Seismic Shear Wall Design Example per 2015 WFCM and 2015 SDPWS (DES413-4)

Copyright Materials

This presentation is protected by US and International Copyright laws. Reproduction, distribution, display and use of the presentation without written permission is prohibited.

© American Wood Council 2016
Description

There are several design tools and standards to assist engineers, architects, and building officials with the design of shear walls. Prescriptive approaches such as those outlined in AWC's 2015 Wood Frame Construction Manual (WFCM) tend to provide conservative results. Engineered approaches such as those outlined in AWC's 2015 Special Design Provisions for Wind and Seismic (SDPWS) typically result in more efficient designs. This course will outline several resources available for shear wall design, compare design results, and provide an example for resisting seismic loads on a structure using both the WFCM and SDPWS.
Learning Objectives

At the end of this program, participants will be better able to:

- Identify and understand the basic shear wall system to resist lateral seismic loads
- Understand the difference between segmented and perforated shear wall design
- Understand hold down design and special conditions that pertain to seismic hold downs
- Identify and analyze shear walls per the 2015 WFCM and 2015 SDPWS and understand the differences between them

Polling Question

What is your profession?
- a) Architect
- b) Engineer
- c) Code Official
- d) Builder/Product Manufacturer
- e) Other
Outline

Shear Wall Design Examples
- 2015 IBC/IRC Recognition
- Background and Assumptions
- 2015 WFCM Prescriptive
- 2015 WFCM Engineered
- 2015 SDPWS

WFCM and IRC/IBC

2015 WFCM is referenced in 2015 IRC/IBC
**WFCM and IRC**

**IRC R301.1.1 Alternative Provisions**

**R301.1.1 Alternative provisions.** As an alternative to the requirements in Section R301.1 the following standards are permitted subject to the limitations of this code and the limitations therein. Where engineered design is used in conjunction with these standards, the design shall comply with the *International Building Code*.


---

**WFCM and IBC**

**IBC Section 2301.2**

**2301.2 General design requirements.** The design of structural elements or systems, constructed partially or wholly of wood or wood-based products, shall be in accordance with one of the following methods:

1. *Allowable stress design* in accordance with Sections 2304, 2305 and 2306.
2. *Load and resistance factor design* in accordance with Sections 2304, 2305 and 2307.
3. *Conventional light-frame construction* in accordance with Sections 2304 and 2308.
4. AWC WFCM in accordance with Section 2309.
WFCM and IBC

IBC Section 2309

SECTION 2309
WOOD FRAME CONSTRUCTION MANUAL
2309.1 Wood Frame Construction Manual. Structural design in accordance with the AWC WFCM shall be permitted for buildings assigned to Risk Category 1 or 3, subject to the limitations of Section 1.1.3 of the AWC WFCM and the load assumptions contained therein. Structural elements beyond these limitations shall be designed in accordance with accepted engineering practice.

Applicability Limits

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Limitation</th>
<th>Reference</th>
<th>Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING DIMENSIONS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Roof Height (MRH)</td>
<td>95'</td>
<td>1.1.3.1a</td>
<td>1.2</td>
</tr>
<tr>
<td>Number of Stories</td>
<td>3</td>
<td>1.1.3.1a</td>
<td>-</td>
</tr>
<tr>
<td>Building Length and Width</td>
<td>80'</td>
<td>1.1.3.1b</td>
<td>-</td>
</tr>
<tr>
<td>LOAD ASSUMPTIONS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(See Chapter 2 or Chapter 3 tables for load assumptions applicable to the specific regulated requirements)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Type</td>
<td>Load Assumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partition Dead Load</td>
<td>0-8 psi of floor area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall Assembly Dead Load</td>
<td>11-18 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor Dead Load</td>
<td>10-20 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof/Ceiling Assembly Dead Load</td>
<td>0-25 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor Live Load</td>
<td>30-40 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof Live Load</td>
<td>20 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceiling Live Load</td>
<td>10-30 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground Snow Load</td>
<td>0-70 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Load</td>
<td>110-1195 mph wind speed (700-yr. return period, 3-second gust)</td>
<td>Exposure B, Exposure C</td>
<td></td>
</tr>
<tr>
<td>Seismic Load</td>
<td>Seismic Design Category (SDC)</td>
<td>SDC A, B, C, D, E, F, and G</td>
<td></td>
</tr>
</tbody>
</table>
2015 WFCM – Non-Residential

- **Applications**
  - Single-story
  - Slab-on-grade
  - L and W < 80’

- **Examples**
  - Commercial/Retail
    - Restaurants
    - Office Buildings

- **Design**
  - Lateral (Wind and Seismic)
  - Gravity

---

2015 WFCM

**Table of Contents**

- 1 General Information 1
  - 1.1 Scope 3
  - 1.2 Materials Standards 4
  - 1.3 Definitions 5
  - 1.4 Symbols 9
  - Figures 11

- 2 Engineered Design 13
  - 2.1 General Provisions 15
  - 2.2 Connections 17
  - 2.3 Floor Systems 19
  - 2.4 Wall Systems 21
  - 2.5 Roof Systems 23
  - List of Figures 26
  - List of Tables 61

