



1



2

About CWC

Codes and Standards (structural, fire, sustainability)

- Building code development
- Design standards development

Technical tools

- Publications
- Design tools, including WoodWorks software











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WoodWorks[®]
SOFTWARE FOR WOOD DESIGN

Canadian Edition



SIZER
Gravity Design



CONNECTIONS
Fasteners



DATABASE EDITOR
Customize Materials



SHEARWALLS
Lateral Design

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<http://woodworks-software.com/>

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SHEARWALLS Lateral Design

- Model **light-frame** wood structures up to **7 storeys**.
- Generate **wind** and **seismic** loads.
- **Distribute** loads to **shearlines**.
- **Distribute** loads to shearwall **segments** within a shearline.
- Add loads **manually**.
- Design shearwalls for **worst case** of wind and seismic.

6

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SHEARWALLS Lateral Design



Lakehouse Condos, Grimsby, ON Kirkor Architects + Planners, Tacoma Engineers

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SHEARWALLS
Lateral Design

SHEARWALLS Capabilities:

- Model **light-frame** wood structures up to **6-storey**.
- Generate **wind** and **seismic** loads based on location.
- **Distribute** loads to each **shearline**.
- **Distribute** loads to each shearwall **segment** within a shearline.
- Design shearwalls for **worst case** of wind and seismic.
- Add loads **manually**.

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SHEARWALLS
Lateral Design

National Building Code of Canada

Division B Acceptable Solutions

Part 1	General
Part 2	Reserved
Part 3	Fire Protection, Occupant Safety and Accessibility
Part 4	Structural Design
Part 5	Environmental Separation
Part 6	Heating, Ventilating and Air-conditioning
Part 7	Plumbing Services
Part 8	Safety Measures at Construction and Demolition Sites
Part 9	Housing and Small Buildings
Appendix A	Explanatory Material
Appendix B	Fire and Safety in Small Buildings
Appendix C	Climatic Information
Appendix D	Fire-Performance Ratings
User's Guide	NBC 2015 Structural Commentaries (Part 4)



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SHEARWALLS
Lateral Design

Table C-2
Climatic Design Data for Selected Locations in Canada

Province and Location	Elev., m	Design Temperature				De- gree- Days Below 18°C	15 Min. Rain, mm	One Day Rain, 1/50, mm	Ann. Rain, mm	Moist. Index	Ann. Tot. Ppn., mm	Driv- ing Rain Wind Pres- sures, Pa, 1/5	Snow Load, kPa, 1/50		Hourly Wind Pressures, kPa								
		January		July 2.5%									S _s	S _r	1/10	1/50							
		2.5% °C	1% °C	Dry °C	Wet °C																		
Ottawa (Metropolitan)																							
Ottawa (City Hall)	70	-25	-27	30	23	4440	23	86	750	0.84	900	160	2.4	0.4	0.32	0.41							
Ottawa (Barrhaven)	98	-25	-27	30	23	4500	25	92	750	0.84	900	160	2.4	0.4	0.32	0.41							
Ottawa (Kanata)	98	-25	-27	30	23	4520	25	92	730	0.84	900	160	2.5	0.4	0.32	0.41							

Settings

Company Information

Project Description

Format

Options

Design

Hold-downs

License Management

Loads and Forces

Plan View

Elevation View

Member dimensions

Selfweights

Site information

Wall height

2.4

m

Floor

1

kPa

Province*

Ontario

Wall display thickness*

140

mm

Ceiling

1

kPa

City*

Ottawa (City Hall)

Floor/ceiling depth

254

mm

Roof

1

kPa

Velocity pressure

0.41

kPa

Opening height*

1

m

Snow

1

kPa

Importance category

Normal

10

10



SHEARWALLS
Lateral Design

4.1.7. Wind Load

Static Procedure
4.1.7.3. to 4.1.7.7.

Dynamic Procedure
4.1.7.8.

4.1.7.12. Wind Tunnel
Procedure

4.1.8. Earthquake Load and Effects

Simplified approach
Very low seismic only
4.1.8.1. -2) to -15)

Detailed approach
4.1.8.2. to 4.1.8.22.

4.1.8.12. Dynamic
Analysis Procedure

4.1.8.11. Equivalent
Static Force Procedure

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SHEARWALLS
Lateral Design

Wind Loads

4.1.7.3. Static Procedure

1) The specified external pressure or suction due to wind on part or all of a surface of a *building* shall be calculated as follows:

$$p = I_W q C_e C_t C_g C_p$$

(Low Buildings)

4.1.7.6. External Pressure Coefficients for Low Buildings

Permitted when:

- Building **height ≤ 20m**, and
- Height is **the smallest** dimension of the building

(Other Buildings)

4.1.7.5. External Pressure Coefficients

Applicable to any building height

SHEARWALLS checks whether building qualifies for Low Buildings method

12

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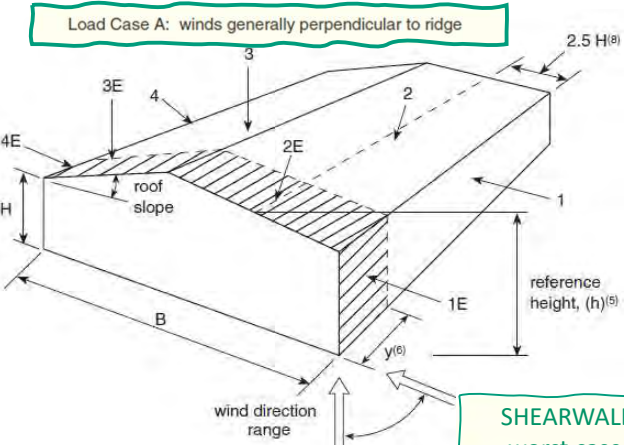


SHEARWALLS
Lateral Design

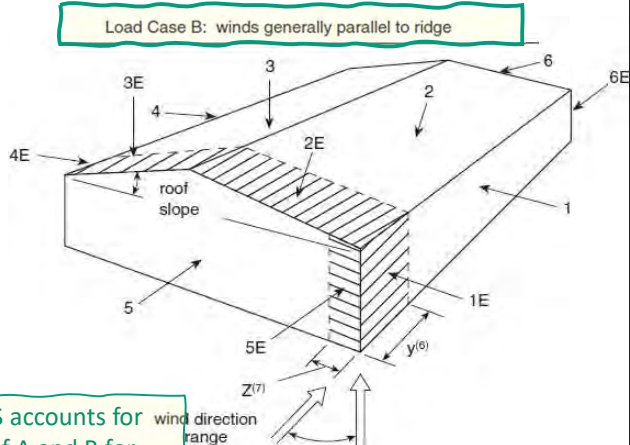
Wind Loads

Low Buildings (Figure NBC 4.1.7.6-A)

Load Case A: winds generally perpendicular to ridge



Load Case B: winds generally parallel to ridge



SHEARWALLS accounts for worst case of A and B for MWFRS

13

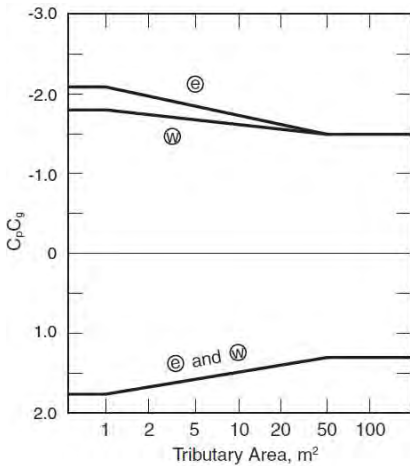
6

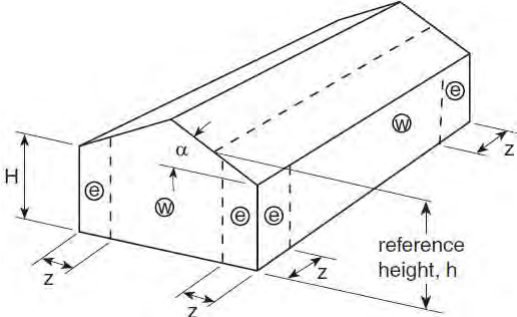


Wind Loads

Low Buildings (Figure NBC 4.1.7.6-B)

Components and Cladding design: out-of-plane sheathing bending, fasteners withdrawal.





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Wind Loads

Other Buildings (NBC 4.1.7.5)

