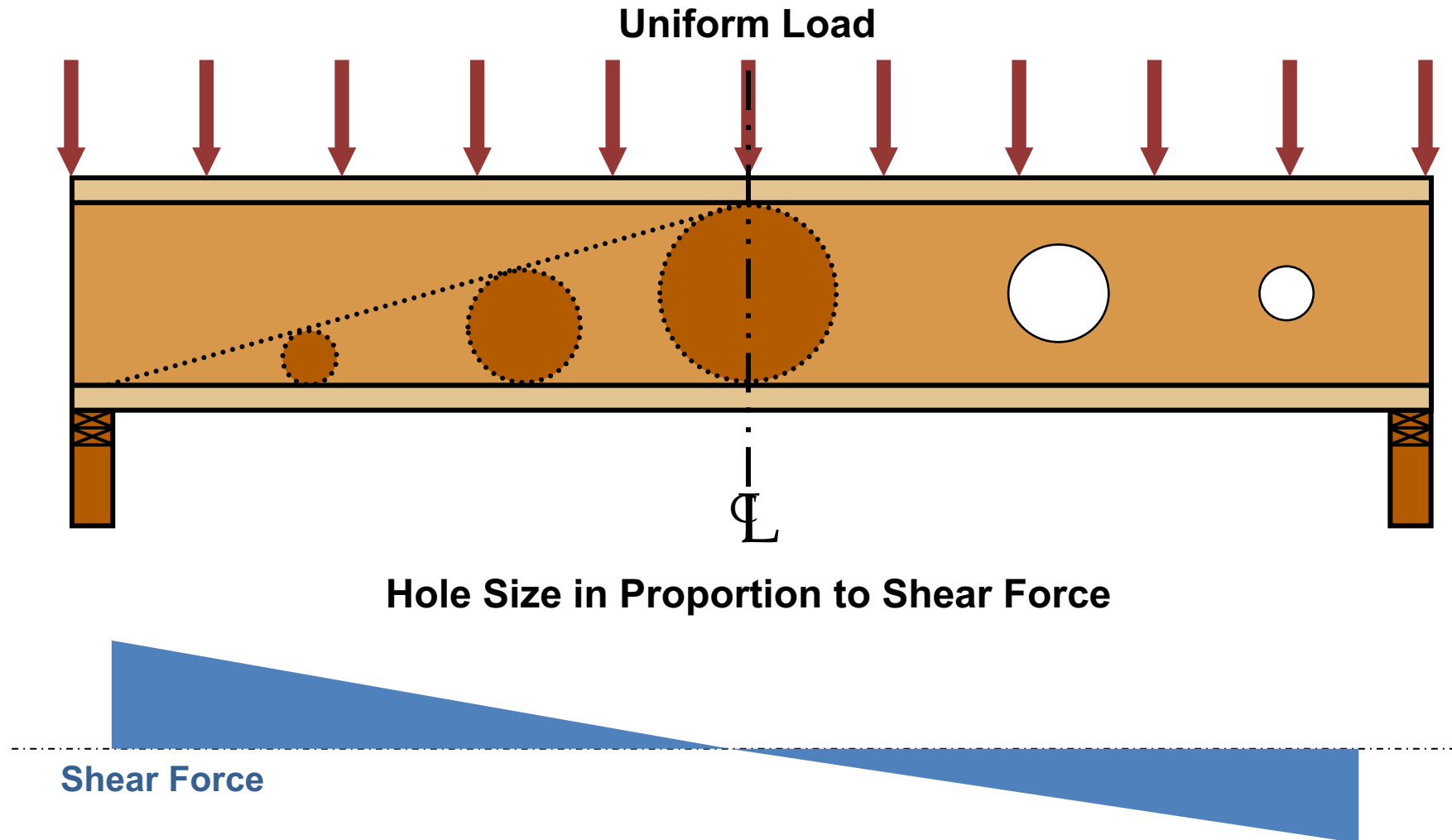




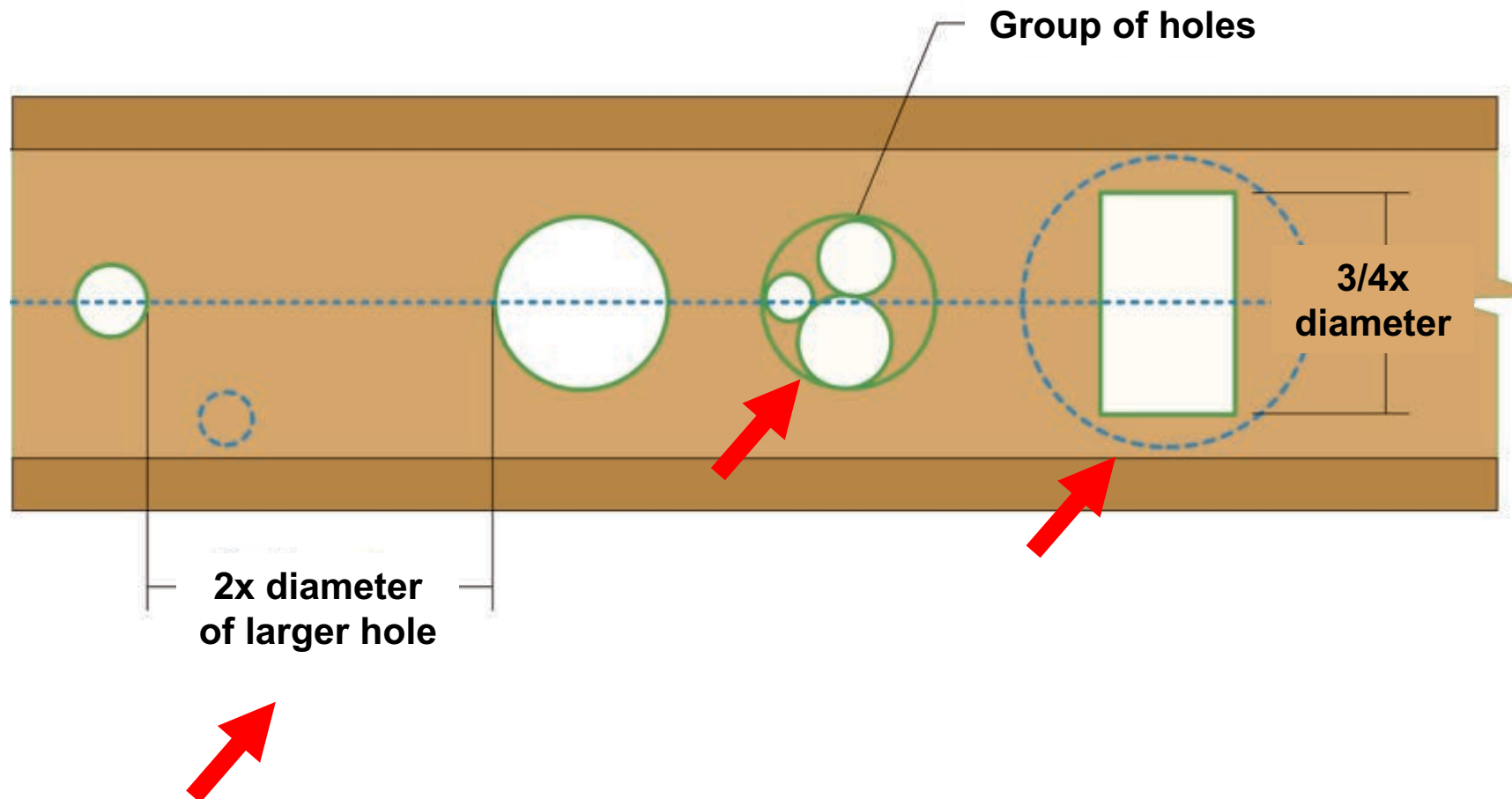




# Building From the Ground Up: Floors



# Building From the Ground Up: Floors





# 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**

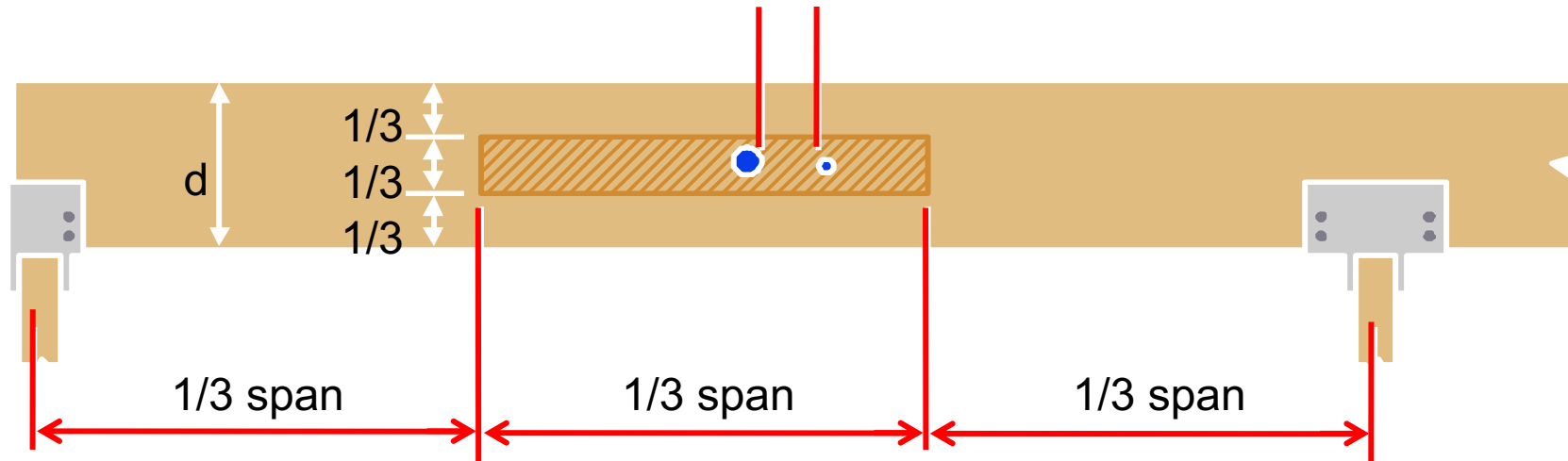
## **Glued Laminated Timber Beams (Glulam)**



