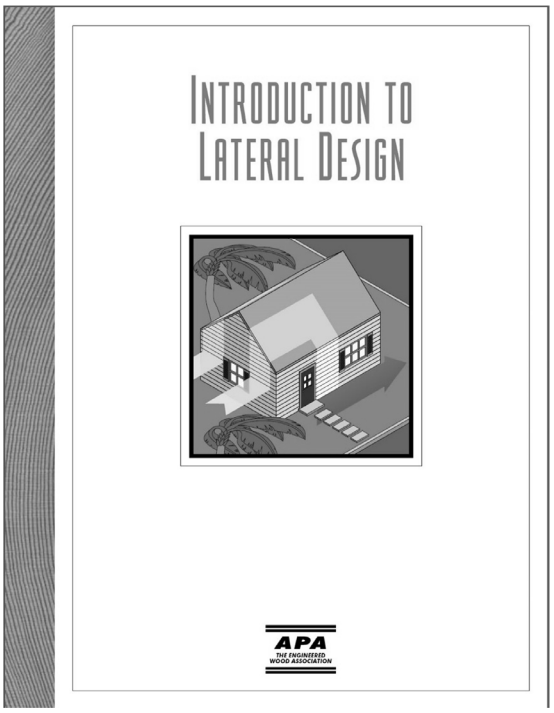
Diaphragms and Shear Walls



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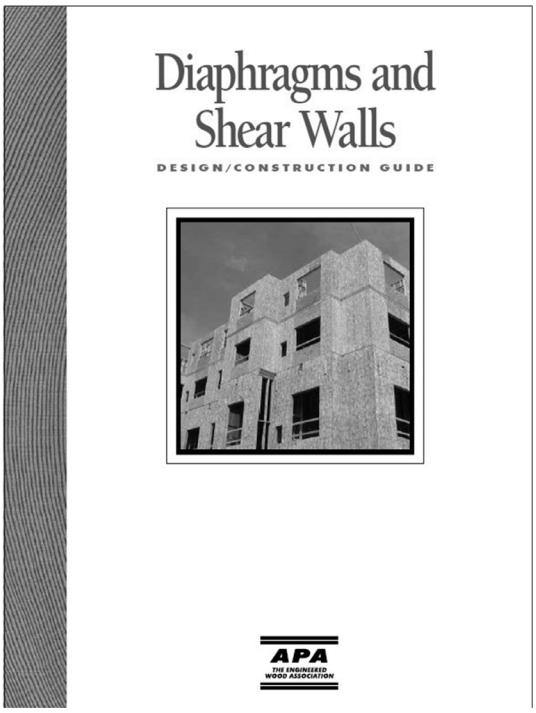

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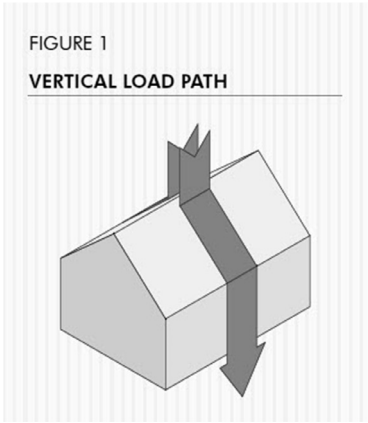
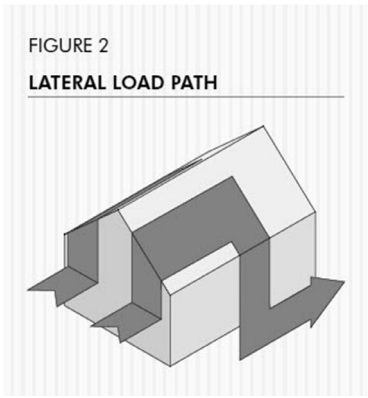
Load Paths

Vertical Loads
- gravity
- D, L, Lr, S,

Lateral Loads
- wind
- seismic





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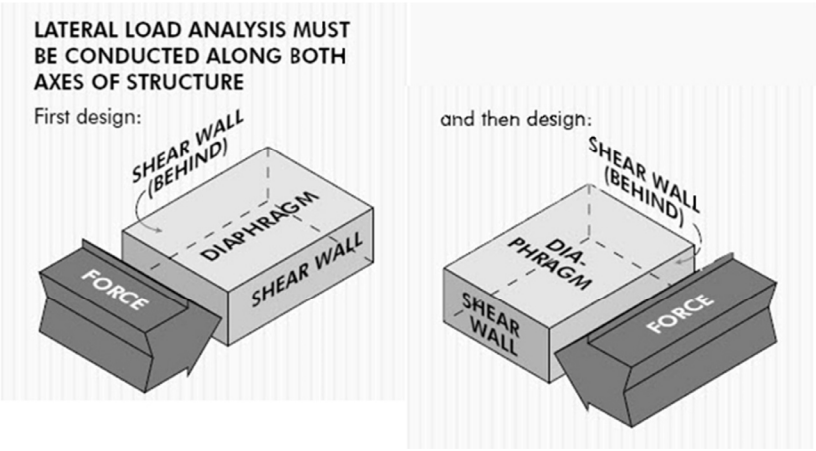
Diaphragms and Shear Walls



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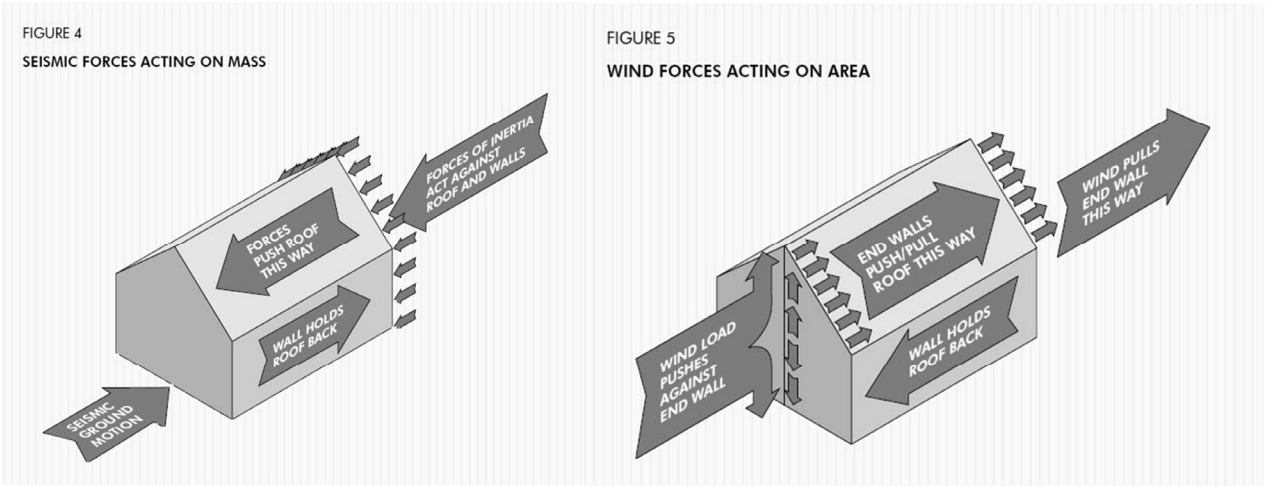
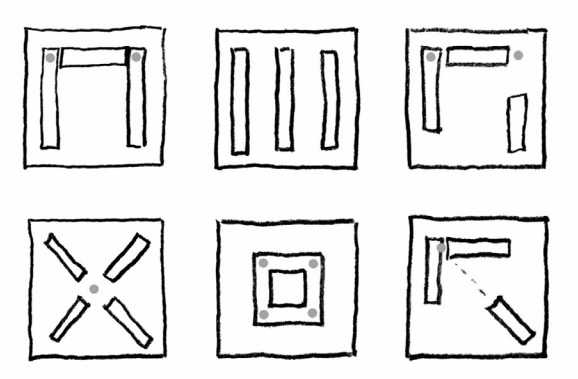


Lateral Force Resistance

Stability requires at least 2 points of intersection.

