



Designing Engineered Wood Diaphragm Systems for Panelized Roofs

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

Webinar Attendee Survey



Aleeta Dene
Engineered Wood Specialist
Southwest Region




<https://www.apawood.org/presentation-survey>




Course Description

Diaphragms play a vital role in a building's lateral load path. Whether that lateral load is from seismic or wind, 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 and subdiaphragm systems. Participants will learn best practices as they are guided through a simple design example.



Learning Objectives

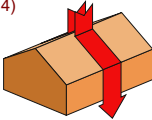
1. Understand the importance of the diaphragm in the overall load path of a wood building.
2. Identify the proper sheathing and nailing patterns for a wood diaphragm.
3. Discuss how design choices affect the overall diaphragm deflection.
4. Distinguish the benefits and drawbacks of using a subdiaphragm.



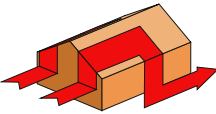
Lateral Load Path

Load Path


“Any system or method of construction to be used shall be based on a rational analysis in accordance with well established principles of mechanics. Such analysis shall result in a system that provides a complete load path capable of transferring loads from their point of origin to the load-resisting elements.”
(IBC 2021 1604.4)

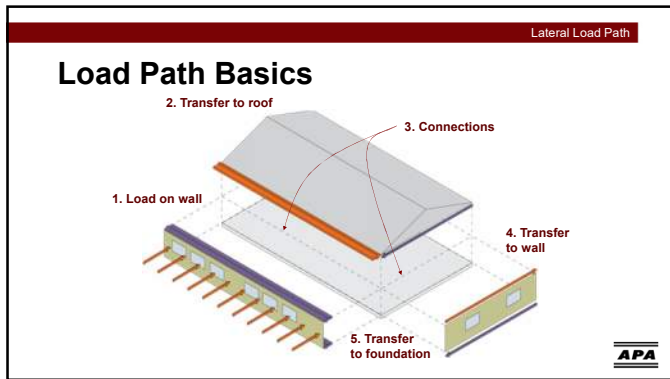


VERTICAL



HORIZONTAL





Lateral Load Path

2021 International Building Code

2021 IBC
 ▪ Chapter 16: Structural Design
 ▪ ASCE 7-16

The image shows the covers of two code books: 'Minimum Design Loads and Associated Criteria for Buildings and Other Structures' (ASCE 7-16) and the '2021 International Building Code'. The APA logo is in the bottom right corner.

Lateral Load Path

Governing Codes for Engineered Wood Design


2021 IBC
 ▪ Chapter 23: Wood
 ▪ ANSI/AWC NDS (National Design Specification for Wood Construction)
 ▪ ANSI/AWC SDPWS (Special Design Provisions for Wind and Seismic)

The image shows the covers of three code books: '2021 International Building Code', 'ANSI/AWC NDS (National Design Specification for Wood Construction)', and 'ANSI/AWC SDPWS (Special Design Provisions for Wind and Seismic)'. The APA logo is in the bottom right corner.

Lateral Load Path

2021 IBC
SDPWS-21
(Special Design Provisions for Wind and Seismic)

- <https://awc.org/publications/2021-sdpws/> (Free view-only)



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Lateral Load Path

Wood Shear Wall and Diaphragm Design

Shear Values

- Function of fastener size and spacing, panel thickness and the specific gravity of the framing materials
- Values in tables in ANSI/AWC SDPWS-21
- Alternately, capacities can be calculated by principles of mechanics

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Lateral Load Path

2021 IBC

Shear Wall and Diaphragm Tables

- Tables removed from Ch 23 except for staples
- ANSI/AWC SDPWS-21 lists nominal values – require adjusting for ASD or LRFD

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Lateral Load Path

2021 SDPWS

	Cases 1&3: Continuous Panel Joints Perpendicular to Framing	Cases 2&4: Continuous Panel Joints Parallel to Framing	Cases 5&6: Continuous Panel Joints Perpendicular and Parallel to Framing
Long Panel Direction Perpendicular to Supports			
Long Panel Direction Parallel to Supports			

(c) Panel span rating for out of plane loads may be lower than the span rating with the long panel direction perpendicular to supports. (See Section 3.2.2 and Section 3.2.3)

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Lateral Load Path

Load Path Basics

Loaded wall versus resisting walls

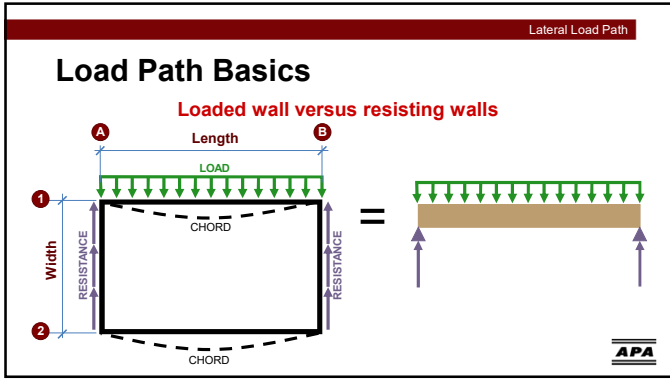
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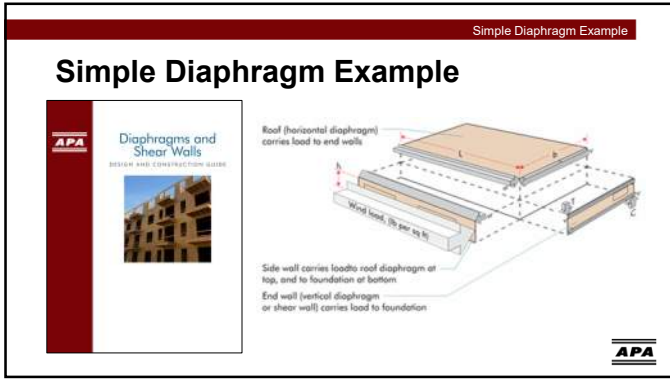
Lateral Load Path