- 3 Prescriptive Design 115
  - 3.1 General Provisions 115
  - 3.2 Connections 116
  - 3.3 Floor Systems 119
  - 3.4 Wall Systems 121
  - 3.5 Roof Systems 123
  - List of Figures 123
  - List of Tables 146

- Supplement 311
- References 315
2015 WFCM

2015 WFCM uses ASCE 7-10 seismic design provisions

SDPWS and IBC

2015 SDPWS is referenced in 2015 IBC
SDPWS and IBC

SECTION 2305
GENERAL DESIGN REQUIREMENTS FOR LATERAL FORCE-RESISTING SYSTEMS
2305.1 General. Structures using wood-frame shear walls or wood-frame diaphragms to resist wind, seismic or other lateral loads shall be designed and constructed in accordance with AF&PA SDPWS and the applicable provisions of Sections 2305, 2306 and 2307.

SECTION 2306
ALLOWABLE STRESS DESIGN
2306.1 Allowable stress design. The design and construction of wood elements in structures using allowable stress design shall be in accordance with the following applicable standards:
- American Wood Council
- NDS National Design Specification for Wood Construction
- SDPWS Special Design Provisions for Wind and Seismic

SECTION 2307
LOAD AND RESISTANCE FACTOR DESIGN
2307.1 Load and resistance factor design. The design and construction of wood elements in structures using load and resistance factor design shall be in accordance with AWC NDS and AWC SDPWS.

Polling Question

The Wood Frame Construction Manual (WFCM) is for single family dwellings only?

a) True
b) False
Outline

- 2015 IBC/IRC Recognition
- Background and Assumptions
- 2015 WFCM Prescriptive
- 2015 WFCM Engineered
- 2015 SDPWS

Segmented Shear Wall (SSW) Method
Perforated Shear Wall (PSW) Method

Design Example

Assumptions
- Seismic Design Category D₁
- 7/16 Wood Structural Panel Exterior Sheathing
- 16” o.c. SPF studs (G=0.42)
- Ground Snow Load = 30 psf
- Partial Attic = Roof/Ceiling Dead Load = 25 psf
- L=36’
- W=30’
- L/W=1.2
- 2-story
- 8’ wall height
- 6’8” door height
- 4’ window height
- Don’t check deflection
Design Example

Design first floor shear wall

Outline

• 2015 IBC/IRC Recognition
• Background and Assumptions
• 2015 WFCM Prescriptive
• 2015 WFCM Engineered
• 2015 SDPWS
### WFCM Prescriptive

#### Table 3  Prescriptive Design Limitations

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Limitation</th>
<th>Reference Section</th>
<th>Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BUILDING DIMENSIONS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building</td>
<td>33'</td>
<td>2.1.3.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Number of Stories</td>
<td>3</td>
<td>2.1.3.1a</td>
<td>-</td>
</tr>
<tr>
<td>Building Length and Width</td>
<td>80'</td>
<td>2.1.3.1b</td>
<td>-</td>
</tr>
<tr>
<td><strong>FLOOR SYSTEMS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber Joists</td>
<td>26'</td>
<td>3.1.3.2a</td>
<td>-</td>
</tr>
<tr>
<td>Joist Spacing</td>
<td>24&quot; o.c.</td>
<td>3.1.3.2b</td>
<td>-</td>
</tr>
<tr>
<td>Cantilevers - Supporting loadbearing walls</td>
<td>d</td>
<td>3.1.3.2c</td>
<td>2.1a</td>
</tr>
<tr>
<td>Setbacks - Loadbearing walls</td>
<td>d</td>
<td>3.1.3.2d</td>
<td>2.1d</td>
</tr>
<tr>
<td>Floor Diaphragm</td>
<td>d&lt;sub&gt;f&lt;/sub&gt;</td>
<td>3.1.3.2e</td>
<td>2.1i</td>
</tr>
<tr>
<td>Floor Diaphragm Aspect Ratio</td>
<td></td>
<td>Tables 3.16B and 3.16C</td>
<td>3.1.3.2f</td>
</tr>
<tr>
<td>Floor Diaphragm Openings</td>
<td>Lesser of 12' or 50% of Building Dimension</td>
<td>3.1.3.2g</td>
<td>2.1k</td>
</tr>
</tbody>
</table>
WFCM Prescriptive

2015 WFCM Prescriptive – Segmented Shear Wall

Interpolate = 14.7’
Required length of full height sheathing (FHS)

WFCM Prescriptive

2015 WFCM Prescriptive – Segmented

Adjusted = 14.7’ (1.2) = 17.6’
Required length of FHS
## WFCM Prescriptive

### 2015 WFCM Prescriptive – Segmented

#### Table 3.17D Shear Wall Assembly Allowable Unit Shear Capacities, Maximum Shear Wall Segment Aspect Ratios, and Sheathing Type Adjustments

