Shear Exhilaration!

Wood Shear Wall and Diaphragm Design per the 2021 IBC

Presented by Aleeta Dene, P.E.

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

AIA Continuing Education Provider

Webinar Attendee Survey

Aleeta Dene, P.E.

https://www.apawood.org/shear-exhilaration-survey

Course Description

The overall strength of a building is a function of all of the components – roof, walls, floors, and foundation – working together as a unit. This session will provide a top-to-bottom overview of lateral design for wood framed structures with a focus on shear walls. Topics of discussion include load path continuity, shear wall design approaches, and force transfer around openings in shear walls.

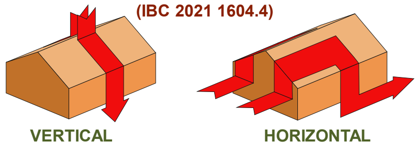
Learning Objectives

1. Understand basic lateral load path through a simple building.
2. Recognize key components of a traditional shear wall and their role.
3. Comprehend the differences between shear wall design approaches.
4. Understand the mechanics behind designing force transfer around shear wall openings.

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)

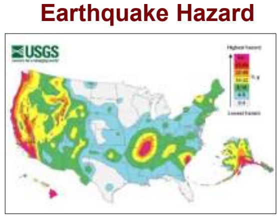


Vertical (Gravity) Load Path

Lateral Loads: National Issue

Wind Hazard

Earthquake Hazard



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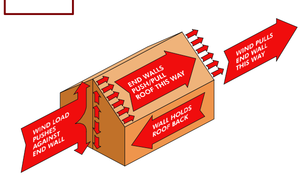
Lateral Loads (Wind)

$F = PA$

Effort is devoted to determining:
P – wind pressure



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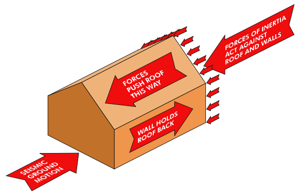
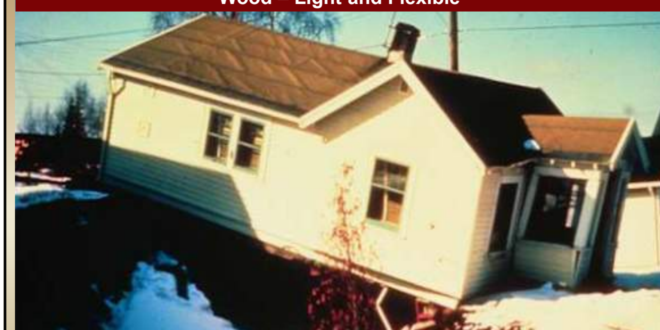
Lateral Loads(Seismic)

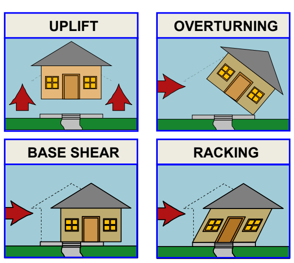
$F = ma$ ← Effort is devoted to determining: a – acceleration



Wood – Light and Flexible



General Modes of Failure




UPLIFT


3-D Connector

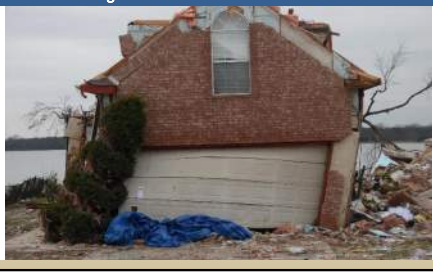
Floor-to-Floor Load Transfer Options

BASE SHEAR

OVERTURNING

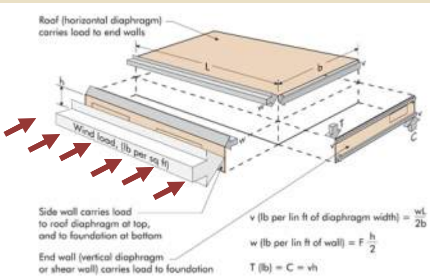
Lateral Forces

Racking – Rowlett/Garland Tornados 2015



APA Publications

General Lateral Load Path



2021 International Building Code (IBC)

2021 IBC

- Chapter 16 Loads
  - ASCE 7

Governing Codes for Engineered Wood Design

2021 IBC

- Chapter 23 Wood
- ANSI/AWC NDS (National Design Specification for Wood Construction)
- Special Design Provisions for Wind and Seismic SDPWS-21

2021 IBC

- SDPWS-21 (Special Design Provisions for Wind and Seismic)
  - https://awc.org/publications/2021-sdpws/
  - Free view-only

Wood Structural Panels = Plywood or OSB (IBC Section 202 & IRC Section R202)

What About CLT?

Alternates?