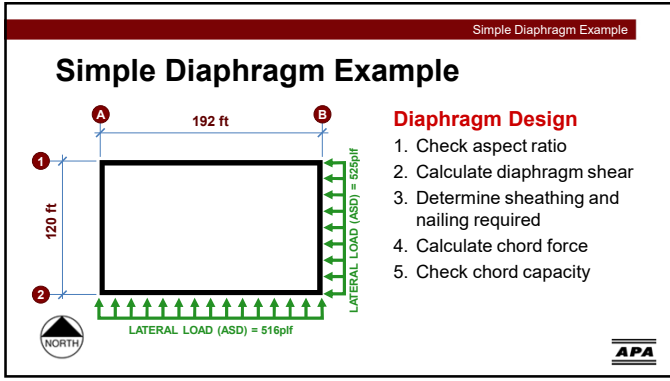
Load Path Basics

Loaded wall versus resisting walls

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- Diaphragm Design**
1. Check aspect ratio
 2. Calculate diaphragm shear
 3. Determine sheathing and nailing required
 4. Calculate chord force
 5. Check chord capacity

Simple Diaphragm Example

Simple Diaphragm Example

Check Aspect Ratio
SDPWS 2021

Table 4.2.2 Maximum Diaphragm Aspect Ratios
(Flat or Sloped Diaphragms)

Sheathed Wood-Frame Diaphragm Assemblies	Maximum L/W Ratio
Wood structural panel, unblocked	3:1
Wood structural panel, blocked	4:1
Single-layer horizontally-sheathed lumber	2:1
Single-layer diagonally-sheathed lumber	3:1
Double-layer diagonally-sheathed lumber	4:1

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Simple Diaphragm Example

Simple Diaphragm Example

Calculate Diaphragm Shear

$$V = \frac{wl}{2B} = \frac{516 \text{ plf} \times 192 \text{ ft}}{2 \times 120 \text{ ft}} = 413 \text{ plf}$$

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Simple Diaphragm Example

Multi-span Diaphragm Example

Calculate Diaphragm Shear

$$V = \frac{wl}{2B} = \frac{516 \text{ plf} \times 96 \text{ ft}}{2 \times 120 \text{ ft}} = 206 \text{ plf}$$

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Simple Diaphragm Example

Simple Diaphragm Example

Calculate Diaphragm Shear

$$V = \frac{wl}{2B} = \frac{525 \text{ plf} \times 120 \text{ ft}}{2 \times 192 \text{ ft}} = 164 \text{ plf}$$

$164 \text{ plf} < 413 \text{ plf}$

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Simple Diaphragm Example

Simple Diaphragm Example

Determine Sheathing and Nailing Required

$V(\text{ASD}) = 413 \text{ plf}$

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Simple Diaphragm Example

Diaphragm Capacities

Table 4.2A Nominal Unit Shear Capacities for Sheathed Wood-Frame Diaphragms

Diaphragm Details	Minimum Shear Capacity (k/ft) or (k/ft) (ASD)	Minimum Shear Capacity (k/ft) or (k/ft) (ASD)	Minimum Shear Capacity (k/ft) or (k/ft) (ASD)	ASD		LRFD	
				ASD (k/ft)	LRFD (k/ft)	ASD (k/ft)	LRFD (k/ft)
Sheathing	1/2" OSB (24" x 48")	1.14	2	100	130	100	130
				100	130	100	130
	3/4" OSB (24" x 48")	1.36	2	120	150	120	150
				120	150	120	150
Sheathing and Stud	1/2" OSB (24" x 48")	1.14	2	100	130	100	130
				100	130	100	130
	3/4" OSB (24" x 48")	1.36	2	120	150	120	150
				120	150	120	150

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Wind Factors
 ASD: $v_f/2.0$
 LRFD: $0.8v_g$

Seismic Factors
 ASD: $v_f/2.8$
 LRFD: $0.5v_g$

Simple Diaphragm Example

Diaphragm Capacities

Table 3
ALLOWABLE SHEAR (POUNDS PER FOOT) FOR MEDIANAL APA PANEL DIAPHRAGMS WITH FRAMING OF DOUGLASS FIR, LARCH OR SOUTHERN PINE¹ FOR WIND² OR SEISMIC LOADING³ (See also IRC Table 2303.2(1) for shear walls attached with sheeps, and ICCES ESR-416 and ESR-158 for concrete capacity.)