On roof

$C_p = -1.0$ for $\frac{H}{D} \geq 1.0$

$C_p = -1.0$ for $x \leq H$ $\frac{H}{D} < 1.0$

$C_p = -0.5$ for $x > H$ $\frac{H}{D} < 1.0$

$C_q = C_q(H)$

On windward face

$C_p = 0.6$ for $\frac{H}{D} < 0.25$

$C_p = 0.27 \left(\frac{H}{D} + 2 \right)$ for $0.25 \leq \frac{H}{D} < 1.0$

$C_p = 0.8$ for $\frac{H}{D} \geq 1.0$

$C_q = C_q(Z)$

On leeward face

$C_p = -0.3$ for $\frac{H}{D} < 0.25$

$C_p = -0.27 \left(\frac{H}{D} + 0.88 \right)$ for $0.25 \leq \frac{H}{D} < 1.0$

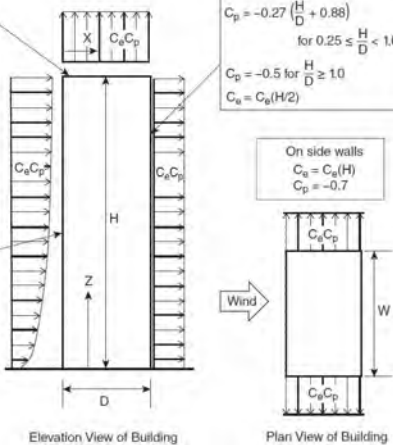
$C_p = -0.5$ for $\frac{H}{D} \geq 1.0$

$C_q = C_q(H/2)$

On side walls

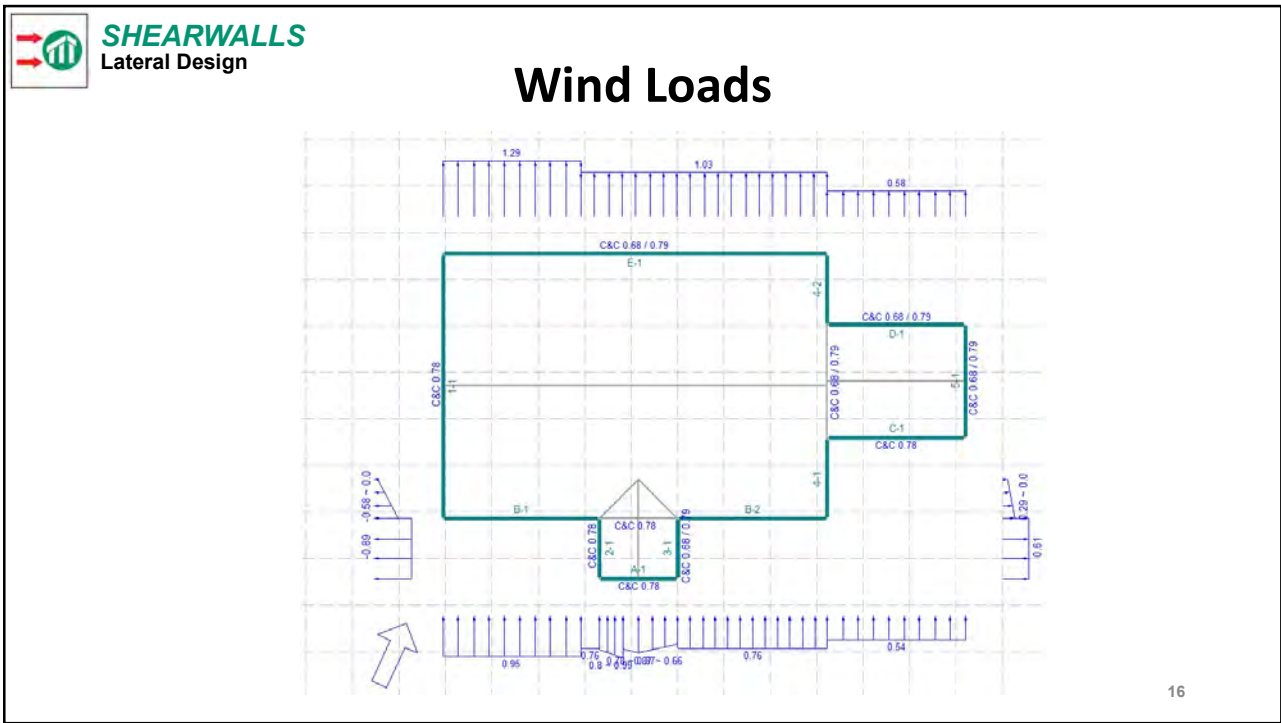
$C_q = C_q(H)$

$C_p = -0.7$

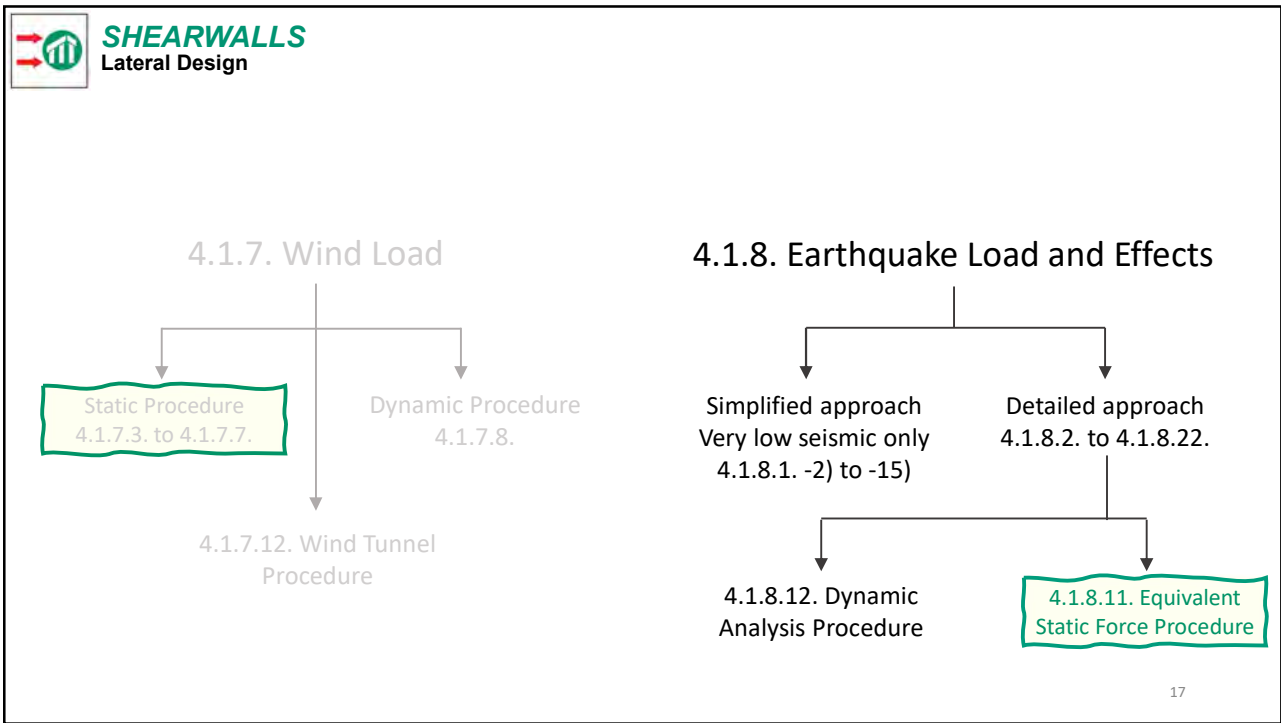


For Main Wind Force Resisting System (MWFRS) and for Component & Cladding (C&C)

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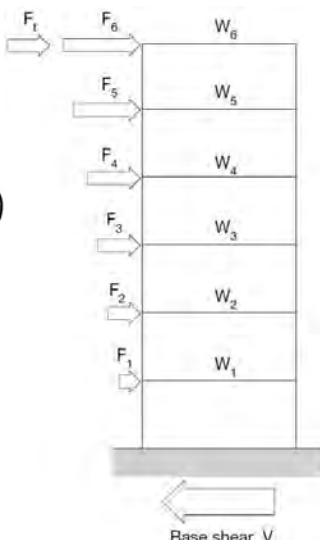


SHEARWALLS
Lateral Design

Seismic Loads

Equivalent Static Force Procedure (NBC 4.1.8.11)

Base shear $V = S(T_a) M_v I_E W / (R_d R_o)$



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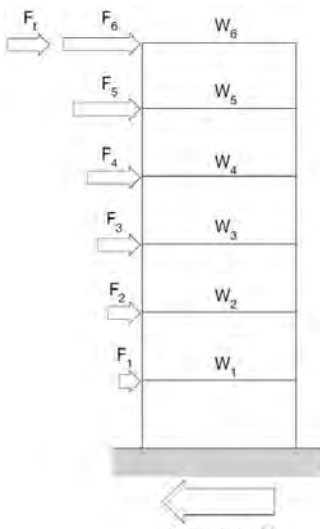
Seismic Loads

Equivalent Static Force Procedure (NBC 4.1.8.11)

- When $I_E F_a S_a(0.2) < 0.35$ (SC1, SC2), no height limit and all irregularities permitted
- or
- For **regular structures**, less than 60m in height with period less than 2s
- or
- For irregular structures (excluding Type 6 and 7), less than 20m in height with period less than 0.5s

Type 6: Weak-storey
Type 7: torsional irregularity

SHEARWALLS checks compliance for Static Procedure



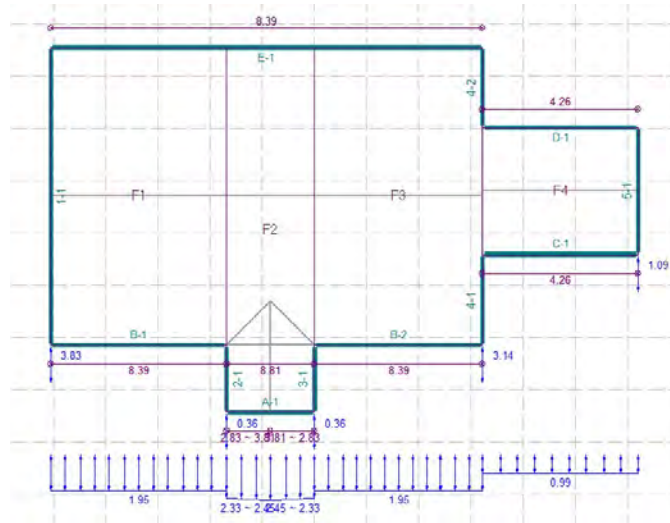
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SHEARWALLS
Lateral Design

Seismic Loads

Equivalent Static Force Procedure (NBC 4.1.8.11)



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SHEARWALLS
Lateral Design

- Model **light-frame** wood structures up to **7 storeys**.
- Generate **wind** and **seismic** loads.
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- Add loads **manually**.
- Design shearwalls for **worst case** of wind and seismic.

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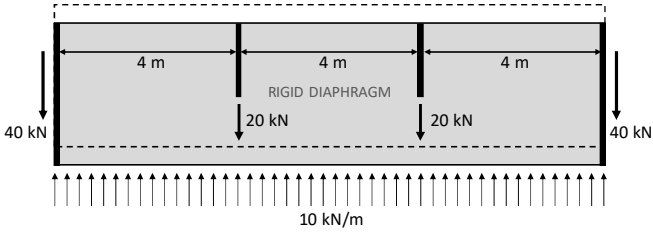


SHEARWALLS

Lateral Design

Lateral Design – Wind and Seismic

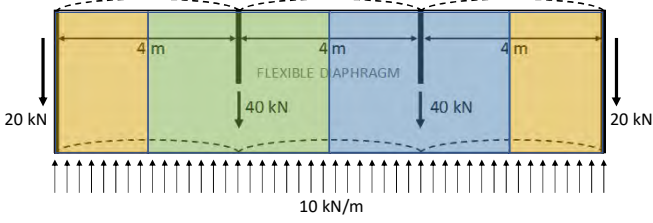
Loads Distribution to each Shearline



40 kN, 4 m, 4 m, 4 m, 20 kN, 20 kN, 10 kN/m

RIGID DIAPHRAGM

Rigid diaphragm assumption
Distributes based on wall stiffness



20 kN, 4 m, 4 m, 4 m, 40 kN, 40 kN, 10 kN/m

FLEXIBLE DIAPHRAGM

Flexible diaphragm assumption
Distributes based on wall tributary area

Design for envelope of rigid and flexible is a common practice

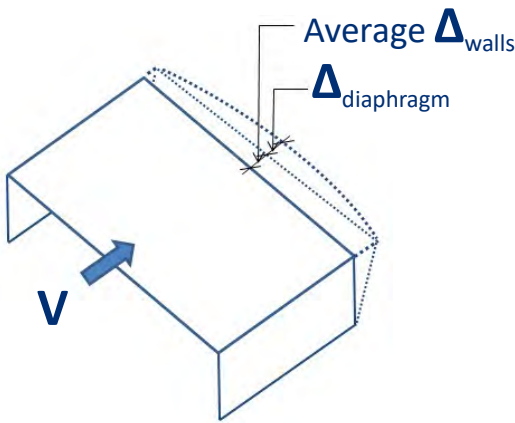
23



SHEARWALLS

Lateral Design

Lateral Design – Wind and Seismic



Average Δ_{walls}
 $\Delta_{diaphragm}$
 V

Flexible diaphragm when:
 $\Delta_{diaphragm} > 2 \times \text{average } \Delta_{walls}$

Rigid diaphragm when:
 $\Delta_{diaphragm} < 0.5 \times \text{average } \Delta_{walls}$

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SHEARWALLS
Lateral Design

12.3.1.1 Flexible Diaphragm Condition

Diaphragms constructed of untopped steel decking or wood structural panels are permitted to be idealized as flexible if any of the following conditions exist:

In structures where the vertical elements are steel braced frames, steel and concrete composite braced frames, or concrete/masonry, steel-tube and concrete composite braced walls.