<table>
<thead>
<tr>
<th>Exterior Wall Sheathing</th>
<th>Nails and Spacing Requirements</th>
<th>ASD Unit Shear Capacity of Wall Assembly (psi)</th>
<th>Maximum Shear Wall Segment Aspect Ratio</th>
<th>Sheathing Type Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wind</td>
<td>Seismic</td>
<td>Wind</td>
</tr>
<tr>
<td>3/8&quot;, 7/16&quot;, and 15/32&quot; Wood Structural Panels (blocked), maximum stud spacing 16&quot; on center</td>
<td>8d common nails - 6&quot; edge spacing</td>
<td>236</td>
<td>239</td>
<td>3.51</td>
</tr>
<tr>
<td>No Sheathing or Non-Rated Sheathing</td>
<td>4d common nails - 2&quot; edge spacing</td>
<td>436</td>
<td>239</td>
<td>3.51</td>
</tr>
<tr>
<td>1/2&quot; Gypsum Wallboard (Unblocked)²</td>
<td>4d common nails - 2&quot; edge spacing</td>
<td>672</td>
<td>478</td>
<td>3.51</td>
</tr>
</tbody>
</table>

4 The aspect ratio is permitted to be increased to a maximum value of 3.5.1 provided the unit shear capacity and sheathing type adjustment factor are adjusted in accordance with SDPWS Section 4.3.3.1 Exception 1 for wood structural panel shear walls or Exception 2 for structural fiberboard shear walls.

SDPWS adjustment = 2b_y/h (for stiffness)

---

### WFCM Prescriptive

#### WFCM 3.4.4.2 Exterior Shear Walls

b. Seismic Loads

Segmented shear walls shall be in accordance with the full height sheathing requirements specified in Table 3.17C. Tabulated values assume wall studs are spaced at a maximum of 16 inches on center and are sheathed with 3/8 inch wood structural panels on the exterior attached with 8d common nails at 6 inches on center at panel edges and 12 inches on center in the field. Exterior sheathing shall be continuous from the bottom plate to the upper top plate, with all panel edges over framing. For other sheathing materials or sheathing configurations see 3.4.4.2.1.
**SDPWS Shear Distribution**

4.3.3.4.1 Shear distribution to individual shear walls in a shear wall line shall provide the same calculated deflection, \( \delta_{tw} \), in each shear wall.

**Exceptions:**
1. Where nominal shear capacities of all wood structural panel shear walls with aspect ratios \( h/b_x \) greater than 2:1 are multiplied by \( 2b_y/h \) for design, shear distribution to individual full-height wall segments shall be permitted to be taken as proportional to the shear capacities of individual full height wall segments used in design. Where multiplied by \( 2b_y/h \), the nominal shear capacities need not be reduced by the adjustment in 4.3.4.2.

---

**2015 WFCM Prescriptive – Segmented – required = 17.6’**

\[
4(4') + 2(2.5')(2(2.5)/8) = 19.1'
\]

- Effective length of FHS > 17.6’ req’d FHS OK
WFCM Prescriptive

2015 WFCM Prescriptive – Segmented – Hold-downs

Segmented shear wall – requires hold downs on each segment

WFCM Prescriptive

2015 WFCM Prescriptive – Perforated Shear Wall

% Full-height sheathing
17.6' / 36' = 49%
Interpolated = 1.42

17.6'(1.42) = 25.0'
Req’d length of FHS

19.1' effective FHS < 25' req’d FHS NG
**WFCM Prescriptive**

**2015 WFCM Prescriptive – Segmented**

**Table 3.17D Shear Wall Assembly Allowable Unit Shear Capacities, Maximum Shear Wall Segment Aspect Ratios, and Sheathing Type Adjustments**

<table>
<thead>
<tr>
<th>Exterior Wall Sheathing</th>
<th>Nails and Spacing Requirements</th>
<th>ASD Unit Shear Capacity of Wall Assembly (psi)</th>
<th>Maximum Shear Wall Segment Aspect Ratio</th>
<th>Sheathing Type Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8&quot;, 1/2&quot;, and 15/32&quot; Wood Structural Panels (Blocked), maximum stud spacing 16° on center</td>
<td>8d common nails - 3° edge spacing</td>
<td>490</td>
<td>350</td>
<td>3.5:1</td>
</tr>
<tr>
<td>No Sheathing or Non-Rated Sheathing</td>
<td></td>
<td>590</td>
<td>350</td>
<td>3.5:1</td>
</tr>
<tr>
<td>1/2&quot; Gypsum Wallboard (Unblocked)^2</td>
<td>8d common nails - 4° edge spacing</td>
<td>980</td>
<td>700</td>
<td>3.5:1</td>
</tr>
</tbody>
</table>

4. The aspect ratio is permitted to be increased to a maximum value of 3.5:1 provided the unit shear capacity and sheathing type adjustment factor are adjusted in accordance with SDPWS Section 4.3.3.4.1 Exception 1 for wood structural panel shear walls or Exception 2 for structural fiberboard shear walls.