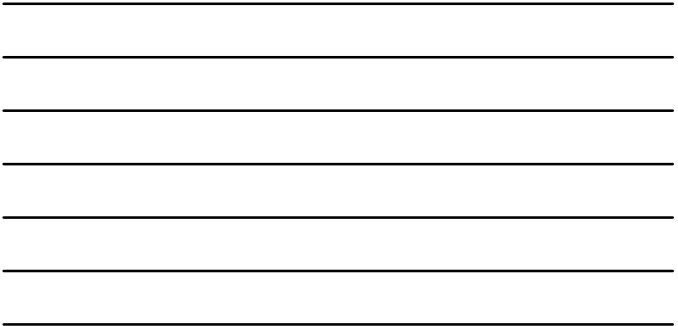
Panel Grade	Panel Size (ft)	Minimum Panel Thickness (in.)	Minimum Edge Nail Spacing (in.)	Blocked Diaphragms						Unblocked Diaphragms	
				Minimum Panel Thickness (in.)	Minimum Edge Nail Spacing (in.)	Minimum Panel Thickness (in.)	Minimum Edge Nail Spacing (in.)	Minimum Panel Thickness (in.)	Minimum Edge Nail Spacing (in.)	Minimum Panel Thickness (in.)	Minimum Edge Nail Spacing (in.)
APA STRUCTURAL I panels	8 ft	1/2	1/4	2	193	303	420	163	153	2	163
				3	230	350	471	183	162	3	193
APA STRUCTURAL I panels	10 ft	3/8	1/4	2	271	360	460	243	183	2	183
				3	303	420	520	273	203	3	213
APA STRUCTURAL I panels	12 ft	1/2	3/8	2	323	420	520	303	213	2	213
				3	360	471	571	333	243	3	243
APA STRUCTURAL I panels	16 ft	3/4	1/2	2	150	220	293	153	103	2	103
				3	163	230	303	163	113	3	113
APA STRUCTURAL I panels	20 ft	1	1/2	2	183	270	350	183	123	2	123
				3	213	300	400	213	143	3	143
APA STRUCTURAL II panels	8 ft	1/2	1/4	2	203	320	420	183	163	2	163
				3	230	350	471	193	173	3	173
APA STRUCTURAL II panels	10 ft	3/8	1/4	2	271	360	460	243	183	2	183
				3	303	420	520	273	203	3	213
APA STRUCTURAL II panels	12 ft	1/2	3/8	2	323	420	520	303	213	2	213
				3	360	471	571	333	243	3	243

Wind Factors
ASD: $v_w/2.0$
LRFD: $0.5v_w$

Seismic Factors
ASD: $v_s/2.8$
LRFD: $0.5v_s$

b. For wind load applications, the values in the table above shall be permitted to be multiplied by 1.4.

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Simple Diaphragm Example

Diaphragm Capacities

Table 4.2A Nominal Unit Shear Capacities for Sheathed Wood-Frame Diaphragms

Blocked Wood Structural Panel Diaphragms^{1,2,3,4,5,6}

Sheathing Grade	Minimum Panel Thickness (in.)	Minimum Edge Nail Spacing (in.)	Minimum Panel Thickness (in.)	Minimum Edge Nail Spacing (in.)	Nominal Unit Shear Capacity (lb/ft)					
					Wind		Seismic		Other	
					ASD	LRFD	ASD	LRFD	ASD	LRFD
APA STRUCTURAL I panels	1/2	1/4	1/2	2	193	230	303	350	163	183
					271	303	360	420	243	273
APA STRUCTURAL I panels	3/8	1/4	1/2	3	271	303	360	420	243	273
					323	360	420	471	303	333
APA STRUCTURAL I panels	1/2	3/8	1/2	2	323	360	420	471	303	333
					360	420	471	520	333	363
APA STRUCTURAL I panels	3/8	1/4	1/2	3	420	460	520	571	403	433
					460	520	571	620	433	463
APA STRUCTURAL II panels	1/2	1/4	1/2	2	203	230	293	350	183	193
					271	303	360	420	243	273
APA STRUCTURAL II panels	3/8	1/4	1/2	3	271	303	360	420	243	273
					323	360	420	471	303	333
APA STRUCTURAL II panels	1/2	3/8	1/2	2	323	360	420	471	303	333
					360	420	471	520	333	363
APA STRUCTURAL II panels	3/8	1/4	1/2	3	420	460	520	571	403	433
					460	520	571	620	433	463

Determine Sheathing and Nailing Required
 $V (ASD) = 413 \text{ plf}$

For wind:
 $v_w(\text{req.}) = 2.0 \times 413 \text{ plf} = 826 \text{ plf}$

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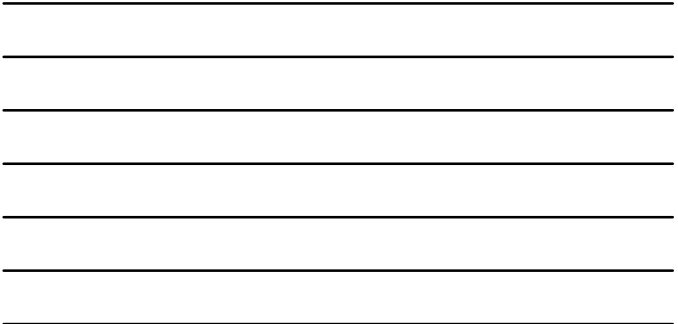
Simple Diaphragm Example

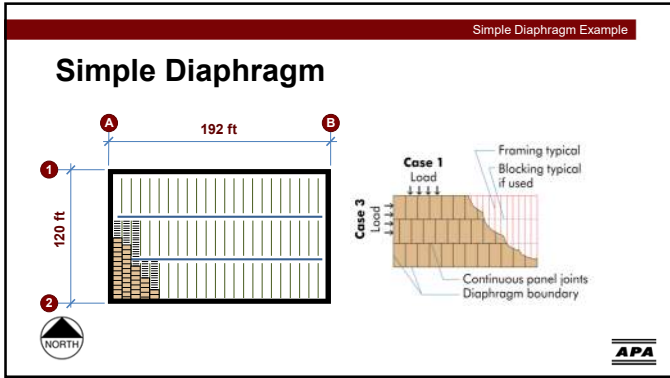
2021 SDPWS

	Cases 1&3 Continuous Panel Joints Perpendicular to Framing	Cases 2&4 Continuous Panel Joints Parallel to Framing	Cases 5&6 Continuous Panel Joints Perpendicular and Parallel to Framing
Long Panel Direction Perpendicular to Supports			
Long Panel Direction Parallel to Supports			

(a) Panel span rating for out-of-phase loads may be lower than the span rating with the long panel direction perpendicular to supports. (See Section 3.2.2 and Section 3.2.3)

