Wind Solutions - Perforated Wood Structural Panel Shear Walls (DES 416)

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**DESCRIPTION**

AWC’s 2015 Special Design Provisions for Wind and Seismic (SDPWS), 2015 Wood Frame Construction Manual (WFCM), and 2015 WFCM High Wind Guides contain provisions for the design of perforated wood structural panel shear walls. This presentation will provide examples of perforated shear wall design utilizing the WFCM, High Wind Guides, SDPWS, and the WoodWorks® software using both prescriptive and engineered solutions within the WFCM and SDPWS.

**LEARNING OBJECTIVES**

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

1. Evaluate a prescriptive and engineered design methodology for perforated wood shear walls.
2. Understand how to design wood structural panels to resist wind loads.
3. Design a wood frame wood structural panel shear wall shear loads.
4. Acquire knowledge on resources to develop solutions for resisting wind loads.
POLLING QUESTION

1. What is your profession?
   a) Architect
   b) Engineer
   c) Building Code Official
   d) Fire Service
   e) Other
**WFCM AND IRC/IBC**

2015 WFCM is referenced in 2015 IRC/IBC

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**APPLICABILITY LIMITS**

Table 1: Applicability Limitations

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<td>Mean Roof Height (MRH)</td>
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<td>11.1.3.1a</td>
<td>1.2</td>
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<td>Number of Stories</td>
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<td>-</td>
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<tr>
<td>Building Length and Width</td>
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<td>11.1.3.1b</td>
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<td><strong>LOAD ASSUMPTIONS</strong></td>
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<tr>
<td>Partition Dead Load</td>
<td>0-6 psf of floor area</td>
<td></td>
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<tr>
<td>Wall Assembly Dead Load</td>
<td>11-18 psf</td>
<td></td>
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</tr>
<tr>
<td>Floor Dead Load</td>
<td>10-20 psf</td>
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<td>Roof/Ceiling Assembly Dead Load</td>
<td>0-25 psf</td>
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<tr>
<td>Floor Live Load</td>
<td>50-40 psf</td>
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<td>Roof Live Load</td>
<td>20 psf</td>
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<td>10-20 psf</td>
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<td>Ground Snow Load</td>
<td>0-70 psf</td>
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<tr>
<td>Wind Load</td>
<td>110-195 mph wind speed (700-year. return period, 3-second gust) Exposure B, C, and D</td>
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<tr>
<td>Seismic Load</td>
<td>Seismic Design Category (SDC) SDC A, B, C, D, Dm, Ds, and Dp</td>
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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

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**2015 WFCM**

2015 WFCM uses SDPWS for shear capacities and ASCE 7-10 provisions for loads

**SDPWS AND IBC**

2015 SDPWS is referenced in 2015 IBC
Perforated Wood Shear Wall Design

**SDPWS**

**2015 SDPWS**

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

**POLLED QUESTION**

2. The Special Design Provisions for Wind and Seismic standard includes which of the following 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
OUTLINE

• 2015 IBC/IRC Recognition
• Background and Assumptions
• Design Examples
  • 2015 WFCM Prescriptive
  • 2015 WFCM Engineered
  • 2015 SDPWS
  • 2015 WFCM High Wind Guides

SEGMENTED SHEAR WALL (SSW) METHOD

• Lots of hold-downs
• Wall need not be fully sheathed
PERFORATED SHEAR WALL (PSW) METHOD

- Only hold-downs @ ends
- Wall must be fully sheathed

WFCM PRESCRIPTIVE

- Wind Speeds 110-195 mph Exp. B & C
- Segmented & Perforated Shear Walls
- Other Application Limits
3.4.4.2 Exterior Shear Walls
   a. Wind Loads Segmented shear walls shall be in accordance with the full height sheathing requirements specified in Table 3.17A. Tabulated values assume wall studs are spaced at a maximum of 16 inches on center, 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, and 1/2 inch gypsum wallboard on the interior attached with 5d common nails at 7 inches on center at panel edges and 10 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.

WFCM PRESCRIPTIVE

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, $\delta_{yw}$, 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 $2b_w/h$ 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 $2b_w/h$, the nominal shear capacities need not be reduced by the adjustment in 4.3.4.2.
POLLING QUESTION

3. The minimum shear walls construction consists of:

a) 3/8” wood structural panels on wall exterior
b) 8d common nails @ 6” oc at panel edges
c) 8d common nails @ 10” oc in panel field
d) All of the above
e) a) and b) only

OUTLINE

• 2015 IBC/IRC Recognition
• Background and Assumptions
• Design Examples
  • 2015 WFCM Prescriptive
  • 2015 WFCM Engineered
  • 2015 SDPWS
  • 2015 WFCM High Wind Guides
DESIGN EXAMPLE

Using the 2015 Wood Frame Construction Manual (WFCM), design the first floor wall shown in the diagram below as a perforated shear wall for a two-story house using Allowable Stress Design (ASD) provisions.