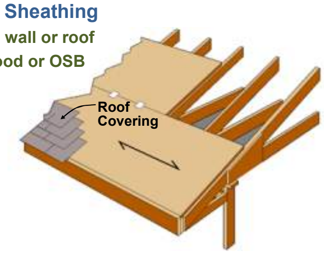
Wood Shear Wall and Diaphragms Design

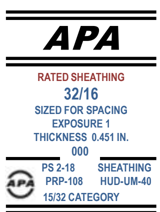
Shear Values

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

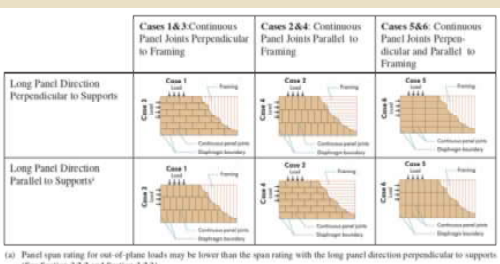
Wood's Strength Direction

- Rated Sheathing
  - Floor, wall or roof
  - Plywood or OSB





2021 IBC



	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	Case 1, Case 3	Case 2, Case 4	Case 5, Case 6
Long Panel Direction Parallel to Supports[a]	Case 1, Case 3	Case 2, Case 4	Case 5, Case 6

(a) 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)

2021 IBC

Shear Wall and Diaphragm Tables

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

Wood Diaphragms Design

Table 4.2C Nominal Unit Shear Values for Sheathed Wood-Frame Diaphragms

Unblocked Wood Structural Panel Diaphragms[1,2,3,4,5]

Sheathing Grade	Common Nail Size[6] Length (in.) x Shank diameter (in.) x Head diameter (in.)	Minimum Nail Bearing Length in Framing Member, ℓ_m (in.)	Minimum Nominal Panel Thickness (in.)	Minimum Nominal Width of Nailed Face at Adjoining Panel Edges and Boundaries (in.)	6 in. Nail Spacing at diaphragm boundaries and supported panel edges: Case 1 v_s (plf)	Case 1 G_a (kips/in.) OSB	Case 1 G_a (kips/in.) PLY	Cases 2,3,4,5,6 v_s (plf)	Cases 2,3,4,5,6 G_a (kips/in.) OSB	Cases 2,3,4,5,6 G_a (kips/in.) PLY
Structural I	6d (2 x 0.113 x 0.266)	1-1/4	5/16	2	460	9.0	7.0	350	6.0	4.5
				3	520	7.0	6.0	390	4.5	4.0
	8d (2-1/2 x 0.131 x 0.281)	1-3/8	3/8	2	670	8.5	7.0	505	6.0	4.5
				3	740	7.5	6.0	560	5.0	4.0
	10d (3 x 0.148 x 0.312)	1-1/2	15/32	2	800	14	10	600	9.5	7.0
				3	895	12	9.0	670	8.0	6.0
Sheathing and Single-Floor	6d (2 x 0.113 x 0.266)	1-1/4	5/16	2	420	9.0	6.5	310	6.0	4.0
				3	475	7.0	5.5	350	5.0	3.5
			3/8	2	460	7.5	5.5	350	5.0	4.0
				3	520	6.0	4.5	390	4.0	3.0
	8d (2-1/2 x 0.131 x 0.281)	1-3/8	3/8	2	600	9.0	6.5	450	6.0	4.5
				3	670	7.5	5.5	505	5.0	3.5
			7/16	2	645	8.5	6.0	475	5.5	4.0
				3	715	7.0	5.5	530	4.5	3.5
			15/32	2	670	7.5	5.5	505	5.0	4.0
				3	740	6.5	5.0	560	4.0	3.5
	10d (3 x 0.148 x 0.312)	1-1/2	15/32	2	715	15	9.0	530	10	6.0
				3	810	12	8.0	600	8.0	5.5
			19/32	2	800	13	8.5	600	8.5	5.5
				3	895	10	7.5	670	7.0	5.0

Wind Factors
ASD: $v_s/2.0$
LRFD: $0.8v_s$

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

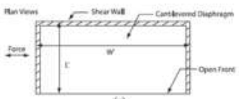
Flexible, Rigid or Semi-Rigid SDPWS 4.1.7 & ASCE 7

Which do you have?

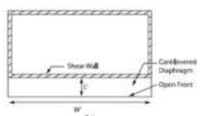
- Idealized as flexible
  - Diaphragm load distributed to shear wall lines based on tributary area (common for wood frame)
    - Deflection of diaphragm > 2x average shear wall line deflection
    - Light-frame construction where any rigid non-structural topping is ≤ 1-1/2" thick AND shear walls meet drift limitations
- Idealized as rigid
  - Diaphragm load distributed to each shear wall based on relative wall stiffness in story below
    - Deflection of diaphragm ≤ 2x shear walls
- Semi-rigid
  - Diaphragm load distributed to shear walls based on relative stiffness of shear wall and diaphragm
- Envelope
  - Larger load of idealized flexible or idealized rigid considered for each element

Open Front Wood Diaphragms (SDPWS-21 4.2.6)

- Open front structures (cantilevered diaphragms)
  - Changes consistent with ASCE 7
  - Increased limitations on story drift and building configuration



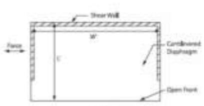
(a)



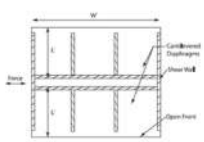
(b)

Prescribed Rigid Wood Diaphragms (SDPWS-21 4.2.6)