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Simple Diaphragm Example

Diaphragm Capacities

Table 4.2A Nominal Unit Shear Capacities for Sheathed Wood-Frame Diaphragms

Sheathed Wood Structural Panel Diaphragms^{1,2,3,4,5}

Sheathing Grade	Minimum Panel Size ⁶ (ft x ft)	Minimum Panel Thickness (in.)	Minimum Panel Spacing (ft)	Minimum Panel Spacing (ft)	Minimum Panel Spacing (ft)	Nominal Unit Shear Capacity (plf)																			
						1	2	3	4	5	6	7	8	9	10	11	12								
Sheathing 1	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Sheathing and Diaphragm	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300

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Determine Sheathing and Nailing Required
 V (ASD) = 413 plf

For wind:
 $V_s(\text{req.}) = 2.0 \times 413 \text{ plf} = 826 \text{ plf}$

15/32 Cat. Panel with 8d @ 6" oc

Simple Diaphragm Example

Diaphragm Capacities

Table 4.2A Nominal Unit Shear Capacities for Sheathed Wood-Frame Diaphragms

Sheathed Wood Structural Panel Diaphragms^{1,2,3,4,5}

Sheathing Grade	Minimum Panel Size ⁶ (ft x ft)	Minimum Panel Thickness (in.)	Minimum Panel Spacing (ft)	Minimum Panel Spacing (ft)	Minimum Panel Spacing (ft)	Nominal Unit Shear Capacity (plf)																			
						1	2	3	4	5	6	7	8	9	10	11	12								
Sheathing 1	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Sheathing and Diaphragm	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
	15/32	1.14	6/16	2	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300

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Determine Sheathing and Nailing Required
 V (ASD) = 413 plf

For seismic:
 $V_s(\text{req.}) = 2.8 \times 413 \text{ plf} = 1,156 \text{ plf}$

15/32 Cat. Panel with 8d @ 2-1/2" oc

Simple Diaphragm Example


Diaphragm Capacities

Table 3
ALLOWABLE SHEAR (POUNDS PER FOOT) FOR HORIZONTAL APA PANEL DIAPHRAGMS WITH FINISHING OR DOUGLAS FIR, LARCH OR SOUTHERN PINE FOR WIND¹ OR SEISMIC² LOADING³
(See also IRC Table 2303.2(1) for shear walls attached with sheeps, and ICCES ESR-136 and ESR-138 for concrete capillary.)

Panel Grade	Minimum Panel Thickness (in.)	Minimum Panel Height (ft.)	Rigid Diaphragms						Unbraced Diaphragms		
			Minimum Shear Capacity (lb/ft)		Minimum Shear Capacity (lb/ft)		Minimum Shear Capacity (lb/ft)		Minimum Shear Capacity (lb/ft)		Minimum Shear Capacity (lb/ft)
			Wind	Seismic	Wind	Seismic	Wind	Seismic	Wind	Seismic	
15/32 Cat. Panel with 8d @ 2-1/2" oc	15/32	2	192	275	275	192	192	192	192	192	

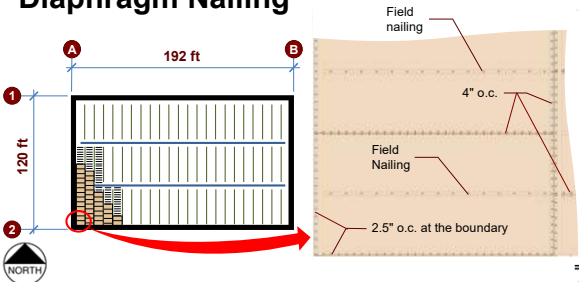
Determine Sheathing and Nailing Required
V (ASD) = 413 plf
For seismic: v_s(req.) = 413 plf

15/32 Cat. Panel with 8d @ 2-1/2" oc




Simple Diaphragm Example

Diaphragm Nailing

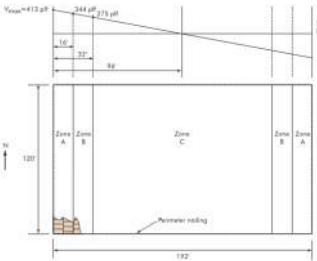


Field nailing
4" o.c.
Field Nailing
2.5" o.c. at the boundary




Simple Diaphragm Example

Variable Diaphragm Nailing



Determine Sheathing and Nailing Required
For Zone A (seismic): v_s(req.) = 413 plf
For Zone B (seismic): v_s(req.) = 344 plf
For Zone C (seismic): v_s(req.) = 275 plf



Simple Diaphragm Example

Diaphragm Sheathing

Determine Sheathing and Nailing Required
For Zone A (seismic):
 $V_s(\text{req.}) = 413 \text{ plf}$
15/32 Cat. Panel with 8d at 2-1/2"oc

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Simple Diaphragm Example

Diaphragm Capacities

Determine Sheathing and Nailing Required
For Zone A (seismic):
 $V_s(\text{req.}) = 413 \text{ plf}$
For Zone B (seismic):
 $V_s(\text{req.}) = 344 \text{ plf}$
15/32 Cat. Panel with 8d @ 4"oc

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Simple Diaphragm Example

Diaphragm Sheathing

Determine Sheathing and Nailing Required
For Zone A (seismic):
 $V_s(\text{req.}) = 413 \text{ plf}$
15/32 Cat. Panel with 8d at 2.5"oc
For Zone B (seismic):
 $V_s(\text{req.}) = 344 \text{ plf}$
15/32 Cat. Panel with 8d at 4"oc
For Zone C (seismic):
 $V_s(\text{req.}) = 275 \text{ plf}$

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Simple Diaphragm Example

Diaphragm Capacities

Table 5
 ALLOWABLE SHEAR (POUNDS PER FOOT) FOR MEDICAL-SPAN PANEL DIAPHRAGMS WITH FINISHING OR DOUGLASS FIR, LARCH OR SOUTHERN PINE FOR WIND¹ OR SEISMIC LOADING²
(See also IRC, Table 2304.2(1) for shear walls attached with sheeps, and ICCES E-348 and E-338 for covered capacities.)