Design first floor shear wall

DESIGN EXAMPLE

Check maximum segment length based on Aspect Ratio Limits

Maximum aspect ratio for Wood Structural Panel Shear Walls $= 3.5:1$ (SDFWS 4.3.4.3)

Minimum segment length $= \frac{\text{Wall Height}}{\text{Aspect Ratio}}$

$$I_{\min} = \frac{9}{3.5} \quad I_{\min} = 2.6 \quad \text{Minimum full height wall segment length (ft)}$$

All full height segments satisfy aspect ratio requirements.
**DESIGN EXAMPLE**

Design Wind Speed = 160 mph (3 sec. gust, 700 year return)  
Exposure B  
Building dimensions:  
L = 40 ft  
W = 32 ft  
Roof pitch = 7:12  
Top plate to ridge height = 9.3 ft  
Wall height = 9 ft  
Door height = 7 ft 6 in.  
Window height = 4.5 ft  
Stud spacing = 16 in. o.c.  
Studs are Southern Pine (G=0.55)  

Check design with and without interior gypsum, neglect deflection.  
Use *Minimum Design Loads for Building and Other Structures (ASCE 7-10)* to determine loads.

---

**WFCM PRESCRIPTIVE**

2015 WFCM Prescriptive – Segmented Shear Wall

**Table 3.17a Segmented Shear Wall Sheathing Requirements for Wind**

<table>
<thead>
<tr>
<th>Shear Wall Line Beneath</th>
<th>20</th>
<th>24</th>
<th>32</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>110</th>
<th>115</th>
<th>120</th>
<th>130</th>
<th>140</th>
<th>150</th>
<th>160</th>
<th>170</th>
<th>180</th>
<th>195</th>
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<tbody>
<tr>
<td>Roof, Ceiling, &amp; 1 Floor</td>
<td>20</td>
<td>5.6</td>
<td>6.4</td>
<td>7.0</td>
<td>8.2</td>
<td>9.5</td>
<td>10.9</td>
<td>12.4</td>
<td>14.0</td>
<td>15.7</td>
<td>18.4</td>
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<td></td>
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<tr>
<td>24</td>
<td>7.0</td>
<td>7.7</td>
<td>8.4</td>
<td>9.8</td>
<td>11.4</td>
<td>13.1</td>
<td>14.9</td>
<td>16.8</td>
<td>18.9</td>
<td>21.1</td>
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<tr>
<td>32</td>
<td>8.2</td>
<td>9.0</td>
<td>9.8</td>
<td>11.5</td>
<td>13.3</td>
<td>15.3</td>
<td>17.4</td>
<td>19.6</td>
<td>22.0</td>
<td>25.8</td>
<td></td>
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<tr>
<td>50</td>
<td>9.4</td>
<td>10.3</td>
<td>11.2</td>
<td>13.1</td>
<td>15.2</td>
<td>17.5</td>
<td>20.0</td>
<td>22.9</td>
<td>26.8</td>
<td>31.5</td>
<td>37.7</td>
<td>44.0</td>
<td>52.2</td>
<td>62.0</td>
<td>73.8</td>
<td></td>
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</tbody>
</table>

*Minimum Length of Full Height Sheathing on Exterior Shear Walls Perpendicular to Building Dimension, L or W (ft)*

---

*Perforated Wood Shear Wall Design*
### WFCM PRESCRIPTIVE

**2015 WFCM Prescriptive – Segmented**

#### Footnotes to Table 3.17A

4. Tabulated sheathing lengths are based on 10 foot walls and 10 foot top plate-to-ridge height. For other configurations, the value may be multiplied by the adjustment factor below:

<table>
<thead>
<tr>
<th>Roof Pitch</th>
<th>Top Plate to Ridge Height (ft)</th>
<th>Wall Height</th>
<th>Roof Only</th>
<th>Roof + 1 Floor</th>
<th>Roof + 2 Floors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0' (flat)</td>
<td>8' 10'</td>
<td>0.35 0.43</td>
<td>0.58 0.72</td>
<td>0.66 0.81</td>
</tr>
<tr>
<td></td>
<td>5'</td>
<td></td>
<td>0.50 0.59</td>
<td>0.66 0.79</td>
<td>0.71 0.86</td>
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<tr>
<td></td>
<td>10'</td>
<td></td>
<td>0.65 0.74</td>
<td>0.74 0.87</td>
<td>0.76 0.91</td>
</tr>
<tr>
<td>&gt;6:12</td>
<td>5'</td>
<td>8' 10'</td>
<td>0.63 0.71</td>
<td>0.72 0.86</td>
<td>0.75 0.90</td>
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<tr>
<td></td>
<td>10'</td>
<td></td>
<td>0.92 1.00</td>
<td>0.87 1.00</td>
<td>0.85 1.00</td>
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<tr>
<td></td>
<td>15'</td>
<td></td>
<td>1.11 1.29</td>
<td>1.01 1.14</td>
<td>0.95 1.10</td>
</tr>
<tr>
<td></td>
<td>20'</td>
<td></td>
<td>1.49 1.58</td>
<td>1.13 1.29</td>
<td>1.04 NP</td>
</tr>
</tbody>
</table>

NP = not permitted

Interpolate = 0.91

---

### WFCM PRESCRIPTIVE

For this example the wall construction will vary from the WFCM baseline wall. The wall in this example will have the following construction:

Studs: 16 in. o.c.
Exterior Sheathing: 15/32 in. WSP w/ 8d common nails @ 3 in. edge/12 in. field o.c.
Interior Sheathing: 1/2 in. GWB w/ 5d common nails @ 7 in. edge/10 in. field o.c.