- Open front structures (cantilevered diaphragms)
  - w/ torsional irreg. L'/W' ≤ 0.67:1 for multistory
    L'/W' ≤ 1:1 for 1-story
  - L' ≤ 35 feet



(c)



(d)

Deflections (4-term equations)

Diaphragm (IBC §2305.2 Eq 23-1)

$$\Delta_{dia} = \frac{5vL^3}{8EAW} + \frac{vL}{4Gt} + 0.188Len + \frac{\Sigma(x\Delta_c)}{2W}$$

Shear Wall (IBC §2305.3 Eq 23-2)

$$\Delta_{sw} = \frac{8vh^3}{EAb} + \frac{vh}{Gt} + 0.75hen + \frac{d_a h}{b}$$

APA Form L350 (www.apawood.org) has comprehensive listing of input parameters and examples

Deflection (3-term equation)

Diaphragm (SDPWS Table 4.2.3)

$$\Delta = \frac{5vL^3}{8EAW} + \frac{0.25vL}{1000G_a} + \frac{\sum(\Delta_c X)}{2W}$$

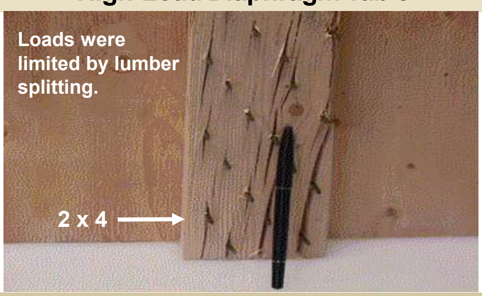
G_a values for blocked and unblocked diaphragms

GE Warehouse Ontario, CA

High Load Diaphragms

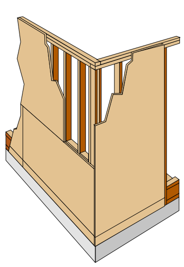
- SDPWS-21 4.2.8.1.2
- Uses multiple rows of nails
- ASD capacity up to 1,800 plf (seismic)
- ASD capacity up to 2,520 plf (wind)
- Shall be subject to special inspection per IBC Section 1705.5.1

Footnotes to High-Load Diaphragm Table



Wood's Strength Direction

- Rated Sheathing
  - Floor, wall or roof
  - Plywood or OSB



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RATED SHEATHING
32/16
SIZED FOR SPACING
EXPOSURE 1
THICKNESS 0.451 IN.
000
PS 2-18 SHEATHING
PRP-108 HUD-UM-40
15/32 CATEGORY

Shear Wall Design Challenges (SDPWS-21 4.3.2)

Segmented

1. Aspect ratio up to 2:1 for wind and seismic
2. Aspect ratio up to 3.5:1, if allowable shear is reduced by 1.25-0.125h/bs

Perforated

1. Code provides specific requirements
2. The capacity is determined based on empirical equations and tables

Force Transfer

1. Code does not provide guidance for this method
2. Different approaches using rational analysis could be used

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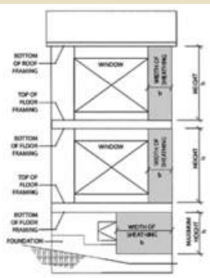
Height to Width Ratio (SDPWS-21 Figure 4D)

- For shear walls and perforated shear walls
  - h:w must not exceed 2:1 or 3.5:1 ratio



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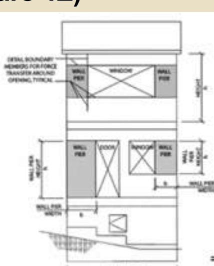
Height to Width Ratio (SDPWS-21 Figure 4E)

- For force transfer around opening shear walls
  - h:w must not exceed 2:1 or 3.5:1 ratio



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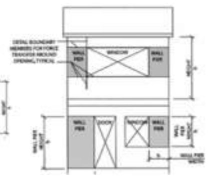
Aspect Ratio (SDPWS-21 4.3.3.2)

- Definition of h and w is the same as previous code
  - ALL shear walls with 2:1 < aspect ratios ≤ 3.5:1 shall apply reduction factor, aspect ratio factor
  - Aspect ratio factor (WSP) = 1.25-0.125h/b
    - Formerly applied only to high seismic

Excerpt Fig 4D
h:w ratio Segmented

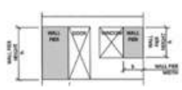


Excerpt Fig. 4E
h:w ratio FTAO

Shear Distribution Within Wall Line (SDPWS-21 4.3.5.5.1)

- Individual shear walls in line shall provide the same calculated deflection. Exception:
  - Nominal shear capacities of shear walls having 2:1 < aspect ratio ≤ 3.5:1 are multiplied by 2b/h for design. Aspect ratio factor (4.3.3.2) need not be applied.