2. In one- and two-family dwellings.

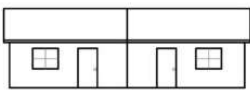
3. In structures of light-frame construction where all of the following conditions are met:

(a) Topping of concrete or similar materials is not placed over wood structural panel diaphragms except for nonstructural topping no greater than 1.5 in. (38 mm) thick, and

(b) Each line of vertical elements of the seismic force-resisting system complies with the allowable story drift of Table 12.12-1.

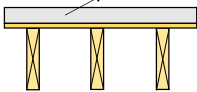


One Family Dwelling



Two Family Dwelling

or



Nonstructural topping $\leq 38\text{ mm}$

and



$\Delta_1 \leq 0.025h_s$ (seismic)

Each vertical element of SFRS

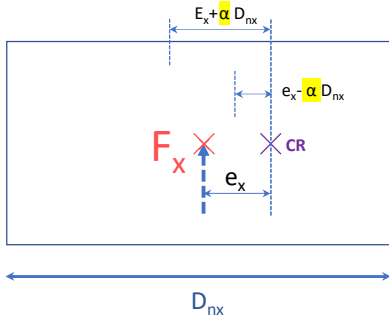
25

25



SHEARWALLS
Lateral Design

Torsional analysis



Wind:
 $\alpha = 0\%$

Seismic:
 $\alpha = 5\%$ for flexible diaphragm (NBC Structural Commentary J174)
 $\alpha = 10\%$ for rigid diaphragm (NBC 4.1.8.11. (11))

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SHEARWALLS
Lateral Design

- Model **light-frame** wood structures up to **7 storeys**.
- Generate **wind** and **seismic** loads.
- **Distribute** loads to **shearlines**.
- **Distribute** loads to shearwall **segments** within a shearline.
- Add loads **manually**.
- Design shearwalls for **worst case** of wind and seismic.

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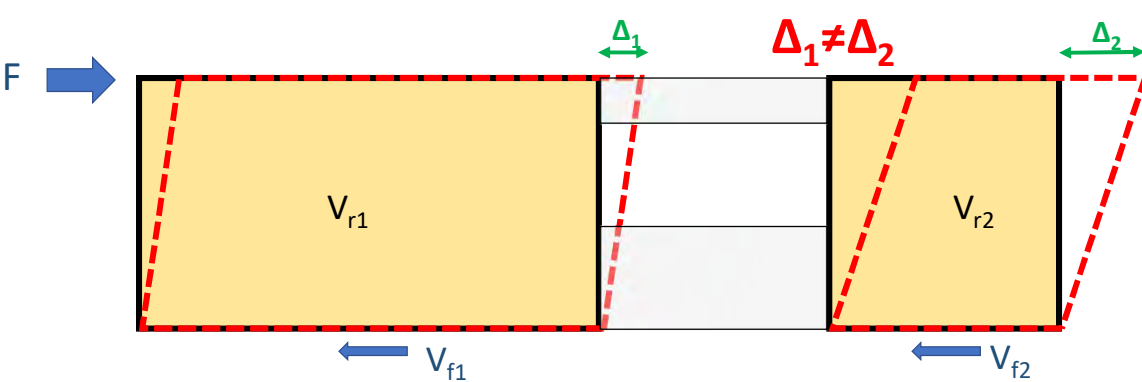
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SHEARWALLS
Lateral Design

Lateral Design – Wind and Seismic

Capacity-based load distribution $V_{fi} = F \frac{V_{r,i}}{\sum V_{r,i}}$



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SHEARWALLS
Lateral Design

Lateral Design – Wind and Seismic

Deflection-based load distribution $V_{fi} = F \frac{K_{si}}{\sum K_{si}}$

SHEARWALLS iterates until $\Delta_1 = \Delta_2$

30

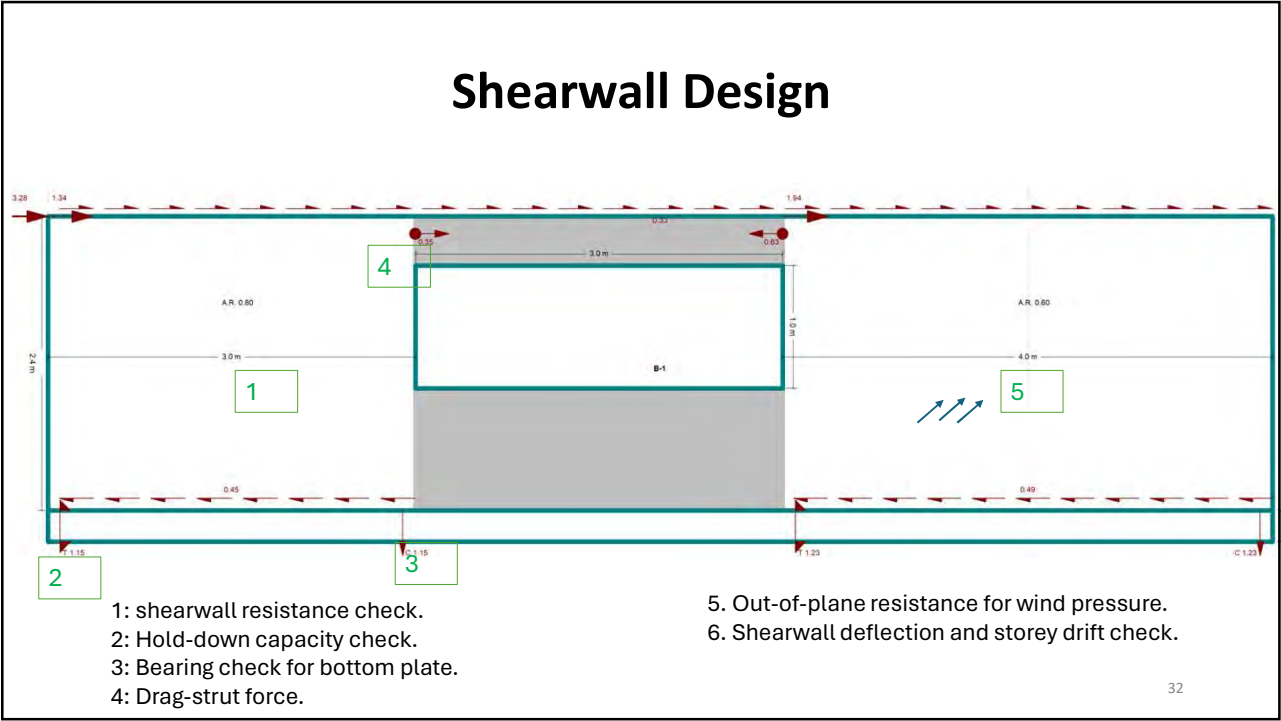
30

SHEARWALLS
Lateral Design

- Model **light-frame** wood structures up to **7 storeys**.
- Generate **wind** and **seismic** loads.
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- Add loads **manually**.
- Design shearwalls for **worst case** of wind and seismic.

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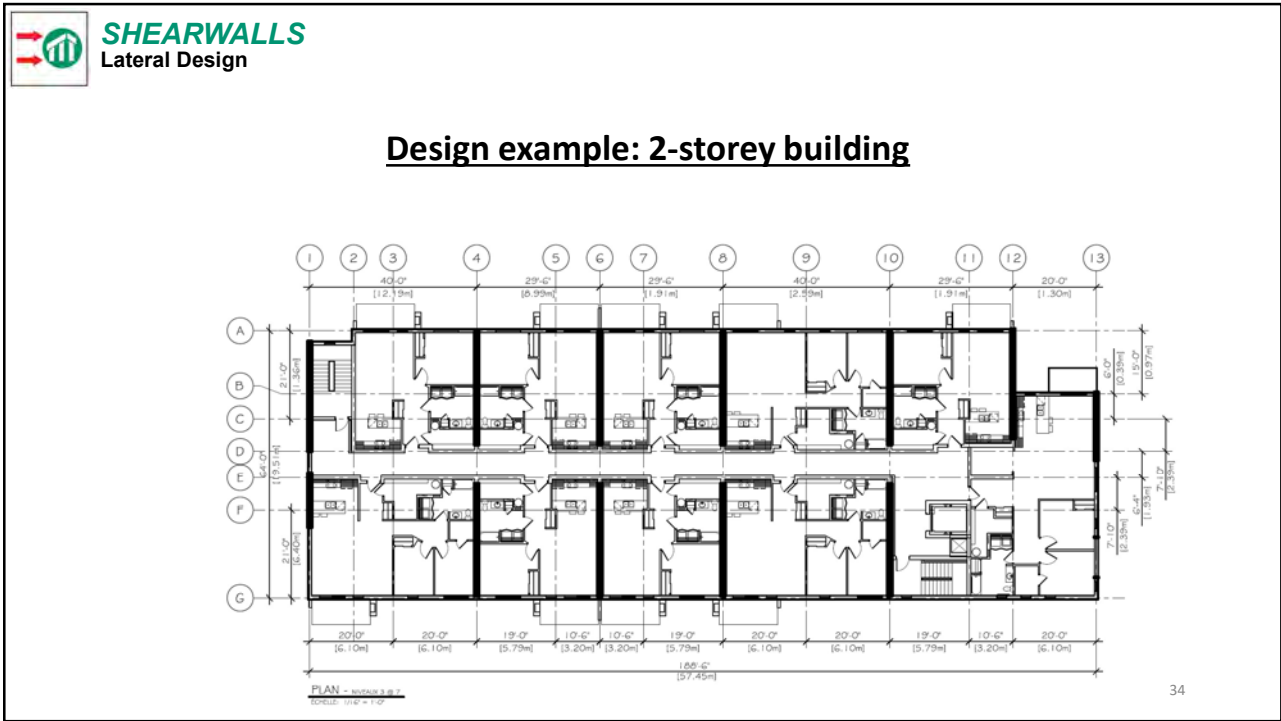
31