Sheathing Type Adjustment Factor (Wind) = 0.90 (WFCM Table 3.17D)

\[
\begin{align*}
L_{SSW} &= 19.9 - 0.6 - 0.91 \\
L_{SSW} &= 10.9 \\
L_{SSW} &= L_{SSW} (1 + \frac{0.272}{1}) \\
\end{align*}
\]

Required Full Height Sheathing Length on Segmented Shear Wall (ft)

\[
\frac{L_{SSW}}{L_{tot}} = 0.272 \\
\]

Required Full Height Sheathing Segmented Shear Wall (%)

\[
L_{PSW} := L_{SSW} \cdot 1.78 \\
L_{PSW} = 19.3 \\
\]

Required Full Height Sheathing Length on Perforated Shear Wall (ft)
**Perforated Wood Shear Wall Design**

**WFCM PRESCRIPTIVE**

For this example the wall construction will vary from the WFCM baseline wall. The wall in this example will have the following construction:
- Studs: 16 in. o.c.
- Exterior Sheathing: 15/32 in. WSP w/ 8d common nails @ 3 in. edge/12 in. field o.c.
- Interior Sheathing: None/Unrated
- Sheathing Type Adjustment Factor (Wind) = 0.89 (WFCM Table 3.17D)

\[
L_{SSW} = 19.9 - 0.69 - 0.91
\]

\[
L_{SSW} = 12.5\ 	ext{ Required Full Height Sheathing Length on Segmented Shear Wall (ft)}
\]

\[
\frac{L_{SSW}}{L_{tot}} = 0.312\ 	ext{ Required Full Height Sheathing Segmented Shear Wall (%)}
\]

Perforated Shear Wall Length Adjustment Factor = 1.70 (WFCM Table 3.17E)

\[
L_{PSW} = L_{SSW} \cdot 1.70
\]

\[
L_{PSW} = 21.2\ 	ext{ Required Full Height Sheathing Length on Perforated Shear Wall (ft)}
\]

**Note:** Max. aspect ratio = 3.5:1 for PSW segments

---

**2015 WFCM Prescriptive – Perforated Shear Wall**

**% Full-height sheathing**

- 10.9’ / 40’ = 27%
- Interpolated = 1.78
- 10.9’(1.78) = 19.3’
  - w/ blocked gypsum
- 12.5’ / 40’ = 31%
- 12.5’(1.70) = 21.2’
  - w/o gypsum

**Table 3.17E Perforated Shearwall Full Height Sheathing Adjustments**

<table>
<thead>
<tr>
<th>Window Height</th>
<th>25%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>10' Wall</td>
<td>1.00</td>
<td>1.30</td>
<td>1.54</td>
<td>1.72</td>
<td>1.92</td>
<td>2.14</td>
<td>2.36</td>
<td>2.50</td>
<td>2.63</td>
</tr>
<tr>
<td>12' Wall</td>
<td>1.00</td>
<td>1.33</td>
<td>1.58</td>
<td>1.82</td>
<td>2.02</td>
<td>2.28</td>
<td>2.55</td>
<td>2.82</td>
<td>3.02</td>
</tr>
</tbody>
</table>

**Note:** Max. aspect ratio = 3.5:1 for PSW segments

---

**Perforated Wood Shear Wall Design**

> 22’ Full-height sheathing > 21.2’ OK

Note: 2015 WFCM Prescriptive – Perforated Shear Wall

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**WFCM PRESCRIPTIVE**

2015 WFCM Prescriptive – Hold-downs

Hold-downs
3,924 / 0.60
= 6,540 lbs
w/ blocked gypsum

3,924 / 0.69
= 5,687 lbs
w/o gypsum

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

---

**WFCM ENGINEERED**

2015 WFCM Engineered

\[ w_{\text{roof}} = 169 \text{ plf} \]

\[ w_{\text{floor}} = 194(0.91)^* = 177 \text{ plf} \]

\[ w_{\text{total}} = 346 \text{ plf} \]

\[ 346 \text{ (32')}/2 = 5,536 \text{ lbs} \]

*Footnote 2: \((H+1)/11\)
adjustment = \((9+1)/11\)
Perforated Wood Shear Wall Design

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

2 Walls having aspect ratios exceeding 1.5:1 shall be blocked shear walls and the maximum aspect ratio shall not exceed 2:1 in accordance with SDPWS Table 4.3.4.