SDPWS adjustment = 2b_y/h

**WFCM Prescriptive**

**2015 WFCM Prescriptive – Perforated Shear Wall**

With 4/12 nailing
17.6' (0.68) = 12.0' (segmented)

% Full-height sheathing
12.0' / 36' = 33%
Interpolated = 1.67

12.0'(1.67) = 20.0'
Req’d length FHS

19.1' effective FHS < 20’ req’d FHS NG
2015 WFCM Prescriptive – Segmented

Table 3.17D Shear Wall Assembly Allowable Unit Shear Capacities, Maximum Shear Wall Segment Aspect Ratios, and Sheathing Type Adjustments

<table>
<thead>
<tr>
<th>Exterior Wall Sheathing</th>
<th>Interior Wall Sheathing</th>
<th>ASD Unit Shear Capacity of Wall Assembly (psf)</th>
<th>Maximum Shear Wall Segment Aspect Ratio</th>
<th>Sheathing Type Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8&quot;, 7/16&quot;, and 15/32&quot; Wood Structural Panels (Blocked), maximum stud spacing 16&quot; on center</td>
<td>8d common nails - 3&quot; edge spacing</td>
<td>630</td>
<td>451</td>
<td>3.5:1</td>
</tr>
<tr>
<td>No Sheathing or Non-Rated Sheathing</td>
<td></td>
<td>730</td>
<td>451</td>
<td>3.5:1</td>
</tr>
<tr>
<td>1/2&quot; Gypsum Wallboard (Unblocked)</td>
<td>8d common nails - 3&quot; edge spacing</td>
<td>1260</td>
<td>902</td>
<td>3.5:1</td>
</tr>
</tbody>
</table>

4 The aspect ratio is permitted to be increased to a maximum value of 3.5:1 provided the unit shear capacity and sheathing type adjustment factor are adjusted in accordance with SDPWS Section 4.3.3.4.1 Exception 1 for wood structural panel shear walls or Exception 2 for structural fiberboard shear walls.

SDPWS adjustment = 2b_s/h

2015 WFCM Prescriptive – Perforated Shear Wall

With 3/12 nailing

17.6' (0.53) = 9.3'

(segmented)

% Full-height sheathing

9.3' / 36' = 26%

Interpolated = 1.84

9.3'(1.84) = 17.1'

Req’d length FHS

19.1' effective FHS > 17.1’ req’d FHS OK
PSW requires fully sheathed wall
• Nailing at 3/12

PSW requires hold-downs only at the ends
WFCM Prescriptive

2015 WFCM Prescriptive – Hold-downs

Hold-downs
= 1,912 lbs
For segmented wall @ 6/12 nailing

1,912 / 0.53
= 3,608 lbs
For PSW @ 3/12 nailing

- Need to combine with top floor hold-down requirements
- Based on capacity of first shear wall panel
- Does not include dead load

Polling Question

Segmented shear walls typically require more hold downs than perforated shear walls.

a) True
b) False
Outline

- 2015 IBC/IRC Recognition
- Background and Assumptions
- 2015 WFCM Prescriptive
- 2015 WFCM Engineered
- 2005 SDPWS

WFCM Engineered

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Limitation</th>
<th>Reference Section</th>
<th>Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BUILDING DIMENSIONS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building</td>
<td>33</td>
<td>2.1.5.1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Number of Stories</td>
<td>3</td>
<td>1.5.5.1.1</td>
<td>-</td>
</tr>
<tr>
<td>Building Length and Width</td>
<td>0'07</td>
<td>1.5.5.1.2</td>
<td>-</td>
</tr>
<tr>
<td><strong>FLOOR SYSTEMS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber Joists</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint Span</td>
<td>20</td>
<td>2.1.5.2.1</td>
<td>-</td>
</tr>
<tr>
<td>Joint Spacing</td>
<td>24&quot; o.c.</td>
<td>2.1.5.2.2</td>
<td>-</td>
</tr>
<tr>
<td>Cantilevers - Supporting loadbearing</td>
<td>d</td>
<td>2.1.5.2.3</td>
<td>2.1a</td>
</tr>
<tr>
<td>Setbacks - Loadbearing wall</td>
<td>d</td>
<td>2.1.5.2.4</td>
<td>2.1d</td>
</tr>
<tr>
<td>Wood I-Joints</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-Joint Spacing</td>
<td>24&quot; o.c.</td>
<td>2.1.5.3.1</td>
<td>-</td>
</tr>
<tr>
<td>Cantilevers</td>
<td>(see manufacturer)</td>
<td>2.3.2.6</td>
<td>2.3a, 2.3b, 2.3c</td>
</tr>
<tr>
<td>Setbacks</td>
<td>(see manufacturer)</td>
<td>2.3.2.5</td>
<td>2.4d</td>
</tr>
<tr>
<td>Wood Floor Trusses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trans Spans</td>
<td>20</td>
<td>2.1.5.2.5</td>
<td>-</td>
</tr>
<tr>
<td>Trans Spacing</td>
<td>24&quot; o.c.</td>
<td>2.1.5.2.6</td>
<td>-</td>
</tr>
<tr>
<td>Cantilevers</td>
<td>(see trust plans)</td>
<td>2.3.3.6</td>
<td>2.3a, 2.3b, 2.3c</td>
</tr>
<tr>
<td>Setbacks</td>
<td>(see trust plans)</td>
<td>2.3.5.5</td>
<td>-</td>
</tr>
<tr>
<td>Floor Diaphragms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical Floor Offset</td>
<td>4&quot;</td>
<td>2.1.5.2.7</td>
<td>2.3l</td>
</tr>
<tr>
<td>Floor Diaphragm Aspect Ratio</td>
<td>4:1</td>
<td>2.1.5.2.8</td>
<td>2.3l</td>
</tr>
<tr>
<td>Floor Diaphragm Openings</td>
<td>Lesser of 12&quot; or 50% of Building Dimension</td>
<td>2.1.5.2.9</td>
<td>2.1k</td>
</tr>
</tbody>
</table>