32



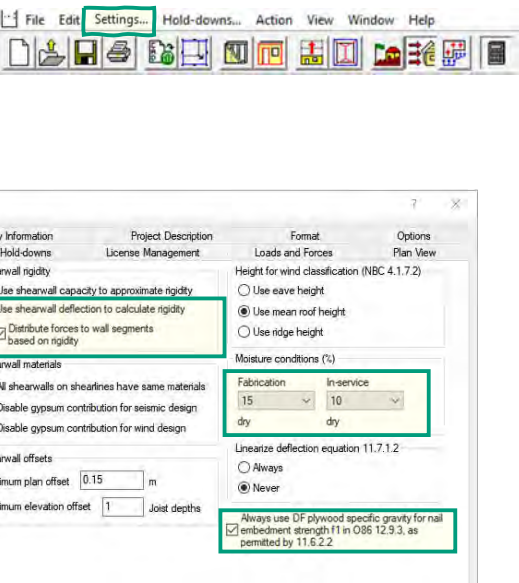
33



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SHEARWALLS
Lateral Design



Settings

- Use **O86-19/NBC 2015**
- **Low-buildings** method for wind load generation
- **Rigid & flexible diaphragm**
- **Deflection-based** method for load distribution
- Moisture content:
 - **15%** (Fabrication)
 - **10%** (in service)
- Use **DF plywood SG** for embedment strength f_1

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SHEARWALLS
Lateral Design

Design

Default Values

Company Information

Project Description

Format

Options

Design procedures

Design code

Wind load generation method

Include deflection analysis

Worst-case rigid vs. flexible diaphragms (envelope design)

Hold-down forces based on

Drag strut forces based on

Save as default for new files

Hold-downs

Shearwall rigidity

Distribute forces to wall segments based on rigidity

Shearwall materials

Disable gypsum contribution for seismic design

Disable gypsum contribution for wind design

Shearwall offsets

Maximum plan offset

Maximum elevation offset

Joist depths

Reset original settings

Loads and Forces

Height for wind classification (NBC 4.1.7.2)

Moisture conditions (%)

Fabrication

In-service

Linearize deflection equation 11.7.1.2

Always use DF plywood specific gravity for nail embedment strength f1 in O86 12.9.3, as permitted by 11.6.2.2

OK

Cancel

Help

Disable gypsum contribution for seismic

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SHEARWALLS
Lateral Design

Shearwall materials

Disable gypsum contribution for seismic design

Disable gypsum contribution for wind design

NBC Table 4.1.8.9

Type of SFRS	R _d	R _o	Restrictions ⁽²⁾			
			Seismic Category			
			SC1	SC2	SC3	SC4
Timber Structures Designed and Detailed According to CSA O86						
Shear walls						
Nailed shear walls: wood-based panel	3.0	1.7	NL	NL	30	20
Shear walls: wood-based and gypsum panels in combination	2.0	1.7	NL	NL	20	20

$$V = S(T_a) M_v I_E W / (R_d R_o)$$

Disable gypsum for seismic reduces seismic force by 33% but also reduces seismic resistance.

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SHEARWAL

Lateral Design

File

Edit

Settings...

Hold-downs...

Action

View

Window

Help



Settings

- Select **PEI** for **Province** and **Charlottetown** for **City**
(automatically update wind & seismic data from *NBC Appendix C*)

Settings

Elevation View

Design

Default Values

Company Information

Hold-downs

Project Description

License Management

Format

Loads and Forces

Options

Plan View

Member dimensions

Wall height2.8m

Wall display thickness*140mm

Floor/ceiling depth254mm

Opening height*2m

Opening bottom offset*0m

Roof geometry

Construction*Flat Roof

Slope*10.0deg

Overhang*0mm

Self weights

Floor0.5kPa

Ceiling0.3kPa

Roof0.5kPa

Snow0.5kPa

Interior wall0.3kPa

Exterior wall0.5kPa

Site information

Province*PEI

City*Charlottetown

Velocity pressure0.56kPa

Importance categoryNormal

Standard walls for exterior footprint

Top levelExterior with Hold-downs

Other levelsExterior with Hold-downs

Reset original standard walls

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SHEARWAL

Lateral Design

File

Edit

Settings...

Hold-downs...

Action

View

Window

Help



Settings

- Select **Metric** unit system

Settings

Design

Default Values

Hold-downs

License Management

Loads and Forces

Options

Plan View

Elevation View

Company Information

Project Description

Format

Options

Unit system

Metric

Imperial (English) formatting

Distancee.g. 3'-5"

Thicknesse.g. 1'-3-4"

Footpae

Font size

Printer

Screen

Results text810

Diagram text88

Use landscape mode for results for fonts greater than 10

45

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SHEARWALLS
Lateral Design

Open file:

01_setting_SW2024.wsw

46

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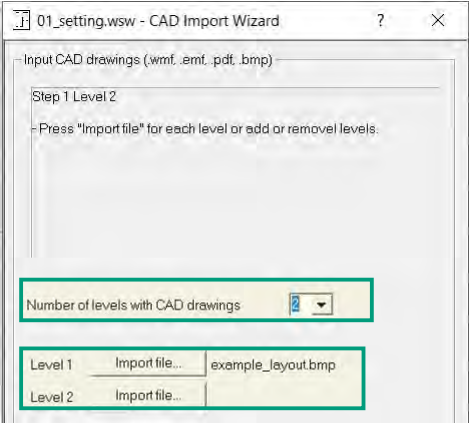


SHEARWALLS
Lateral Design



Import CAD Drawing

- Specify # of levels
- Import CAD file



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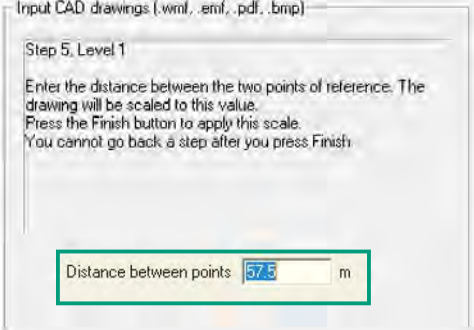
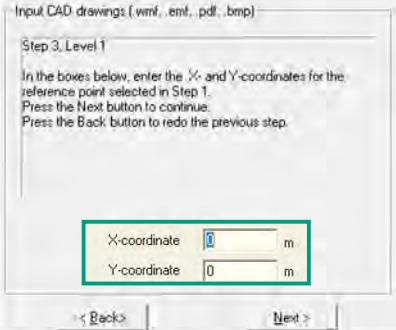
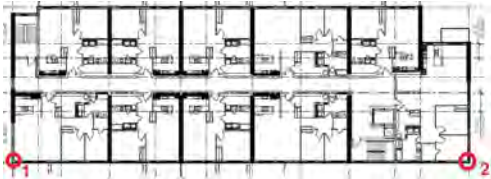


SHEARWAL
Lateral Design



Import CAD Drawing

- Select 1st reference point on the drawing
(Tip: Use Zoom control to place crosshair on drawing)
- Input x and y coordinates
- Select 2nd reference point
- Define distance between 2 points



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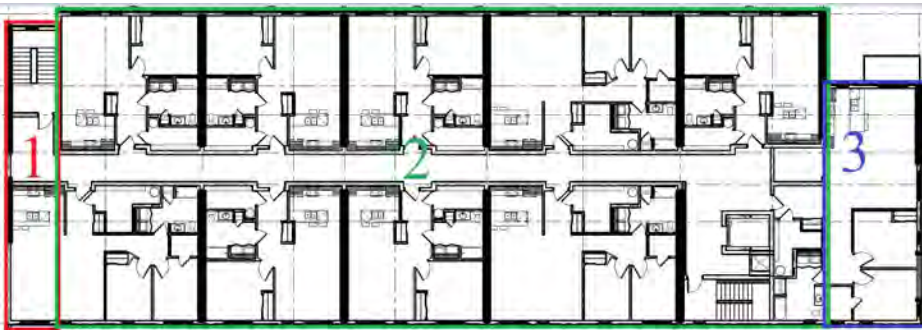


SHEARWAL
Lateral Design



Create structure blocks

- Determine # of structure blocks based on floor layout



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SHEARWALLS
Lateral Design



Create structure blocks

- Input block **name**, **# of levels**, **X & Y coordinates**
- Consider **rigid & flexible** diaphragm analysis
- Specify **wall height**, **floor/ceiling depth**, **base elevation**
- Adjust hold-down inputs:
 - Length subjected to shrinkage:
affects shrinkage component of hold-down deflection.
 - Anchor bolt length:
affects hold-down elongation.

06_loads_2024 - Structure Input

Blocks

Block name: West

No. of levels: 2

Diaphragm flexibility:
☒ Rigid analysis
☒ Flexible analysis
☐ Ceiling acts as upper level diaphragm

X extent: 3.2

Y extent: 18.6

location: 0

Y location: 0

Units: m

Levels

	Wall height m	Floor/ceiling depth mm	Hold-downs: Length subject to shrinkage mm	Anchor bolt length mm	Diaphragm elevation m
Rooftop structure					
Level 6					
Level 5					
Level 4					
Level 3		300			5.40
Level 2	2.4	300	415	415	2.70
Level 1	2.4	0	38	38	0.00

Changes apply to all blocks

Base elevation: 0

For help on the 'hold-down' items, click on '?' box in the upper right corner then on the item.

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SHEARWALLS
Lateral Design

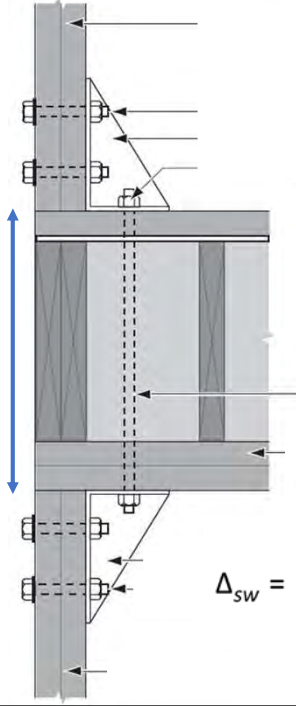


Hold-downs:

Length subject to shrinkage mm

Anchor bolt length mm

Anchor bolt length



Hold-downs

Hold-down: HDU11-SDS25

Short name:

Vertical bolt (add'l elongation)
☐ No anchor bolt ☒ With anchor bolt

Diameter: 25.4 mm Center line offset: 25.4 mm

Max length for given displacement: 152.4 mm

$$\Delta_{sw} = \frac{2vH_s^3}{3EAL_s} + \frac{vH_s}{B_v} + 0.0025H_se_n + \frac{H_s}{L_s}d_a$$

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Moisture conditions (%)

Fabrication15dryIn-service10dry

Length subject to shrinkage

Level 1:

Shrinkage creates gap between steel bracket and nut, which contribute to d_a .

Blocking not shown for clarity

300 mm

38 mm

$38 \times 2 + 300 = 376 \text{ mm}$

Level 2:

300 mm

Upper shearwall

Bolts

Connector bracket

Anchor bolt

Threaded rod

Double continuous plate

Connector bracket

Bolts

Lower shearwall

$38 \times 3 + 300 = 414 \text{ mm}$

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53

Length subject to shrinkage

Lumber

Engineered Wood product (EWP)

Level 2: $38 \times 3 + 300 = 414 \text{ mm}$

Upper shearwall

Bolts

Connector bracket

Anchor bolt

Threaded rod

Double continuous plate

Connector bracket

Bolts

Lower shearwall

Level 2: $38 \times 3 = 114 \text{ mm}$

EWP typically has fabrication MC below in-service MC. No shrinkage.