# Building From the Ground Up: Floors

## 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.

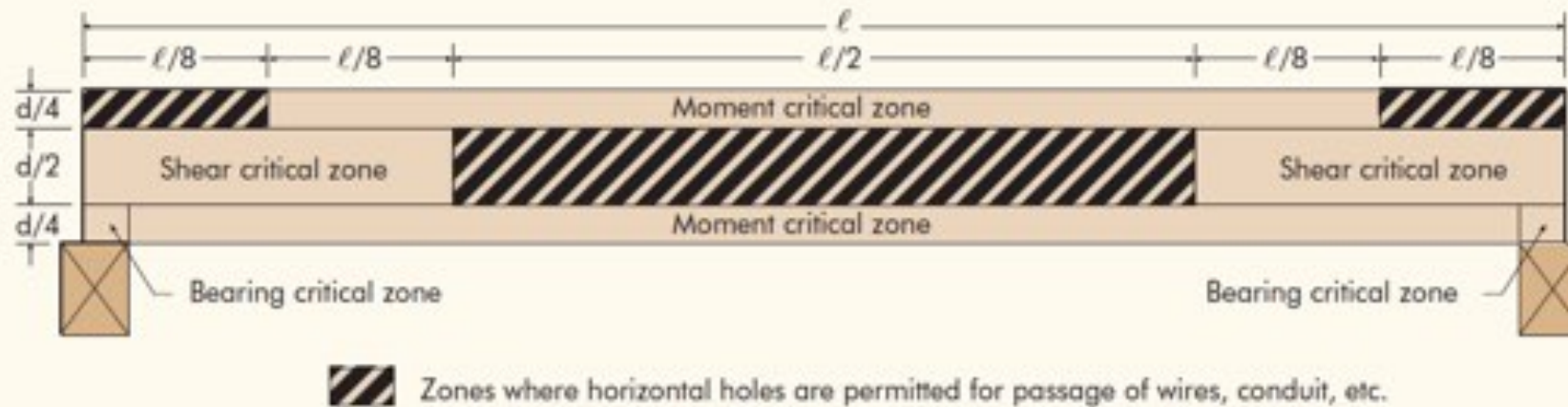
No holes greater than 2" in diameter. No more than 3 holes per span.