Force is more evenly resisted with centroid of walls in the kern of slab

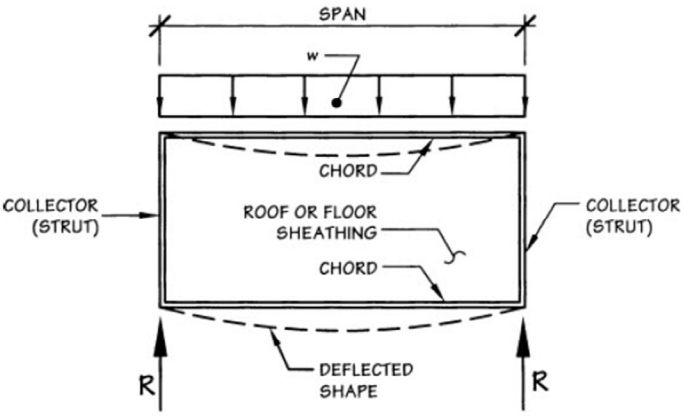


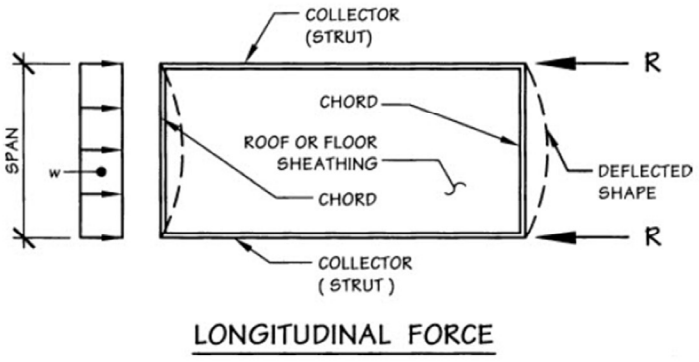
Definitions

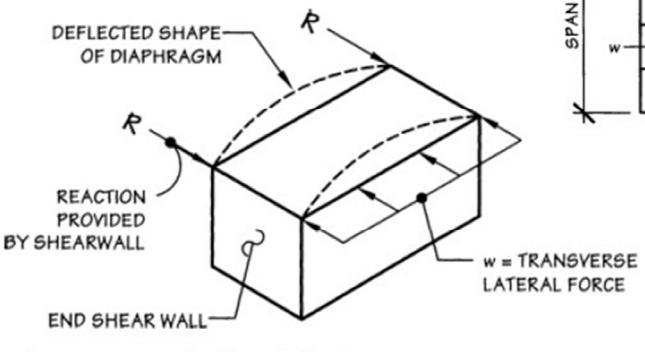
Diaphragm – a flat structure which acts as a deep beam to resist in plane loads.

Shear Wall – a vertical structure which acts as a cantilevered diaphragm

Chord – the edge member of a diaphragm







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Definitions

Blocked Diaphragm – all panel edges are supported by (and nailed to) framing member.

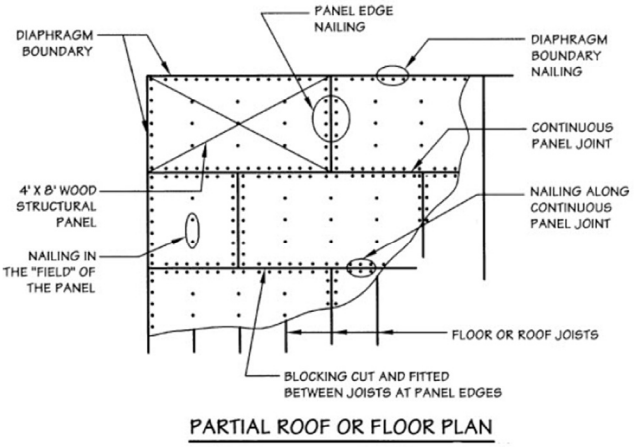

Figure 9.5b. Blocked diaphragm.

Unblocked Diaphragm – only the short, 4 ft edge is supported by framing member. This is the most common situation.

Drag Strut – at the edge of the diaphragm. It distributes the shear force from one diaphragm to another – e.g. from floor diaphragm to shear wall.

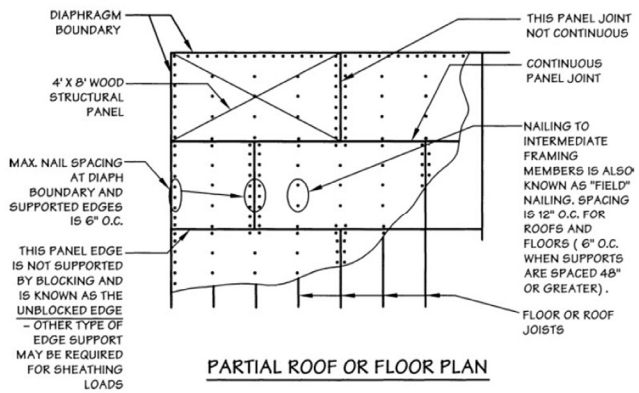

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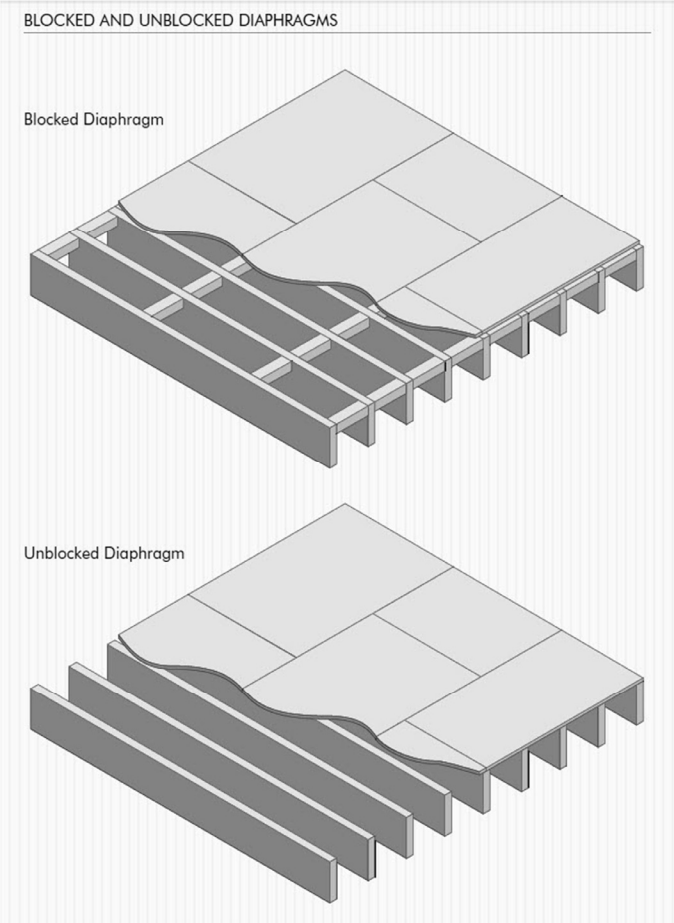
Figure 9.5a. Unblocked diaphragm.