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WFCM ENGINEERED

2015 WFCM Engineered – Segmented

Required Capacity = 5,536 lbs
7/16” WSP Capacity = 630 plf
1/2” Gypsum Capacity = 100 plf
Total = 730 plf

\[
\frac{5,536}{730} = 7.6' \text{ (w/ blocked gypsum)}
\]

\[
\frac{5,536}{630} = 8.7' \text{ (w/o gypsum)}
\]
2015 WFCM Engineered - Perforated Reference SDPWS Capacities and Adjustments

\[ V = 5,536 \text{ lbs} \]
\[ v = 730 \text{ plf (w/ blocked gypsum)} \]
\[ v = 630 \text{ plf (w/o gypsum)} \]

\[ \%\text{FHS} = \frac{L_i}{L_{tot}} \]
\[ L_i = 2(5') + 4\left[\frac{(2\times3')\times3'}{9'}\right] = 18' \]
\[ L_{tot} = 40' \]
\[ \%\text{FHS} = 18'/40' = 45\% \]

Interpolated \( c_o \) Factor = 0.55

\[ 730(0.55) = 402 \text{ plf} \]
\[ 5,536/402 = 13.8' < 18' \text{ (w/ blocked gypsum)} \]

\[ 630(0.55) = 347 \text{ plf} \]
\[ 5,536/347 = 16' < 18' \text{ (w/o gypsum)} \]

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

\[ T = v \cdot h \]
\[ v = 730 \text{ plf (w/ blocked gypsum)} \]
\[ v = 630 \text{ plf (w/o gypsum)} \]
\[ h = 9' \]

\[ T = 730(9') = 6,570 \text{ lbs} \]
\[ T = 630(9') = 5,670 \text{ lbs} \]

- 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)
### 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 Spacing (in.)</th>
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<td>6</td>
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<td></td>
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<td></td>
<td></td>
<td>$v_u$</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>5/16</td>
<td>1-1/4</td>
<td>Nail (common or galvanized box)</td>
<td>560</td>
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<tr>
<td>Wood Structural Panels</td>
<td>3/8</td>
<td>1-3/8</td>
<td>8d</td>
<td>645</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>7/16</td>
<td>1-3/8</td>
<td>8d</td>
<td>715</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>1&quot;</td>
<td>1-1/2</td>
<td>8d</td>
<td>755</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>5/16</td>
<td>1-3/8</td>
<td>6d</td>
<td>550</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>3/8</td>
<td>1-3/8</td>
<td>8d</td>
<td>670</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>7/16</td>
<td>1-3/8</td>
<td>8d</td>
<td>730</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>1&quot;</td>
<td>1-1/2</td>
<td>6d</td>
<td>670</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>5/16</td>
<td>1-3/8</td>
<td>8d</td>
<td>550</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>3/8</td>
<td>1-3/8</td>
<td>8d</td>
<td>670</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>7/16</td>
<td>1-3/8</td>
<td>8d</td>
<td>730</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>1&quot;</td>
<td>1-1/2</td>
<td>6d</td>
<td>670</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>5/16</td>
<td>1-3/8</td>
<td>8d</td>
<td>550</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>3/8</td>
<td>1-3/8</td>
<td>8d</td>
<td>670</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>7/16</td>
<td>1-3/8</td>
<td>8d</td>
<td>730</td>
</tr>
<tr>
<td>Wood Structural Panels</td>
<td>1&quot;</td>
<td>1-1/2</td>
<td>6d</td>
<td>670</td>
</tr>
</tbody>
</table>

**ASD Capacity** = 1065/2 = 533 plf

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

<table>
<thead>
<tr>
<th>Sheathing Material</th>
<th>Material Thickness</th>
<th>Fastener Type &amp; Size</th>
<th>Min. Fastener Edge Spacing (in.)</th>
<th>WIND $v_u$ (plf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Gypsum and Portland Cement Plaster</td>
<td>1/2&quot;</td>
<td>Nail (common or galvanized box)</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>16</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

**ASD Capacity** = 200/2 = 100 plf
**SDPWS**

2015 SDPWS – Perforated Shear Wall

Shear Capacity Adjustment Factor (SDPWS Eqns. 4.3-5 & 4.3-6)

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

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

\[ h = 9' \]

\[ L_i = 2(5) + 4\left[\frac{2*3}{9}*3\right] = 18' \]

\[ L_{tot} = 40' \]

\[ A_o = 4(4.5')(3') + (6')(7.5') = 99 \text{ ft}^2 \]

\[ r = 0.62 \]

\[ C_o = 0.78 \] (based on total sheathed area)

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

---

**SDPWS**

2015 SDPWS – Perforated Shear Wall

\[ C_o = 0.78 \]

w/ blocked gypsum

633 (0.78) = 494

5,536/494 = 11.2'

w/o gypsum

533 (0.78) = 416

5,536/416 = 13.3'

18' Effective Full-height sheathing > 13.3' OK
Perforated Wood Shear Wall Design

**SDPWS**

**2015 SDPWS – Perforated Shear Wall**

![Diagram of perforated shear wall]

