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

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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.

1. AF&PA Wood Frame Construction Manual (WFCM).

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 II, 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 Section</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>
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<tr>
<td>LOAD ASSUMPTIONS</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(See Chapter 2 or Chapter 3 tables for load assumptions applicable to the specific regulated requirement)</td>
<td></td>
<td></td>
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<tr>
<td>Load Type</td>
<td>Load Assumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partition Dead Load</td>
<td>0-8 psf of floor area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall Assembly Dead Load</td>
<td>11-18 psf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor Dead Load</td>
<td>10-20 psf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof/Ceiling Assembly Dead Load</td>
<td>0-25 psf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor Live Load</td>
<td>30-40 psf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof Live Load</td>
<td>20 psf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceiling Live Load</td>
<td>10-30 psf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground Snow Load</td>
<td>0-70 psf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Load</td>
<td>110-195 mph wind speed (700-yr. return period, 3-second gust)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seismic Load</td>
<td>Seismic Design Category (SDC)</td>
<td>SDC A, B, C, D, and D, and D,</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 uses ASCE 7-10 seismic design provisions

What's Changed

SDPWS and IBC

2015 SDPWS is referenced in 2015 IBC

What's Changed
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

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 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 Aspect Ratio</td>
<td>d&lt;sub&gt;u&lt;/sub&gt;</td>
<td>3.1.3.2e</td>
<td>2.1i</td>
</tr>
<tr>
<td>Floor Diaphragm Openings</td>
<td>Lesser of 12&quot; or 50% of Building Dimension</td>
<td>3.1.3.2g</td>
<td>2.1k</td>
</tr>
</tbody>
</table>

WFCM Prescriptive

- Seismic Design Categories A-D
- Segmented & Perforated Shear Walls
- Other Application Limits
WFCM Prescriptive

2015 WFCM Prescriptive – Segmented Shear Wall

Table 3.17C

Segmented Shear Wall Sheathing Requirements for Seismic

<table>
<thead>
<tr>
<th>Shear Wall Line Below</th>
<th>GSC</th>
<th>D/C</th>
<th>L/W</th>
<th>Full-height sheathing length, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof, Ceiling, &amp; 1st Floor</td>
<td>12</td>
<td>2.0</td>
<td>3.7</td>
<td>14.7'</td>
</tr>
<tr>
<td>16</td>
<td>7.7</td>
<td>10.7</td>
<td>13.7</td>
<td>14.6'</td>
</tr>
</tbody>
</table>

Interpolate = 14.7'

Required length of full height sheathing (FHS)

WFCM Prescriptive

2015 WFCM Prescriptive – Segmented

Footnotes to Table 3.17C

Adjusted = 14.7' (1.2) = 17.6'

Required length of FHS
### 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 (psf)</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>5/8&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>336</td>
<td>239</td>
<td>3.51</td>
</tr>
<tr>
<td>No Sheathing or Non-Rated Sheathing</td>
<td></td>
<td>236</td>
<td>239</td>
<td>3.51</td>
</tr>
<tr>
<td>1/2&quot; Gypsum Wallboard (Unblocked)</td>
<td>4d common nails - 2&quot; edge spacing</td>
<td>436</td>
<td>239</td>
<td>3.51</td>
</tr>
<tr>
<td>5/8&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>3.51</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 4.3.3.4.1 Exception 1 for wood structural panel shear walls or Exception 2 for structural fiberboard shear walls.

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

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### 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, $\delta_{\text{ws}}$, in each shear wall.

**Exceptions:**
1. Where nominal shear capacities of all wood structural panel shear walls with aspect ratios ($h/b_w$) greater than 2:1 are multiplied by $2b_h/h$ 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 $2b_h/h$, the nominal shear capacities need not be reduced by the adjustment in 4.3.4.2.