Diaphragm Types

Blocked
- all edges supported and nailed
- stronger
- more expensive

Unblocked
- more common type
- lower capacity
- less stiff



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Diaphragm Selection For Shear Force

roof and floor diaphragms

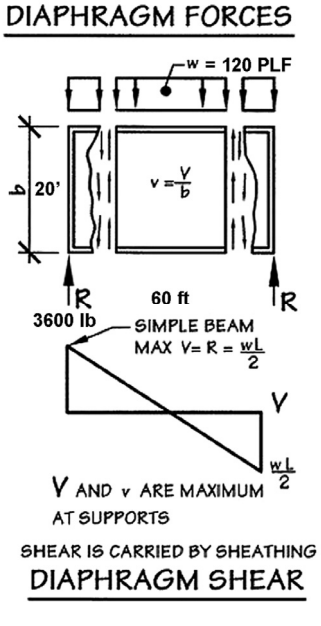
Example 1:

residential roof diaphragm

trussed roof (2x dim. lumber)

unblocked any case

capacity 180 plf - any direction



APA X305

TABLE 1

DIAPHRAGMS: RECOMMENDED SHEAR (POUNDS PER FOOT) FOR HORIZONTAL APA PANEL DIAPHRAGMS WITH FRAMING OF DOUGLAS-FIR, LARCH OR SOUTHERN PINE[a] FOR WIND OR SEISMIC LOADING

					Blocked Diaphragms				Unblocked Diaphragms	
					Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)[b]				Nails Spaced 6" max. at Supported Edges[b]	
					6	4	2-1/2[c]	2[c]		
Panel Grade	Common Nail Size	Minimum Nail Penetration in Framing (inches)	Minimum Nominal Panel Thickness (inch)	Minimum Nominal Width of Framing Member (inches)	Nail Spacing (in.) at other panel edges (Cases 1, 2, 3 & 4)				Case 1 (No unblocked edges or continuous joints parallel to load)	All other configurations (Cases 2, 3, 4, 5 & 6)
					6	6	4	3		
APA STRUCTURAL I grades	6d	1-1/4	5/16	2 3	185 210	250 280	375 420	420 475	165 185	125 140
	8d	1-3/8	3/8	2 3	270 300	360 400	530 600	600 675	240 265	180 200
	10d[d]	1-1/2	15/32	2 3	320 360	425 480	640 720	730 820	285 320	215 240
APA RATED SHEATHING, APA RATED STURD-I-FLOOR and other APA grades except Species Group 5	6d[e]	1-1/4	5/16	2 3	170 190	225 250	335 380	380 430	150 170	110 125
			3/8	2 3	185 210	250 280	375 420	420 475	165 185	125 140
	8d	1-3/8	3/8	2 3	240 270	320 360	480 540	545 610	215 240	160 180
			7/16	2 3	255 285	340 380	505 570	575 645	230 255	170 190
			15/32	2 3	270 300	360 400	530 600	600 675	240 265	180 200
	10d[d]	1-1/2	15/32	2 3	290 325	385 430	575 650	655 735	255 290	190 215
			19/32	2 3	320 360	425 480	640 720	730 820	285 320	215 240

(a) For framing of other species: (1) Find specific gravity for species of lumber in the AFPA National Design Specification. (2) Find shear value from table above for nail size for actual grade. (3) Multiply value by the following adjustment factor: Specific Gravity Adjustment Factor = [1 – (0.5 – SG)], where SG = specific gravity of the framing. This adjustment shall not be greater than 1.

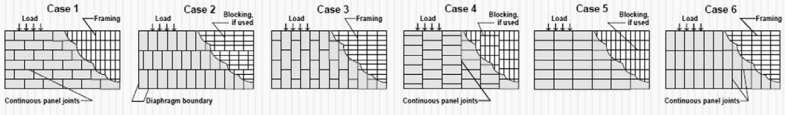
(b) Space nails maximum 12 in. o.c. along intermediate framing members (6 in. o.c. when supports are spaced 48 in. o.c.).

(c) Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where nails are spaced 2 inches o.c. or 2-1/2 inches o.c.

(d) Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 inches are spaced 3 inches o.c.

(e) 8d is recommended minimum for roofs due to negative pressures of high winds.

Notes: Design for diaphragm stresses depends on direction of continuous panel joints with reference to load, not on direction of long dimension of sheet. Continuous framing may be in either direction for blocked diaphragms.



Diaphragm Selection For Shear Force

roof and floor diaphragms

Example 2:

commercial roof diaphragm

trussed roof (2x dim. lumber)

capacity 350 plf - Case 1 blocked

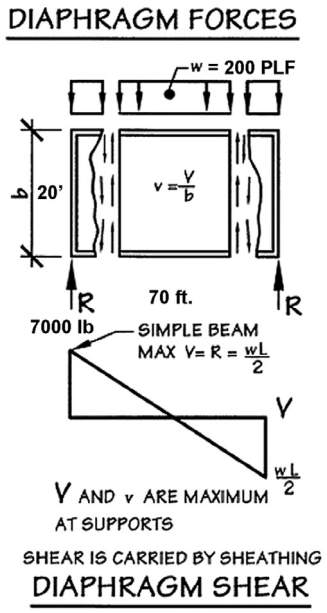


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TABLE 1

DIAPHRAGMS: RECOMMENDED SHEAR (POUNDS PER FOOT) FOR HORIZONTAL APA PANEL DIAPHRAGMS WITH FRAMING OF DOUGLAS-FIR, LARCH OR SOUTHERN PINE[a] FOR WIND OR SEISMIC LOADING

					Blocked Diaphragms				Unblocked Diaphragms	
					Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)[b]				Nails Spaced 6" max. at Supported Edges[b]	
					6	4	2-1/2[c]	2[c]		
Panel Grade	Common Nail Size	Minimum Nail Penetration in Framing (inches)	Minimum Nominal Panel Thickness (inch)	Minimum Nominal Width of Framing Member (inches)	Nail Spacing (in.) at other panel edges (Cases 1, 2, 3 & 4)				Case 1 (No unblocked edges or continuous joints parallel to load)	All other configurations (Cases 2, 3, 4, 5 & 6)
					6	6	4	3		
APA STRUCTURAL I grades	6d	1-1/4	5/16	2 3	185 210	250 280	375 420	420 475	165 185	125 140
	8d	1-3/8	3/8	2 3	270 300	360 400	530 600	600 675	240 265	180 200
	10d[d]	1-1/2	15/32	2 3	320 360	425 480	640 720	730 820	285 320	215 240
APA RATED SHEATHING, APA RATED STURD-I-FLOOR and other APA grades except Species Group 5	6d[e]	1-1/4	5/16	2 3	170 190	225 250	335 380	380 430	150 170	110 125
			3/8	2 3	185 210	250 280	375 420	420 475	165 185	125 140
	8d	1-3/8	3/8	2 3	240 270	320 360	480 540	545 610	215 240	160 180
			7/16	2 3	255 285	340 380	505 570	575 645	230 255	170 190
			15/32	2 3	270 300	360 400	530 600	600 675	240 265	180 200
	10d[d]	1-1/2	15/32	2 3	290 325	385 430	575 650	655 735	255 290	190 215
			19/32	2 3	320 360	425 480	640 720	730 820	285 320	215 240

(a) For framing of other species: (1) Find specific gravity for species of lumber in the AFPA National Design Specification. (2) Find shear value from table above for nail size for actual grade. (3) Multiply value by the following adjustment factor: Specific Gravity Adjustment Factor = [1 – (0.5 – SG)], where SG = specific gravity of the framing. This adjustment shall not be greater than 1.

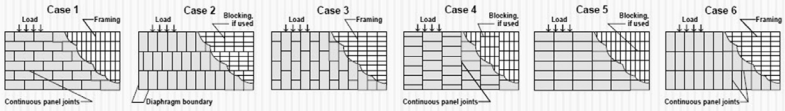
(b) Space nails maximum 12 in. o.c. along intermediate framing members (6 in. o.c. when supports are spaced 48 in. o.c.).

(c) Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where nails are spaced 2 inches o.c. or 2-1/2 inches o.c.

(d) Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 inches are spaced 3 inches o.c.

(e) 8d is recommended minimum for roofs due to negative pressures of high winds.

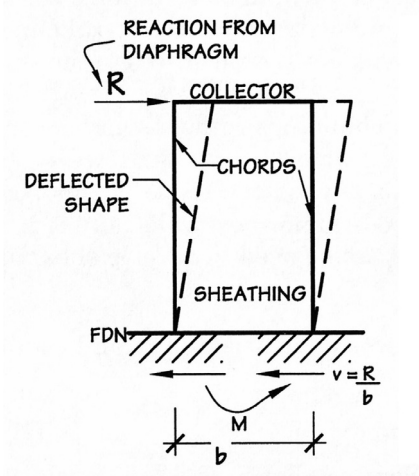
Notes: Design for diaphragm stresses depends on direction of continuous panel joints with reference to load, not on direction of long dimension of sheet. Continuous framing may be in either direction for blocked diaphragms.