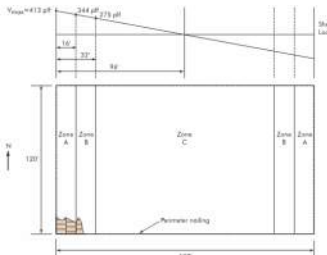
Panel Grade	Nail Size	Minimum Panel Thickness (in.)	Minimum Panel Height (ft.)	Medial Diaphragms				End Diaphragms			
				Minimum Shear (lb/ft)		Minimum Shear (lb/ft)		Minimum Shear (lb/ft)		Minimum Shear (lb/ft)	
				W	E	W	E	W	E	W	E
15/32 Cat. Panel with 8d @ 6" oc	1.04	3/8	2	192	210	210	210	192	210	210	210
				210	210	210	210	210	210	210	210
15/32 Cat. Panel with 8d @ 4" oc	1.04	3/8	2	210	210	210	210	210	210	210	210
				210	210	210	210	210	210	210	210
15/32 Cat. Panel with 8d @ 2.5" oc	1.04	3/8	2	210	210	210	210	210	210	210	210
				210	210	210	210	210	210	210	210
15/32 Cat. Panel with 8d @ 6" oc	1.04	3/8	2	210	210	210	210	210	210	210	210
				210	210	210	210	210	210	210	210

Determine Sheathing and Nailing Required
 For Zone A (seismic): $v_s(\text{req.}) = 413 \text{ plf}$
 For Zone B (seismic): $v_s(\text{req.}) = 344 \text{ plf}$
 For Zone C (seismic): $v_s(\text{req.}) = 275 \text{ plf}$
15/32 Cat. Panel with 8d @ 6" oc




Simple Diaphragm Example

Diaphragm Sheathing

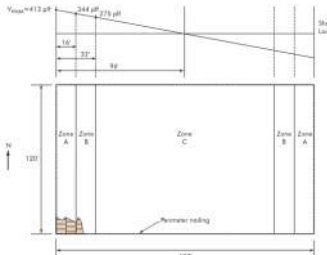


Determine Sheathing and Nailing Required
 For Zone A (seismic): $v_s(\text{req.}) = 413 \text{ plf}$
15/32 Cat. Panel with 8d at 2.5" oc
 For Zone B (seismic): $v_s(\text{req.}) = 344 \text{ plf}$
15/32 Cat. Panel with 8d at 4" oc
 For Zone C (seismic): $v_s(\text{req.}) = 275 \text{ plf}$
15/32 Cat. Panel with 8d at 6" oc




Simple Diaphragm Example

Diaphragm Sheathing



Sheathing Specification
15/32 Performance Category Rated Sheathing, Exposure 1, 32/16 span rating



Simple Diaphragm Example

Diaphragm Sheathing

PERFORMANCE CATEGORY AND NOMINAL THICKNESS (in.) BY SPAN RATING
(The predominant Performance Category for each span rating is highlighted in bold type.)

Span Rating	Performance Category										
	3/8	7/16	15/32	1/2	19/32	5/8	23/32	3/4	7/8	1	1-1/8
Sheathing											
W24	0.375	0.437	0.469								
24/0	0.375	0.437	0.469	0.500							
24/16		0.437	0.469	0.500							
32/16			0.469	0.500	0.594	0.625					
40/20				0.594	0.625	0.719	0.750				
48/24						0.719	0.750	0.875			

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Simple Diaphragm Example

Diaphragm Chords

Calculate Chord Force

N-S Direction:

$$T(ASD) = \frac{wl^2}{8B} = \frac{516 \text{ pif} (192 \text{ ft})^2}{8(120 \text{ ft})} = 19,814 \text{ lbs.}$$

E-W Direction:

$$T(ASD) = \frac{wl^2}{8B} = \frac{525 \text{ pif} (120 \text{ ft})^2}{8(192 \text{ ft})} = 4,922 \text{ lbs.}$$

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Simple Diaphragm Example

Diaphragm Chords

Check Chord Capacity

2x12 DF-L No. 1 Ledger

Tension:

$$F_t = F_t C_D C_M C_t C_f C_i = 675 \text{ psi} (1.6)(1)(1)(1)(0.8) = 864 \text{ psi}$$

$$F_t^A = 864 \text{ psi} (16.88 \text{ in}^2) = 14,586 \text{ lbs. N.G.}$$

Use a 3x12 DF-L No. 1 ledger (Grid 1 and 2)

$$F_t^A = 864 \text{ psi} \times 28.13 \text{ in}^2 = 24,304 \text{ lbs.}$$

Compression:

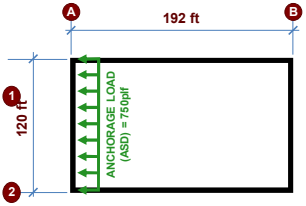
$$F_c = F_c C_D C_M C_t C_f C_i C_p = 1,500 \text{ psi} (1.6)(1)(1)(1)(0.8)(1) = 1,920 \text{ psi}$$

F_c^A okay by inspection

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Subdiaphragm Example

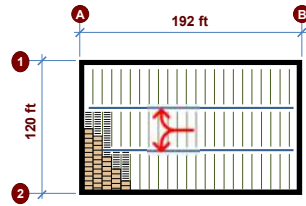
Subdiaphragm Example



Subdiaphragm Design
 "A portion of a diaphragm used to transfer wall anchorage forces to diaphragm cross-ties"
SDPWS 2021