# Building from the ground up: Floors

## Field notching and drilling glulam (Form S560)

FIGURE 3

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



# Building from the ground up: Floors

## Large Diameter Holes in LVL and Glulam Beams (Forms V900, V700)



### TECHNICAL NOTE

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

Number V900B  
February 2020



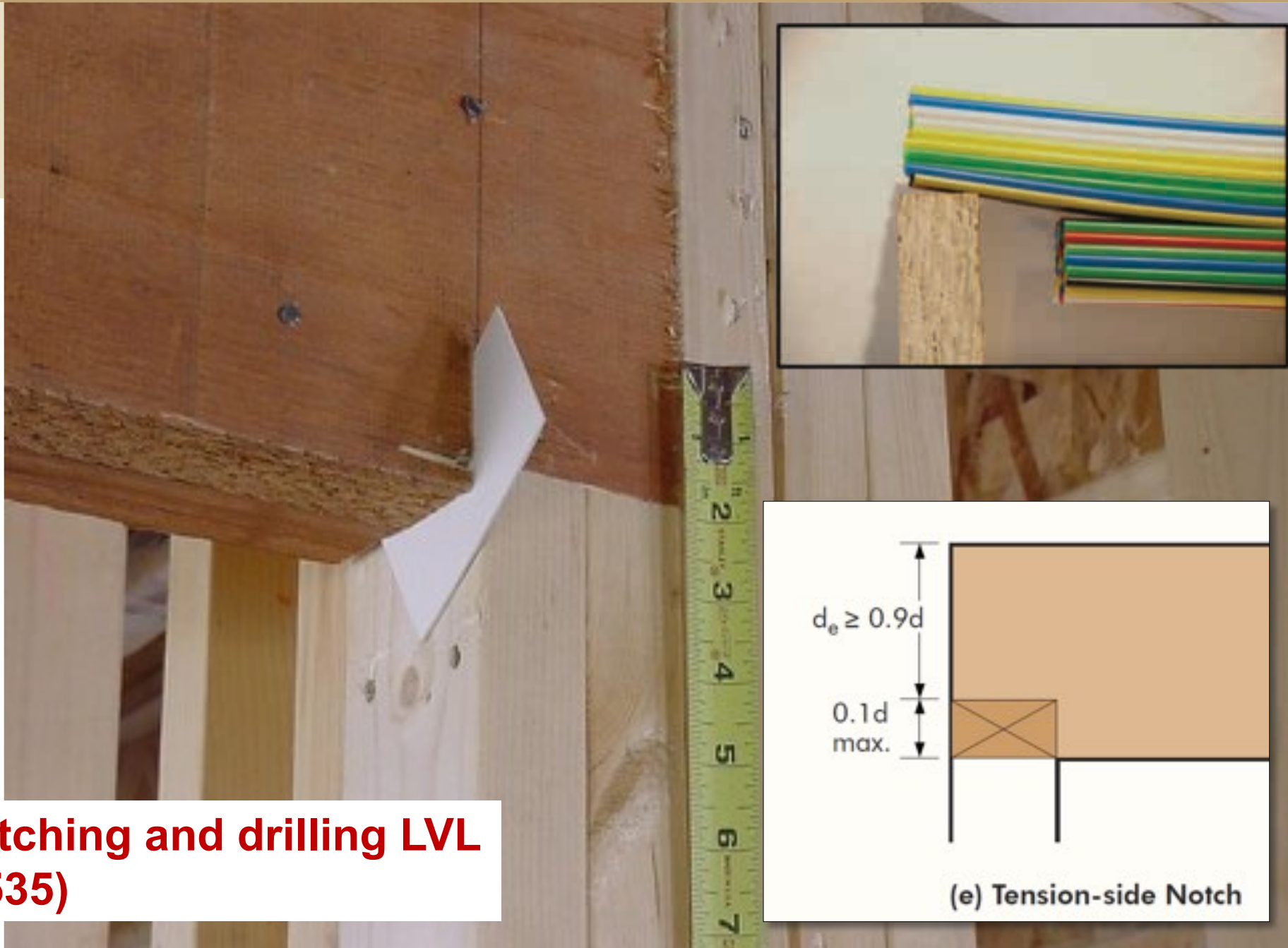
### TECHNICAL NOTE

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

Number V700B  
February 2020



■ **Field notching and drilling LVL (Form G535)**



# Building From the Ground Up: **Floors**



# Building From the Ground Up: **Floors**

## Season checks

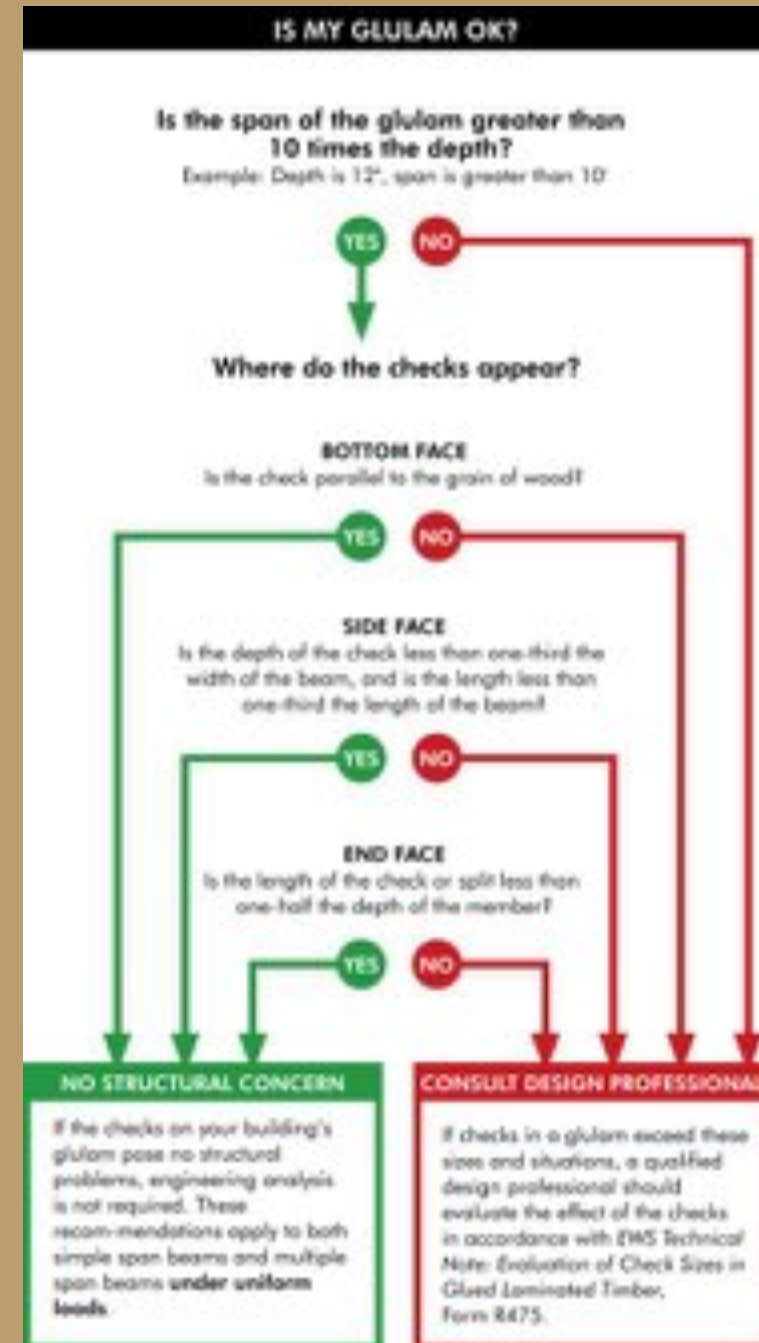




# Building From the Ground Up: Floors

## Checking Evaluation

- Guidelines established for what size checks are OK without an engineering analysis
- Published in an Owners Guide to Checking (APA Form F450)

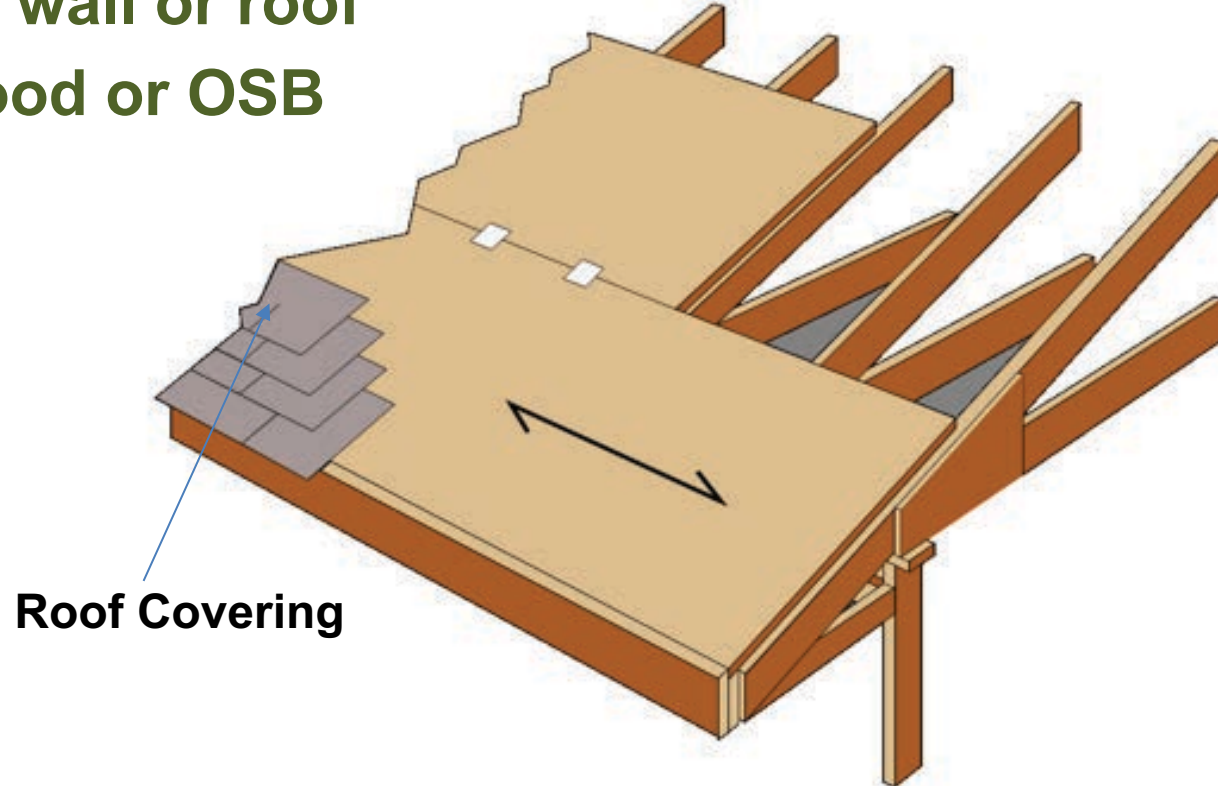




# Building From the Ground Up: Roof

## ■ Rated Sheathing

- Floor, wall or roof
- Plywood or OSB



# Building From the Ground Up: Roof

## APA Form E30, Table 34

TABLE 34

RECOMMENDED UNIFORM ROOF LIVE LOADS FOR APA RATED SHEATHING\* AND  
APA RATED STURD-I-FLOOR WITH STRENGTH AXIS PERPENDICULAR TO SUPPORTS<sup>b</sup>

Panel Span Rating	Minimum Panel Performance Category	Maximum Span (in.)		Allowable Live Loads (psf) <sup>c</sup>							
		With Edge Support <sup>e</sup>	Without Edge Support	Spacing of Supports Center-to-Center (in.)							
				12	16	20	24	32	40	48	60
APA RATED SHEATHING*											
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	3/8	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 <sup>f</sup>	7/8	60	40	—	—	—	305	165	100	70	35
60/48 <sup>f</sup>	1-1/8	60	48	—	—	—	305	165	100	70	35

# Building From the Ground Up: Roof

## APA Form E30 Table 37

TABLE 37

RECOMMENDED ROOF LOADS (PSF) FOR APA RATED SHEATHING WITH  
STRENGTH AXIS PARALLEL TO SUPPORTS<sup>a,b</sup> (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 <sup>c</sup>	15	25
	15/32, 1/2	32/16	24	30 <sup>d</sup>	40 <sup>d</sup>
	19/32, 5/8	40/20	24	70 <sup>e</sup>	80 <sup>e</sup>
	23/32, 3/4	48/24	24	105 <sup>f</sup>	115 <sup>f</sup>
APA RATED SHEATHING	7/16	24/16	16	35	45
	15/32, 1/2	32/16	24 <sup>c</sup>	15 <sup>g</sup>	25 <sup>g</sup>
	19/32, 5/8	40/20	24	40 <sup>h</sup>	50 <sup>h</sup>
	23/32, 3/4	48/24	24	70 <sup>e</sup>	80 <sup>e</sup>

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.