- 5,536 lbs
- 18' Effective Full-height sheathing > 13.3' OK

**SDPWS**

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

\[ T = \frac{C_o \cdot V \cdot h}{C_i \cdot \sum L_i} \]  

where:
- \( C_o \) = shear capacity adjustment factor from Table 4.3.3.5
- \( V \) = induced shear force in perforated shear wall, lbs
- \( h \) = height of perforated shear wall, ft
- \( L_i \) = sum of perforated shear wall segment lengths \( L_i \) ft. Lengths of perforated shear wall segments with aspect ratios greater than 2:1 shall be adjusted in accordance with 4.3.4.3

- Req'd Hold-down Capacity = 3,549 lbs

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

2015 WFCM/SDPWS Shear Wall Length Comparison  
[Bracketed text indicates values without gypsum]

<table>
<thead>
<tr>
<th>AWC Standard</th>
<th>Full Height Sheathing</th>
<th>Hold-downs, lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015 WFCM Prescriptive</td>
<td>19.3’ [21.2’] (3/12)</td>
<td>6,540 [5,687]</td>
</tr>
<tr>
<td>2015 WFCM Engineered</td>
<td>13.8’ [16’] (3/12)</td>
<td>6,570 [5,670]</td>
</tr>
<tr>
<td>2015 SDPWS</td>
<td>11.2’ [13.3’] (4/12)</td>
<td>3,549 [PSW]</td>
</tr>
</tbody>
</table>

### WOODWORKS® DESIGN OFFICE 11 SOFTWARE

- **SIZER**  
  - Gravity Design  
  - Concept mode  
  - Beam mode  
  - Column mode

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

- **CONNECTIONS**  
  - Fasteners

- **DATABASE EDITOR**  
  - Add proprietary products

[woodworks-software.com](http://woodworks-software.com)
WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

**CAD IMPORT**
1. Specify # of levels
2. Export metafile (.pdf, .emf, .wmf, .bmp) for each level from CAD & import each level
3. Select “Start positioning”
4. Use Zoom controls to place crosshairs on CAD drawing
5. Input (x,y) coordinates & distances

WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

**DESIGN SETTINGS**
Perforated Wood Shear Wall Design

Assume 15/32 in. thick Wood Structural Panel (WSP) Sheathing, 8d nails @ 4 in. o.c. edge spacing. SDPWS Table 4.3A nominal capacity = 1065 lbs/ft (Wind)

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WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

Perforated Wood Shear Wall Design

Stud spacing = 16 in. o.c.
Studs are Southern Pine (G=0.55)

WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

L = 40 ft
W = 32 ft

Perforated Wood Shear Wall Design
**Perforated Wood Shear Wall Design**

**WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE**

Exterior surface:
- 15/02" Structural sheathing w/ 5d nails @ 4/12"
- Interior surface:
- 1/2" Gypsum WBoard 1-ply w/ 5d nails @ 7/7"

Effective length of Full Height Segments (ft) using adjustment from SDPWS 4.3.3.4.1 Exception

Area of openings (ft²)
- (SDPWS Eqn. 4.3-6)
- (SDPWS Eqn. 4.3-5)

---

**Perforated Wood Shear Wall Design**

---

**Perforated Wood Shear Wall Design**

---

**Perforated Wood Shear Wall Design**
Design Wind Speed = 160 mph (3 sec. gust, 700 year return)
Exposure B
WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

Perforated Wood Shear Wall Design

WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

Perforated Wood Shear Wall Design
WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

V := 5520 Wind reaction on shear wall (lbs)

Perforated Wood Shear Wall Design
### SHEATHING MATERIALS by WALL GROUP

<table>
<thead>
<tr>
<th>Grp</th>
<th>Surf</th>
<th>Material</th>
<th>Rating Thick</th>
<th>GU in</th>
<th>Ply</th>
<th>Or</th>
<th>Gvrt lbs/in</th>
<th>Size</th>
<th>Type</th>
<th>Df</th>
<th>Eg</th>
<th>Fd</th>
<th>Blk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ext</td>
<td>Structural sheath Gyp WB 1-ply</td>
<td>32/16 15/32</td>
<td>3</td>
<td>Vert</td>
<td>27000</td>
<td>8d</td>
<td>Nail</td>
<td>N</td>
<td>4</td>
<td>12</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>int</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5d</td>
<td>Nail</td>
<td>N</td>
<td>7</td>
<td>7</td>
<td>N</td>
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</table>

### FRAMING MATERIALS and STANDARD WALL by WALL GROUP

<table>
<thead>
<tr>
<th>Wall Grp</th>
<th>Species</th>
<th>Grade</th>
<th>b in</th>
<th>d in</th>
<th>Spc</th>
<th>SG psi^6</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>S. Pine</td>
<td>Stud</td>
<td>1.50</td>
<td>5.50</td>
<td>16</td>
<td>0.55</td>
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### WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