Subdiaphragm Example

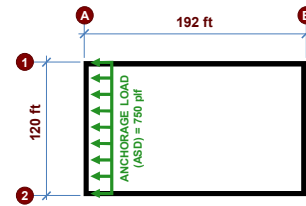
Subdiaphragm Example



Subdiaphragm Design
 "A portion of a diaphragm used to transfer wall anchorage forces to diaphragm cross-ties"
SDPWS 2021

Subdiaphragm Example

Subdiaphragm Example



Subdiaphragm Design

1. Choose subdiaphragm depth
2. Calculate subdiaphragm shear
3. Determine sheathing and nailing required
4. Check chord
5. Calculate connection forces

Subdiaphragm Example

Subdiaphragm Example

Choosing a 16ft depth:

$$V(ASD) = 750 \text{ plf}(40 \text{ ft}/2) = 938 \text{ plf}$$

$$16 \text{ ft}$$

$$v_r(\text{req.}) = 2.8(938 \text{ plf}) = 2,625 \text{ plf}$$

$$2,625 \text{ plf} > \text{max shear } 2,295 \text{ plf}$$

Simple Diaphragm Example

Diaphragm Nailing

Table 4.2A Nominal Unit Shear Capacities for Sheathed Wood-Frame Diaphragms

Sheathed Wood Structural Panel Diaphragms (ASD)

Sheathing Material	Minimum Panel Thickness (in.)	Minimum Panel Length (ft)	Minimum Panel Width (ft)	Minimum Nailing (No. per Panel)	Minimum Nailing (No. per Edge)	Nominal Unit Shear Capacity (plf)						
						4-in. Nailing (No. per Panel)	4-in. Nailing (No. per Edge)	6-in. Nailing (No. per Panel)	6-in. Nailing (No. per Edge)	8-in. Nailing (No. per Panel)	8-in. Nailing (No. per Edge)	
Sheathing	1/4"	10	10	2	2	15	20	25	30	35	40	45
						30	40	50	60	70	80	
						45	60	75	90	105	120	
						60	80	100	120	140	160	
Diaphragm	3/8"	10	10	2	2	25	30	35	40	45	50	55
						45	60	75	90	105	120	
						60	80	100	120	140	160	
	1/2"	10	10	2	2	35	40	45	50	55	60	65
						55	70	85	100	115	130	
						75	95	115	135	155	175	
	3"	10	10	2	2	75	85	95	105	115	125	135
						105	120	135	150	165	180	
						135	155	175	195	215	235	
		12	10	10	2	2	115	130	145	160	175	190
							165	190	215	240	265	290
							215	250	285	320	355	390

Subdiaphragm Example

Subdiaphragm Example

Choosing a 24ft depth:

$$V(ASD) = 750 \text{ plf}(40 \text{ ft}/2) = 625 \text{ plf}$$

$$24 \text{ ft}$$

$$v_r(\text{req.}) = 2.8(625 \text{ plf}) = 1,750 \text{ plf}$$

Subdiaphragm Example

Subdiaphragm Example

Table 4.2A Nominal Unit Shear Capacities for Sheathed Wood-Frame Diaphragms

Blockwood Structural Panel Diaphragms^{1,2,3,4}

Sheathing Species	Common Panel Size (Nominal Length by Nominal Width)	Minimum Sheathing Thickness (in.)	Minimum Nailing Pattern (in. Spacing)	Sheathing Material		Minimum Sheathing Thickness (in.)		Minimum Nailing Pattern (in. Spacing)		Minimum Sheathing Thickness (in.)		Minimum Nailing Pattern (in. Spacing)			
				Nominal Thickness (in.)	Nominal Thickness (in.)	Nominal Thickness (in.)	Nominal Thickness (in.)	Nominal Thickness (in.)	Nominal Thickness (in.)	Nominal Thickness (in.)	Nominal Thickness (in.)				
												1	2	3	4
Sheathed ¹	(12 x 12) (12 x 12)	1/4	2	10d	10d	3/8	3/8	12	12	10d	10d	12	12		
				16d	16d	1/2	1/2	16	16	16d	16d	16	16		
		3/8	2	10d	10d	3/8	3/8	12	12	10d	10d	12	12		
				16d	16d	1/2	1/2	16	16	16d	16d	16	16		
		(12 x 16) (12 x 16)	1/4	2	10d	10d	3/8	3/8	12	12	10d	10d	12	12	
					16d	16d	1/2	1/2	16	16	16d	16d	16	16	
	3/8		2	10d	10d	3/8	3/8	12	12	10d	10d	12	12		
				16d	16d	1/2	1/2	16	16	16d	16d	16	16		
	Sheathed and Edge-Glued ^{2,3}		(12 x 12) (12 x 12)	1/4	2	10d	10d	3/8	3/8	12	12	10d	10d	12	12
						16d	16d	1/2	1/2	16	16	16d	16d	16	16
		3/8	2	10d	10d	3/8	3/8	12	12	10d	10d	12	12		
				16d	16d	1/2	1/2	16	16	16d	16d	16	16		
1/2		2	10d	10d	3/8	3/8	12	12	10d	10d	12	12			
			16d	16d	1/2	1/2	16	16	16d	16d	16	16			

Determine Sheathing and Nailing Required

For Zone A (seismic):
 $V_s = 1,485 \text{ plf}$

For Zone B (seismic):
 $V_s = 1,010 \text{ plf}$

For Zone C (seismic):
 $V_s = 755 \text{ plf}$

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Subdiaphragm Example

Subdiaphragm Example

Assuming 24ft depth:

$V(ASD) = 750 \text{ plf}(40 \text{ ft}/2) = 625 \text{ plf}$

$v_s(\text{req.}) = 2.8(625 \text{ plf}) = 1,750 \text{ plf}$

$1,750 \text{ plf} > 1,485 \text{ plf (Zone A)}$

Options:

- Increase nailing to 2" o.c.
- Use 10d nails
- Increase subdiaphragm depth

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Subdiaphragm Example

Subdiaphragm Example

Choosing 32ft depth:

