RISA Webinar

In-Depth Look at Wood Wall Design in RISA

Presenter: Deborah Brisbin, P.E.
Walls geometry is based on the Design Rules Spreadsheet (Studs, etc.)

Design criteria can be set in the Design Rules

Or you can narrow down the criteria in the Wood Schedules

Wood Wall Parameters
Using this Spreadsheet

- Select the Code
  Then select the “Group” for design OR Select a Single Panel

- Based on the Excel Spreadsheets outside of the RISA programs
  C:\RISA\RISA_Wood_Schedules\ShearPanels

Wood Wall Parameters
Required Fields

Label

**Min Panel Thickness** - Used to set the elastic stiffness of the wall panel used during the FEM solution.

**Ga** - Apparent Shear Stiffness – from NDS Equation 4.3-1

**One/Two Sided** – used during optimization

**Boundary Nail Spacing** – used during optimization

**Shear Capacity** – value for code check capacity

All other fields are Optional

Wood Wall Parameters
Shear Capacity

- Based the Seismic Loads or the Wind Loads capacities with Global Parameters turned on

- Must use the Load Categories in Basic Load Cases & Load Combinations

Wood Wall Parameters
**Required Fields**

**Label**

**Deflection at Peak Load** used to calculate the deflection per APA/NDS formula.

\[ \Delta_a = \frac{8vhl^3}{EAb} + \frac{vh}{1000G_e} + \frac{h\Delta_a}{b} \]

\( \Delta_a \) = Total vertical elongation of wall anchorage system (including fastener slip, device elongation, rod elongation, etc.) at the induced unit shear in the shear wall, in

Since this is the PEAK Load, to find the actual deflection it is scaled per the actual tension force; by multiplying this value by the holddown ratio given in the output.

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**Wood Wall Parameters**
Required Fields

**CD Factor** - the assumed load duration factor that was used to find the **Allowable Tension** value for that hold down. (1.33 per Simpson Catalog)

**Allowable Tension** – from the manufacturer’s catalog - adjusted based on the difference between the assumed and actual load duration factors.

All other fields are Optional

**Wood Wall Parameters**
Program Default – Continuous Pinned

Manually set to “FREE” Boundary Condition with HD’s

NOTE: All Wall Boundary Conditions need to be added in the wall panel editor.
Joint Reactions Spreadsheet

- Per Wall Reactions- Forces & Moment

Display Individual Plate forces – Plot Options – Display Joint Reactions

Boundary Conditions Assumptions
Walls consists of Plate Elements

- Automatically meshed

Mesh Size controlled by Global Parameters

Turn on the Mesh in Plot Options

FEA Analysis
Wall Panel Loads

Distributed Loads
- Global Axis (X,Y,Z)
- Local Axis (x,y,z)

Joint Loads
- Joint Loads can be anywhere on the wall
- Need to create a Joint first

Surface Loads
- Not advisable for Wood Walls with Flexible Diaphragms
  Very little Out of Plane Stiffness
Segmented Design based on “Regions” defined within a wall

- A Region must be Rectangular

- Regions can be defined by the user
  - Auto-Defined
  - OR Not defined and Auto-Defined at run-time

- Only the Full-height Regions are designed

- Hold Downs are automatically placed at each side of the region
Select Design Method in Wall Panel Editor:
Segmented
Perforated
FTAO

Or in the Wall Panel Spreadsheet
• Each Region has Detail Report
  Designing the Chords & Hold-downs per region

• No Header Design in Segmented Design \(\rightarrow\) Ineffective Section

• h/w ratio is required for design (NDS Table 4.3.4)
Echo Input
Geometry of the Entire wall
Max H/W Ratio- per Region
Enveloped Results
Controlling Region
Region Information
Deflection Information

Wall Detail Report
NDS Special Design Provisions for Wind And Seismic
Eq 4.3-1

\[
\delta_{sw} = \frac{8vh^3}{EAb} + \frac{vh}{1000G_a} + \frac{h\Delta_a}{b}
\]

E = Modulus of elasticity of end posts (chords), psi
A = Area of end post (chord) cross-section, in²

Ga = Apparent Shear Stiffness from nail slip and panel deformation.
This value (in combination with the Min Panel Thickness) is used to set the elastic stiffness of the wall panel that will be used during the FEM solution.

\[\Delta_a = \text{Total vertical elongation of wall anchorage system (including fastener slip, device elongation, rod elongation, etc.) at the induced unit shear in the shear wall, in}\]

Deflection & FEA Analysis
FEM Deflection → NDS Imperial Equation

**SSAF (Shear Stiffness Adjustment Factor)**
This column allows the user to manually adjust the shear stiffness of a particular wall panel.