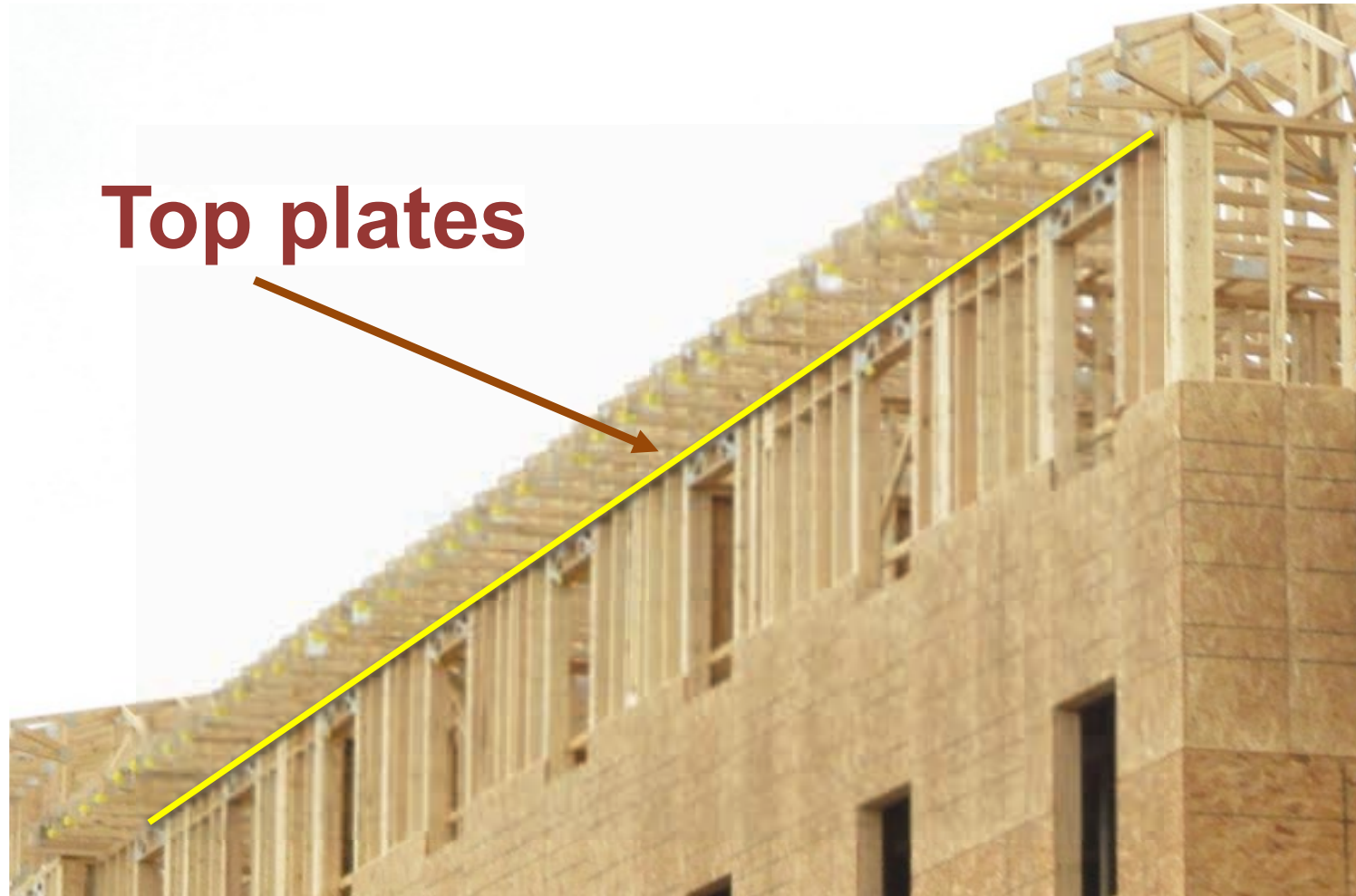
e. For 4-ply plywood, reduce load by 30 psf.

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**





# Building From the Ground Up: Roof

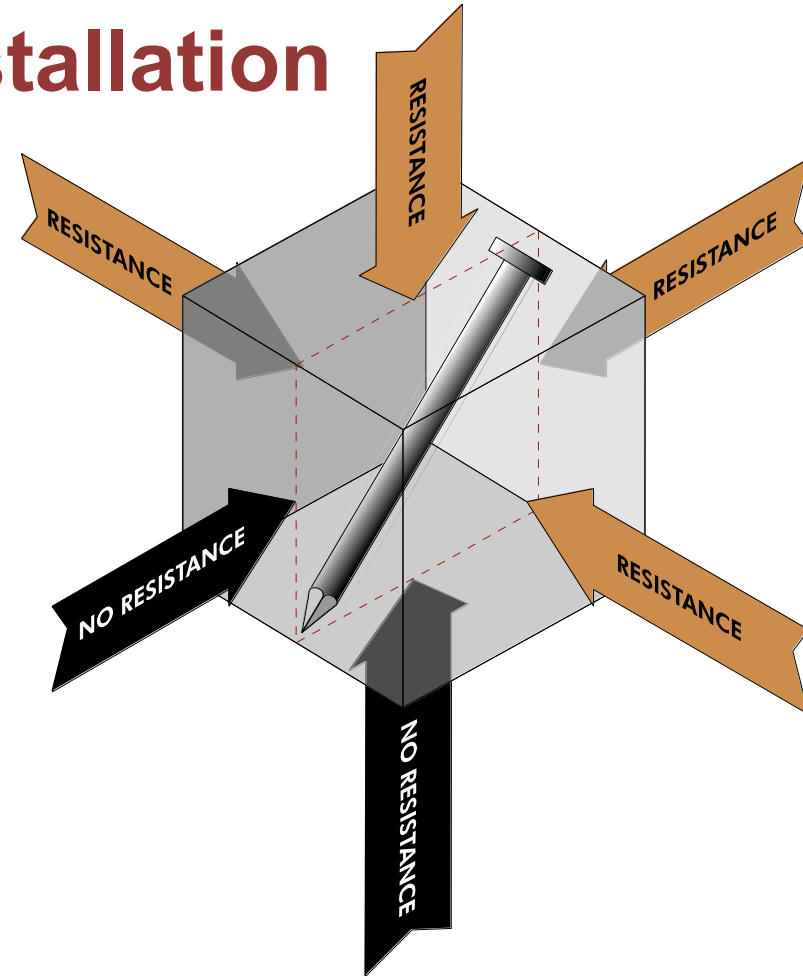
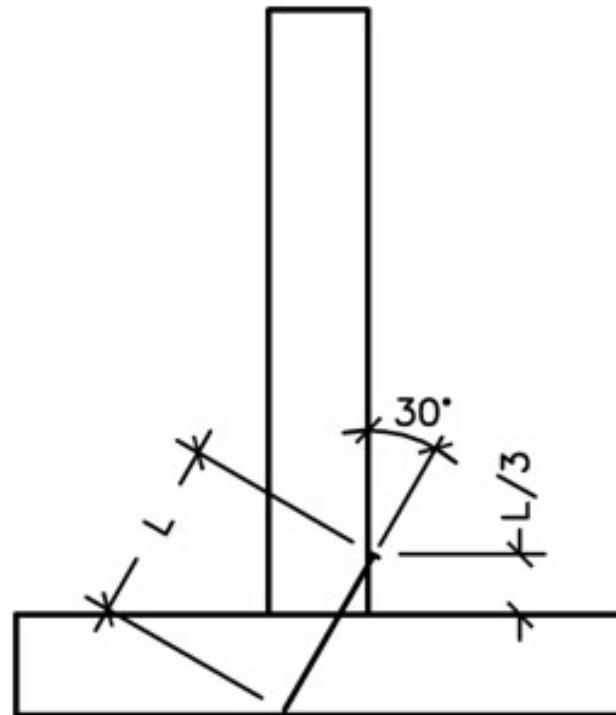
## Top Plate Connection