WFCM p. 14
WFCM Engineered

\[ W_{FD2} = 83,680 \text{ lbs} \]

\[ V_{FD2} = 1.1 \times (83,680) \times 0.83 / 6.5 = 8,228 \text{ lbs} \]

WFCM Engineered - Commentary

Simplified Approach
ASCE 7-10 Section 12.14.8

Share at the roof diaphragm level, \( V_{R0} \):

\[ V_{R0} = 1.5 \times W_{RB} \times S_{R} \]

where:

- \( 1.5 \) = vertical force distribution factor for two-story construction in accordance with simplified procedures of ASCE 7-10 section 12.14.8. A factor of 1.0 applies for one-story construction and a factor of 1.2 applies for three-story construction.
- \( S_{R} \) = design, percent damped, spectral response acceleration parameter at short periods in accordance with ASCE 7-10.
2015 WFCM Engineered – Segmented

**Table 3.17D Shear Wall Assembly Allowable Unit Shear Capacities, Maximum Shear Wall Segment Aspect Ratios, and Sheathing Type Adjustments**

<table>
<thead>
<tr>
<th>Exterior Wall Sheathing</th>
<th>Nails and Spacing Requirements</th>
<th>ASD Unit Shear Capacity of Wall Assembly (plf)</th>
<th>Maximum Shear Wall Segment Aspect Ratio</th>
<th>Sheathing Type Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8&quot;, 7/16&quot;, and 15/32&quot; Wood Structural Panels (Blocked)</td>
<td>8d common nails - 6&quot; edge spacing</td>
<td>306</td>
<td>229</td>
<td>3.5:1</td>
</tr>
<tr>
<td>1/2&quot; Gypsum Wallboard (Unblocked)</td>
<td>6d clinch nails - 3&quot; edge spacing</td>
<td>436</td>
<td>229</td>
<td>3.5:1</td>
</tr>
<tr>
<td>3/8&quot;, 7/16&quot;, and 15/32&quot; Wood Structural Panels (Blocked)</td>
<td>8d common nails - 6&quot; edge spacing</td>
<td>672</td>
<td>478</td>
<td>3.5:1</td>
</tr>
</tbody>
</table>

4 The aspect ratio is permitted to be increased to a maximum value of 3.5:1 provided the unit shear capacity and sheathing type adjustment factor are adjusted in accordance with SDPWS Section 4.3.3.4.1 Exception 1 for wood structural panel shear walls or Exception 2 for structural fiberboard shear walls.

**SDPWS adjustment = 2b_s/h (for stiffness)**

---

**WFCM Engineered**

2015 WFCM Engineered – Segmented

Required Capacity = 8,228/2 = 4,114 lbs
7/16" WSP Capacity = 239 plf

4,114 lbs / 239 plf = 17.2’
Req’d length of FHS

Plan View

4,114

8,228
Reference SDPWS Capacities and Adjustments

**2015 WFCM Engineered – Segment**

- **V** = 4,114 lbs
- **v** = 239 plf
- **%FHS** = \( \frac{L_i}{L_{tot}} \)
- **L_i** = 16' + 2(2(2.5)/8)2.5' = 19.1'
- **L_{tot}** = 36'
- **%FHS** = 19.1' / 36' = 53%
- Interpolated C_0 Factor = 0.59

239(0.59) = 141 plf

4,114/141 = 29.2' Req’d FHS

29.2' > 19.1’ effective FHS **NG**

**Note:** \( L_i \) per SDPWS 4.3.4.3 adjustment = 2b/h

**2015 WFCM Engineered – Perforated**

Table 4.3.3.5 Shear Capacity Adjustment Factor, C_0

<table>
<thead>
<tr>
<th>Maximum Unconstrained Opening Height</th>
<th>Window Height</th>
<th>Door Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>10' H</td>
<td>10' H/2</td>
<td>10' H/4</td>
</tr>
<tr>
<td>8’ Wall</td>
<td>2.4’</td>
<td>4.0’</td>
</tr>
<tr>
<td>10’ Wall</td>
<td>3.4’</td>
<td>5.0’</td>
</tr>
</tbody>
</table>