With this adjustment factor the user can match up the deflections from their hand calculations with the FEM joint deflections at the top nodes in the wall.

**Deflection & FEA Analysis**
Enveloped Results

Controlling Region

Wall Detail Report
• Echo Input
• Region Geometry
  Region H/W
  Capacity Adjustment Factor per 4.3.4.1
  Wind ASIF - NDS give 40% increase in the lateral tabular values
  Stud Spacing - Per Design Rules

Design Summary

• Shear capacity from Wall Panel database
  (based on IBC 06 Table 2306.4.1)

• Chords Forces

Region Detail Report
Chord Forces

- Calculated differently Tension vs. Compression
- Tension: NDS 2005 4.3.6.4.2 includes Dead Load stabilizing moment
- Compression: Include only the tributary area of one stud spacing

Segmented Design: Chord forces based on only one Region

FTAO & Perforated: Chord Forces based on the entire wall

Chord Force = \( \frac{M}{L} - \frac{P}{2} \) for Tension

Chord Force = \( \frac{M}{L} + \frac{P}{\# \text{Studs}} \) for Compression

M = Max Moment in the wall
L = Length of the wall
P = Axial Force in the wall

Chord Design
Stud Design

- Stud design is based on the Enveloping the maximum section forces from each region over the entire wall.

- Stud Spacing based on Required Capacity (unless spacing explicit in Design Rules)

- Code Check: Required Cap / Provided Cap

- Optimizing spacing starts at max and work its way down at 2” increments

NOTE: All the load combos considered
Run a batch solution with only Gravity only loads

Region Detail Report
Hold Down Forces

• Tension only forces

• Provided Cap is the **Allowable Tension** column of the hold-down database.

• The hold-down LC Governing is the largest tension force.

**NOTE:** The HD Deflection is reported for the maximum shear LC, which may not result in the largest hold-down component, but typically results in the highest total deflection.

Region Detail Report
Selected Shear Panel

- Echo all information from Shear Panel Database
- Adjusted Capacity:
  - Seismic force controls: 2bs/h from IBC06 2305.3.8.2.2.3
  - Wind force controls: 1.4 Increase

Selected Hold-Down

- Echo all information from Hold-Down Database
- The "Base Capacity" is the capacity from the manufacturer divided by the assumed Cd value from the database. The actual capacity of the hold-down is the Base Capacity*CD factor.
Cross Section Detailing

- Wall thickness, and stud spacing
- Sheathing panel designation.
- Chord sizes/forces with $T =$ Tension, or $C =$ Compression forces
- Hold down designations/forces

Note: If either chord is only experiencing a compression ONLY force, the hold down will not be drawn.

Region Detail Report
Perforated Design

• Use only the portions of wall that have full height sheathing

• Treat the wall instead as a significantly shorter wall.

• Amplifies the chord and hold down design forces significantly while at the same time increasing the design unit shear

• There are a number of Code constraints- which are enforced in RISA (NDS05 4.3.5.3)

• Hold Downs only at the ends of the walls
Perforated Design - Header Design

- All Load combinations enveloped
- Header suggestion: Run Gravity Loads for design
- Code check based on Shear and Moment only
  Not Axial Loads
The length of the wall is calculated:

$$\sum L_i = L_1 + L_2$$

Max induced unit shear force (NDS05 4.3-6):

$$v_{\text{max}} = \frac{V}{C_0 \cdot \sum L_i}$$

Tension and Compression Chord forces (NDS05 4.3-5)

$$T = \frac{V \cdot h}{C_0 \cdot \sum L_i}$$

$C_0 =$ Shear Capacity Adjustment Factor (NDS05 Table 4.3.3.4)

or

Calc using equ. available in NDS08

$$C_0 = \left(\frac{r}{3 - (2 \times r)}\right) \cdot \frac{L_{\text{tot}}}{\sum L_i}$$

$$r = \frac{1}{1 + \left(\frac{A_0}{h \cdot \sum L_i}\right)}$$
Ao defined by NDS05 Table 4.3.3.4
“maximum opening height shall be taken as the Maximum opening clear height in a perforated shear wall.”