*Midwest Tornadoes 2003  
APA Report SPE-1118*

# Building From the Ground Up: Roof

## Toe-nail installation



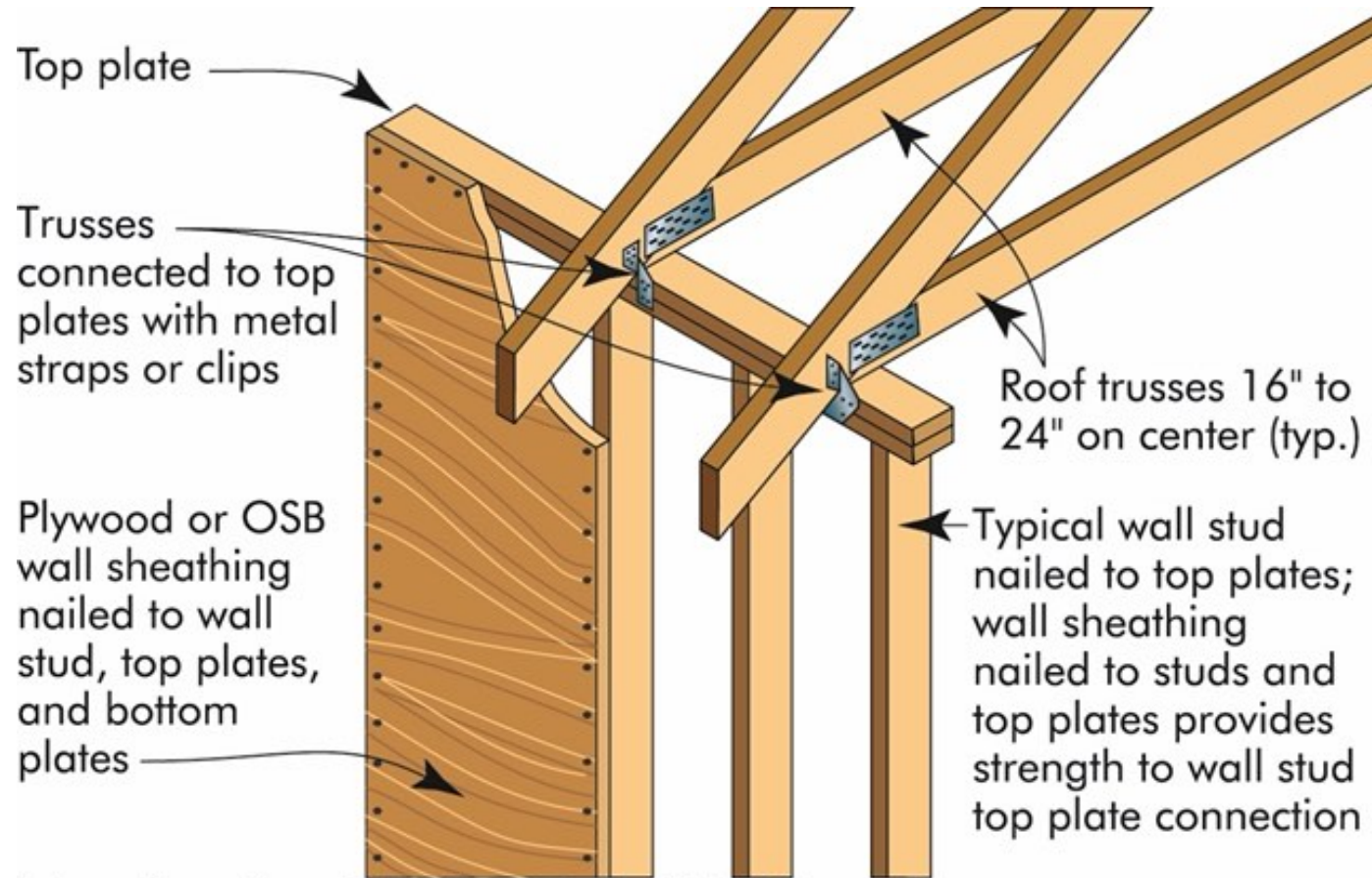
# Building From the Ground Up: **Roof**

## 3-dimensional metal connectors



# Building From the Ground Up: Roof

## Top plate connection

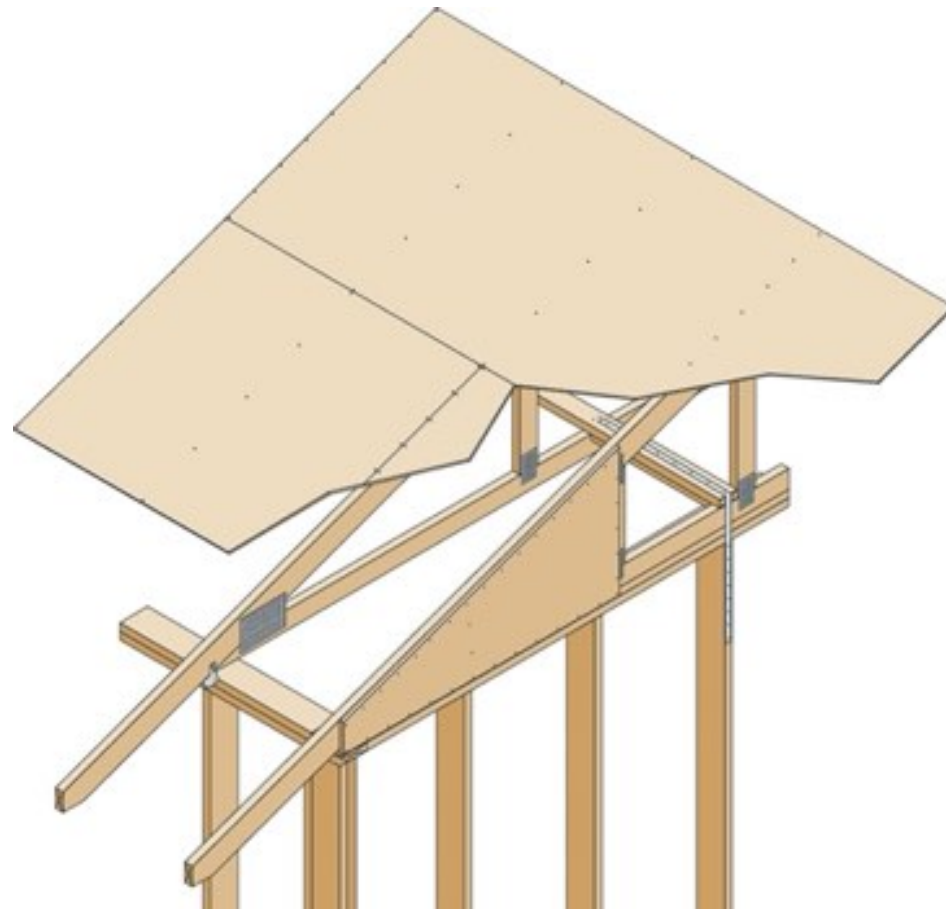


Adapted from Figure 8-7 – Alternative A, FEMA 342



# Building From the Ground Up: **Roof**

## **Gable ends**



# Building From the Ground Up: **Roof**





## PANEL EDGE SUPPORT FOR NARROW-WIDTH ROOF SHEATHING

Number R2754

August 1997

The roof sheathing recommendations of APA – The Engineered Wood Association assume a 24-inch minimum panel width. When panels less than 24 inches in width (narrow-width panels) occur in roof construction, additional edge support is recommended.

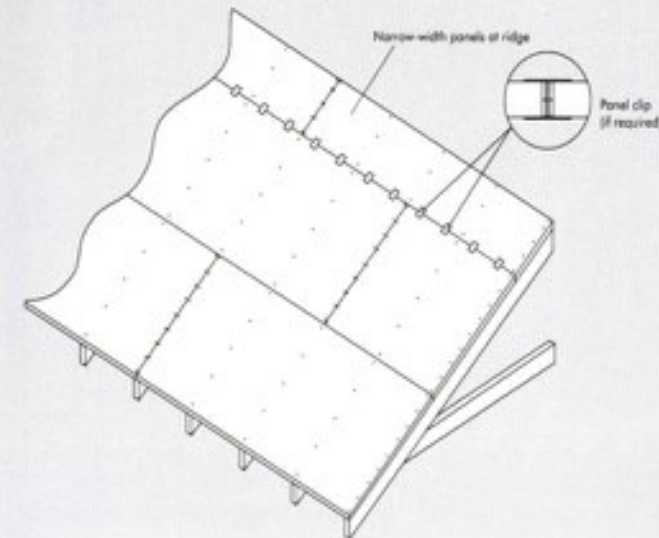
It is not uncommon for a building's geometry to necessitate the use of less-than-full-width panels at roof ridges or valleys (see Figure 1). While adjustments for uniform load are available (see ABGs Plywood Design Specification and Technical Note N373) for structural-use panels of widths less than 24 inches, it is recognized that uniform load capacity

does not necessarily control the performance of roof sheathing panels.

An APA test program was initiated to investigate the performance of 24-inch and narrower roof sheathing panels. The results are the basis for the edge support recommendations discussed in this technical note.

FIGURE 1

### NARROW-WIDTH PANELS



**APA**

The Engineered Wood Association



# Building From the Ground Up: Special Topics

## Special topics

- On-site moisture management
- Shrinkage





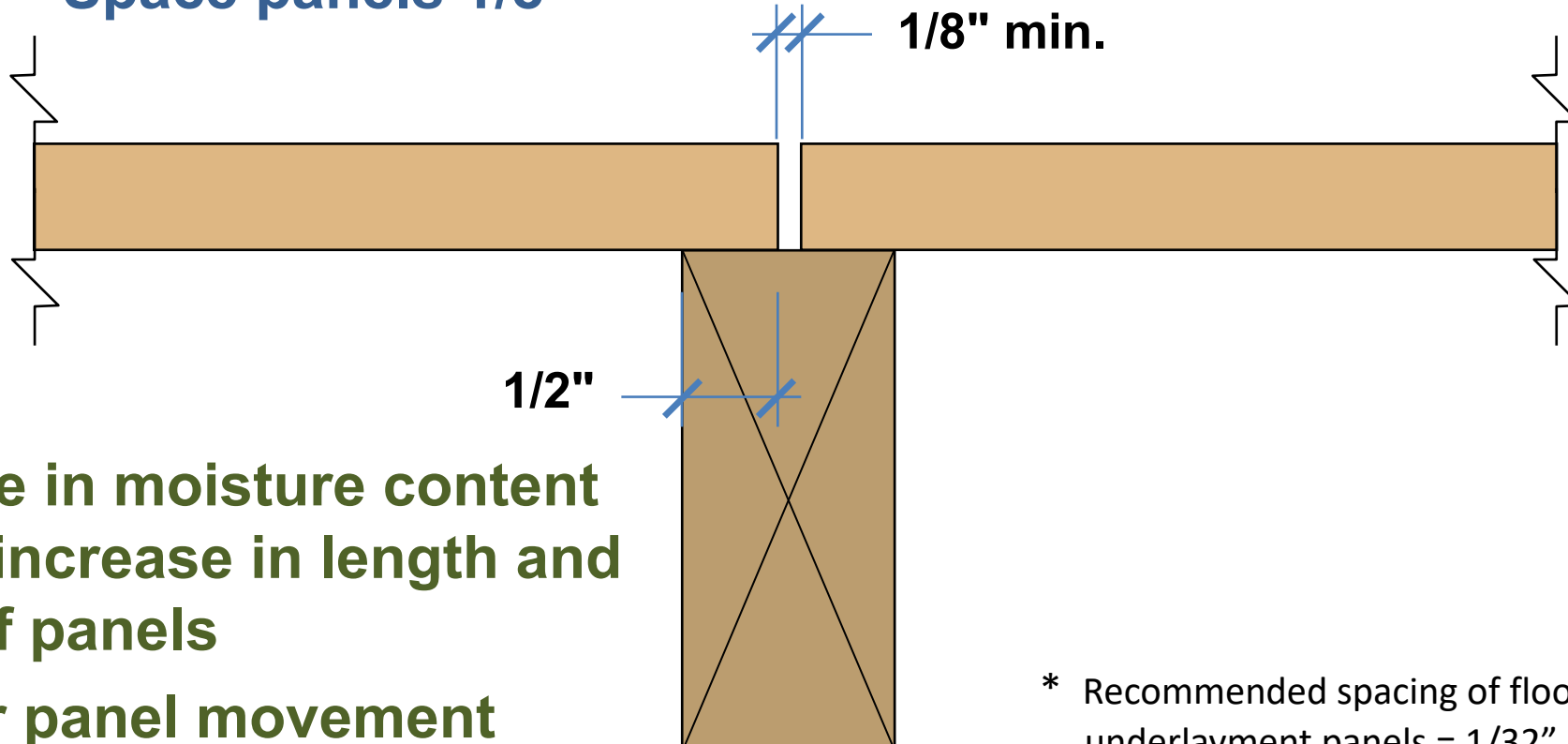
# Building From the Ground Up: **Special Topics**