Percent Full-Height Shading | Shear Capacity Adjustment Factor
---|---
0% | 1.00 | 0.70 | 0.50 | 0.40 | 0.33 |
10% | 1.00 | 0.69 | 0.53 | 0.43 | 0.36 |
20% | 1.00 | 0.71 | 0.56 | 0.46 | 0.38 |
30% | 1.00 | 0.74 | 0.59 | 0.49 | 0.42 |
40% | 1.00 | 0.77 | 0.63 | 0.53 | 0.45 |
50% | 1.00 | 0.80 | 0.67 | 0.57 | 0.50 |
60% | 1.00 | 0.83 | 0.71 | 0.63 | 0.56 |
70% | 1.00 | 0.87 | 0.77 | 0.69 | 0.61 |
80% | 1.00 | 0.91 | 0.83 | 0.77 | 0.71 |
90% | 1.00 | 0.95 | 0.91 | 0.87 | 0.83 |
100% | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
2015 WFCM Engineered – Segmented

Table 3.17D Shear Wall Assembly Allowable Unit Shear Capacities, Maximum Shear Wall Segment Aspect Ratios, and Sheathing Type Adjustments

<table>
<thead>
<tr>
<th>Exterior Wall Sheathing</th>
<th>Nails and Spacing Requirements</th>
<th>ASD Unit Shear Capacity of Wall Assembly (psf)</th>
<th>Maximum Shear Wall Segment Aspect Ratio</th>
<th>Sheathing Type Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8”, 7/16”, and 15/32” Wood Structural Panels (Blocked), maximum stud spacing 10” on center</td>
<td>8d common nails - 3” edge spacing</td>
<td>Wind</td>
<td>Seismic</td>
<td></td>
</tr>
<tr>
<td>No Sheathing or Non-Rated Sheathing</td>
<td>490</td>
<td>350</td>
<td>3.5</td>
<td>2.4</td>
</tr>
<tr>
<td>1/2” Gypsum Wallboard (Unblocked)</td>
<td>590</td>
<td>350</td>
<td>3.5</td>
<td>2.4</td>
</tr>
<tr>
<td>3/8&quot;, 7/16&quot;, and 15/32” Wood Structural Panels (Blocked)</td>
<td>980</td>
<td>700</td>
<td>3.5</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Note: Li per SDPWS 4.3.4.3 adjustment = 2b_s/h for stiffness.

2015 WFCM Engineered - Perforated

Reference SDPWS Capacities and Adjustments

V = 4,114 lbs

v = 350 plf

%FHS = L_i / L_tot

L_i = 16’ + 2[(2.5)/8]2.5’ = 19.1’

L_tot = 36’

%FHS = 19.1’ / 36’ = 53%

Interpolated C_o Factor = 0.59

350(0.59) = 207 plf

4,114/207 = 19.9’ Req’d FHS

19.9’ > 19.1’ effective FHS NG

Note: L_i per SDPWS 4.3.4.3 adjustment = 2b_s/h
**WFCM Prescriptive**

**2015 WFCM Prescriptive – Segmented**

Table 3.17D Shear Wall Assembly Allowable Unit Shear Capacities, Maximum Shear Wall Segment Aspect Ratios, and Sheathing Type Adjustments

<table>
<thead>
<tr>
<th>Exterior Wall Sheathing</th>
<th>Nails and Spacing Requirements</th>
<th>ASD Unit Shear Capacity of Wall Assemblage (psi)</th>
<th>Maximum Shear Wall Segment Aspect Ratio</th>
<th>Sheathing Type Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8&quot;, 7/16&quot;, and 15/32&quot; Wood Structural Panels (Blocked)</td>
<td>8d common nails - 3&quot; edge spacing</td>
<td>630</td>
<td>451</td>
<td>3.5</td>
</tr>
<tr>
<td>No Sheathing or Non-Rated Sheathing</td>
<td></td>
<td>1/2&quot; Gypsum Wallboard (Unblocked)</td>
<td>730</td>
<td>451</td>
</tr>
</tbody>
</table>

4 The aspect ratio is permitted to be increased to a maximum value of 3.5:1 provided the unit shear capacity and sheathing type adjustment factor are adjusted in accordance with SDPWS Section 4.3.3.4.1 Exception 1 for wood structural panel shear walls or Exception 2 for structural fiberboard shear walls.