2015 WFCM Prescriptive – Segmented – required = 17.6'

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

- 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

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**WFCM Prescriptive**

**2015 WFCM Prescriptive – Perforated Shear Wall**

<table>
<thead>
<tr>
<th>% Full-height sheathing</th>
<th>17.6’ / 36’ = 49%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpolated</td>
<td>1.42</td>
</tr>
</tbody>
</table>

17.6’(1.42) = 25.0’

Req’d length of FHS

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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 (psf)</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 - 3&quot; edge spacing</td>
<td>Wind 350, Sonic 350</td>
<td>3.5 : 1</td>
<td>2 : 1.67</td>
</tr>
<tr>
<td>No Sheathing or Non-Rated Sheathing</td>
<td>6d common nails - 3&quot; edge spacing</td>
<td>Wind 490, Sonic 350</td>
<td>3.5 : 1</td>
<td>2 : 1.67</td>
</tr>
<tr>
<td>1/2&quot; Gypsum Wallboard (Unblocked)²</td>
<td>6d common nails - 3&quot; edge spacing</td>
<td>Wind 590, Sonic 350</td>
<td>3.5 : 1</td>
<td>2 : 1.67</td>
</tr>
<tr>
<td>3/8&quot;, 7/16&quot;, and 15/32&quot; Wood Structural Panels (Blocked)</td>
<td>8d common nails - 3&quot; edge spacing</td>
<td>Wind 780, Sonic 700</td>
<td>3.5 : 1</td>
<td>2 : 1.67</td>
</tr>
</tbody>
</table>

² 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 lightweight 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
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
Hold-downs = 1,912 lbs
For segmented wall @ 6/12 nailing

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

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 2: Engineered Design Limitations

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Limitation</th>
<th>Reference Section</th>
<th>Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building</td>
<td>Mean Roof Height (MBH)</td>
<td>2.1.5.1</td>
<td>1.2</td>
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<tr>
<td></td>
<td>Number of Stories</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Building Length and Width</td>
<td>2.1.5.1.a</td>
<td></td>
</tr>
<tr>
<td>Lumber Joists</td>
<td>Joint Span</td>
<td>2.2.5.2</td>
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<td></td>
<td>Joint Spacing</td>
<td>2.2.5.2</td>
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<td>Cantilevers - Supporting loadbearing</td>
<td>2.1.5.2.c</td>
<td>1.2a</td>
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<td></td>
<td>Setbacks - Loadbearing wall</td>
<td>2.1.5.2.d</td>
<td>2.1d</td>
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<tr>
<td>Wood I-Joists</td>
<td>Joint Spacing</td>
<td>2.2.5.2</td>
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<td>Cantilevers</td>
<td>(see manufacturer)</td>
<td>2.3.2.6</td>
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<td></td>
<td>Setbacks</td>
<td>(see manufacturer)</td>
<td>2.3.2.6</td>
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<tr>
<td>Wood Floor Trusses</td>
<td>Truss Span</td>
<td>2.2.5.2</td>
<td></td>
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<tr>
<td></td>
<td>Cantilevers</td>
<td>(see truss plans)</td>
<td>2.3.3.6</td>
</tr>
<tr>
<td></td>
<td>Setbacks</td>
<td>(see truss plans)</td>
<td>2.3.3.5</td>
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<td>Floor Diaphragms</td>
<td>Vertical Floor Offset</td>
<td>4.1</td>
<td>2.1.5.2</td>
</tr>
<tr>
<td></td>
<td>Floor Diaphragm Aspect Ratio</td>
<td>4.1</td>
<td>2.1.5.2</td>
</tr>
<tr>
<td></td>
<td>Floor Diaphragm Openings</td>
<td>4.1</td>
<td>Lesser of 1/2 or 50% of Building Dimension</td>
</tr>
</tbody>
</table>