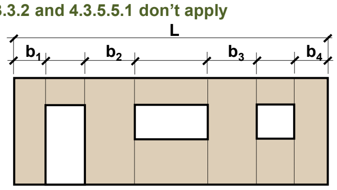
Excerpt Fig 4D
h:w ratio Segmented



Excerpt Fig. 4E
h:w ratio FTAO

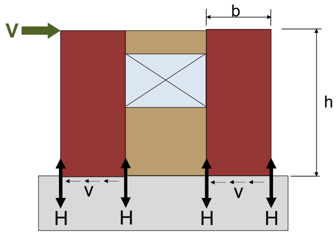
Aspect Ratio for Perforated Shear Walls (SDPWS-21 4.3.3.4)

- For wall segments 2:1 < aspect ratio ≤ 3.5:1
  - Multiply those segments by $2b_i/h$ in order to calculate b_i and Σb_i
  - Sections 4.3.3.2 and 4.3.5.5.1 don't apply



Segmented Wood Shear Walls

- Only full height segments are considered
- Max aspect ratio
  - 2:1 – without adjustment
  - 3.5:1 – with adjustment



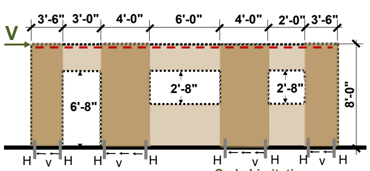
Aspect ratio h:b as shown in figure

Segmented Approach

1. Unit Shear
   $V = V/L_{total\ segments}$
2. Hold-down forces
   $H = vh$
3. Allowable ASD Shear 2:1 < 3.5:1 walls apply reduction factor
   $v_{allowable} = (v_{from\ table\ 4.3A}\ /2.8_{\ for\ seismic})(1.25\text{-}0.125h/b) > V$ lbs/ft
   $v_{allowable} = (v_{from\ table\ 4.3A}\ /2.8_{\ for\ seismic})(2b/h) > V$ lbs/ft
4. Allowable ASD Shear 4' walls (2:1 h:b)
   $v_{allowable} = (v_{from\ table\ 4.3A}\ /2.8_{\ for\ seismic}) > V$ lbs/ft

Note: For simplicity, dead load contribution and various footnote adjustments are omitted.

Segmented Approach



V = 3,750 lbs

Code Limitation

height/width Ratio = 8:3.5

1.25 – 0.125h/b = 1.25-0.125(8/3.5) = 0.964

OR

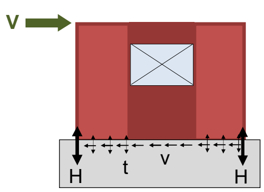
2b/h = 2(3.5)/8 = .875

Segmented Approach

1. Unit Shear
   V = V/L = 3,750/15 = 250 lbs/ft
2. Hold-down forces
   H = vh = 250 x 8 = 2,000 lbs
   8 – hold-downs @ 2000+ lb capacity
3. Allowable Shear 3'-6" walls
   $v_{allowable}$ = (1065/2.8) (1.25-.125(8/3.5)) = 367 lbs/ft > 250 lbs/ft
   $v_{allowable}$ = (1065/2.8) (2(3.5/8)) = 333 lbs/ft > 250 lbs/ft
   15/32 Category Rated Sheathing 8d @ 4" o.c. at 3.5' walls
1. Allowable Shear 4' walls (2:1 h:w)
   $v_{allowable}$ = (730/2.8) lb/ft = 261 > 250 lbs/ft
   15/32 Category Rated Sheathing 8d @ 6" o.c. @ 4' walls

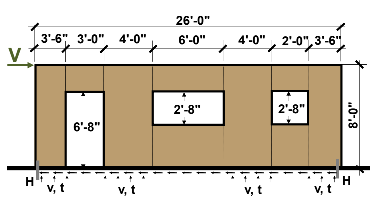
Perforated Shear Wall

- Openings accounted for by empirical adjustment factor
- Hold-downs only at ends
- Uplift between hold downs, t, at full height segments is also required



Aspect ratio applies to full height segment

Perforated Shear Wall Approach



V = 3,750 lbs

Height/width ratio = 8:3.5

2b/h = (2)(3.5)/8 = 0.875

Perforated Shear Wall Approach

1. **Unit shear in the wall**

   $\Sigma b_i = 0.875 \times (3.5+3.5) + 8 = 14'$

   $v = 3{,}750/14 = 268$ lb/ft

2. **Percent of full-height sheathed**

   $A_{fhs}/A_{wall} = 14/26 = 0.54$ (54%)

3. **Percent of wall area openings**

   A_o/A_{wall} = (6'-8" x 3 + 2'-8" x 8')/(26' x 8') = 0.20 (20%)

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Perforated Shear Wall Approach

- Table 4.3.5.6 Shear Capacity Adjustment Factor, C_O

Table 4.3.5.6 Shear Capacity Adjustment Factor, C_o[1]

Percent Full-Height Sheathing (A_{fhs}/A_{wall})	Percentage Wall Area Openings (A_o / A_{wall})									
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
	Shear Capacity Ratio, C_o									
10%	1.00	1.00	1.00	1.00	0.77	0.63	0.53	0.45	0.40	0.36
20%	1.00	1.00	1.00	0.91	0.71	0.59	0.50	0.43	0.38	-
30%	1.00	1.00	1.00	0.83	0.67	0.56	0.48	0.42	-	-
40%	1.00	1.00	1.00	0.77	0.63	0.53	0.45	-	-	-
50%	[illegible]	1.00	0.91	0.71	0.59	0.50	-	-	-	-
60%	[illegible]	1.00	0.83	0.67	0.56	-	-	-	-	-
70%	1.00	1.00	0.77	0.63	-	-	-	-	-	-
80%	1.00	0.91	0.71	-	-	-	-	-	-	-
90%	1.00	0.83	-	-	-	-	-	-	-	-
100%	1.00	-	-	-	-	-	-	-	-	-

54% → 0.88

1. Definitions of A_{fhs}, A_o, and A_{wall} are provided in Eqn. 4.3-6.

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Perforated Shear Wall Approach

4. **C_o – Shear resistance adjustment factor**

   $C_o = 0.88$

5. **Adjusted shear resistance**

   $v_{allowable}$ = 1065/2.8 x 0.88 = 335 lbs/ft > 268 lbs/ft

   1065/2.8 → 15/32 Category Rated Sheathing 8d @ 4" o.c.