SDPWS adjustment = 2b/h

**WFCM Engineered**

**2015 WFCM Engineered - Perforated**

Reference SDPWS Capacities and Adjustments

V = 4,114 lbs

v = 451 plf

%FHS = Lₐ / Lₜₒₜₜ = 16" + 2[2(2.5)/8]2.5' = 19.1'

Lₜₒₜₜ = 36'

%FHS = 19.1'/36' = 53%

Interpolated Cᵢ Factor = 0.59

451(0.59) = 266 plf

4,114/266 = 15.5' Req’d FHS

15.5' < 19.1' effective FHS OK

Note: Lₐ per SDPWS 4.3.4.3 adjustment = 2b/h
2015 WFCM Engineered - Perforated

\[ T = v \times h \]

- \( v = 239 \text{ plf} \) – segmented @ 6/12
- \( v = 451 \text{ plf} \) – perforated @ 3/12
- \( h = 8' \)

- \( T = 239(8') = 1,912 \text{ lbs} \) - segmented
- \( T = 451(8') = 3,608 \text{ lbs} \) - perforated

WFCM Engineered

- Need to combine with top floor hold-down requirements
- Based on capacity of first shear wall panel
- Can account for dead load (WFCM 2.2.4)
Polling Question

2015 WFCM references which of the following standards for design loads.

a) ASCE 7-05
b) ASCE 7-10
c) ASCE 10-15
d) All of the above

Outline

- 2015 IBC/IRC Recognition
- Background and Assumptions
- 2015 WFCM Prescriptive
- 2015 WFCM Engineered
- 2015 SDPWS
SDPWS

2015 SDPWS

- Engineered
- Res and Non-Res
- ASD & LRFD
- Efficiencies in designs
- Shear wall provisions
  - Segmented
  - Perforated
  - Force Transfer Around Openings

Minimum Design Loads

ASCE 7-10 Minimum Design Loads for Buildings and Other Structures

14.5.1 Reference Documents

The quality, testing, design, and construction of members and their fastenings in wood systems that resist seismic forces shall conform to the requirements of the applicable following reference documents:

1. AF&PA NDS
2. AF&PA SDPWS
2015 SDPWS – WSP Capacity

Footnote 1: ASD capacity = half the nominal capacity
Footnote 2: use 15/32 capacity for studs at 16\(^\circ\) o.c.
Footnote 3: SG adjustment factor = 0.92 for SPF
ASD Capacity = 520 (0.92) / 2 = 239 plf

SDPWSS

2015 SDPWSS

Table 4.3.4 Maximum Shear Wall Aspect Ratios

<table>
<thead>
<tr>
<th>Shear Wall Sheathing Type</th>
<th>Maximum h/h, Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood structural panels, unblocked</td>
<td>2:1</td>
</tr>
<tr>
<td>Wood structural panels, blocked</td>
<td>3.5:1</td>
</tr>
<tr>
<td>Particleboard, blocked</td>
<td>2:1</td>
</tr>
<tr>
<td>Diagonal sheathing, conventional</td>
<td>2:1</td>
</tr>
<tr>
<td>Gypsum wallboard</td>
<td>2:1</td>
</tr>
<tr>
<td>Portland cement plaster</td>
<td>2:1</td>
</tr>
<tr>
<td>Structural fiberboard</td>
<td>3.5:1</td>
</tr>
</tbody>
</table>

Exceptions:
1. Where nominal shear capacities of all wood structural panel shear walls with aspect ratios (h/b) greater than 2:1 are multiplied by 2b/h for design, shear distribution to individual full-height wall segments shall be permitted to be taken as proportional to the shear capacities of individual full height wall segments used in design. Where multiplied by 2b/h, the nominal shear capacities need not be reduced by the adjustment in 4.3.4.2.
4.3.4 Shear Wall Aspect Ratios and Capacity Adjustments

4.3.4.1 The size and shape of shear walls shall be limited to the aspect ratios in Table 4.3.4.

4.3.4.2 For wood structural panel shear walls with aspect ratios \((h/b_s)\) greater than 2:1, the nominal shear capacity shall be multiplied by the Aspect Ratio Factor (WSP) = \(1.25 - 0.125h/b_s\). For structural fiberboards, shear walls with aspect ratios \((h/b_s)\) greater than 1:1, the nominal shear capacity shall be multiplied by the Aspect Ratio Factor (fiberboard) = 1.09 - 0.09 \(h/b_s\).

**Aspect Ratio factor (for strength)**

---

**Shear Distribution**

Required Capacity = 4,114 lbs

\[\text{WSP} = 239 \text{ plf}\]

Aspect Ratio > 2:1

Adjustment factor (based on stiffness) = \(2b_s/h\)

\[= 2(2.5)/8 = 0.625 \quad \leftarrow \text{Governs}\]

Aspect Ratio Factor = \(1.25 - 0.125h/b_s\)

\[= 1.25 - 0.125(8)/2.5 = 0.84\]

WSP = 259(0.625) = 149 plf
2015 SDPWS – Segmented Shear Wall

Required Capacity = 4,114 lbs
239(4)(4') + 149(2)(x) = 4,114
x = 0.97

Required length FHS = 16' + 0.97' = 17.0'
Actual length = 21' OK
Shear Capacity Adjustment Factor

\[ h = 8' \]
\[ L_i = 16' + 2[2(2.5)/8]2.5' = 19.1' \]
\[ L_{tot} = 36' \]
\[ A_o = 4(4')(2.5') + (5')(6.67') = 73.4 \text{ ft}^2 \]
\[ r = 0.68 \]
\[ C_0 = 0.77 \text{ (based on total sheathed area)} \]

Comparison: SDPWS/WFCM Engineered (tabulated) \( C_0 = 0.59 \)