$V(ASD) = 750 \text{ plf}(40 \text{ ft}/2) = 469 \text{ plf}$

$v_s(\text{req.}) = 2.8(469 \text{ plf}) = 1,313 \text{ plf}$

$1,313 \text{ plf} < 1,485 \text{ plf (Zone A)}$

APA

Subdiaphragm Example

Subdiaphragm Example

Choosing 32ft depth:

V(ASD) = $\frac{750 \text{ plf}(40 \text{ ft}^2)}{32 \text{ ft}} = 469 \text{ plf}$

$v_u(\text{req.}) = 2.8(469 \text{ plf}) = 1,313 \text{ plf}$

1,313 plf < 1,485 plf (Zone A)

T(ASD) = $\frac{wL^2}{8B} = \frac{750 \text{ plf} (40 \text{ ft})^2}{8(32 \text{ ft})} = 4,688 \text{ lbs.}$

NORTH
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Subdiaphragm Example

Subdiaphragm Example

15/32 Performance Category, Rated Sheathing, Exposure 1 8d nails

- 2.5"/4"/12" pattern at Zone A
- 6"/6"/12" pattern at Zone C

NORTH
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Subdiaphragm Example

Subdiaphragm Example

Purlin Anchorage Force:
F (for 8 ft spacing) = 750 plf(8 ft) = 6,000 lbs.

Subpurlin Anchorage Force:
F (for 2 ft spacing) = 750 plf(2 ft) = 1,500 lbs.

Girder Force:
F (40 ft spacing) = 750 plf(40 ft) = 30,000 lbs.

NORTH
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Diaphragm Deflection Example

Calculate Deflection

Loading case	Equation
1. Mid-span deflection of a simple span simply supported diaphragm with uniformly distributed load	$\delta_{dia} = \frac{5vL^3}{8EAW} + \frac{0.25vL}{1000G_s} + \frac{\sum x\Delta_c}{2W}$ (4.2-1)
2. End deflection of a cantilever diaphragm with uniformly distributed load	$\delta_{dia} = \frac{3vL^3}{EAW} + \frac{0.5vL}{1000G_s} + \frac{\sum x\Delta_c}{W}$ (4.2-2)
3. End deflection of a cantilever diaphragm with concentrated load at the end	$\delta_{dia} = \frac{9vL^3}{EAW} + \frac{vL}{1000G_s} + \frac{\sum x\Delta_c}{W}$ (4.2-3)

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Diaphragm Deflection Example

Calculate Deflection

SDPWS (Eq. 4.2-1):

$$\delta_{dia} = \frac{5vL^3}{8EAW} + \frac{0.25vL}{1000G_s} + \frac{\sum x\Delta_c}{2W}$$

↑ Bending ↑ Shear ↑ Chord Slip

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Diaphragm Deflection Example

Calculate Deflection

1st Term:

$$\frac{5vL^3}{8EAW} = \frac{5(413 \text{ plf})(192 \text{ ft})^3}{8(1,600,000 \text{ psi})(28.13 \text{ in}^2)(120 \text{ ft})} = 0.34 \text{ in}$$

2nd Term:

$$\frac{0.25vL}{1000G_s} = \frac{0.25(413 \text{ plf})(192 \text{ ft})}{1000(11)} = 1.80 \text{ in}$$

Last Term:

$$\frac{\sum x\Delta_c}{2W} = \frac{2(1/32)(2(12 \text{ ft} + 24 \text{ ft} + 36 \text{ ft} + 48 \text{ ft} + 60 \text{ ft} + 72 \text{ ft} + 84 \text{ ft}) + 96 \text{ ft})}{2(120 \text{ ft})} = 0.2 \text{ in}$$

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Diaphragm Deflection Example

Calculate Deflection

SDPWS (Eq. 4.2-1):

$$\delta_{dia} = 0.34 \text{ in} + 1.80 \text{ in} + 0.2 \text{ in}$$

14.5% 77% 8.5%

$$= 2.34 \text{ in}$$

IBC (Eq. 23-1):

$$\delta_{dia} = 0.34 \text{ in} + \frac{vL}{4Gt} + 0.188Le_n + 0.2 \text{ in}$$

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Diaphragm Deflection Example

Calculate Deflection

IBC (Eq. 23-1):

$$\delta_{dia} = 0.34 \text{ in} + \frac{vL}{4Gt} + 0.188Le_n + 0.2 \text{ in}$$

↑
ADJUST THIS IF YOU HAVE MULTIPLE NAILING PATTERNS!

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Diaphragm Deflection Example

Calculate Deflection

IBC (Eq. 23-1):

$$\delta_{dia} = 0.34 \text{ in} + \frac{vL}{4Gt} + 0.188Le_n + 0.2 \text{ in}$$

Adjust nail slip coefficient

$$= 0.188 \left(\frac{v_n}{V_n} \right)$$

OR

$$= 0.188 \left(\frac{\text{Area 2} + \text{Area 3}}{\text{Area 1}} \right)$$

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Diaphragm Deflection Example

Diaphragm Nailing

Determine Sheathing and Nailing Required
V (ASD) = 413 plf

15/32 Cat. Panel with 8d at 2.5"oc

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Diaphragm Deflection Example

Calculate Deflection

IBC (Eq. 23-1):

$$\delta_{dia} = 0.34 \text{ in} + \frac{vL}{4Gt} + 0.188L e_n + 0.2 \text{ in}$$

Adjust nail slip coefficient
 $= 0.188 \left(\frac{\text{Area 2} + \text{Area 3}}{\text{Area 1}} \right)$

Load per nail
 $413 \text{ plf} \left(\frac{25 \text{ ft}}{12} \right) = 97.7 \text{ lb}$