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<http://woodworks-software.com/>

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SHEARWALLS

Lateral Design

Length subject to shrinkage

Moisture conditions (%)

Fabrication

15

dry

In-service

10

dry

$$S = D \times (\omega_i - \omega_f) \times c$$

where

S = shrinkage or swelling in the dimension being considered (thickness, width, or length), mm

D = actual dimension (thickness, width, or length), mm

ω_i = the lesser of the initial moisture content or the fibre saturation point (28%)

ω_f = the final moisture content

c = shrinkage coefficient*

For lumber

- = 0.002 for shrinkage or swelling perpendicular to the grain
- = 0.00005 for shrinkage or swelling parallel to the grain

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SHEARWALLS

Lateral Design

Open file:

02_blocks_SW2024.wsw

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SHEARWALLS
Lateral Design



Define standard walls

- Define standard walls using “Edit standard walls” for structures with repetitive wall types
- Input **sheathing**, **fastener** and **framing** details
- Hold-downs not included in standard wall (will be assigned to walls in a later step)

04_Level1_walls_2024_recent - Wall and Shearline Input

Standard wall

Wall 2x6 - Lvl 1

Edit standard walls...

☒ Design in group

Wall 1-2

Type / Hold-down configuration

Shearline

Non-wood or proprietary walls

Hold-downs on all segments

Auto

Capacity (kN)

Deflection (mm)

04_Level1_walls_2024_recent - Edit Standard Walls

Standard wall

Wall 2x6 - Lvl 1

Wall 2x6 - Lvl 1

☒ Design as a group

Edit standard wall

Type / Hold-down configuration

Hold-downs on all segments

New

Copy

Delete

OK

Cancel

Materials for Shearline

Exterior side

Interior side

Both sides the same

Sheathing

Material

OSB

Thickness

11

mm

Panel mark

1R24/2F16

Orientation

Horizontal

Gypsum underlay

None

mm

Fasteners

Type

Power-driven nails

Len. (in)

2-1/2"

Dia. (mm)

3.05

Edge spacing

100

mm

Interior spacing

150

mm

Framing

Material

Lumber

Thickness b"

38

mm

End studs:

Species

S-P-F

Width d"

140

mm

Left

3

Grade

No.1/No.2

Stud spacing

400

mm

Right

3

58



SHEARWALLS
Lateral Design

Standard wall (Level 1)

05_Level2_walls_2024_recent - Wall and Shearline Input

Standard wall

Wall 2x4 - Lvl 1

Edit standard walls...

☒ Design in group

Wall 4-2

Type / Hold-down configuration

Shearline

Non-wood or proprietary walls

Hold-downs on all segments

Auto

Capacity (kN)

Deflection (mm)

05_Level2_walls_2024_recent - Edit Standard Walls

Standard wall

Wall 2x4 - Lvl 1

Wall 2x4 - Lvl 1

☒ Design as a group

Edit standard wall

Type / Hold-down configuration

Hold-downs on all segments

New

Copy

Delete

OK

Cancel

Materials for Shearwall 4-2, level 1

Side 1

Side 2

Both sides the same

Sheathing

Material

OSB

Thickness

11

mm

Panel mark

1R24/2F16

Orientation

Horizontal

Gypsum underlay

None

mm

Fasteners

Type

Power-driven nails

Len. (in)

2-1/2"

Dia. (mm)

3.05

Edge spacing

100

mm

Interior spacing

300

mm

Framing

Material

Lumber

Thickness b"

38

mm

End studs:

Species

S-P-F

Width d"

89

mm

Left

3

Grade

No.1/No.2

Stud spacing

400

mm

Right

3

Hold-downs for selected walls

Left end

HDU2-SDS25

Double-bracket

Hold-down settings...

Right end

HDU2-SDS25

Double-bracket

Hold-down settings...

Apply to openings

Design group(s)

Not designed

60



Standard wall (Level 2)

06_loads_SW2024 - Wall and Shearline Input

Standard wall

Wall 2x6 - Lvl 2

Edit standard walls...

Design in group

Wall 3-1

Type / Hold-down configuration

Hold-downs on all segments

Location X Start Y End Y Height

3.2 10.9 19.5 2.7 m

Dead load supported 0 kN/m

Apply DL to shearline

Non-wood or proprietary walls

Capacity (kN) Deflection (mm)

Wind

Seismic

Not to be designed

Materials for Shearwall 3-1, level 2

Side 1 Side 2

Both sides the same

Sheathing

Material OSB

Type Power-driven nails

Thickness 11 mm

Len. (in) 2-1/2"

Dia. (mm) 3.05

Panel mark 1R24/2F16

Blocking

Edge spacing 150 mm

Orientation Horizontal

Interior spacing 300 mm

Gypsum underlay None

Framing

Material Lumber

Thickness b" 38 mm

End studs

Species S-P-F

Width d" 140 mm

Left 2

Grade No.1/No.2

Stud spacing 400 mm

Right 2

Hold-downs for selected walls

Left end HDU2SDS2.5

Double-bracket

Hold-down settings...

Right end HDU2SDS2.5

Double-bracket

Edit database...

Apply to openings

Design group(s) Not designed

06_loads_SW2024 - Wall and Shearline Input

Standard wall

Wall 2x4 - Lvl 2

Edit standard walls...

Design in group

Wall 4-2

Type / Hold-down configuration

Hold-downs on all segments

Location X Start Y End Y Height

12.2 10.9 19.5 2.7 m

Dead load supported 0 kN/m

Apply DL to shearline

Non-wood or proprietary walls

Capacity (kN) Deflection (mm)

Wind

Seismic

Not to be designed

Materials for Shearwall 4-2, level 2

Side 1 Side 2

Both sides the same

Sheathing

Material OSB

Type Power-driven nails

Thickness 11 mm

Len. (in) 2-1/2"

Dia. (mm) 3.33

Panel mark 1R24/2F16

Blocking

Edge spacing 150 mm

Orientation Horizontal

Interior spacing 300 mm

Gypsum underlay None

Framing

Material Lumber

Thickness b" 38 mm

End studs

Species S-P-F

Width d" 89 mm

Left 2

Grade No.1/No.2

Stud spacing 400 mm

Right 2

Hold-downs for selected walls

Left end HDU2SDS2.5

Double-bracket

Hold-down settings...

Right end HDU2SDS2.5

Double-bracket

Edit database...

Apply to openings

Design group(s) Not designed

61



Open file:

03_Standard_walls_SW2024.wsw

62

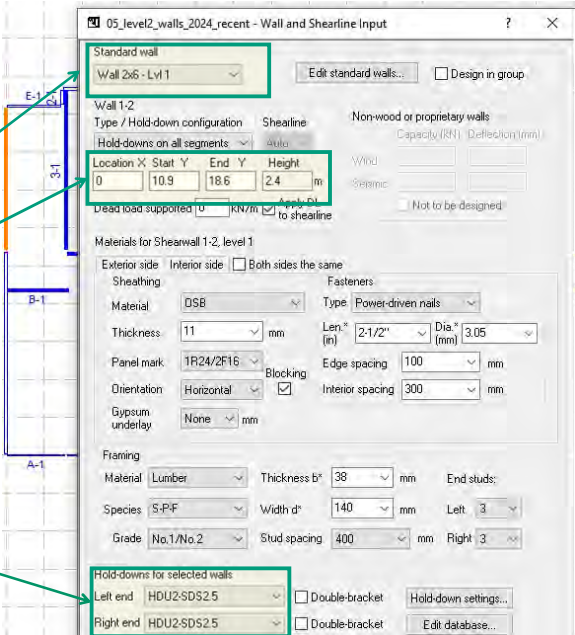


SHEARWALL
Lateral Design



Modify exterior walls

- Divide Walls 1-1 into segments (i.e., left-click, drag and release)
- Assign a pre-defined standard wall type
- Adjust X, Y coordinates to exact wall locations
- Select hold-down models



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SHEARWALL
Lateral Design



Modify exterior walls

Single-bracket vs double-bracket hold-downs

Hold-downs for selected walls

Left end HDU2-SDS2.5

Right end HDU2-SDS2.5

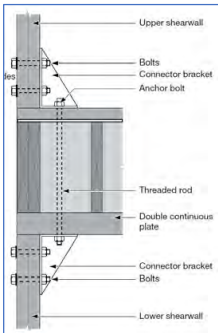
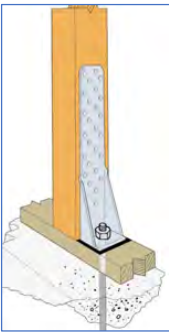
☐ Apply to openings

☐ Double-bracket

☐ Double-bracket

Hold-down settings...

Edit database...



Single-bracket for Level 1 & double-bracket for upper levels as default

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Hold-down Database

Hold-downs for selected walls

Left end: HDU2-SDS2.5, Right end: HDU2-SDS2.5, Apply to openings: ☐

☐ Double-bracket, ☐ Double-bracket

Hold-down settings... Edit database...

Hold-downs

Hold-down: HDU2-SDS2.5, Short name:

New

☒ Default for Shearwall

Vertical bolt (add'l elongation)

☐ No anchor bolt, ☒ With anchor bolt

Diameter: 15.9 mm, Center line offset: 25.4 mm

Max length for given displacement: 152.4 mm

☐ Always use displacement at maximum capacity, ☐ Shrinkage compensating device

Design Properties (mm, kN)

Select	Thickness of stud(s) b	Stud width d	Cap D-Fir-L	Cap S-P-F	Displacement
	76	89	14.28	12.9	2.3

Model No.	Ga.	Dimensions (in.)						Fasteners	Minimum Wood Thickness (in.)	Factored Tensile Resistance (K _f = 1.15)		Deflection ^a at Factored Resistance
		W	H	B	Q ¹	S ₀	D-Fir-L			S-P-F		
										lb.	lb.	in.
										kN	kN	mm
DTT2Z								(8) 1/4" x 1 1/2"	1 1/2	2805	2520	0.25
DTT2Z-SDS2.5								(8) 1/4" x 2 1/2"	3	12.48	11.21	6.35
										3060	2950	0.25
										13.61	13.12	6.35
HDU2-SDS2.5	14	2 1/2	8 1/2	3 1/4	1 3/8	1 3/8	5/8	(8) 1/4" x 2 1/2"	3	3210	2900	0.092
										14.28	12.90	2.34

Custom hold-downs (e.g., MiTek) can be added.

New slide

Source: www.strongtie.com/resources/literature/wood-construction-connectors-catalog-cn

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Create interior walls

- Place cursor approx. at intended location on drawing, click, drag and release.
- Choose standard wall type
- Adjust X, Y coordinates to achieve exact wall locations

05_level2_walls_2024_recent - Wall and Shearline Input

Standard wall

Wall 2x4 - Lvl 1

Edit standard walls...