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<tbody>
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<td>Level 1</td>
<td>0.00</td>
<td>0.00</td>
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<td>18.00</td>
<td>-</td>
<td>9.00</td>
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<td>Prf</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>40.00</td>
<td>18.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Segment 1</td>
<td></td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>3.00</td>
<td>3.00</td>
<td>2.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Opening 1</td>
<td></td>
<td></td>
<td>3.00</td>
<td>6.00</td>
<td>3.00</td>
<td>3.00</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Segment 2</td>
<td></td>
<td></td>
<td>0.00</td>
<td>6.00</td>
<td>9.00</td>
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<td>2.00</td>
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<td></td>
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<td>3.00</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Opening 4</td>
<td></td>
<td></td>
<td>23.00</td>
<td>28.00</td>
<td>5.00</td>
<td>5.00</td>
<td>1.80</td>
<td>-</td>
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<tr>
<td>Segment 5</td>
<td></td>
<td></td>
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<td>28.00</td>
<td>3.00</td>
<td>3.00</td>
<td>-</td>
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<tr>
<td>Opening 5</td>
<td></td>
<td></td>
<td>29.00</td>
<td>31.00</td>
<td>3.00</td>
<td>3.00</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Segment 6</td>
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<td></td>
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<td>34.00</td>
<td>3.00</td>
<td>3.00</td>
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<td>-</td>
</tr>
</tbody>
</table>
WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

WIND SHEAR FORCES (Directly Applied by User)

<table>
<thead>
<tr>
<th>Shear Line</th>
<th>Level</th>
<th>Profile</th>
<th>Distribution Method</th>
<th>Magnitude [lbs]</th>
<th>Wind Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>Point</td>
<td>Both</td>
<td>5520</td>
<td>Both</td>
</tr>
</tbody>
</table>

Perforated Wood Shear Wall Design

WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

SHEAR RESULTS

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Line A Level 1</td>
<td>lnA, Lev1</td>
<td>Both</td>
<td>306.7, 391.0, 5520</td>
<td>1.0, 1.0, 100, 532, 0.78</td>
<td>A, 496, 8922</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Legend:
- W Gp: Wall design group defined in Sheathing and Framing Materials tables, where it shows associated Standard Wall. "Y" means that this wall is critical for all walls in the Standard Wall group.
- For Dir: Direction of wind force along shearline.
- ASD Shear force on segment = ASD factored shear force per unit FHS vmax = Collector shear force for perforated walls as per SDPWS eqn. 4.3.8 = V/FHS/Co. Full height sheathing (FHS) factored for narrow segments as per 4.3.4.3
- App-Cub = For wall: Unfactored structural wood panel factor Cub from SDPWS 4.3.3.2. For segment: Aspect ratio adjustment from SDPWS 4.3.3.2.4
- Int - Unit shear capacity of interior sheathing; Ext - Unit shear capacity of exterior sheathing. For wall: Unfactored. For segment: Include Cub factor and aspect ratio adjustments.
- Co - Adjustment factor for perforated walls from SDPWS Equation 4.3-3.
- C1 - Sheathing combination rule: A = Add capacities; S = Strongest side or twice weakest; G = Stiffness-based using SDPWS 4.3-3.
- Comb - Combined interior and exterior unit shear capacity including perforated wall factor Co.
- V = Total factored shear capacity of shearline, wall or segment.
WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

Assume 15/32 in. thick Wood Structural Panel (WSP) Sheathing, 8d nails @ 4 in. o.c. edge spacing. SDPWS Table 4.3A nominal capacity = 1065 lbs/ft (Wind)

Perforated Wood Shear Wall Design

---

WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

<table>
<thead>
<tr>
<th>Grp</th>
<th>Surf</th>
<th>Material</th>
<th>Rating</th>
<th>Sheathing Thick in</th>
<th>GU</th>
<th>Ply</th>
<th>Or</th>
<th>Gvty lbs/in</th>
<th>Size</th>
<th>Type</th>
<th>Df</th>
<th>Eg</th>
<th>Fd</th>
<th>Bk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ext</td>
<td>Structural sheath</td>
<td>32/16</td>
<td>15/32</td>
<td>-</td>
<td>3</td>
<td>Vert</td>
<td>27000</td>
<td>8d</td>
<td>Nail</td>
<td>N</td>
<td>4</td>
<td>12</td>
<td>Y</td>
</tr>
</tbody>
</table>

Perforated Wood Shear Wall Design
**WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE**