Three Shear Wall Types

Design considerations:

- Sheathing – type and thickness
- Sheathing nailing – size and spacing
- Chord design – tension and compression
- Collector design – tension and comp.
- Anchorage – hold-downs, shear ties
- Shear panel proportions – h:w (see SDPWS)
- Deflection



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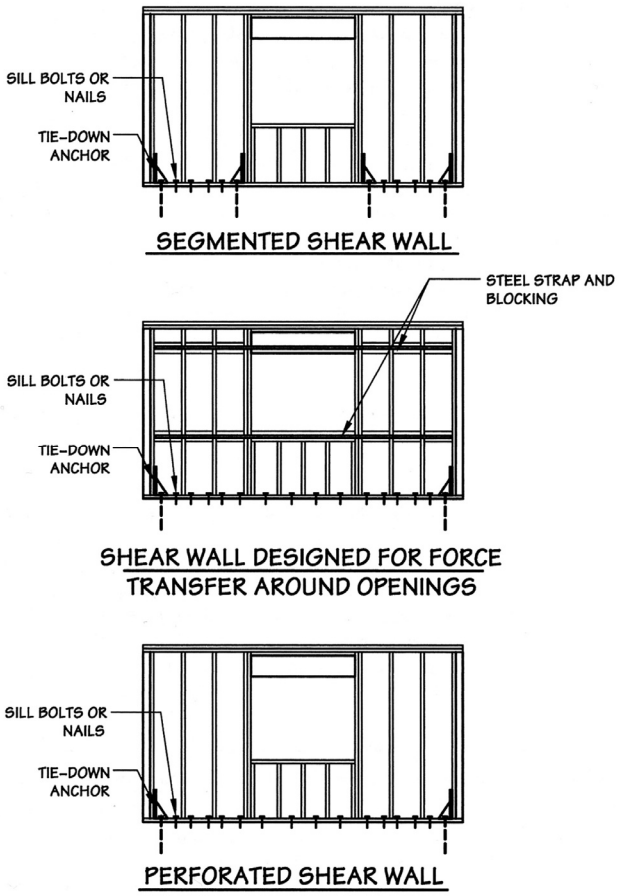


Shear Wall Types – 1. Segmented

Acts like a vertical cantilever beam

Let-in Wall Bracing – 45° - limited to single or top story

Wall Board – requires 8 ft length

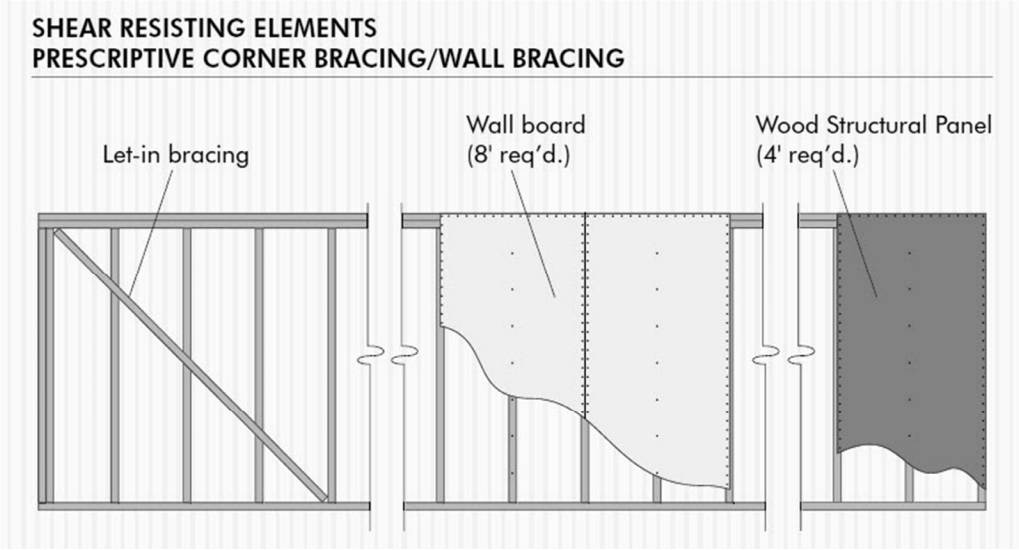
Wood Structural Panel – requires 4 ft length – 3 times stronger by length

Table 4.3.4 Maximum Shear Wall Aspect Ratios

Shear Wall Sheathing Type	Maximum h/b_s Ratio
Wood structural panels, unblocked	2:1
Wood structural panels, blocked	3.5:1
Particleboard, blocked	2:1
Diagonal sheathing, conventional	2:1
Gypsum wallboard	2:1[1]
Portland cement plaster	2:1[1]
Structural Fiberboard	3.5:1

1 Walls having aspect ratios exceeding 1.5:1 shall be blocked shear walls.

AWC SDPWS 2015 (in 2021 Tab. 4.3.3)



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Shear Wall Types – 2. Force transfer around openings

The full wall acts as a unit. Requires rational analysis

Only 2 end hold-down ties are generally needed.

The wall elements need to be tied across tension zones - around openings

Heavier sheathing and nailing is generally required.

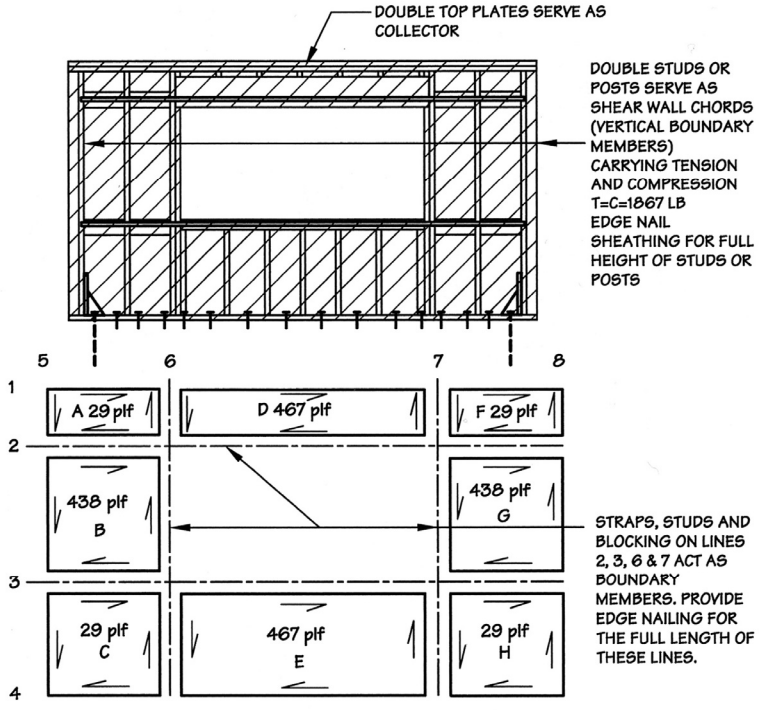

Figure 10.8*i* Boundary members and fastening for shearwall designed with continuity around openings.

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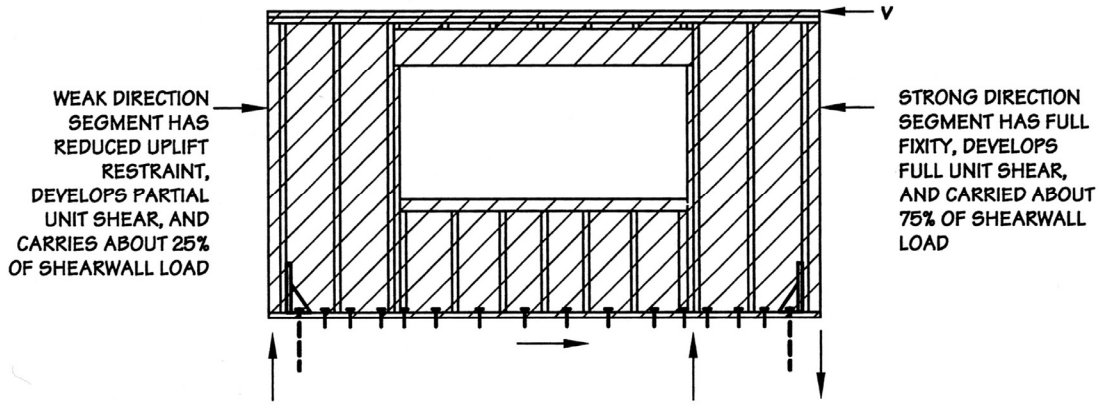
Shear Wall Types – 3. Perforated shearwall

- Semi-empirical method based on testing.
- Similar to the force transfer method, but with simplified details.
- Generally lower capacity and lower stiffness.
- Follows maximum L/W ratios – see limitations of use.
- Capacity of the “weak direction” (lacking tension tie-down) is reduce by C_o factor (IBC).