Note: \( L_i \) per SDPWS 4.3.4.3 adjustment = \( 2b_s/h \)

---

2015 SDPWS – Perforated Shear Wall

\[ C_0 = 0.77 \]
\[ 239 \text{ plf (0.77)} = 184 \text{ plf} \]
\[ 4,114/184 = 22.3' \text{ req'd FHS} \]

\[ 22.3' > 21' \text{ actual FHS NG} \]

6/12 nail spacing
2015 SDPWS – WSP Capacity

Table 4.3A Nominal Unit Shear Capacities for Wood-Frame Shear Walls[1,3,6,7]

<table>
<thead>
<tr>
<th>Sheathing Material</th>
<th>Minimum Nominal Panel Thickness (in)</th>
<th>Minimum Fastener Penetration in Framing Member or Blocking (in)</th>
<th>Fastener Type &amp; Size</th>
<th>Panel Edge Fastener</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5/16</td>
<td>1/4</td>
<td>6d</td>
<td>Vx (plf) (kips/in)</td>
</tr>
<tr>
<td>Wood Structural Panel – Sheathing*</td>
<td>7/16</td>
<td>–3/8</td>
<td>6d</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>15/32</td>
<td>1/2</td>
<td>10d</td>
<td>4</td>
</tr>
</tbody>
</table>

Footnote 1: ASD capacity = half the nominal capacity
Footnote 2: use 15/32 capacity for studs at 16" o.c.
Footnote 3: SG adjustment factor = 0.92 for SPF
ASD Capacity = 760 (0.92) / 2 = 350 plf

SDPWS

2015 SDPWS – Perforated Shear Wall

C₀ = 0.77
350 plf (0.77) = 270 plf
4,114/270 = 15.2’ req’d FHS
15.2’ < 21’ actual FHS OK
4/12 nail spacing
**SDPWS**

**2015 SDPWS – Perforated Shear Wall**

4,114 lbs

21’ actual FHS > 15.2' req’d FHS  OK

**SDPWS**

**2015 SDPWS – Hold-downs (Segmented)**

\[ T = v h \]

\[ v = \frac{4,114}{19.1'} = 215 \text{ plf} \]

\[ h = 8' \]

\[ T = 215(8') = 1,723 \text{ lbs} \]

- Need to combine with top floor hold-down requirements
- Based on loads
- Can account for dead load (4.3.6.4.2)
2015 SDPWS – Hold-downs (Perforated)

\[ V = 4,114 \text{ lbs} \]
\[ h = 8' \]
\[ C_o = 0.77 \]
\[ L_i = 16' + 2[2(2.5)/8]2.5' \]
\[ L_i = 19.1' \]
\[ T = 2,238 \text{ lbs} \]

\[ T = C_o \frac{V h}{\sum L_i} \quad (4.3-8) \]

where:

- Need to combine with top floor hold-down requirements
- Based on loads
- Can account for dead load (4.3.6.4.2)

Seismic Design Example - Summary

2015 WFCM/SDPWS Shear Wall Length Comparison

1st of 2-story; W=30'; L = 36'; GSL = 30psf; SDC D1

<table>
<thead>
<tr>
<th>AWC Standard</th>
<th>Segmented (SSW)</th>
<th>Perforated (PSW)</th>
<th>Hold-downs, lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015 WFCM Prescriptive</td>
<td>17.6' (6/12)</td>
<td>17.1' (3/12)</td>
<td>1,912 [SSW]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3,608 [PSW]</td>
</tr>
<tr>
<td>2015 WFCM Engineered</td>
<td>17.2' (6/12)</td>
<td>15.5' (3/12)</td>
<td>1,912 [SSW]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3,608 [PSW]</td>
</tr>
<tr>
<td>2015 SDPWS</td>
<td>17.0' (6/12)</td>
<td>15.2' (4/12)</td>
<td>1,723 [SSW]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2,238 [PSW]</td>
</tr>
</tbody>
</table>

Parenthetical values show nail spacing: (edge/field)
Polling Question

The Special Design Provisions for Wind and Seismic (SDPWS) standard includes which of the following design methods that is not included in the WFCM:

a) segmented shear wall
b) perforated shear wall
c) force transfer around openings shear wall
d) Hold-downs

Questions?

• This concludes The American Institute of Architects Continuing Education Systems Course

www.awc.org
info@awc.org
Resources

www.apawood.org

WoodWorks® Version 11
Released November 2016

NDS 2015, SDPWS 2015, IBC 2015 and ASCE 7-10 compliant

Sizer Stand-alone
Design beams and columns.

Design Office Suite
Get the full set of programs. In addition to designing beams and columns, design walls for wind and earthquake loads and design connections with nails, lags, screws and more.
Purchase online: woodworks-software.com

10% discount for AWC members

Design Office Suite:  $995 ($895.50)
Sizer, Shearwalls, Connections

Sizer standalone:  $350 ($315.00)

- Discounts for multi-seat purchases
- Discounts to upgrade from previous versions
- Free for educators and building officials