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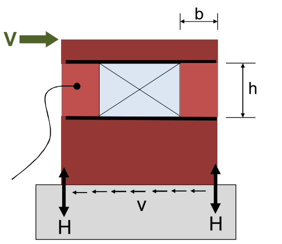
Perforated Shear Wall Approach

6. Uplift at perforated shear wall ends (hold-downs)
   H = 3750 x 8/(0.88 x 14)= 2,435 lbs
7. In-plane shear anchorage
   v_{max} = 3750/(0.88 x 14) = 304 plf
8. Uplift anchorage between shear wall ends
   v_{max} = 3750/(0.88 x 14) = 304 plf (at full segments only)
9. Deflection is determined based on the deflection of any segment of the wall divided by C_o

FTAO

- Openings accounted for by strapping or framing
  - "based on a rational analysis"
- Hold-downs only at ends
- h/b ratio defined by wall pier



Aspect ratio h:b as shown in figure

History of FTAO Research at APA

Joint research project

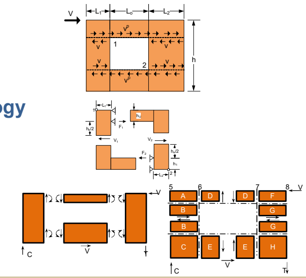
- APA –The Engineered Wood Association (Skaggs & Yeh)
- University of British Columbia (Lam & Li)
- USDA Forest Products Laboratory (Rammer & Wacker)

Study was initiated in 2009 to:

- Examine the variations of walls with code-allowable openings
- Examine the internal forces generated during full-scale testing
- Evaluate the effects of size of openings, size of full-height piers and different construction techniques
- Create analytical modeling to mimic testing data

Different Techniques for FTAO

- Drag Strut Analogy
- Cantilever Beam Analogy
- Diekmann Method
  - Thompson Method



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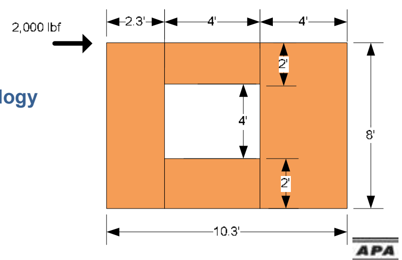
Design Example Summary

- Drag Strut Analogy
  - F1 = 284 lbf
  - F2 = 493 lbf
- Cantilever Beam Analogy
  - F1 = 1,460 lbf
  - F2 = 2,540 lbf
- Diekmann Method
  - F1 = 567 lbf
  - F2 = 986 lbf



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Conclusions

- Comparison of analytical methods with tested values for walls detailed as FTAO
  - The drag strut technique was consistently un-conservative
  - The cantilever beam technique was consistently ultra-conservative
  - Thompson provides similar results as Diekmann
  - Thompson and Diekmann techniques provided reasonable agreement with measured strap forces
- Better guidance to engineers will be developed by APA for FTAO
  - Summary of findings for validation of techniques
  - New tools for IBC wall bracing

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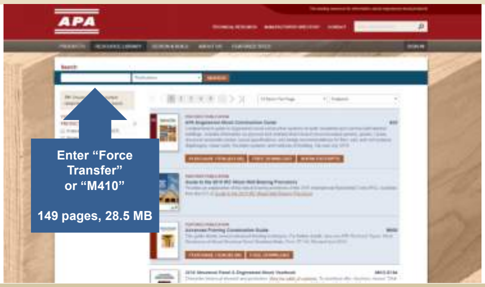
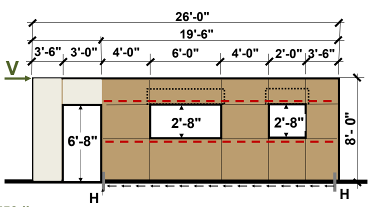
Report Available

www.apawood.org/publications



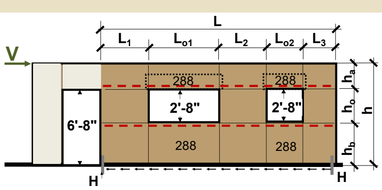
FTAO Approach



V = 3,750 lbs

Height/width ratio =
2'-8" : 3'-6" = 0.76:1

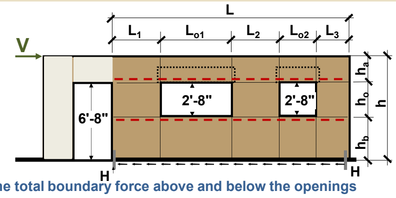
FTAO Approach



1. Calculate the hold-down forces:
   H=Vh/L = 3750 x 8'/19.5' = 1538 lbs
2. Solve for the unit shear above and below the openings:
   $v_a = v_b = H/(h_a+h_b)$ = 1538/(1.33'+4') = 288 plf

The unit shear above and below the openings is equivalent

FTAO Approach



3. Find the total boundary force above and below the openings

   First opening: $O_1 = v_a \times (L_{o1}) = 288$ plf x 6' = 1731 lbs

   Second opening: $O_2 = v_a \times (L_{o2}) = 288$ plf x 2' = 577 lbs

   The corner forces are based on the shear above and below the openings and only the piers adjacent to that unique opening.