Wall 4-2

Type / Hold-down configuration

Hold-downs on all segments

Location X: 12.2, Start Y: 10.9, End Y: 19.5, Height: 2.4 m

Dead load supported: 0 kN/m, Apply DL to shearline

Shearline

Auto

Non-wood or

Wind

Seismic

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SHEARWALL
Lateral Design



Unknowns

- Several material & fasteners inputs can be left unknown
- Shearwalls will generate the most optimized wall detailing based on applied loads

Shearwalls - Wall and Shearline Input

Standard wall

Edit standard walls...

Design in group

Wall 1-1

Type / Hold-down configuration

Hold-downs on all segments

Location

Start

End

Height

0

0

20

2.4 m

Dead load supported

0 kN/m

Apply DL to shearline

Non-wood or proprietary walls

Causeway (kN)

Deflection (mm)

Wood

Seismic

Not to be designed

Materials for Shearwall 1-1, level 1

Exterior side

Interior side

Both sides the same

Sheathing

Material

DF Plywood

Type

Common wire nails

Thickness

(unknown)

mm

Piles

(unknown)

mm

Orientation

Horizontal

Blocking

Gypsum underlay

None

mm

Fasteners

Len. (in)

(unknown)

Dia. (mm)

(unknown)

Edge spacing

(unknown)

mm

Interior spacing

(unknown)

mm

Framing

Material

Lumber

Thickness b"

38

mm

End studs

Species

S-P-F

Width d"

140

mm

Left

2

Grade

No.1/No.2

Stud spacing

(unknown)

mm

Right

2

mm

Hold-downs for selected walls

Left end

HDU2-SDS2.5

Double-bracket

Hold-down settings...

Right end

HDU2-SDS2.5

Double-bracket

Edit database...

Apply to openings

Design group(s)

Not designed

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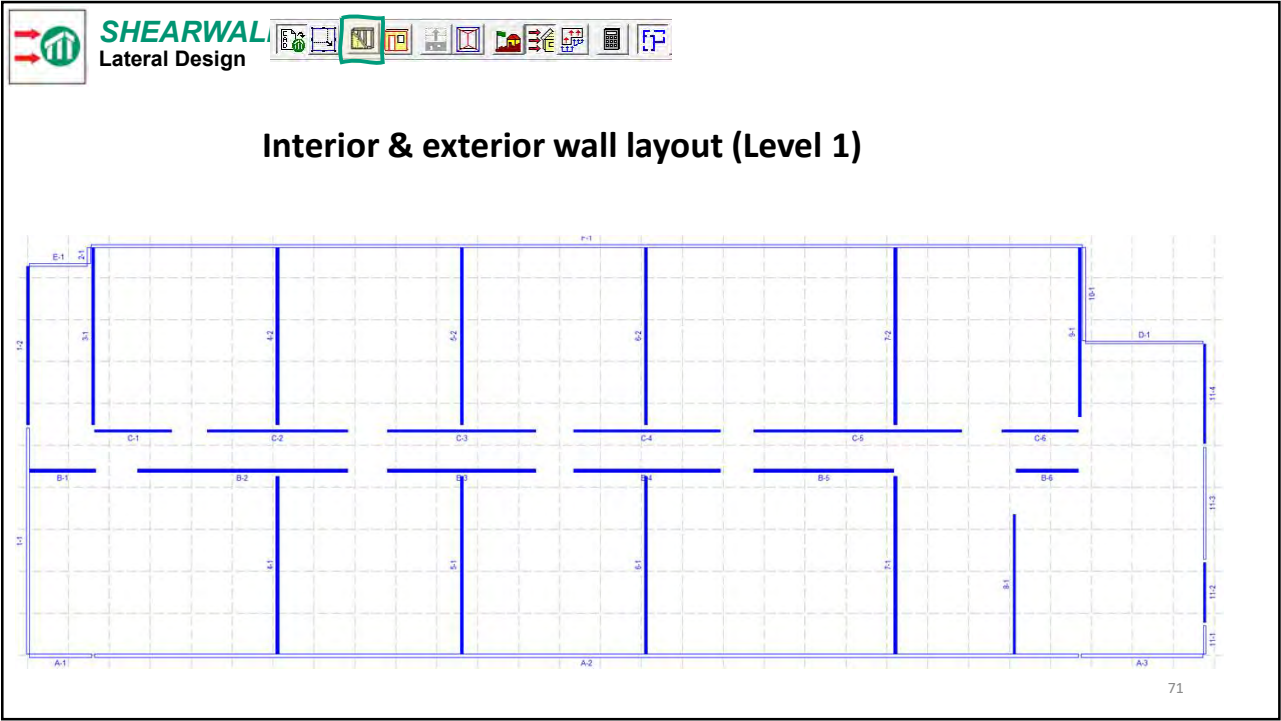
SHEARWALLS
Lateral Design

Open file:

04_level1_walls_SW2024.wsw

70

70



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Extend walls upwards

- Wall and opening geometries copied to upper level(s)
- Upper-level wall types based on setting

Settings

Company Information

Design

Default Values

Hold-downs

License Management

Loads and Forces

Plan View

Elevation View

Member dimensions

Wall height

2.4

m

Wall display thickness*

140

mm

Floor/ceiling depth

254

mm

Opening height*

2

m

Opening bottom offset*

0

m

Roof geometry

Construction*

Flat Roof

Slope*

10.0

deg

Overhang*

0

mm

Self weights

Floor

0.5

kPa

Ceiling

0.3

kPa

Roof

0.5

kPa

Snow

0.5

kPa

Interior wall

0.3

kPa

Exterior wall

0.5

kPa

Site information

Province*

Alberta

City*

Calgary

Velocity pressure

0.48

kPa

Importance category

Normal

Standard walls for exterior footprint

Top level

Exterior with Hold-downs

Other levels

Exterior with Hold-downs

Reset original standard walls

72

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SHEARWALLS
Lateral Design



Modify Level 2 walls

- Assign level 2 walls with pre-defined standard wall types
- “Double-bracket” automatically checked for hold-downs in upper levels

Hold-downs for selected walls

Left end

HDU2-SDS2.5

▼

Right end

HDU2-SDS2.5

▼

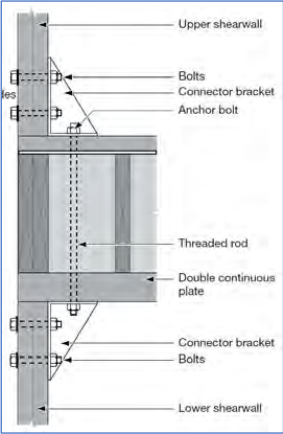
☒ Apply to openings

☒ Double-bracket

☒ Double-bracket

Hold-down settings...

Edit database...



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SHEARWALLS
Lateral Design

Open file:

05_level2_walls_SW2024.wsw

74

74

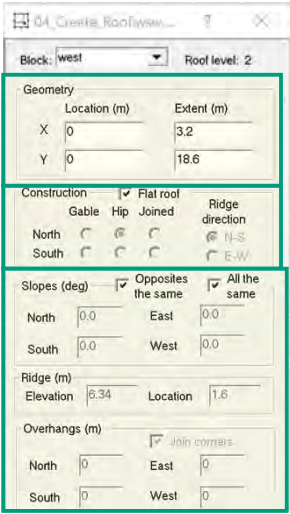


SHEARWAL
Lateral Design



Create roof blocks

- Roof blocks automatically created based on structure blocks
- Specify geometry, roof type, slope, ridge elevation and overhang length



75

75



SHEARWAL
Lateral Design

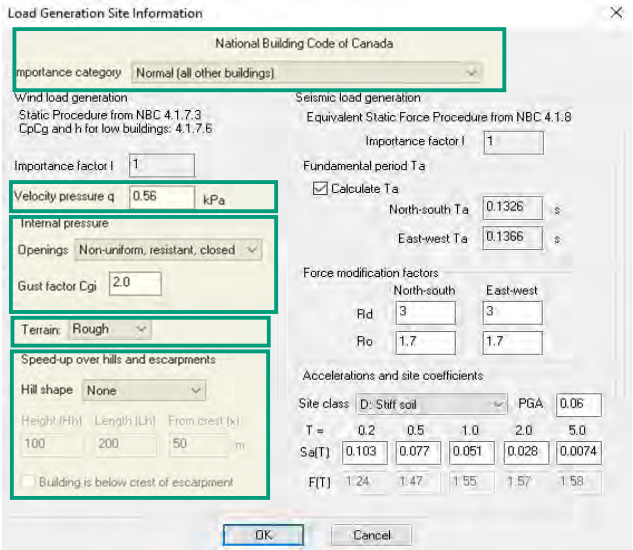


Review Site Information (wind)

Normal Importance category

Wind pressure for Charlottetown automatically populated

Review opening type, gust factor, terrain type, hill shape inputs



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Rough or Open Terrain Option

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79

Review Site Information (Seismic)

Code **period** calculated based on building height $0.05 (h_n)^{3/4}$

Custom period can be entered

Ductility R_d & Overstrength R_o
(Default: wood sheathed, no GWB)

Site Class **D**
Seismic data for **Charlottetown** automatically populated

80

80



SHEARWALL
Lateral Design



Generate Wind & Seismic Loads

Building levels: 1 to 2

☒ Wind loads

Wind direction: Both Directions

Building face: All

MWFRS loads: Generate

☒ Line loads

Area loads on: ☒ Walls

☒ Roof panels

☐ Exclude roof portion covered by other roof

☒ Gable ends

Hip roofs: ☐ Treat as side panel

☒ C&C wall loads

☒ Seismic loads

☐ Generate loads only (not building masses)

Generate building masses first...
Self-weights (kN/m²):

☒ Floors: 2.66

☒ Roof: 1.1

☒ Horizontal projection

☒ Ceiling: 0

☒ Full snow load, only 25% applied: 3.48

☒ Interior walls: 0

☒ Exterior walls: 0

Generate dead loads for overturning calculations:

☒ From wall self-weight

☒ From load supported by wall

Generate loads on selected levels

Delete all generated loads

Delete all and regenerate

Main Wind Force Resisting System (MWFRS)

Components & cladding

Floor/roof weight

Snow load

Wall weight included in floor

Click “Generate loads...” to generate wind & seismic

84

84



SHEARWALLS
Lateral Design



Dead or wind uplift load concentrated at end chords

Tension end: Wall length L / 2

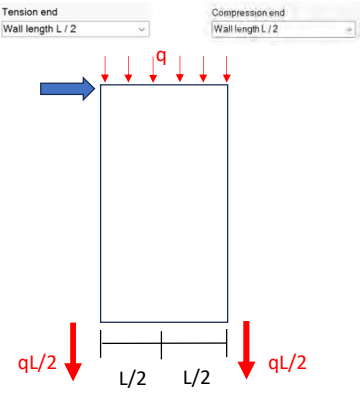
Compression end: Wall length L / 2

Wall heights: 1.0 1.0

☒ Include dead load on entire wall if it completely counteracts overturning

Tension end: Wall length L / 2

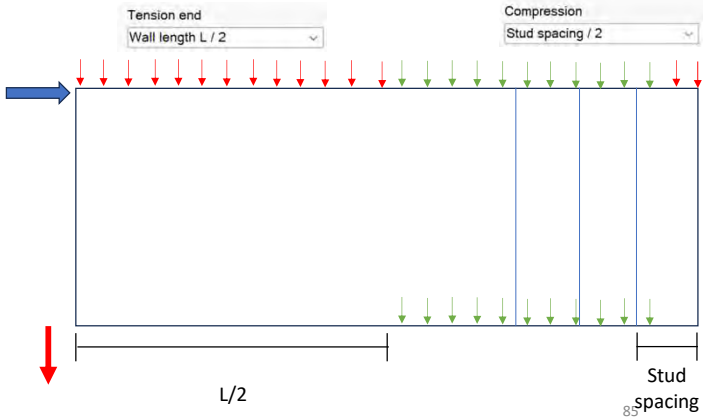
Compression end: Wall length L / 2



New slide

Tension end: Wall length L / 2

Compression: Stud spacing / 2



Options for vertical load concentrated at end:

None

Wall length L / 2

Times wall heights (max L/2)

To hold-down offset

Stud spacing / 2

85

85



SHEARWALL
Lateral Design



Add manual loads & forces

- shear forces transferred from **adjoining structure**
- manual building masses due to **non-uniform mass distribution**
- wind uplift** and **dead loads**
- wind and seismic loads due to **other components**, e.g., air conditioner unit.