# Building From the Ground Up: Special Topics

## Installation Recommendations\*

- Space panels 1/8"



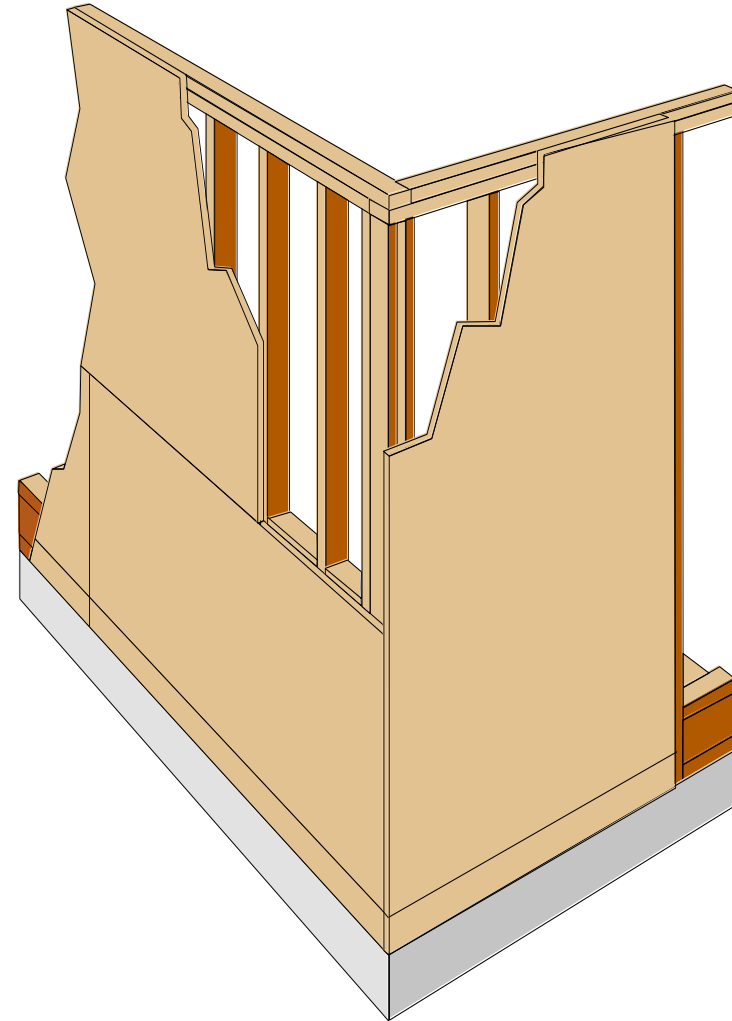
1. Increase in moisture content means increase in length and width of panels
2. Plan for panel movement

\* Recommended spacing of floor underlayment panels = 1/32"

# Building From the Ground Up: Special Topics

## Grade and clearance

- **Did we make the grade?**
  - How's the slope? 6" in first 10'
  - Do we have ground to frame minimums?
  - Is there a capillary break?
  - What's the finish detail?



# 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?





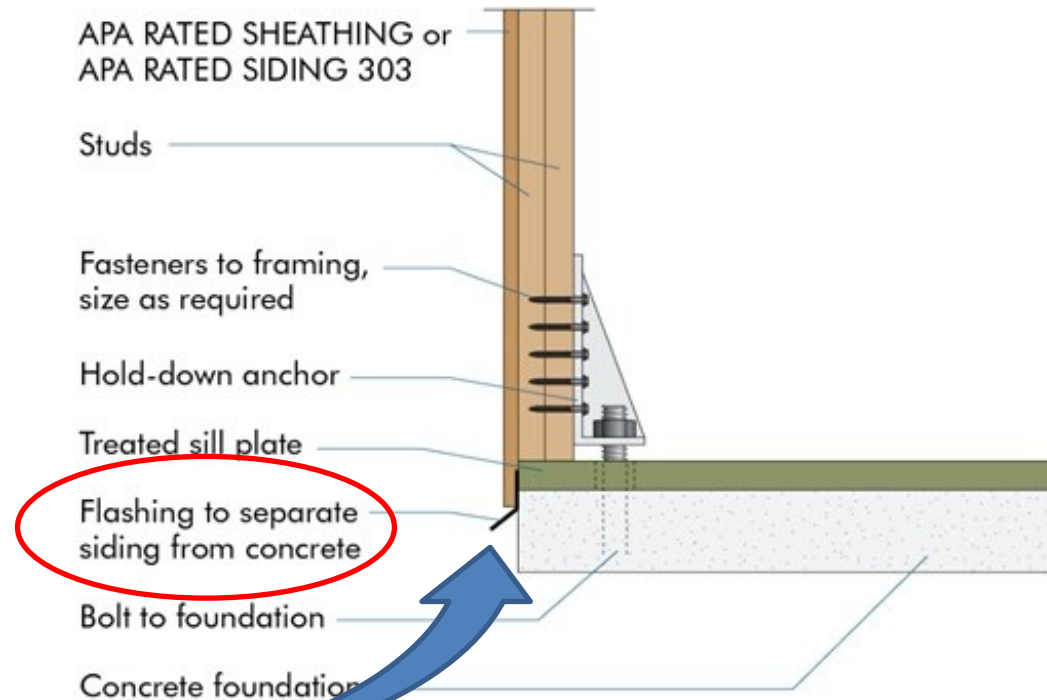
# Building From the Ground Up: Special Topics

## Use Flashing

Flashing keeps the panel from contacting the concrete.

### SHEAR WALL HOLD-DOWN ANCHOR

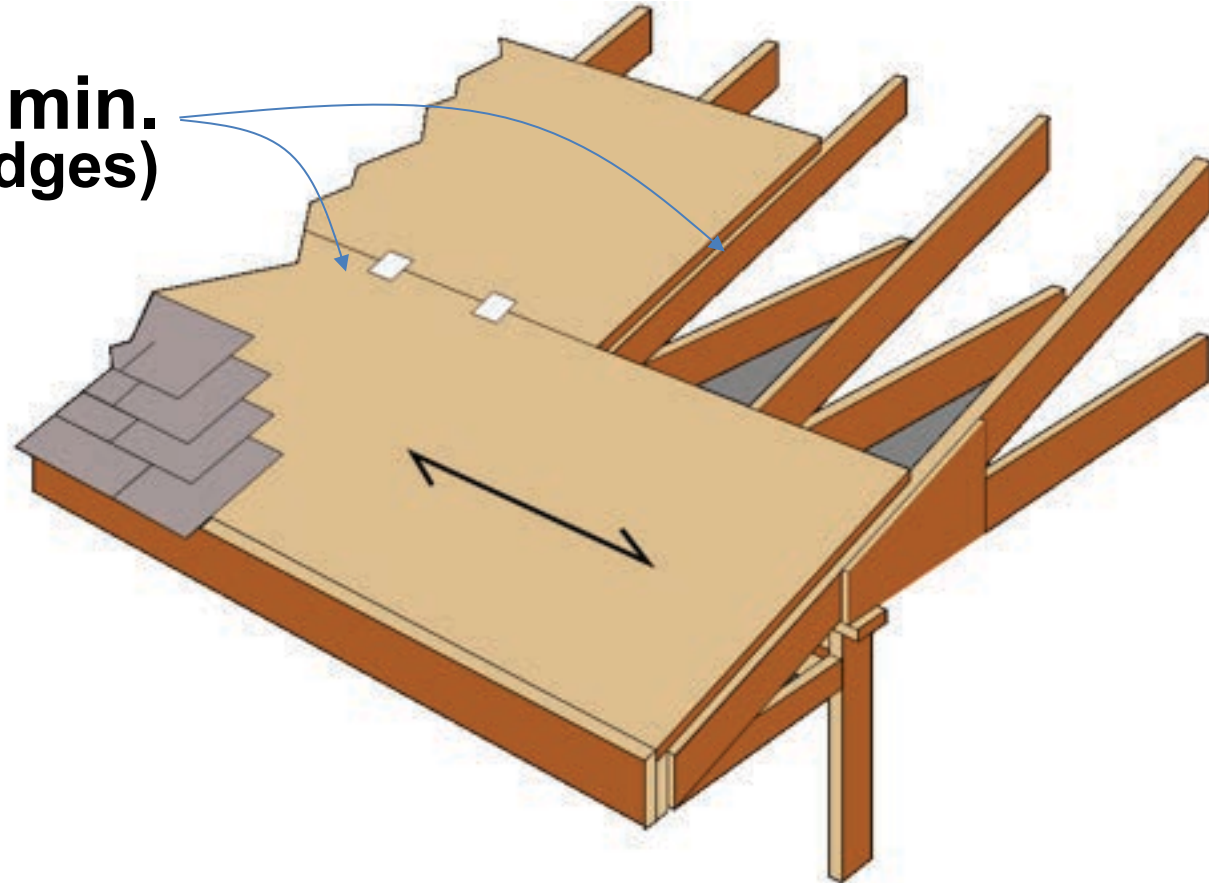
Shear wall overturning moments may be transferred by a fabricated steel bracket such as this. Regular foundation bolts may be all that is required in some cases depending on engineering analysis.