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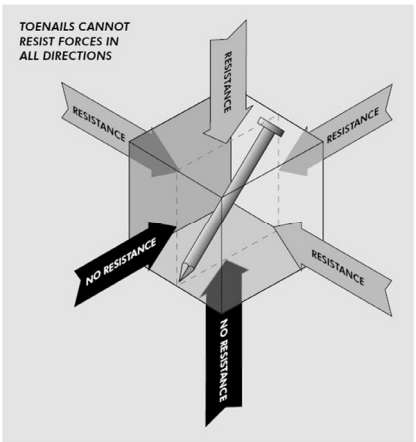
Shear Wall Connections

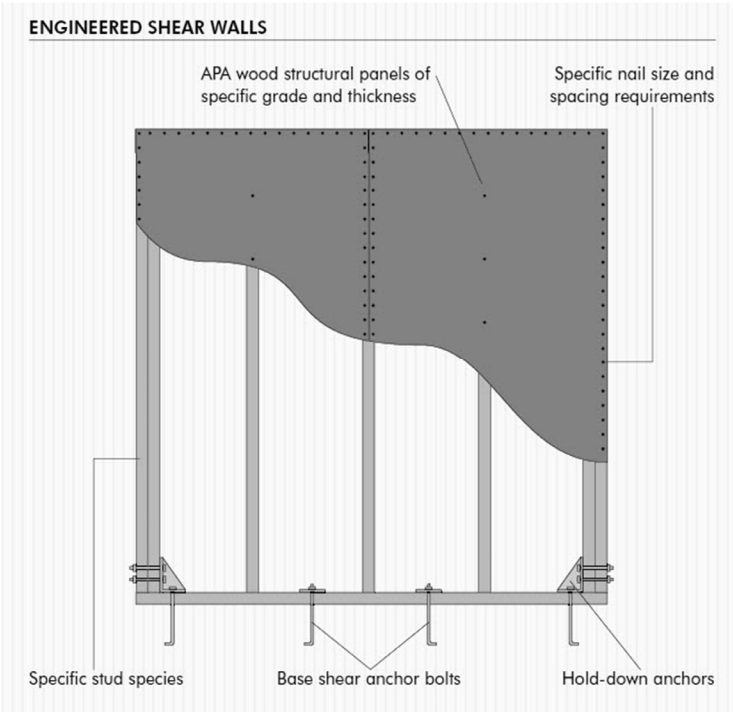
Connections need to transmit force in 6 directions (3 axes)

Toenails – not adequate

Hold–down Anchors

Base Shear Anchors





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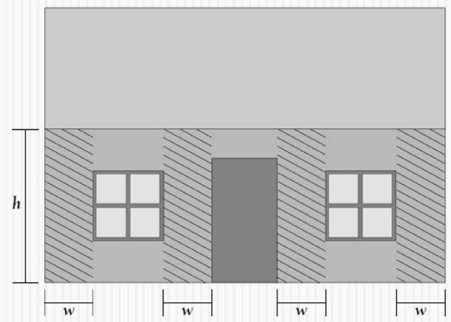
Shear Wall Design Elements

- Panel Thickness
- Panel Grade
- Nail spacing
- Base shear anchors
- Hold down anchors (at ends of each wall)
- Placement for lateral stability
- Fastening at edges (chords)

FIGURE 11
SHEAR WALL SEGMENT

Local building codes typically stipulate a minimum w of $h/3.5$



A Shear Wall...	A Diaphragm...
Is vertical	Is horizontal (or nearly so)
Is designed like a cantilevered beam	Is designed as a simply supported beam
Table has only blocked values, because a shear wall is always blocked*	Table has both blocked and unblocked diaphragm values

*A code requirement.

FIGURE 13
OVERTURNING

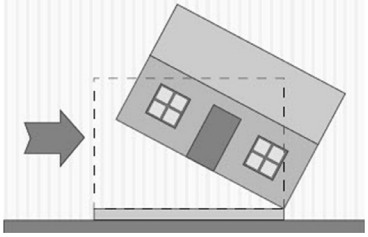
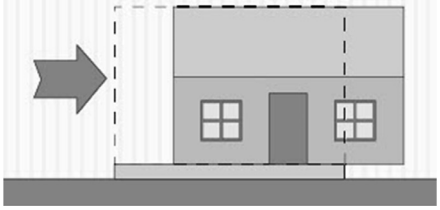


FIGURE 12
BASE SHEAR



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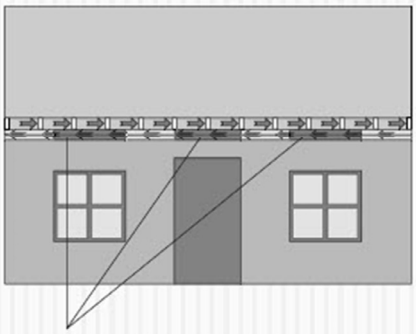
Drag Struts

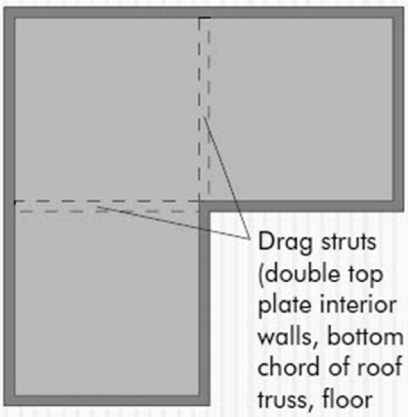
Double Top Plate

FIGURE 14
TOP PLATE DRAG STRUTS



Double top plate acts like a drag strut in these locations (over openings).

FIGURE 15
DRAG STRUTS USED TO TIE AN "L" SHAPED BUILDING TOGETHER



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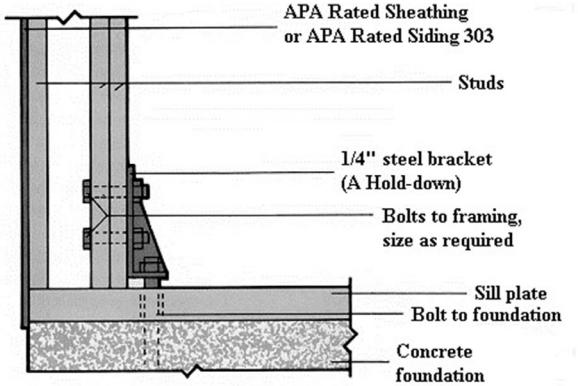
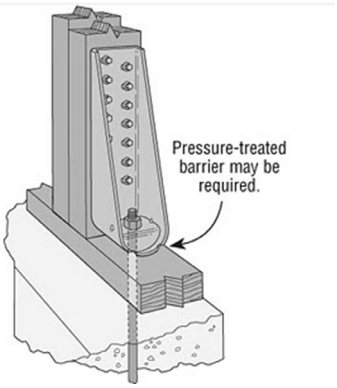
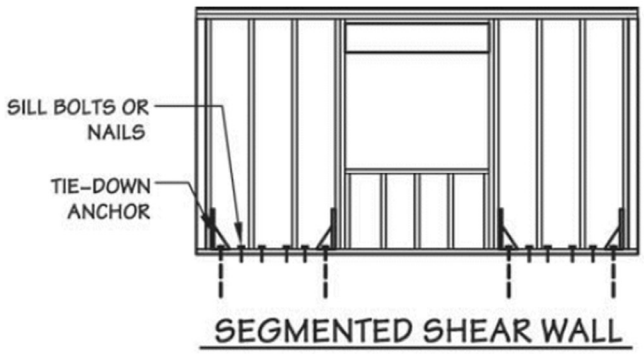
Anchors and Tie-downs