For this example, **dead loads** are added to counter overturn and reduce hold-down force and deflection.

Type

☐ Seismic

☐ Wind shear

☐ Wind C&C

☐ Wind uplift

☒ Dead load

☐ Building mass

Profile

☐ Point load

☒ Line load

☐ Area load

Level(s)

From

To

2

2

Location

Apply to...

Wall line

A

From X=

To X=

0

57.5

Wind direction

Tributary width (m)

0

0

Magnitude (kN/m)

From

To

6.01

6.01

☐ Add as a factored force directly (parallel to the shearline)

Distribution method

Both

OK

Cancel

86

86



SHEARWALL
Lateral Design



Add manual dead load

- Select a wall segment in plan view
- Select *Dead load* as *Type*, *Line load* as *Profile*
- Choose *Selected wall* (coordinates automatically populated)
- Input load magnitude

Alternatively, add dead load in Wall input.

Type

☐ Seismic

☐ Wind shear

☐ Wind C&C

☐ Wind uplift

☒ Dead load

☐ Building mass

Profile

☐ Point load

☒ Line load

☐ Area load

Level(s)

From

To

2

2

Location

Apply to...

Selected wall

From Y=

To Y=

10.3

18.8

Wind direction

Tributary width (m)

0

0

Magnitude (kN/m)

From

To

6.01

6.01

☐ Add as a factored force directly (parallel to the shearline)

Distribution method

Both

OK

Cancel

Shearwalls - Wall and Shearline Input

Standard wall

Exterior with Anchorages

Edit standard walls...

Design in group

Wall B-1

Type / Hold-down configuration

Where required only

Location

Y

Start

X

End

X

Height

Wind

Seismic

Non-wood or proprietary walls

Capacity (kN)

Deflection (mm)

Not to be designed

Dead load supported

0

kN/m

Apply DL to shearline

☒

87

87



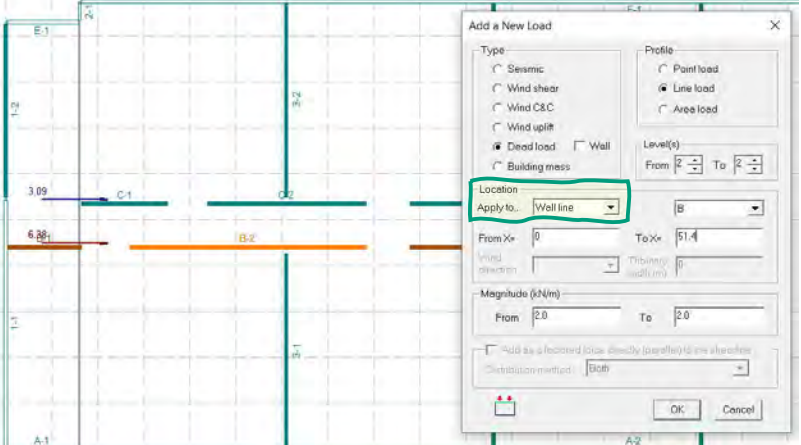
SHEARWALLS
Lateral Design



Add manual dead load

To add same uniform dead load on all segments of a shearline:

1. Select a wall segment in the shearline plan view
2. Choose *wall line* for location



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SHEARWALLS
Lateral Design

Open file:

06_loads_SW2024.wsw

89

89



SHEARWALLS – Results Reports

File Edit Settings... Hold-downs... Action View Window Help



a b c d e

Reports

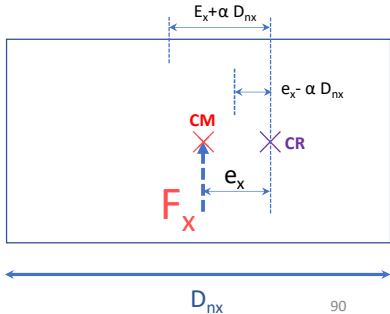
a. Design results

b. Seismic load generation details

c. Wind load generation details

d. Torsion analysis details

e. Detailed shearwall design



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Design Results

Go To Table Level: 1 T

Project Information >

Structural Data >

Loads >

Design Summary >

Wind Design >

Seismic Design >

Design Results include:

1. Project info (design settings and site information)

2. Structural data (including storey, roof, wall and opening dimensions, shearwall materials)

3. **Loads** (wind/seismic shear loads, wind components and cladding loads)

4. **Design Summary**

5. **Wind & seismic design** for shearwalls:

(1) **Shear resistance**

(2) **Shearwall deflection, storey drift**

(3) Hold-down, bearing design & drag-strut force

(4) Components and cladding design (wind only)

(5) Irregularity detection (seismic only)

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SHEARWALLS

Lateral Design



Design Summary provides high-level design results for:

- Shearwalls
- Hold-downs
- Storey drift
- C&C (wind only)
- Over-capacity ratio (seismic only)
- Irregularity (seismic only)
- Gypsum wallboard percentage (seismic only)

review **Design Summary** first

Design Summary

SHEARWALL DESIGN

Wind Shear Loads, Flexible Diaphragm

All shearwalls have sufficient design capacity.

Storey drift (NBC 4.1.3.5.(3)): Within limits. Refer to Storey Drift table.

Wind Shear Loads, Rigid Diaphragm

All shearwalls have sufficient design capacity.

Storey drift (NBC 4.1.3.5.(3)): Within limits. Refer to Storey Drift table.

Components and Cladding Wind Loads, Out-of-plane Sheathing

All shearwalls have sufficient design capacity.

Components and Cladding Wind Loads, Nail Withdrawal

All shearwalls have sufficient design capacity.

Seismic Loads, Flexible Diaphragm

All shearwalls have sufficient design capacity.

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SHEARWALLS

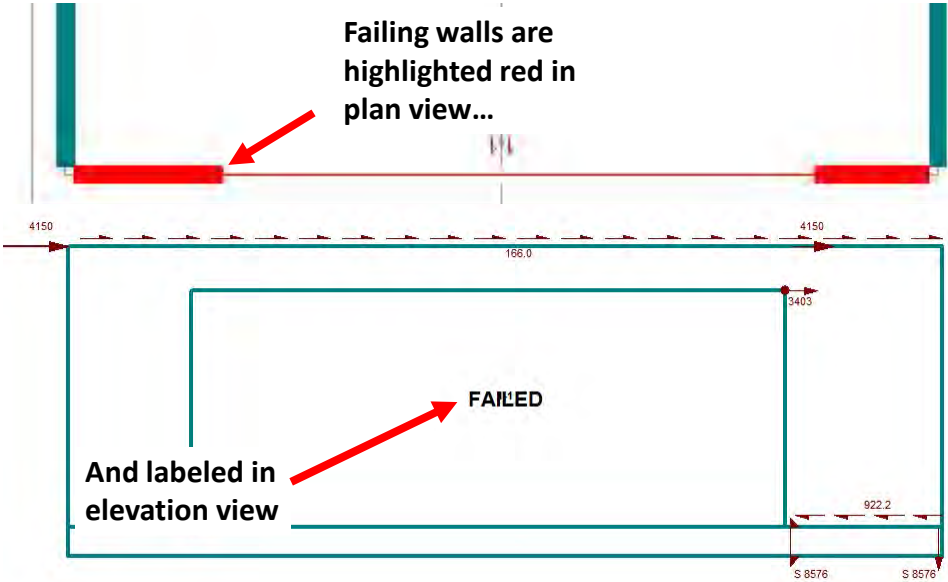
Lateral Design

Visual Design Summary

Failing walls are highlighted red in plan view...

And labeled in elevation view

FAILED



93

93

123456789101112131415161718192021222324252627282930313233343536373839404142434445464748495051525354555657585960616263646566676869707172737475767778798081828384858687888990919293949596979899100

Design Results – Shear Resistance

SHEAR RESULTS (rigid seismic design)										
North-south Shearlines	W Gp	For Dir	Shear Force		Vhd (vd) / L		Capacities (kN/m)			Ratio Fv/V
			FHS [m]	Fv/L [kN/m]	Int	Ext	Jhd	Vrs (vpb) / L	Vrs/L	
								Int	Ext	
Line 1										
Level 2										
Lnl, Lev2	—	Both	7.70	0.65	—	—	—	—	—	0.30
Wall 1-2	4^	Both	7.70	1.58	—	5.32	1.00	—	15.36	0.30
Level 1										
Lnl, Lev1	—	Both	7.70	1.03	—	—	—	—	—	0.35
Wall 1-2	2	Both	7.70	2.50	—	7.05	1.00	—	15.36	0.35

1. Length of full height sheathing = Total wall length – Length of openings

2. Shear force per unit length

3. Shear resistance governed by connection resistance (O86 11.6.2.2.(a))

$$V_{rs} = \phi v_d J_D n_s J_{us} J_s J_{hd} L_s$$

4. Hold-down Adjustment factor (O86 11.5.5)

5. Shear resistance governed by panel buckling (O86 11.6.2.2.(b))

$$V_{rs} = \phi v_{pb} K_D K_S K_T L_s$$

6. Shear Resistance (smaller of resistances by connection resistance and panel buckling)

7. Design Ratio (=Shear Force/Resistance)

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123456789101112131415161718192021222324252627282930313233343536373839404142434445464748495051525354555657585960616263646566676869707172737475767778798081828384858687888990919293949596979899100