WFCM p. 14
WFCM Engineered

$S_{DS}$ for $D_1 = 0.83$

$R = 6.5$

1.1 = vertical force distribution factor

0.7 = ASD load factor

$W_{FD2} = 83,680$ lbs

$V_{FD2} = 1.1 \times (83,680) \times 0.83 / 6.5 = 8,228$ lbs
**WFCM Engineered**

**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) Wind</th>
<th>Maximum Shear Wall Segment Aspect Ratio Wind</th>
<th>Sheathing Type Adjustment Factor Wind</th>
<th></th>
<th>Sheathing Type Adjustment Factor Seismic</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 - 2&quot; edge spacing</td>
<td>205 229</td>
<td>3.5:1</td>
<td>2.1:1</td>
<td>1.30</td>
<td>1.00</td>
</tr>
<tr>
<td>No Sheathing or Non-Rated Sheathing</td>
<td>8d common nails - 2&quot; edge spacing</td>
<td>406 229</td>
<td>3.5:1</td>
<td>2.1:1</td>
<td>1.30</td>
<td>1.00</td>
</tr>
<tr>
<td>1/2&quot; Gypsum Wallboard (Unblocked)</td>
<td>8d common nails - 2&quot; edge spacing</td>
<td>272 229</td>
<td>3.5:1</td>
<td>2.1:1</td>
<td>1.30</td>
<td>1.00</td>
</tr>
</tbody>
</table>

* 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 (for stiffness)

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**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

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Plan View
V = 4,114 lbs

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

\[ \%\text{FHS} = \frac{L_i}{L_{\text{tot}}} = \frac{16' + 2\times(2.5)/8}{36'} = 53\% \]

Interpolated \( C_v \) Factor = 0.59

\[ 239(0.59) = 141 \text{ plf} \]

4,114/141 = 29.2’ Req’d FHS

29.2’ > 19.1’ effective FHS NG
### 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>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>3/8&quot;, 7/16&quot;, and 15/32&quot; Wood Structural Panels (Blocked), maximum stud spacing 10&quot; on center</td>
<td>No Sheathing or Non-Rated Sheathing</td>
<td>8d common nails - 3&quot; edge spacing</td>
<td>2b/h</td>
<td>0.89</td>
</tr>
<tr>
<td>1/2&quot; Gypsum Wallboard (Unblocked)</td>
<td>1/4&quot; Drywall Sheathing</td>
<td>6d common nails - 3/4&quot; edge spacing</td>
<td>2b/h</td>
<td>0.74</td>
</tr>
</tbody>
</table>

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

### 2015 WFCM Engineered - Perforated

Reference SDPWS Capacities and Adjustments

\[
V = 4,114 \text{ lbs} \\
v = 350 \text{ plf} \\
%\text{FHS} = \frac{L_i}{L_{tot}} \\
L_i = 16' + 2[2(2.5)/8]2.5' = 19.1' \\
L_{tot} = 36' \\
%\text{FHS} = 19.1'/36' = 53% \\
\text{Interpolated } C_o \text{ Factor} = 0.59 \\
\]

\[
350(0.59) = 207 \text{ plf} \\
4,114/207 = 19.9' \text{ Req'd FHS} \\
19.9' > 19.1' \text{ effective FHS} \text{ NG} \\
\]

*Note: Li per SDPWS 4.3.4.3 adjustment = 2b/h*
WFCM Prescriptive

2015 WFCM Prescriptive – Segmented

SDPWS adjustment = 2bs/h

WFCM Engineered

2015 WFCM Engineered – Perforated

Reference SDPWS Capacities and Adjustments

V = 4,114 lbs

v = 451 plf

%FHS = Lh / Ltot

Lh = 16’ + 2[2(2.5)/8]2.5’ = 19.1’

Ltot = 36’