SEGMENTED SHEAR WALL

Shear Wall Selection Table

special case diaphragm

Example:
Commercial building
shear wall
w/ 5/8” gypsum sheathing
for 1 hr. fire rating.
required capacity = 437 plf

TABLE 2

SHEAR WALLS: RECOMMENDED SHEAR (POUNDS PER FOOT) FOR APA PANEL SHEAR WALLS WITH FRAMING OF DOUGLAS-FIR, LARCH, OR SOUTHERN PINE[a] FOR WIND OR SEISMIC LOADING[b]

Panel Grade	Minimum Nominal Panel Thickness (in.)	Minimum Nail Penetration in Framing (in.)	Panels Applied Direct to Framing: Nail Size (common or galvanized box)	Panels Applied Direct to Framing: Nail Spacing at Panel Edges (in.) 6	4	3	2[e]	Panels Applied Over 1/2" or 5/8" Gypsum Sheathing: Nail Size (common or galvanized box)	Nail Spacing at Panel Edges (in.) 6	4	3	2[e]
APA STRUCTURAL I grades	5/16	1-1/4	6d	200	300	390	510	8d	200	300	390	510
	3/8	1-3/8	8d	230[d]	360[d]	460[d]	610[d]	10d[f]	280	430	550	730
	7/16			255[d]	395[d]	505[d]	670[d]					
	15/32			280	430	550	730					
	15/32	1-1/2	10d[f]	340	510	665	870	—	—	—	—	—
APA RATED SHEATHING; APA RATED SIDING[g] and other APA grades except species Group 5	5/16 or 1/4[c]	1-1/4	6d	180	270	350	450	8d	180	270	350	450
	3/8			200	300	390	510		200	300	390	510
	3/8	1-3/8	8d	220[d]	320[d]	410[d]	530[d]	10d[f]	260	380	490	640
	7/16			240[d]	350[d]	450[d]	585[d]					
	15/32			260	380	490	640					
	15/32	1-1/2	10d[f]	310	460	600	770	—	—	—	—	—
	19/32			340	510	665	870	—	—	—	—	—
			Nail Size (galvanized casing)					Nail Size (galvanized casing)				
APA RATED SIDING 303[g] and other APA grades except species Group 5	5/16[c]	1-1/4	6d	140	210	275	360	8d	140	210	275	360
	3/8	1-3/8	8d	160	240	310	410	10d[f]	160	240	310	410

(a) For framing of other species: (1) Find specific gravity for species of lumber in the AFPA National Design Specification. (2) For common or galvanized box nails, find shear value from table above for nail size for actual grade. (3) Multiply value by the following adjustment factor: Specific Gravity Adjustment Factor = [1 – (0.5 – SG)], where SG = specific gravity of the framing. This adjustment shall not be greater than 1.

(b) All panel edges backed with 2-inch nominal or wider framing. Install panels either horizontally or vertically. Space nails maximum 6 inches o.c. along intermediate framing members for 3/8-inch and 7/16-inch panels installed on studs spaced 24 inches o.c. For other conditions and panel thicknesses, space nails maximum 12 inches o.c. on intermediate supports.

(c) 3/8-inch or APA RATED SIDING 16 oc is minimum recommended when applied direct to framing as exterior siding.

(d) Shears may be increased to values shown for 15/32-inch sheathing with same nailing provided (1) studs are spaced a maximum of 16 inches o.c., or (2) if panels are applied with long dimension across studs.

(e) Framing at adjoining panel edges shall be 3-inch nominal or wider, and nails shall be staggered where nails are spaced 2 inches o.c.

(f) Framing at adjoining panel edges shall be 3-inch nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 inches are spaced 3 inches o.c.

(g) Values apply to all-veneer plywood APA RATED SIDING panels only. Other APA RATED SIDING panels may also qualify on a proprietary basis. APA RATED SIDING 16 oc plywood may be 11/32 inch, 3/8 inch or thicker. Thickness at point of nailing on panel edges governs shear values.

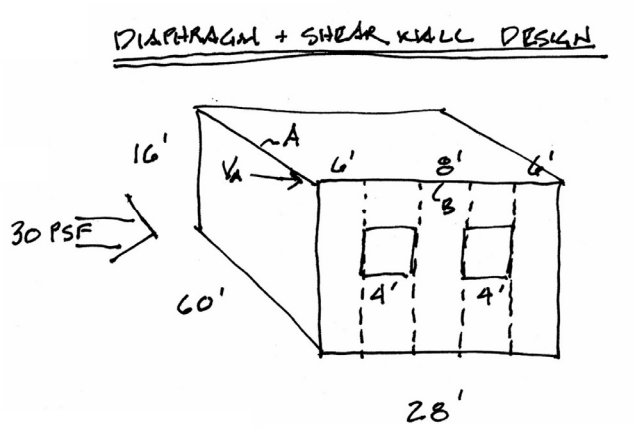
Typical Layout for Shear Walls

APA X305

Diaphragm and Shear Wall Example

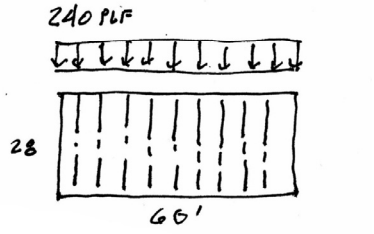
Given: Wood frame structure shown
Lateral wind load = 30 psf
2x rafters and studs

Find: Design roof diaphragm sheathing and shear walls on short side.
Use APA sheathing tables in X305



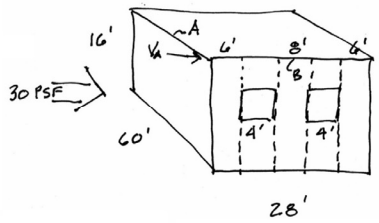
LOAD on CHORD A

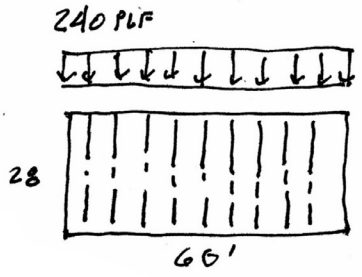
$\frac{16'}{2} \times 30\,PSF = 240\,PLF$



Roof Diaphragm

calculate forces as in a deep beam.



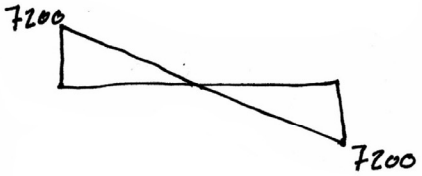


FORCE V_A

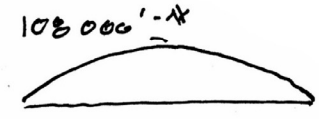
$\frac{wl}{2} = \frac{240\,(60)'}{2} = 7200\,\#$

SHEAR FORCE on EDGE

$\frac{7200\,\#}{28'} = 257\,PLF$



$\frac{wl^2}{8} = \frac{240\,(60)^2}{8} = 108\,000'\text{-}\#$



Roof Diaphragm Panel

Choose Panel from APA chart

Try first the lesser quality:

- unblocked
- APA rated sheathing
- 2” rafters
- edge shear force = 257 plf

Try:
unblocked, case 1, 19/32“
10d nails at 6” edge 12” inter. o.c.
or
blocked, any case, 15/32”
8d nails at 6” edge 12” inter. o.c.