# Building From the Ground Up: Special Topics

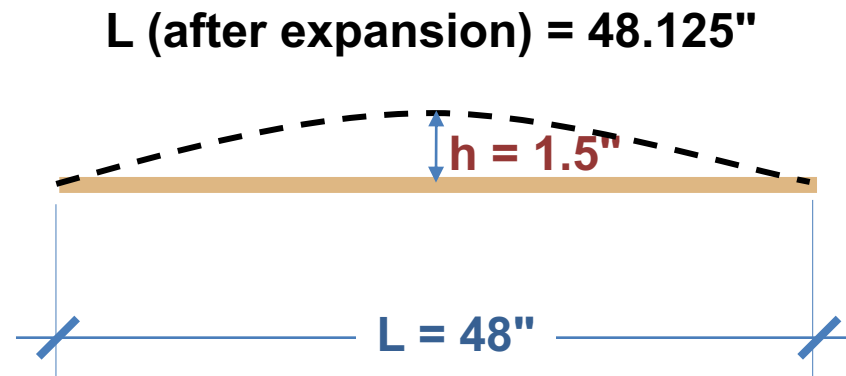
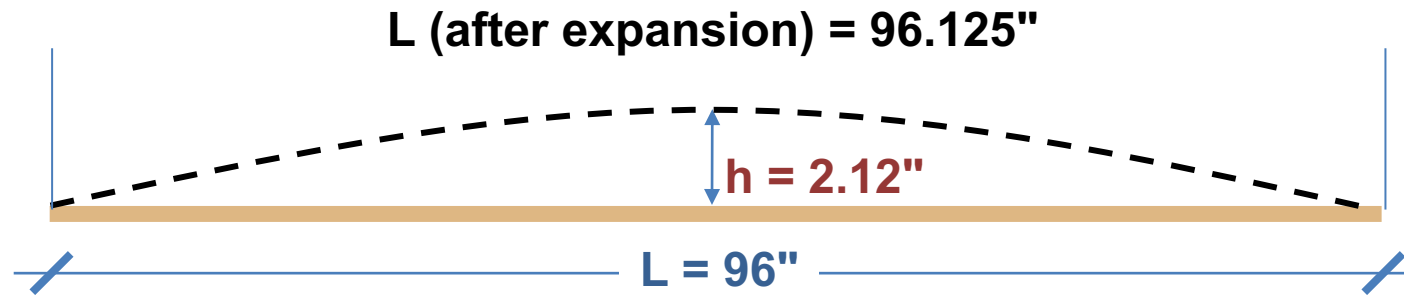
## Allow for panel expansion

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



# Building From the Ground Up: Special Topics

## 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**



# Building From the Ground Up: Special Topics

## High Risk Applications:

- Parallel to supports
- Edge nailing 4" o.c. or closer
- Long lasting rainy weather
- Panels installed within a few days of their manufacture
- Others...



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

# Building From the Ground Up: Special Topics

## Allow panels to acclimate to ambient temperature and humidity

- Low panel moisture content at the time of manufacture
  - Generally 2% to 8% moisture content
- Jobsite relative humidity might vary from 40% to 80%
- Result: panel equilibrium moisture content ranging between 6% and 14%
  - Movement as panels reach equilibrium moisture content

# Building From the Ground Up: Special Topics

**Sequence wall panel installation to allow panels to acclimate to jobsite conditions:**

- **Tack panels in-place prior to installing edge fasteners**
  - **Nail spacing of 12 or 24 inches on center at ends, edges and intermediate supports**
- **After panels become acclimated to jobsite moisture conditions, complete final nailing**
- **Install fasteners 3/8 inch from panel edges and ends**
  - **Ensure proper nail size and spacing**



# 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'



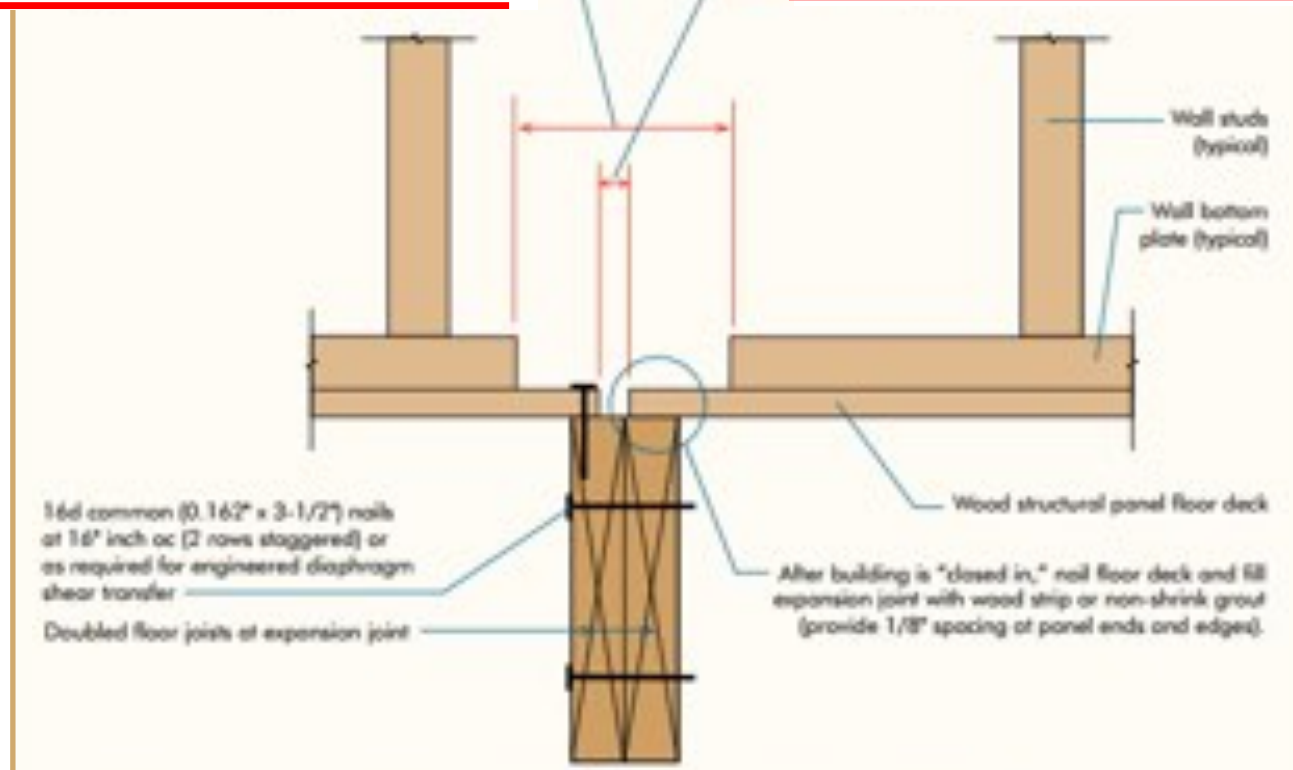
# Building From the Ground Up: Special Topics