Which means...
 $\text{Area 1} = \frac{97.7 \text{ lb}(96 \text{ ft})}{2} = 4,690$

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Diaphragm Deflection Example

Calculate Deflection

IBC (Eq. 23-1):

$$\delta_{dia} = 0.34 \text{ in} + \frac{vL}{4Gt} + 0.188L e_n + 0.2 \text{ in}$$

Adjust nail slip coefficient
 $= 0.188 \left(\frac{v_n}{v_n} \right)$

Load per nail
Zone A @ 32 ft: $275 \text{ plf} \left(\frac{25 \text{ ft}}{12} \right) = 57.3 \text{ lb}$

Which means...
 $\text{Area 2} = \frac{(97.7 \text{ lb} + 57.3 \text{ lb})32 \text{ ft}}{2} = 2,480$

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Diaphragm Deflection Example

Calculate Deflection

IBC (Eq. 23-1):

$$\delta_{dia} = 0.34 \text{ in} + \frac{vL}{4Gt} + 0.188Le_n + 0.2 \text{ in}$$

Adjust nail slip coefficient
 $= 0.188 \left(\frac{v_n}{v_n} \right)$

Load per nail
Zone C: $275 \text{ plf} \left(\frac{6}{12} \text{ ft/nail} \right) = 137.5 \text{ lb}$

Which means...
 $\text{Area 3} = \frac{137.5 \text{ lb} \times 64 \text{ ft}}{2} = 4,400$

Diaphragm Deflection Example

Calculate Deflection

IBC (Eq. 23-1):

$$\delta_{dia} = 0.34 \text{ in} + \frac{vL}{4Gt} + 0.188Le_n + 0.2 \text{ in}$$

Adjust nail slip coefficient
 $= 0.188 \left(\frac{\text{Area 2} + \text{Area 3}}{\text{Area 1}} \right)$

$$= 0.188 \left(\frac{2,480 + 4,400}{4,690} \right)$$

$$= 0.276$$

Diaphragm Deflection Example

Calculate Deflection

IBC (Eq. 23-1):

$$\delta_{dia} = 0.34 \text{ in} + \frac{vL}{4Gt} + 0.267Le_n + 0.2 \text{ in}$$

$$= 0.34 \text{ in} + \frac{(413 \text{ plf})(192 \text{ ft})}{4Gt} + 0.267(192 \text{ ft})e_n + 0.2 \text{ in}$$

Where:
 $Gt = 83,500 \text{ lbs/in}$
 $e_n = 1.2 \left(\frac{2000}{216} \right)^{3.018}$
 $= 1.2 \left[\frac{137.2 \text{ lb/nail}}{216} \right]^{3.018}$
 $= 0.013 \text{ in}$

Diaphragm Deflection Example

Calculate Deflection

SDPWS (Eq. 4.2-1):
 $\delta_{dia} = 0.34 \text{ in} + 1.80 \text{ in} + 0.2 \text{ in} = 2.34 \text{ in}$
 14.5% 77% 8.5%

IBC (Eq. 23-1):

$$\delta_{dia} = 0.34 \text{ in} + \frac{vL}{4G} + 0.188Le_n + 0.2 \text{ in}$$

$$= 0.34 \text{ in} + \frac{413 \text{ plf}(192 \text{ ft})}{4G} + 0.267(192 \text{ ft})e_n + 0.2 \text{ in}$$

$$= 0.34 \text{ in} + 0.24 \text{ in} + 2.12 \text{ in} + 0.2 \text{ in} = 2.90 \text{ in}$$
 11.7% 8.2% 73.2% 6.9%

81.4%

Questions?

?

APA Update Newsletter

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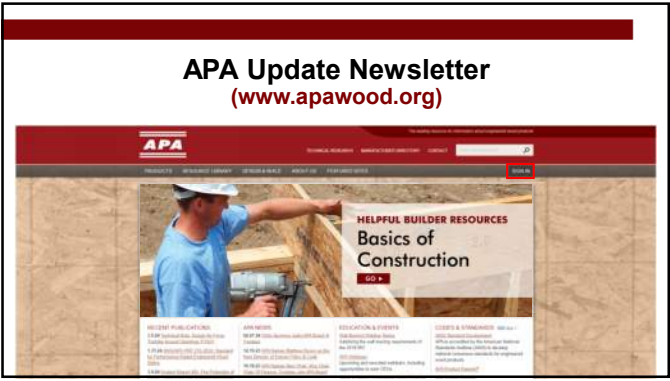
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PUBLICATIONS, VIDEOS, CAD DETAILS AND MORE

UPCOMING WEBINAR
Designing Engineered Wood Diaphragm Systems

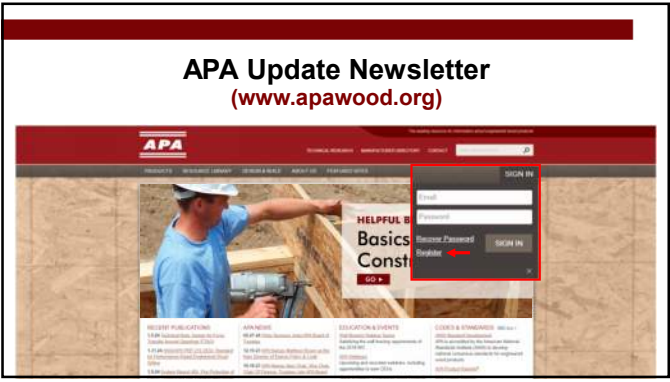
Wednesday, May 22 | 10-11 a.m. PDF
 Diaphragms play a vital role in a building's lateral load path. Whether that lateral load is from seismic activity or wind forces, the diaphragm is responsible for distributing that lateral load to the shear walls. This session provides guidance on the proper

WEBINAR
 Designing Engineered Wood Diaphragm Systems

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