TABLE 1

DIAPHRAGMS: RECOMMENDED SHEAR (POUNDS PER FOOT) FOR HORIZONTAL APA PANEL DIAPHRAGMS WITH FRAMING OF DOUGLAS-FIR, LARCH OR SOUTHERN PINE[a] FOR WIND OR SEISMIC LOADING

					Blocked Diaphragms				Unblocked Diaphragms	
					Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)[b]				Nails Spaced 6" max. at Supported Edges[b]	
					6	4	2-1/2[c]	2[c]		
Panel Grade	Common Nail Size	Minimum Nail Penetration in Framing (inches)	Minimum Nominal Panel Thickness (inch)	Minimum Nominal Width of Framing Member (inches)	Nail Spacing (in.) at other panel edges (Cases 1, 2, 3 & 4)				Case 1 (No unblocked edges or continuous joints parallel to load)	All other configurations (Cases 2, 3, 4, 5 & 6)
					6	6	4	3		
APA STRUCTURAL I grades	6d	1-1/4	5/16	2 3	185 210	250 280	375 420	420 475	165 185	125 140
	8d	1-3/8	3/8	2 3	270 300	360 400	530 600	600 675	240 265	180 200
	10d[d]	1-1/2	15/32	2 3	320 360	425 480	640 720	730 820	285 320	215 240
APA RATED SHEATHING, APA RATED STURD-I-FLOOR and other APA grades except Species Group 5	6d[e]	1-1/4	5/16	2 3	170 190	225 250	335 380	380 430	150 170	110 125
			3/8	2 3	185 210	250 280	375 420	420 475	165 185	125 140
	8d	1-3/8	3/8	2 3	240 270	320 360	480 540	545 610	215 240	160 180
			7/16	2 3	255 285	340 380	505 570	575 645	230 255	170 190
			15/32	2 3	270 300	360 400	530 600	600 675	240 265	180 200
	10d[d]	1-1/2	15/32	2 3	290 325	385 430	575 650	655 735	255 290	190 215
			19/32	2 3	320 360	425 480	640 720	730 820	285 320	215 240

(a) For framing of other species: (1) Find specific gravity for species of lumber in the AFPA National Design Specification. (2) Find shear value from table above for nail size for actual grade. (3) Multiply value by the following adjustment factor: Specific Gravity Adjustment Factor = [1 – (0.5 – SG)], where SG = specific gravity of the framing. This adjustment shall not be greater than 1.

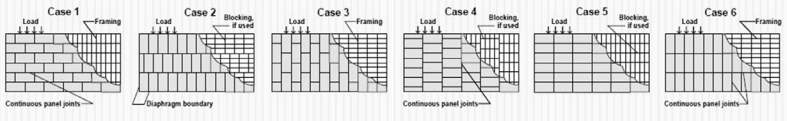
(b) Space nails maximum 12 in. o.c. along intermediate framing members (6 in. o.c. when supports are spaced 48 in. o.c.).

(c) Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where nails are spaced 2 inches o.c. or 2-1/2 inches o.c.

(d) Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 inches are spaced 3 inches o.c.

(e) 8d is recommended minimum for roofs due to negative pressures of high winds.

Notes: Design for diaphragm stresses depends on direction of continuous panel joints with reference to load, not on direction of long dimension of sheet. Continuous framing may be in either direction for blocked diaphragms.



Peter von Buelow

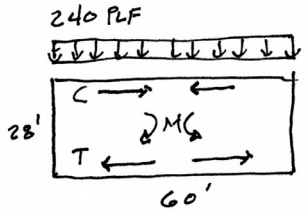
Roof Diaphragm Chord

For the diaphragm, the chords carry the moment couple and the panels carry the web shear

Tension generally controls.

Chords are usually the double top plates of the walls, but for simple but jointed members only 1 member is acting at the joint. Therefore Area is for 1 2x4

CHORD FORCE ON DIAPHRAGM



$M_{MOMENT} = 108000'^{\#}$

$T = C = 108000/28 = 3857^{\#}$

$f_T = \frac{P}{A} = \frac{3857}{5.25} = 735\ psi$

$F_t' = F_t (C_D C_F)$

$C_M = C_t = C_i = 1$

$C_D = 1.6$ (WIND)

$C_F = 1.5$

TRY S-P-F N°2

$F_t = 450\ psi$

$F_t' = 450(1.6\ 1.5) = 1080 psi$

$1080\ psi > 735\ psi$ ∴ ✓OK

USE S-P-F N°2 2x4
DOUBLE TOP PLATE

Shear Wall

Check minimum shear wall width:
by AWC SDPWS
https://awc.org/publications/2021-sdpws/

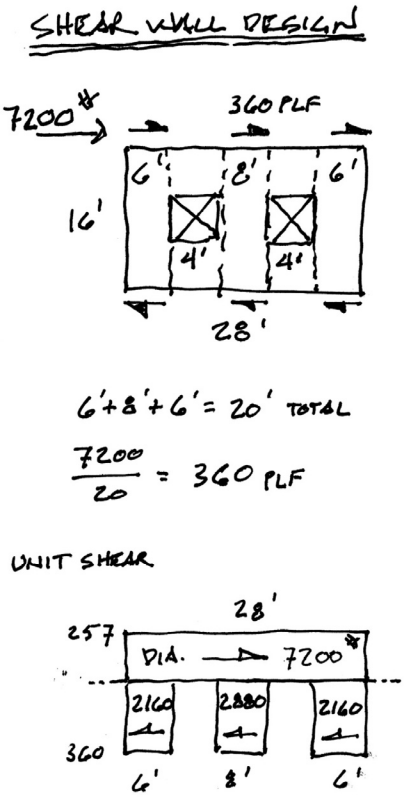
w = h/2 (unblocked) w = h/3.5 (blocked)
w = 16'/2 = 8' w = 16'/3.5 = 4.57'

Table 4.3.4 Maximum Shear Wall Aspect Ratios

Shear Wall Sheathing Type	Maximum h/b_s Ratio
Wood structural panels, unblocked	2:1
Wood structural panels, blocked	3.5:1
Particleboard, blocked	2:1
Diagonal sheathing, conventional	2:1
Gypsum wallboard	2:1[1]
Portland cement plaster	2:1[1]
Structural Fiberboard	3.5:1

1 Walls having aspect ratios exceeding 1.5:1 shall be blocked shear walls.

2015



Calculate the shear carried in plf by walls
Total force / sum of width = PLF

the PLF x wall width = force on wall

Shear Wall Panel

Choose panel from APA shear wall chart

for 360 plf

Try APA rated sheathing
15/32" 8d at 4" o.c.
380 > 360 plf ok

TABLE 2

SHEAR WALLS: RECOMMENDED SHEAR (POUNDS PER FOOT) FOR APA PANEL SHEAR WALLS WITH FRAMING OF DOUGLAS-FIR, LARCH, OR SOUTHERN PINE[a] FOR WIND OR SEISMIC LOADING[b]

Panel Grade	Minimum Nominal Panel Thickness (in.)	Minimum Nail Penetration in Framing (in.)	Panels Applied Direct to Framing: Nail Size (common or galvanized box)	Panels Applied Direct to Framing: Nail Spacing at Panel Edges (in.) 6	4	3	2[e]	Panels Applied Over 1/2" or 5/8" Gypsum Sheathing: Nail Size (common or galvanized box)	Panels Applied Over 1/2" or 5/8" Gypsum Sheathing: Nail Spacing at Panel Edges (in.) 6	4	3	2[e]
APA STRUCTURAL I grades	5/16	1-1/4	6d	200	300	390	510	8d	200	300	390	510
	3/8	1-3/8	8d	230[d]	360[d]	460[d]	610[d]	10d[f]	280	430	550	730
	7/16			255[d]	395[d]	505[d]	670[d]					
	15/32			280	430	550	730					
	15/32	1-1/2	10d[f]	340	510	665	870	—	—	—	—	—
APA RATED SHEATHING; APA RATED SIDING[g] and other APA grades except species Group 5	5/16 or 1/4[c]	1-1/4	6d	180	270	350	450	8d	180	270	350	450
	3/8			200	300	390	510		200	300	390	510
	3/8	1-3/8	8d	220[d]	320[d]	410[d]	530[d]	10d[f]	260	380	490	640
	7/16			240[d]	350[d]	450[d]	585[d]					
	15/32			260	380	490	640					
	15/32	1-1/2	10d[f]	310	460	600	770	—	—	—	—	—
	19/32			340	510	665	870	—	—	—	—	—
APA RATED SIDING 303[g] and other APA grades except species Group 5			Nail Size (galvanized casing)					Nail Size (galvanized casing)				
	5/16[c]	1-1/4	6d	140	210	275	360	8d	140	210	275	360
	3/8	1-3/8	8d	160	240	310	410	10d[f]	160	240	310	410

(a) For framing of other species: (1) Find specific gravity for species of lumber in the AFPA National Design Specification. (2) For common or galvanized box nails, find shear value from table above for nail size for actual grade. (3) Multiply value by the following adjustment factor: Specific Gravity Adjustment Factor = [1 – (0.5 – SG)], where SG = specific gravity of the framing. This adjustment shall not be greater than 1.