%FHS = 19.1’ / 36’ = 53%

Interpolated Cc Factor = 0.59

451(0.59) = 266 plf

4,114/266 = 15.5’ Req’d FHS

15.5’ < 19.1’ effective FHS OK

Note: Lh per SDPWS 4.3.4.3 adjustment = 2bs/h
**WFCM Engineered**

**2015 WFCM Engineered - Perforated**

19.1' effective FHS > 15.5' req’d FHS  OK

\[ T = v \times h \]

\[ v = 239 \text{ plf} – \text{segmented } @ \ 6/12 \]

\[ v = 451 \text{ plf} – \text{perforated } @ \ 3/12 \]

\[ h = 8' \]

\[ T = 239(8') = 1,912 \text{ lbs} - \text{segmented} \]

\[ T = 451(8') = 3,608 \text{ lbs} - \text{perforated} \]

- 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

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

<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>Wood Structural Panel – Sheathing</td>
<td>5/16</td>
<td>1/2</td>
<td>10d</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>7/32</td>
<td>7/16</td>
<td>1-1/2</td>
<td>10d</td>
</tr>
<tr>
<td></td>
<td>15/32</td>
<td>13/32</td>
<td>1-3/4</td>
<td>10d</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

2015 SDPWS

Table 4.3.4 Maximum Shear Wall Aspect Ratios

<table>
<thead>
<tr>
<th>Shear Wall Sheathing Type</th>
<th>Maximum Aspect h/b 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>

Adjustment factor (based on stiffness)

4.3.3.4.1 Shear distribution to individual shear walls in a shear wall line shall provide the same calculated deflection, $\delta$, in each shear wall.

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 fiberboard 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
WSP = 239 plf
Aspect Ratio > 2:1
Adjustment factor (based on stiffness) = 2b_s/h
= 2(2.5)/8 = 0.625 ← 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

\[ 239 \text{plf}(4')(4') + 149 \text{plf}(2)(2.5') = 4569 \text{ lbs adjusted capacity} \]

\[ 4569 \text{ lbs} > 4114 \text{ lbs (req'd capacity)} \quad \text{OK} \]

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

\[ C_o = \left( \frac{r}{3-2r} \right) \frac{L_{tot}}{\sum L_i} \leq 1 \]

\[ r = \frac{1}{1 + \frac{A_o}{h \sum L_i}} \]

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

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

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

---

2015 SDPWS – Perforated Shear Wall

\( C_o = 0.77 \)

\( 239 \text{ plf (0.77)} = 184 \text{ plf} \)

\( 4,114/184 = 22.3' \text{ req'd FHS} \)

\( 22.3' > 21' \text{ actual FHS NG} \)

6/12 nail spacing
### 2015 SDPWS – WSP Capacity

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

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<th>Fastener Type &amp; Size</th>
<th>Panel Edge Fastener</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Structural Panels – Sheathing</td>
<td>5/8</td>
<td>1/4</td>
<td>6d</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td>1/2</td>
<td>8d</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7/8</td>
<td>1/2</td>
<td>8d</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-1/2</td>
<td>10d</td>
<td></td>
<td></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** = \( \frac{760 \times 0.92}{2} = 350 \text{ plf} \)

### 2015 SDPWS – Perforated Shear Wall

\[ C_0 = 0.77 \]

350 plf \( (0.77) = 270 \text{ plf} \)

\[ \frac{4,114}{270} = 15.2' \text{ req'd FHS} \]

15.2' < 21' actual FHS OK

4/12 nail spacing
### 2015 SDPWS – Perforated Shear Wall

**4,114 lbs**

- 21’ actual FHS > 15.2’ req’d FHS — OK

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

\[ T = v \cdot h \]

- \( v = \frac{4,114}{19.1'} = 215 \text{ plf} \)
- \( h = 8' \)
- \( T = 215(8') = 1,723 \text{ lbs} \)

\[ T = C = v \cdot h \quad (4.3-7) \]

*where:*
- \( C \) = compression force, lbs
- \( h \) = shear wall height, ft
- \( T \) = tension force, lbs
- \( v \) = induced unit shear, lbs/ft

- 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' long; 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] 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] 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] 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

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