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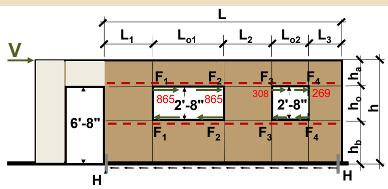

4. Calculate the corner forces:

   $F_1 = O_1(L_1)/(L_1+L_2) = 865$ lbs

   $F_2 = O_1(L_2)/(L_1+L_2) = 865$ lbs

   $F_3 = O_2(L_2)/(L_2+L_3) = 308$ lbs

   $F_4 = O_2(L_3)/(L_2+L_3) = 269$ lbs

   Strap forces

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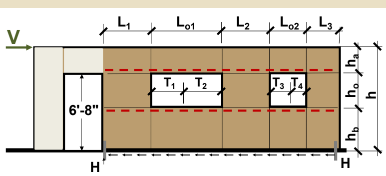

5. Tributary length of openings (ft) (Basis for calculating shear to each pier)

   Ratio of the length of the pier x length of the opening it is adjacent to, then / (length of the pier + length of the pier on the other side of the opening).

   $T_1 = L_1(L_{o1})/(L_1+L_2) = 3'$ $T_2 = L_2(L_{o1})/(L_1+L_2) = 3'$

   $T_3 = L_2(L_{o2})/(L_2+L_3) = 1.1'$ $T_4 = L_3(L_{o2})/(L_2+L_3) = 0.9'$

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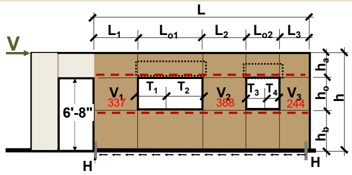
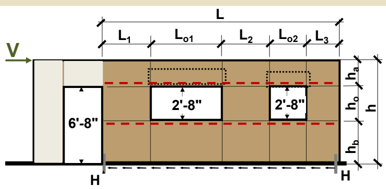
FTAO Approach



6. Unit shear beside the opening
   - $V_1 = (V/L)(L_1+T_1)/L_1$ = 337 plf
   - $V_2 = (V/L)(T_2+L_2+T_3)/L_2$ = 388 plf
   - $V_3 = (V/L)(T_4+L_3)/L_3$ = 244 plf
   - Check $V_1 \times L_1 + V_2 \times L_2 + V_3 \times L_3 = V$? YES

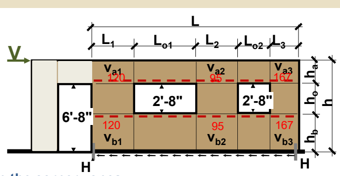
   The shear of each pier = the total shear / the L of the wall x (length of the pier + its tributary length)/ by the length of the pier

FTAO Approach



7. Resistance to corner forces
   - $R_1=V_1L_1$ = 1346 lbs
   - $R_2 = V_2L_2$ = 1551 lbs
   - $R_3 = V_3L_3$ = 853 lbs
8. Difference of the corner force and resistance
   - R_1-F_1 = 481 lbs
   - $R_2-F_2-F_3$ = 378 lbs
   - R_3-F_4 = 583 lbs

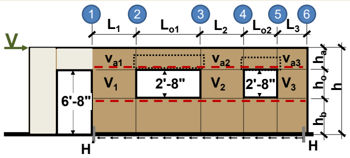
FTAO Approach



9. Unit shear in the corner zones
   - $v_{a1} = (R_1-F_1)/L_1$ = 120 plf
   - $v_{a2} = (R_2-F_2-F_3)/L2$ = 95 plf
   - $v_{a3} = (R_3-F_4)/L_3$ = 167 plf

   The unit shear of the corner zones = panel resistance (R) - the corner forces .
   R = the shear of the pier x the pier length.

FTAO Approach

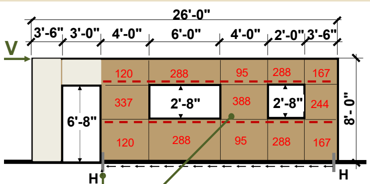


10. Check your solution – YES to all

- Line 1: $v_{a1}(h_a+h_b)+v_1(h_o)=H$?
- Line 2: $v_a(h_a+h_b)-v_{a1}(h_a+h_b)-V_1(h_o)=0$?
- Line 3: $v_{a2}(h_a+h_b)+V_2(h_o)-v_a(h_a+h_b)=0$?
- Line 4 = Line 3
- Line 5: $v_a(h_a+h_b)-v_{a3}(h_a+h_b)-V_3(h_o)=0$?
- Line 6: $v_{a3}(h_a+h_b)+V_3(h_o)=H$?