## Provisions for large structures

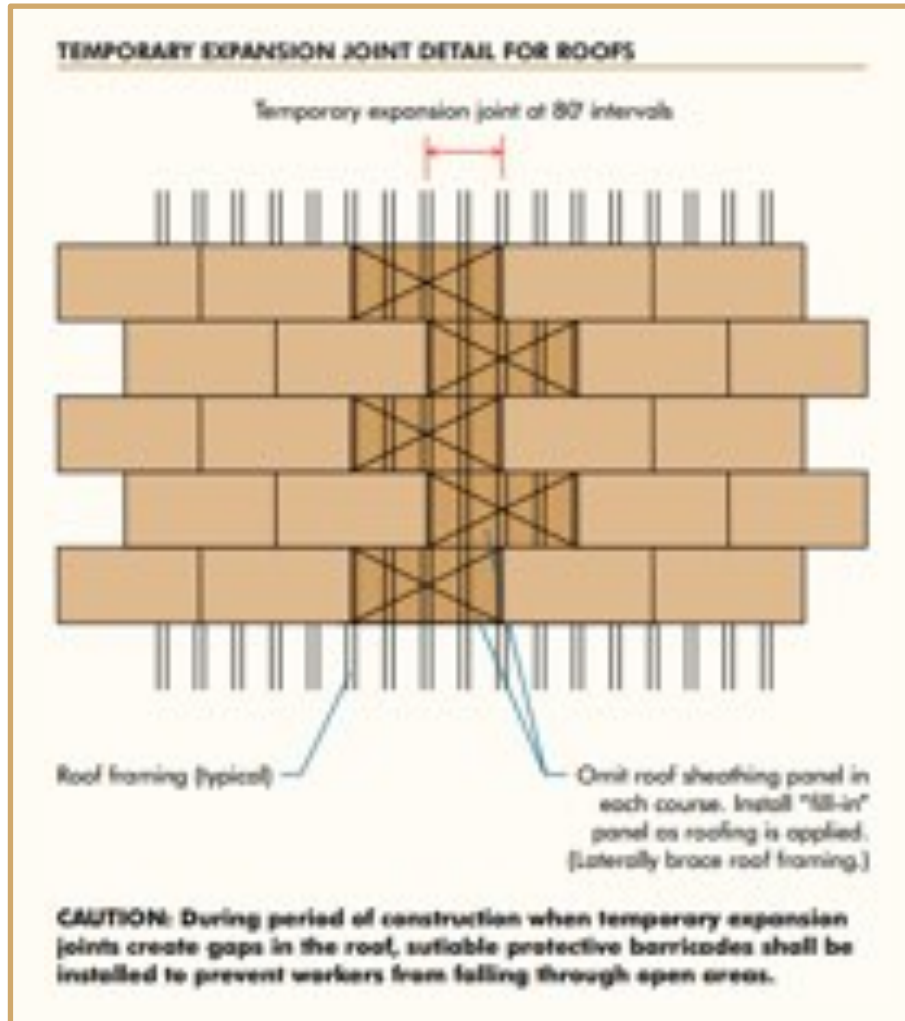
TEMPORARY EXPANSION JOINT DETAIL FOR FLOORS

12" gap in wall bottom plate at expansion joint

3/4" temporary expansion joint at 80' intervals



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## Provisions for large structures

- **Roofs:**
- 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

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**Primarily in horizontal members such as wall plates and floor joists.**



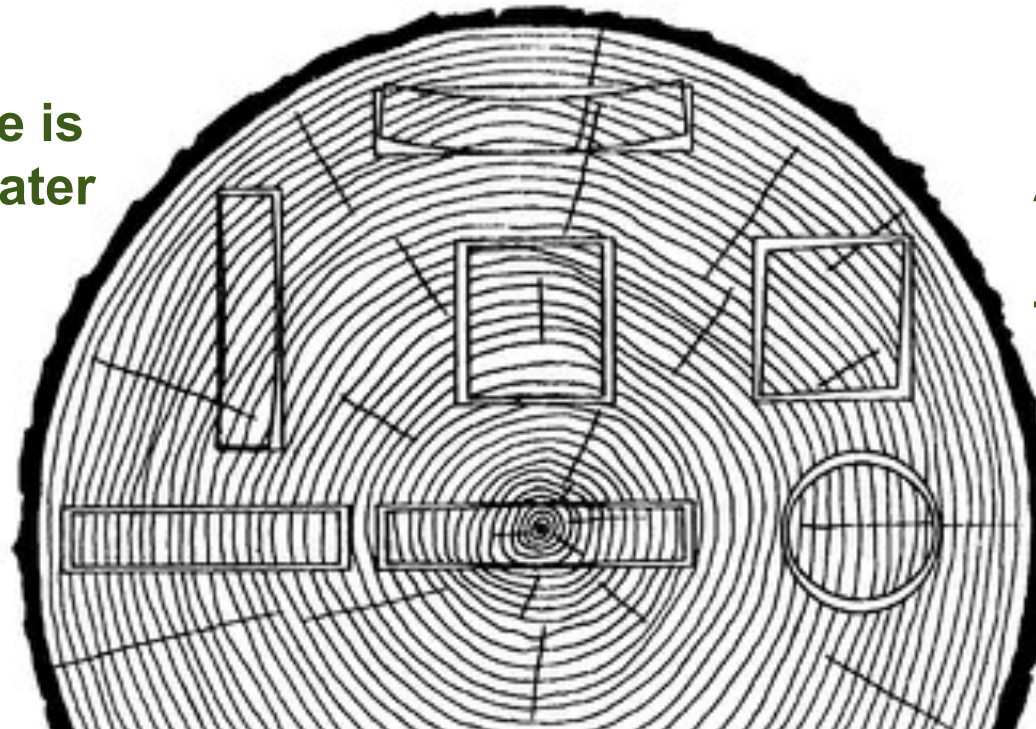


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## Moisture Changes In Wood

- Causes dimensional changes perpendicular to grain

Growing tree is  
filled with water



As wood dries,  
it shrinks perp.  
to grain

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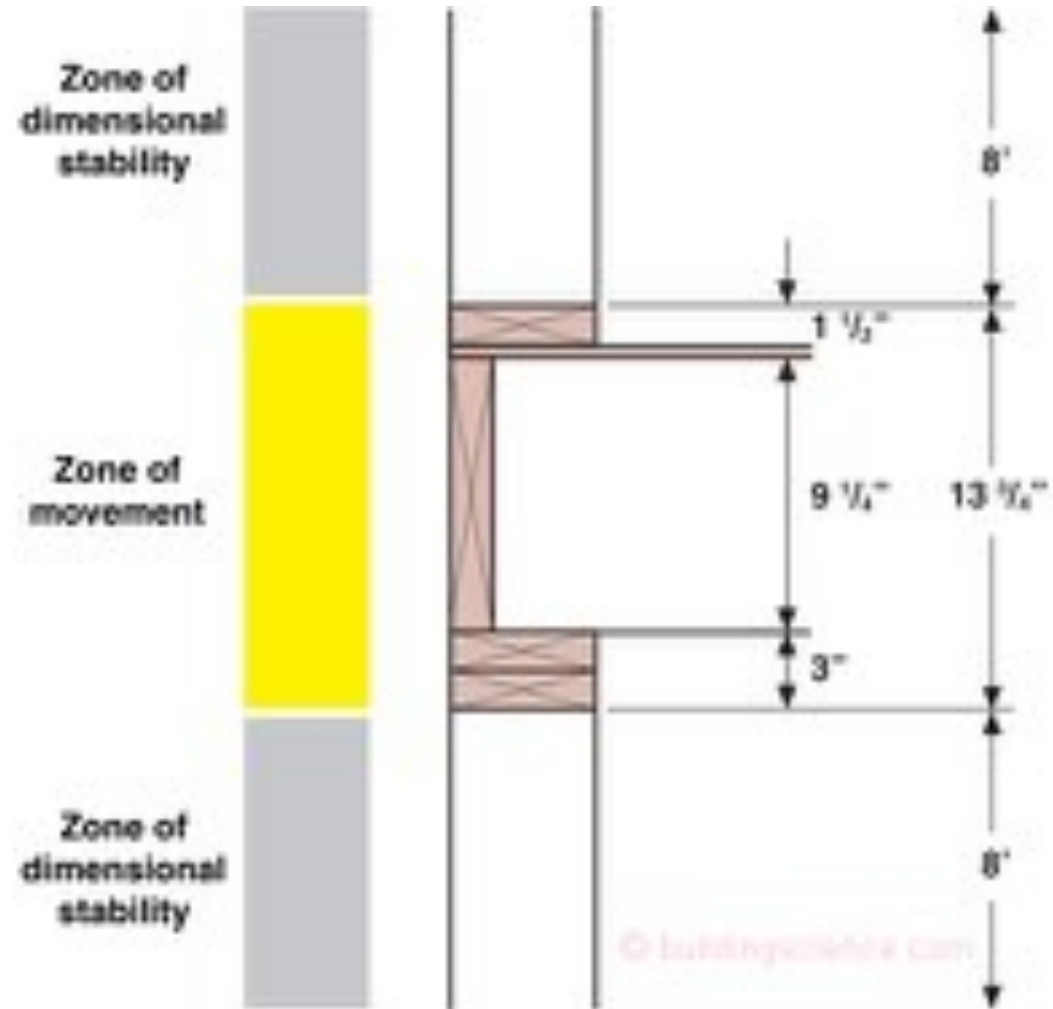
## Wood shrinkage

- ✓ 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.
- ✓ Wood shrinkage must be accounted for in structures > 2 stories.

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## Zone of movement

- Shrinkage occurs primarily in horizontal members such as wall plates and floor joists.



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## **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 horiz. runs, etc.)**
- ✓ **Limit or avoid dissimilar materials.**
- ✓ **Additional information on Shrinkage-in-Wood Framed structures can be found on WoodWorks web page**



# Quick Summary

- **Simple steps make a big difference:**
  - Follow the prints.
  - Space panels.
  - Follow fastening guidelines.
  - Check load paths/stacking.
  - Control moisture.



# Questions? Comments?

This concludes The American Institute  
of Architects Continuing Education  
Systems Course



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