Ao = \[2.5' \times 5' = 15 \text{ ft}^2\]

\[r = \frac{1}{1 + (15/10 \times 7.5)} = .83\]

\[C_0 = \frac{.83}{3-(2 \times 0.83)} \times 10' = .83\]

Perforated Design

<table>
<thead>
<tr>
<th>Materials</th>
<th>Description</th>
<th>Material</th>
<th>Size</th>
</tr>
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<tbody>
<tr>
<td>Top Pl</td>
<td>DF</td>
<td>2-2X6</td>
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<tr>
<td>Sill</td>
<td>DF</td>
<td>2X6</td>
<td></td>
</tr>
<tr>
<td>Wall Stud</td>
<td>DF</td>
<td>2X6</td>
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</tr>
<tr>
<td>Chord</td>
<td>UP</td>
<td>2-2X6</td>
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</tr>
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</table>

Perforated Design
Ao defined by NDS05 Table 4.3.3.4
“maximum opening height shall be taken as the Maximum opening clear height in a perforated shear wall.”

\[ Ao = 2.5' \times 3.5' = 8.75 \text{ ft}^2 \]

\[ r = \frac{1}{1 + \left( \frac{8.75}{10 \times 7.5} \right)} = .90 \]

\[ Co = \frac{.90}{3 - (2 \times .90)} \times 10' = .99 \]

**Perforated Design**

<table>
<thead>
<tr>
<th>Code</th>
<th>NDS 2005: ASD</th>
</tr>
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<tbody>
<tr>
<td>Design Method</td>
<td>Perforated</td>
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<tr>
<td>Wall Material</td>
<td>DF</td>
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<td>Panel Schedule</td>
<td>User Selected</td>
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<td>Optimize HD</td>
<td>No</td>
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<tr>
<td>HD Manufacturer</td>
<td>SIMPSON</td>
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</table>

**Geometry**

- Total Height: 10 ft
- Total Length: 10 ft
- Wall HW Ratio: 1.00
- Max Opening H1: 3.50 ft
- Open/Wall Ht Ratio: 0.35
- Full Ht Sheathed: 7.50 ft
- % Full Ht Sheathed: 75.00

**Materials**

<table>
<thead>
<tr>
<th>Description</th>
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<tbody>
<tr>
<td>Top Fl</td>
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<tr>
<td>Wall Stud</td>
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</tr>
<tr>
<td>Chord</td>
<td>DF</td>
<td>2.2X6</td>
</tr>
</tbody>
</table>

**Design Details**

- Shear Stiffness Adjustment Factor: 1.00
- Wall Capacity Adjustment Factor (2wh): 1.00
- Nailing Capacity Increase for Wind: 1.4

Shear Capacity Adjustment Factor (Co): 0.99
Total Area of Openings (Ao): 8.75 ft²
Sheathing Area Ratio (C): 0.90
Chord Forces
• Each side of the wall is governed by different Load Combinations (T or C)

Stud Design
• Design Spacing

Hold Downs
• Only Tension forces displayed

Perforated & FTAO Design
Force Transfer Around Openings (FTAO)

- Rational analysis of the wall assuming the straps and blocking can be added at the corners of the openings to transfer the sheathing forces across these joints.

- The sheathing resists the shear forces. This method essentially allows you to use the entire area of the wall (minus the opening) to resist the shear in the wall.

- RISA breaks up the wall into “Blocks”

- Only valid for Windows not Doors

FTAQO Wall
• The **average** shear force in each block of the wall is displayed at that location.

• The **maximum** shear in each of these locations will control the design of the wall.

• Area weighted average of the Fxy plate forces to determine the average shear for each block.

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**FTAO Wall**

**Analysis Summary**

<table>
<thead>
<tr>
<th>Block #</th>
<th>Unit Shear (lbf)</th>
<th>low Ratio</th>
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<tr>
<td>1</td>
<td>217,068</td>
<td>0.625</td>
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<tr>
<td>2</td>
<td>435,004</td>
<td>1.000</td>
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<td>3</td>
<td>152,254</td>
<td>0.375</td>
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<td>4</td>
<td>326,066</td>
<td>0.214</td>
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<td>5</td>
<td>428,470</td>
<td>0.375</td>
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<td>6</td>
<td>249,314</td>
<td>0.825</td>
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<td>7</td>
<td>250,281</td>
<td>0.357</td>
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</table>

**Display Panel Contours: Fxy**
• The Strap Forces are shown based on the Blocks

• The moment at the edge of each block **above or below an opening** is transmitted across the opening interface by horizontal tension straps or compression blocks