Once all segment shears are calculated, check the design by summing the shears vertically along each line. The 1st and last = hold-down force, and the rest should = zero.

FTAO Approach



V = 3,750 lbs

15/32 Category Rated Sheathing 8d @ 4"o.c.

Height/width ratio = 2'-8" : 3'-6"

2 – hold-downs @ 1550 lb capacity

FTAO Approach

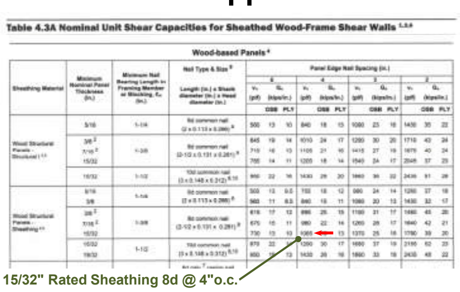
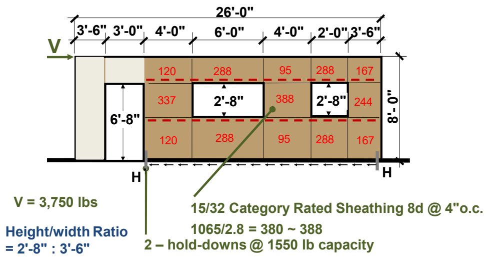


Table 4.3A Nominal Unit Shear Capacities for Sheathed Wood-Frame Shear Walls

Wood-based Panels

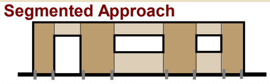
15/32" Rated Sheathing 8d @ 4"o.c.

FTAO Approach



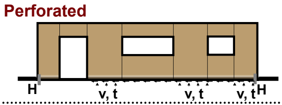
Comparison

Segmented Approach



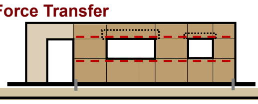
15/32 Category Rated Sheathing
- 8d @ 4"o.c. (3'-6" walls)
- 8d @ 6" o.c. (4' walls)
- 8 – hold-downs @ 2,000+ lb capacity

Perforated



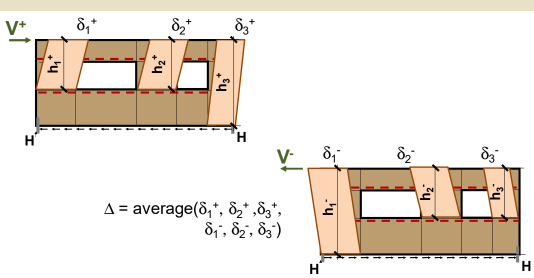
15/32 Category Rated Sheathing
- 8d @ 4"o.c.
- 2 – hold-downs @ 2,435 lb capacity
- extensive plate anchorage

Force Transfer



15/32 Category Rated Sheathing
- 8d @ 4"o.c.
- 2 – hold-downs @ 1,550 lb capacity
- 2 Straps – 865 lb

Deflection Calculations - Concept



Δ = average(δ_1^+, δ_2^+, δ_3^+, δ_1^-, δ_2^-, δ_3^-)

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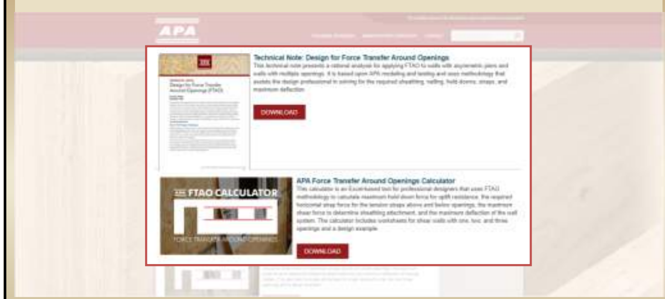
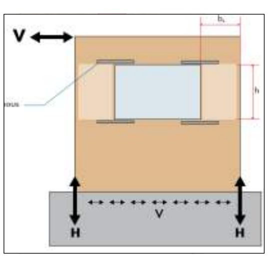


FTAO Technical Note, Form T555



- Technical Note: Design for Force Transfer Around Openings (FTAO)
- Presents a rational analysis for applying FTAO to walls with asymmetric piers and walls with multiple openings
- Based on Wall 12 testing configuration
- Includes a design example with 2 wall openings

APA FTAO Calculator

- Excel-based tool updated January 2022
- Based on design methodology developed by Diekmann
- Calculates:
  - Max hold-down force for uplift resistance
  - Required horizontal strap force above and below openings
  - Max shear force for sheathing attachments
  - Max deflection
- Design example corresponds with FTAO Technical Note, Form T555

APA FTAO Calculator

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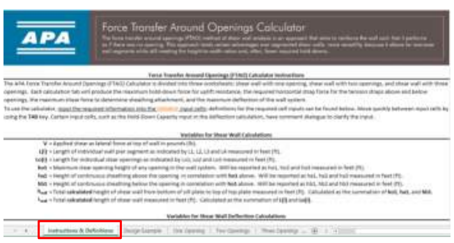