(b) All panel edges backed with 2-inch nominal or wider framing. Install panels either horizontally or vertically. Space nails maximum 6 inches o.c. along intermediate framing members for 3/8-inch and 7/16-inch panels installed on studs spaced 24 inches o.c. For other conditions and panel thicknesses, space nails maximum 12 inches o.c. on intermediate supports.

(c) 3/8-inch or APA RATED SIDING 16 oc is minimum recommended when applied direct to framing as exterior siding.

(d) Shears may be increased to values shown for 15/32-inch sheathing with same nailing provided (1) studs are spaced a maximum of 16 inches o.c., or (2) if panels are applied with long dimension across studs.

(e) Framing at adjoining panel edges shall be 3-inch nominal or wider, and nails shall be staggered where nails are spaced 2 inches o.c.

(f) Framing at adjoining panel edges shall be 3-inch nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 inches are spaced 3 inches o.c.

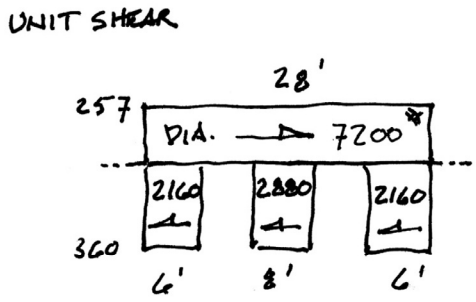
(g) Values apply to all-veneer plywood APA RATED SIDING panels only. Other APA RATED SIDING panels may also qualify on a proprietary basis. APA RATED SIDING 16 oc plywood may be 11/32 inch, 3/8 inch or thicker. Thickness at point of nailing on panel edges governs shear values.

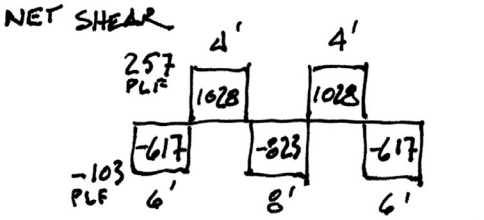
Typical Layout for Shear Walls

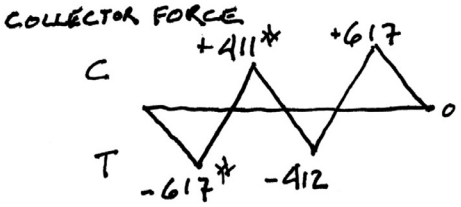
Shear Panel Top Cord (Collector Strut)

Find the greatest net tension force:

1. Find the net PLF force in the top chord by taking the difference between the force applied by the diaphragm and the resisting force of the shear wall.
2. Convert the PLF force to total force on the wall segment by multiplying PLF x w
3. Graph the change in force along the chord starting at one end. The free ends should both be zero.
4. Choose the highest tensile force and find the actual stress in one member (2x4)
5. Check against the factored allowable for the wood species and grade.







MAX TENSION FORCE = 617#

$f_t = \frac{617}{5.25} = 118 psi$

$F'_t = 1080 > 118$ ✓OK

(AS ABOVE FOR SP-F N°2)

Shear Wall Base Anchors

Find the force in each fastener and select them from manufacturer's literature.

BOTTOM PLATE ANCHORS

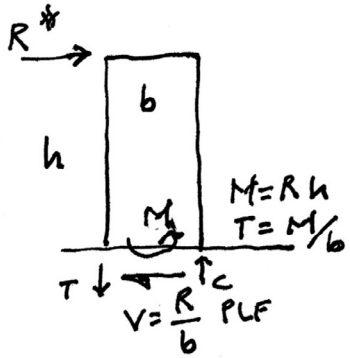
FOR 8' SHEARWALL

R = 2880#

M = R h = 2880(16) = 46080 in-#

$T = \frac{M}{b} = \frac{46080}{8'} = 5760\#$

∴ DESIGN TIE DOWN @ 6K

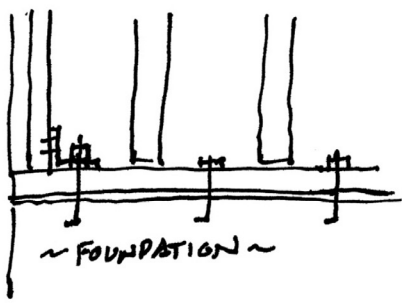


BASE SHEAR

FOR STUDS @ 24" o.c.

4 SPACES - SAY 4 BOLTS

$R/n = \frac{2880}{4} = 720\#/BOLT$



Shear Wall End Holdown Anchor

T=5760 lbs

HDU8-SDS2.5HDG

SIMPSON StrongTie **Simpson Strong-Tie Holdown Selector (USA Version)**

Post Installed Input Information

Demand Load	Wood Species
lbs	DF/SP
5760 lbs	

Post Installed Holdown Solutions

Holdown Application	Holdown Model	Holdown Capacity	Deflection at Demand Load	Minimum Post Thickness	Anchor Bolt Diameter	Required Fasteners	Installed Cost Index*
Screwed	HDU8-SDS2.5	5980 lbs	0.081 in.	3.0 in.	7/8 in.	20-SDS 1/4"X2 1/2"	Lowest
Screwed	HDQ8-SDS3	9230 lbs	0.059 in.	4.5 in.	7/8 in.	20-SDS 1/4"X3"	10%
Screwed	HDU11-SDS2.5	9535 lbs	0.083 in.	5.5 in.	1 in.	30-SDS 1/4"X2 1/2"	20%
Screwed	HDU14-SDS2.5	14375 lbs	0.071 in.	7.25 in.	1 in.	36-SDS 1/4"X2 1/2"	48%
Bolted	HD7B	6645 lbs	0.123 in.	3.0 in.	7/8 in.	3-3/4"x4" M.B.	26%
Bolted	HD9B	7740 lbs	0.118 in.	3.5 in.	7/8 in.	3-7/8"x5" M.B.	127%
Bolted	HD12	11350 lbs	0.087 in.	3.5 in.	1 in.	4-1"x5" M.B.	267%
Bolted	HD19	16775 lbs	0.069 in.	5.5 in. (1)	1 1/8 in.	5-1"x7" M.B.	544%

Note:

Holdown and Tension Tie allowable loads are based on installation with an anchor rod length of 6" from the concrete to the top of the holdown seat. The products may be raised to any height with consideration of the increased deflection due to additional bolt elongation.

*The Installed Cost Index is used to compare the relative installed costs of similar connectors in order to identify which are the least expensive to install. The values are determined by combining the estimated cost of the connector, fasteners and labor for each installation and then presenting them in order from "lowest" cost to highest, showing the percentage of cost increase for each option.

Shear Wall – base plate anchor

for A307 bolts Fy = 36 ksi Fv = 10 ksi (threads included)

root area for 3/8” bolt = 0.0742 in^2

shear capacity = 10000 x 0.0742 = 742 lbs. > 720lbs ok

Steel L Hook Anchor Bolts

Multiple product options available

Brands

CALDWELL, FABORY and GRAINGER APPROVED

↑ Anchor Dia.	Anchor Length	Thread Length	Anchor Hook Length	Brand	Item #
Hot Dipped Galvanized Fastener Finish					
3/8"	6"	1-3/4"	1"	GAV	21Y486
3/8"	8"	1-3/4"	1"	GAV	21Y487
1/2"	6"	1-3/4"	1-1/2"	GAV	21Y488
1/2"	8"	1-3/4"	1-1/2"	GAV	21Y463
1/2"	10"	1-3/4"	1-1/2"	GAV	21Y464