### SHEAR RESULTS

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ltn, Lvl 1</td>
<td>1</td>
<td>Both</td>
<td>306.7</td>
<td>391.0</td>
<td>5520</td>
<td>1.0</td>
<td>532</td>
<td>0.78</td>
<td>417</td>
<td>751</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- **W Gp:** Wall design group defined in Sheathing and Framing Materials tables, where it shows associated Standard Wall. "**" means that this wall is critical for all walls in the Standard Wall group.
- **For Dir:** Direction of wind force along sheathline.
- **v:** Design shear force on segment = ASD factored shear force per unit PSF.
- **v vvmx:** Shear force for perforated walls as per SDPW 4.3.8 = V/FHS/GC. Full height sheathing (FHS) factored for narrow segments are per 4.3.9.3.
- **V:** ASD factored shear force. For sheathline, total shear force for wall, total of all segments on wall. For segment: force on segment.
- **AppCub:** For wall: Unfactored structural wood panel factor Cub from SDPW 4.3.3.2. For segment: Aspect ratio adjustment from SDPW 4.3.3.4.1.
- **Int:** Unit shear capacity of interior sheathling, Ext: Unit shear capacity of exterior sheathling. For wall: Unfactored. For segment: Include Cub factor and aspect ratio adjustments.
- **Co:** Adjustment factor for perforated walls from SDPW 4.3.3.2.
- **S:** Sheathing combination rule, A = Add capacities, S = Strongest side or twice weakest, G = Stiffness-based using SDPW 4.3.3.
- **Cmb:** Combined interior and exterior unit shear capacity including perforated wall factor Co.
- **V:** Total factored shear capacity of sheathline, wall or segment.
- **Resp. Rsp.** Response ratio = v/Cmb = design shear force/unit shear capacity. "**" indicates that the wind design criterion was critical in selecting.

### HOLD-DOWN DESIGN (flexible wind design)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>L End</td>
<td>0.00</td>
<td>0.00</td>
<td>1</td>
<td>3519</td>
<td>3519</td>
<td>HD55-S552</td>
<td>5645</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>A-1</td>
<td>R End</td>
<td>39.75</td>
<td>0.00</td>
<td>1</td>
<td>3519</td>
<td>3519</td>
<td>HD55-S552</td>
<td>5645</td>
<td>0.62</td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- **Line A:** At wall or opening - Sheathline and wall number. At vertical element - Sheathline
- **Pos'n:** Position of stud that holds-down is attached to.
- **Location:** Location of stud that holds-down is attached to, left or right side of opening.
- **Load Case:** Shear = Wind shear overturning component, based on sheathline forces, factored for ASD by 0.8. For perforated walls, T from SDPW 4.3.8.4.
- **Hold-down:** Perforated shear overturning, dead and uplift forces. They also include the uplift forces for perforated walls from SDPW 4.3.8.4.
- **Cmb'd:** Combined ASD factored overturning, dead and uplift forces. They also include the uplift forces for perforated walls from SDPW 4.3.8.4.
- **Crit Resp.:** Critical Response = Combined ASD factor + Allowable ASD tension load.

**Notes:**
- Refer to Shear Results table for factor Co, and sheathline dimensions table for the sum of F, used to calculate tension force T for perforated walls from SDPW 4.3.8.
### WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

#### MWFRS DEFLECTION (flexible wind design)

<table>
<thead>
<tr>
<th>Wall segment</th>
<th>W Gp</th>
<th>Dir</th>
<th>Srf</th>
<th>v plf</th>
<th>b ft</th>
<th>h ft</th>
<th>Bending A sq.in</th>
<th>Defl in</th>
<th>Ga kips/ in</th>
<th>Nail slip in</th>
<th>Shear Defl in</th>
<th>Hold Defl in</th>
<th>Total Defl in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Line A</td>
<td>1 Both</td>
<td>Ext</td>
<td>391.0</td>
<td>18.00</td>
<td>9.00</td>
<td>16.5</td>
<td>.006</td>
<td>13.1</td>
<td>177</td>
<td>.028</td>
<td>.269</td>
<td>0.07</td>
</tr>
</tbody>
</table>

#### SERVICEABILITY DEFLECTION (flexible wind design)

<table>
<thead>
<tr>
<th>Wall segment</th>
<th>W Gp</th>
<th>Dir</th>
<th>Srf</th>
<th>v plf</th>
<th>b ft</th>
<th>h ft</th>
<th>Bending A sq.in</th>
<th>Defl in</th>
<th>Ga kips/ in</th>
<th>Nail slip in</th>
<th>Shear Defl in</th>
<th>Hold Defl in</th>
<th>Total Defl in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Line A</td>
<td>1 Both</td>
<td>Ext</td>
<td>254.6</td>
<td>18.00</td>
<td>9.00</td>
<td>16.5</td>
<td>.004</td>
<td>18.6</td>
<td>115</td>
<td>.008</td>
<td>.123</td>
<td>0.06</td>
</tr>
</tbody>
</table>

---

### WOODWORKS® SHEARWALLS SOFTWARE EXAMPLE

#### STORY DRIFT (flexible wind design)

<table>
<thead>
<tr>
<th>Level</th>
<th>Dir</th>
<th>Wall height ft</th>
<th>Actual Story Drift (in)</th>
<th>Allowable Story Drift ft</th>
<th>Drift in</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E&lt;-&gt;W</td>
<td>9.00</td>
<td>0.19 A</td>
<td>9.00</td>
<td>0.22</td>
<td>0.87</td>
</tr>
</tbody>
</table>

**Legend:**
- Max defl – Largest deflection for any shearline on level in this direction; refer to Serviceability Deflections table.
- Line – Shearline with largest deflection on level in this direction.
- hs = Story height = Height of walls plus joist depth between this level and the one above.
- Drift = Allowable story drift on this level = story height / 500
- Ratio = Proportion of allowable story drift experienced on this level in this direction.
POLLING QUESTION