FTAO Calculator: Design Example

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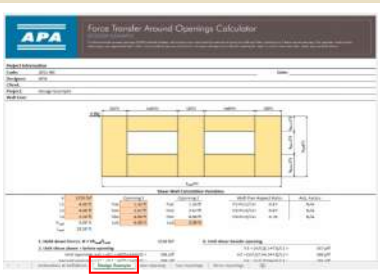

FTAO Calculator: Three Openings

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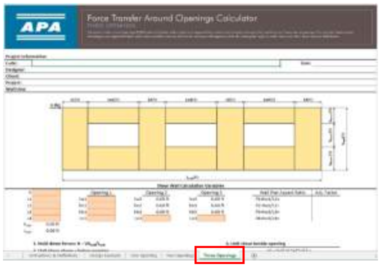


FTAO Calculator: Design Output

Design output:

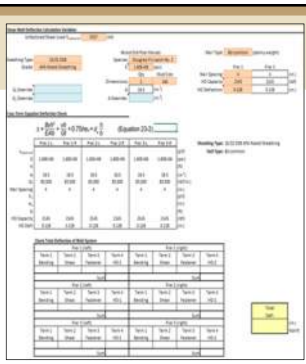
- Required sheathing capacity (includes adjustment factor)
- Required strap force above and below openings
- Required hold-down force
- Maximum deflection

Design Summary

Req. Sheathing Capacity	388 plf	4-Term Deflection	0.329 in.	3-Term Deflection	0.352 in.
Req. Strap Force	866 lbf	4-Term Story Drift %	0.014 %	3-Term Story Drift %	0.015 %
Req. HD Force	1538 lbf		See Page 2		See Page 3
Req. Shear Wall Anchorage Force	192 plf				

*The Design Summary assumes that the shear wall is designed as blocked.

FTAO Calculator



The calculator does not check the sheathing selection for the required capacity calculated above.

FTAO Calculator

Three-Term Equation Deflection Check

$$\delta_{sw} = \frac{8vh^3}{EAb} + \frac{vh}{1000G_a} + \frac{h\Delta_a}{b} \quad (4.3\text{-}1)$$

	Pier 1-L	Pier 1-R	Pier 2-L	Pier 2-R	Pier 3-L	Pier 3-R	
Sheathing:	7/16	7/16	7/16	7/16	7/16	7/16	
Nail:	8d common	8d common	8d common	8d common	8d common	8d common	
v_{ult}:	337	337	388	388	244	244	(plf)
v_{design}:	481	481	554	554	348	348	(plf)
E:	1.60E+06	1.60E+06	1.60E+06	1.60E+06	1.60E+06	1.60E+06	(psi)
h:	8.00	4.00	4.00	4.00	4.00	8.00	(ft)
A:	16.5	16.5	16.5	16.5	16.5	16.5	(in.²)
Ga:	22.0	22.0	22.0	22.0	22.0	22.0	(kips/in.)
b:	4.00	4.00	4.00	4.00	3.50	3.50	(ft)
HD Capacity:	2145	2145	2145	2145	2145	2145	(lbf)
HD Defl:	0.128	0.128	0.128	0.128	0.128	0.128	(in.)

Check Total Deflection of Wall System

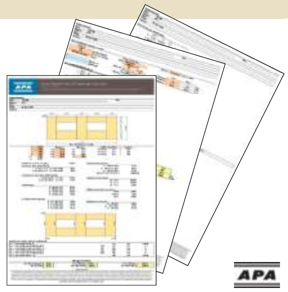
Pier 1 (left)			Pier 1 (right)		
Term 1 Bending	Term 2 Shear	Term 3 Fastener	Term 1 Bending	Term 2 Shear	Term 3 Fastener
0.019	0.175	0.459	0.002	0.087	0.115
	Sum	0.653		Sum	0.205
Pier 2 (left)			**Pier 2 (right)**		
Term 1 Bending	Term 2 Shear	Term 3 Fastener	Term 1 Bending	Term 2 Shear	Term 3 Fastener
0.003	0.101	0.132	0.003	0.101	0.132
	Sum	0.236		Sum	0.236

Total Defl.	
0.535	(in.)
0.0140	%drift

FTAO Calculator: Final Output

Final Design Output

- Summary of input parameters
- FTAO shear wall analysis
- Summary of final design requirements
- Total calculated deflection
- Three-page shear wall design to include in calculation package
  - Print directly from Excel
  - Save as PDF



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Questions?

APA Update Newsletter
(www.apawood.org)

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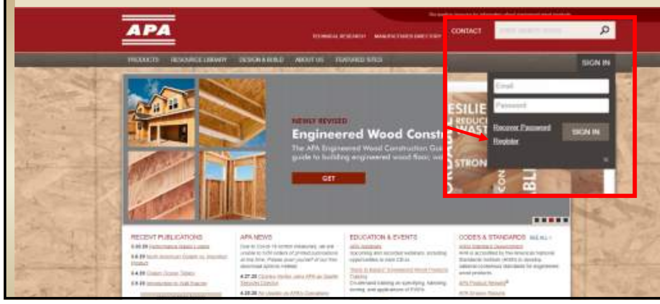

Field Services Division Territories

Thank you!