• The moment at the edge of each block that is to the **right or left of an opening** is transmitted across the opening by tension straps or compression blocks. However it is likely that the sheathing and king studs will be capable of transmitting these forces.
FTAO Wall Results ↔ Perforated Wall Results

- Echo Input
- Design Details
  SSAF
  Capacity Adjustment Factor per 4.3.4.1
- Wall Deflections NDS Eq 4.3-1
- Wall Results:
  Max Unit Shear: Max Block Shear from Header Detail Report
  Total Shear

NOTE: NDS 2005 defines a 8d nail as being:
2.5" x 0.1310" common, or
2.5" x 0.113" galvanized box
Walls can be stacked on top of each other using Straps

- Straps are used for anchorage to the wall panel below
- You can only add straps after Regions are added
- Strap forces are only Tension forces

<table>
<thead>
<tr>
<th>Region</th>
<th>Shear Panel</th>
<th>Shear UC</th>
<th>Shear LC</th>
<th>Strap Force (k)</th>
<th>Strap LC</th>
<th>Chord UC</th>
<th>Chord LC</th>
<th>Stud UC</th>
<th>Stud LC</th>
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<td>R1</td>
<td>R5_3/8_6d@3</td>
<td>0.976</td>
<td>1</td>
<td>4.000</td>
<td>2</td>
<td>0.333</td>
<td>2</td>
<td>0.000</td>
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<table>
<thead>
<tr>
<th>Full-Height Region Label</th>
<th>H/W Ratio</th>
<th>Shear UC</th>
<th>Shear LC</th>
<th>Strap Force (k)</th>
<th>Strap LC</th>
<th>Chord UC</th>
<th>Chord LC</th>
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<th>Stud LC</th>
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<tr>
<td>R1</td>
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<td>0.976</td>
<td>1</td>
<td>4.000</td>
<td>2</td>
<td>0.333</td>
<td>2</td>
<td>0.000</td>
<td>1</td>
</tr>
</tbody>
</table>
Straps can be used to tie walls to Columns below

- You will need to manually add these straps in the Wall Panel Editor
Problem: R3 Does not meet the Aspect Ratio. Design Not Done

Fix: Draw Post and Beam next to the wall
Problem: Soft Story Hand Calculations

Strap Forces for both situations: 2k both sides of the upper wall

Deflection is different for these two assumptions (SSAF)

Common Problems
Problem: Soft Story Hand Calculations

What's Right?

Engineering Judgment !!

- How is it being built?
  - Continuous sheathing or a strap only at the end post?

Another Option:
Assume Fully Pinned under wall

Common Problems
Problem: Discontinuous Walls

- Add Post to center of wall
  Post can be “Compression Only”
- Add Boundary Condition at the base of the wall

Common Problems

- Loads are transferred into the wall below.
Problem: Discontinuous Walls

- Different Reactions due to the Post
- Different Chord Forces
- Different Deflections

Common Problems
Problem: Platform Framing (FTAO only)

Fix: Adjust your opening height to include the depth of the floor framing.

This will reduce the portion of the wall above the opening thus reducing the amount of area to transfer shear forces.
- Diaphragm defined by “Slab Edge”
- Lateral walls resisting Lateral loads
**Rigid Diaphragm:** Lateral Loads applied in X Direction:

**Flexible Diaphragm:** Loads are distributed to the Lateral walls resisting X direction loads:

**Rigid Diaphragm:** Lateral Loads applied in Z Direction:

**Flexible Diaphragm:** Loads are distributed to the Lateral walls resisting Z direction loads:

Diaphragm Loads
Transfer Loads: Turned On
Plates Connected

Transfer Loads: Turned Off
Plates Not Connected
The lateral loads on the walls are created in the Transient Area Load Cases

- Automatically Generated
- Automatically applied
- For Viewing purposes only
- You can “Copy” these loads if needed

### Flexible Diaphragms

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<th>BLC Description</th>
<th>Category</th>
<th>X Gravity</th>
<th>Y Gravity</th>
<th>Z Gravity</th>
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<th>Point</th>
<th>Distrib.</th>
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</tbody>
</table>
What’s causing the differences between the FEM results and NDS Results?

Rotation

What’s really happening?

Multiple Story Building
Questions?

Please let us know if you have questions. We will answer as many questions as time permits during the webinar.

Once the webinar is closed, we will post all Q&A’s, at the models used and the Power Point presentation, to our website: www.risatech.com

We will be also be sending you a PDH certificate after the presentation.

For further information, contact us at: info@risatech.com

Thank you for Attending!