4. The WoodWorks® Shearwalls software has the ability to automatically generate wind and seismic loads, as well as the ability to manually input lateral loads?

a) True
b) False

2015 WFCM HIGH WIND GUIDES
**2015 WFCM HIGH WIND GUIDES**

Scope restrictions

- Mean Roof Height (MRH) maximum = 33’
- Top plate to ridge height maximum = 10’
- Roof truss/rafter maximum span = 36’
- Maximum building dimension (L or W) = 80’

**2015 WFCM HIGH WIND GUIDES**

Additional restrictions beyond WFCM

- Openings limited to 6’-8”
  - Can go up to 8’ with 5% increase in FHS lengths (Tables 12/13)
- Aspect Ratios are limited based on wind speed
- Buildings must be rectangular (max. 4’ wall offset)
  - Non-rectangular buildings can use inscribed method
  - Separate structures must be designed per WFCM
**DESIGN EXAMPLE**

**Assumptions**
140 mph (700-yr, 3-second gust) Exposure B
L = 36'
W = 30'
5/12 roof pitch
Top plate to ridge = 6.25'
2-story
8’ wall height
6’8” door height
4’ window height
Wood Structural Panel Exterior Sheathing w/ Gable End Walls

**L/W** = 36’/30’ = 1.2
DESIGN EXAMPLE

Wall Heights = 8'

OK

Table 5. Exterior Wall - Maximum Wood Stud Lengths

<table>
<thead>
<tr>
<th>Exterior Studs</th>
<th>#2 Stud</th>
<th>#2 Stud</th>
<th>#2 Stud</th>
<th>Stud</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Loadbearing Studs</td>
<td>12&quot; c.c.</td>
<td>12&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
</tr>
<tr>
<td></td>
<td>16&quot; c.c.</td>
<td>12&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
</tr>
<tr>
<td></td>
<td>24&quot; c.c.</td>
<td>10&quot; - 0&quot;</td>
<td>8&quot; - 5&quot;</td>
<td>5&quot; - 5&quot;</td>
</tr>
<tr>
<td>Loadbearing Studs Supporting Roof and Ceiling Only</td>
<td>12&quot; c.c.</td>
<td>9&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
</tr>
<tr>
<td></td>
<td>16&quot; c.c.</td>
<td>9&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
</tr>
<tr>
<td></td>
<td>24&quot; c.c.</td>
<td>9&quot; - 9&quot;</td>
<td>5&quot; - 5&quot;</td>
<td>8&quot; - 8&quot;</td>
</tr>
<tr>
<td>Loadbearing Studs Supporting Roof, Ceiling, and 1 Floor Only</td>
<td>12&quot; c.c.</td>
<td>9&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
</tr>
<tr>
<td></td>
<td>16&quot; c.c.</td>
<td>9&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
<td>9&quot; - 9&quot;</td>
</tr>
<tr>
<td></td>
<td>24&quot; c.c.</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
</tbody>
</table>

NP= Not Permitted

1 Maximum stud lengths are for studs located in interior wind zones. For studs located within 4 feet of corners, space studs at 80% of the tabulated spacing or design studs per the WFCM.
Perforated Wood Shear Wall Design

Assumes perforated shear wall with hold-downs only at the ends

WFCM HIGH WIND GUIDE

Load Bearing Walls

Second Floor
Using 6" edge/ 12" field spacing:
L/W = 36'/30' = 1.2
Interpolated = 36.2% = 13'
Available = 23.5' OK
Hold Down Capacity = 4,360 lb
Load Bearing Walls

First Floor
Using 6" edge/ 12" field spacing:
L/W = 36'/30' = 1.2
Interpolated = 59.8% = 21.5'
Available = 21' NG!

Using 4" edge/ 12" field spacing:
L/W = 36'/30' = 1.2
Interpolated = 46.8% = 16.9'
Available = 21' OK
Hold Down Capacity = 5,900 lb
Combined Hold-down: 5,900 + 4,360 = 10,260 lb

Gable End – Second Floor
Using 6" edge/ 12" field spacing:
L/W = 36'/30' = 1.2
Interpolated = 47.4% = 14.2'
Maximum Openings = 15.8'
Hold Down Capacity = 4,360 lb

Gable End – First Floor
Using 6" edge/ 12" field spacing:
L/W = 36'/30' = 1.2
Interpolated = 75% = 22.5'
Maximum Openings = 7.5'
Hold Down Capacity = 4,360 lb
Combined Hold-down: 4,360 + 4,360 = 8,720 lb
WFCM HIGH WIND GUIDE

Controlling Hold-Down

10,260 lb > 8,720 lb
10,260 lb can be used at all 4 corners

POLLING QUESTION

5. The 2015 WFCM uses shear wall design capacities from which of the following:
   a) 2015 International Building Code
   b) 2015 SDPWS
   c) ASCE 7-10
   d) None of the above
This concludes the American Institute of Architects Continuing Education Systems Course.