SHEATHING MATERIALS by WALL GROUP [mm]												
Wall Grp	Surf	Sheathing: Material	Mark/ Ply	Thk	GU mm	Or	Bv	Dia	Fasteners Len	Pen	Spacing Edg Int	Note #
1	Ext	DF Plywood	3	7.5	—	Horz	4600	2.87	2-1/4	50	150 300	Y 1.0
2	Ext	OSB	M3	11	—	Horz	11000	3.05	2-1/2	53	100 300	Y 1.0 4
3	Ext	OSB	M3	11	—	Horz	11000	3.05	2-1/2	53	150 300	Y 1.0 4
4	Ext	OSB	M3	11	—	Horz	11000	3.33	2-1/2	53	150 300	Y 1.0 4

Vhd (vd) / L		Capacities (kN/m)			Vrs/L
Int	Ext	Jhd	Vrs (vpb) / L	Ext	
—	5.32	1.00	—	15.36	5.32
—	7.05	1.00	—	15.36	7.05

Shearwall Selection Tables

Stud Species:
S-P-F

Factored Shear Resistance $v_{rs}^{1,2,3,4}$ (kN/m)

Common nail size		Panel thickness (mm)	Nail spacing at panel edges (mm)				
Length (in.)	Diameter (mm)		150	125	100	75	50*
2-1/2	3.33+	9.5	5.05	6.06	7.50	8.42	8.42
		12.5	5.59	6.71	8.31	10.6	13.7
		15.5	6.13	7.36	9.11	11.6	15.1
		OSB	9.5	5.05	6.06	7.50	9.05
2-1/2	3.33+	11	5.39	6.38	7.90	10.1	13.1
		12	5.50	6.60	8.17	10.4	13.5
		15	6.04	7.25	8.98	11.4	14.8

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Design Results – Drag Strut

COLLECTOR FORCES (flexible wind design)

Level 1	Line-Wall	Position on Wall or Opening	Location [m]		Drag Strut Force [kN]	Strap/Blocking Force [kN]
			X	Y	→ ←	→ ←
Line 1	1-2	Left Wall End	0.00	10.90	-3.0 3.0	
Line 3	3-1	Left Wall End	3.20	10.90	-10.0 10.7	
Line 4	4-1	Right Wall End	12.20	8.60	1.4 -1.4	
	4-2	Left Wall End	12.20	10.90	-1.4 1.5	
Line 5	5-1	Right Wall End	21.20	8.60	1.4 -1.4	
	5-2	Left Wall End	21.20	10.90	-1.4 1.4	

New slide

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Design Results – Hold-down and bottom plate

Hold-Down and Compression Design (flexible wind design)

Level 1	Line-Wall	Posit'n	Location [m]		Tensile Hold-down or Compressive Stud Force [kN]					1	2	3
			X	Y	Note	Shear	Dead	Uplift	Cmb'd	Hold-down	Cap [kN]	Crit Resp.
Line 1	1-1	L End	1.80	-2.90		40.3	23.3	0.0	16.94	HDU2-SDS2.5	12.9	1.31*
	1-1	L End	1.80	-2.90		-40.3	32.4	0.0	72.66	Compression	59.7	1.22*
	1-1	R End	1.80	7.70		40.3	23.3	0.0	16.94	HDU2-SDS2.5	12.9	1.31*
	1-1	R End	1.80	7.70		-40.3	32.4	0.0	72.66	Compression	59.7	1.22*

1. Hold-down or compression force at wall end

2. Hold-down resistance or bearing resistance of bottom plate

3. Design ratio

New slide

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123456789101112131415161718192021222324252627282930313233343536373839404142434445464748495051525354555657585960616263646566676869707172737475767778798081828384858687888990919293949596979899100

Design Results – Deflections

Shearwall Deflection

DEFLECTION (flexible wind design)

Wall, segment	W Gp	Dir	Srf	v kN/m	Ls m	Hs m	1 Bending A mm2	2 Defl mm	3 Shear Defl mm	4 vs N	5 Nail slip en mm	6 Defl mm	7 Hold Defl mm	8 Total Defl mm
Level 1														
Line 1														
1-2	2	Both	Ext	0.36	7.70	2.40	10640	.00	.08	36	.00	.02	0.0	0.1

O86 Clause 11.7.1.2:

$$\Delta_{sw} = \frac{2vH_s^3}{3EAL_s} + \frac{vH_s}{B_v} + 0.0025H_s e_n + \frac{H_s}{L_s} d_a$$

a) BENDING – Δ_b

b) SHEAR – Δ_v

c) NAIL SLIP – Δ_n

d) ANCHORAGE SLIP – Δ_a

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123456789101112131415161718192021222324252627282930313233343536373839404142434445464748495051525354555657585960616263646566676869707172737475767778798081828384858687888990919293949596979899100

Hold-down Deflection

HOLD-DOWN DISPLACEMENT (flexible wind design)

Wall, segment	Dir	Hold-down	Tens. force kN	1 Vert Displacement Manuf mm	2 Add mm	3 Slippage Vf kN	4 Shrink +Extra mm	5 Comp. force kN	6 Crush da mm	7 Total da mm	8 Horz Defl mm		
Level 1													
Line 1													
1-1	Both	HDU2	9.86	1.8	.00	1.79	-	-	.00	35.45	0.41	2.2	0.6

1. Elongation of anchor bolts

2. Vertical slippage of hold-down fasteners (typically included in elongation)

3. Shrinkage of wood between hold-down brackets, and aditional d_a

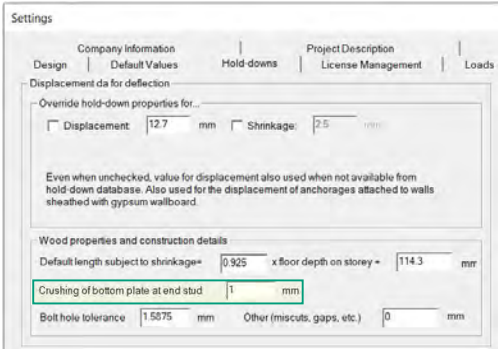
4. **Crushing** of bottom plate

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4. Crushing of shearwall bottom plate

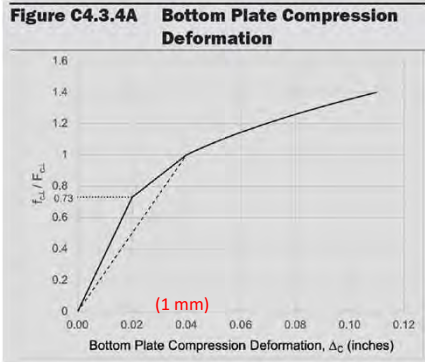
Old version



Constant 1 mm crushing at any load level

New version

Crushing:



Crushing follows load-displacement curve (solid line):
1 mm when loaded at capacity

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Lateral Design – Wind and Seismic

Deflection limits (including torsion effects)

	Seismic (4.1.8.13.)	Wind (4.1.3.5.(3))
Inter-storey drift $\Delta_i \leq$	$1\%h_s$ Post-disaster	$0.2\%h_s$
	$2\%h_s$ High	$0.2\%h_s$
	$2.5\%h_s$ Normal	$0.2\%h_s$

Using calculated deflections and multiplied by $R_d R_o / I_E$

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SHEARWALLS
Lateral Design

STOREY DRIFT (flexible wind design)

Level	Dir	Actual Storey Drift (mm)		Allowable Storey Drift		
		Max defl	Line	hs m	Drift mm	Ratio
1	N<->S	0.5	3	2.70	5.4	0.09
	E<->W	0.1	B		5.4	0.03
2	N<->S	0.2	8	2.70	5.4	0.03
	E<->W	0.1	B		5.4	0.01

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SHEARWALLS
Lateral Design

Design Results

Component & Cladding Design (wind only)

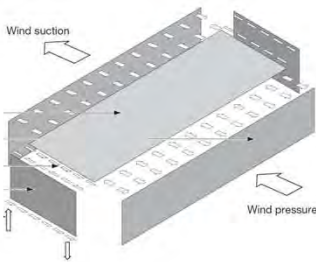
1			2		3	4		5	6	Service Condition Factor	
COMPONENTS AND CLADDING by SHEARLINE			Sheathing [kN/m^2]		Force/Cap	Fastener Withdrawal [kN]		Cap	Force/Cap		
Line	Lev	Grp	Force	Cap		Force End	Int		End	Int	
1	1	2	1.27	15.87	0.08	0.15	0.13	0.19	0.80	0.68	1.00

Sheathing Out-of-plane bending design:

- Out-of-plane bending force
- Sheathing bending capacity
- Design Ratio

Fastener withdrawal design:

- Withdraw force per fastener
- Fastener withdrawal capacity
- Design Ratio



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Design Results

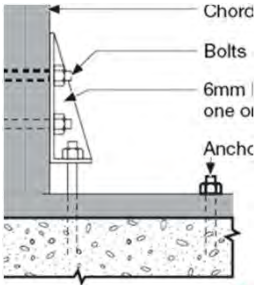
Capacity-based design (seismic only)

✓ Drag struts
(11.8.6)

20% increase in seismic force

✓ Hold downs
(11.8.2)

✗ Anchor bolts
(11.8.2)



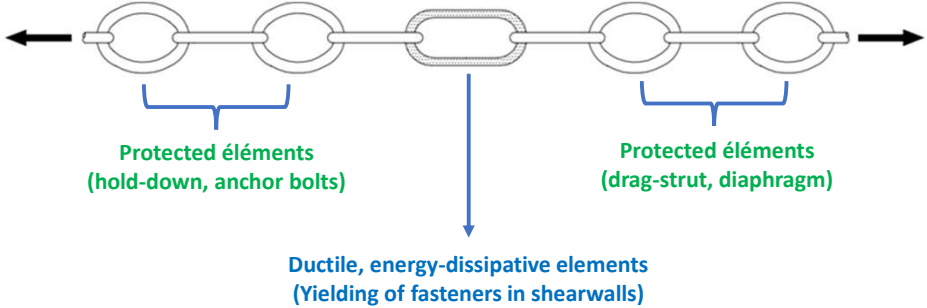
New slide

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SHEARWALLS
Lateral Design

Seismic design philosophy: Capacity-based design



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<http://woodworks-software.com/>

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SHEARWALLS

Lateral Design

Design Results

Irregularity Detection (seismic only)

Irregularity Table detects seismic irregularities as per NBC 4.1.8.6.

No.	Irregularity Type	NBC 4.1.8... Commentary	Irregular for...		Fails for...		Notes
			Levels	Dir/Ln	Levels	Dir/Ln	
1	Vertical Stiffness	7 (1) (c) ; 10 (2) (a) J-118, 150	2, 1	Both	None	None	a
2	Weight (mass)	7 (1) (c) J-118	1, 2	Both	None	None	a
3	Vertical Geometric	7 (1) (c) ; 10 (2) (a) J-118, 150	None	None	None	None	-
4	In-Plane Disc. (offset)	7 (1) (c) ; 10 (2) (a) 15 (5), J-118, 150, 208	None	None	None	None	-
4	In-Plane Disc. (stiffness)	7 (1) (c) ; 10 (2) (a) J-118, 150	None	None	None	None	-
5	Out-of-Plane Offsets	7 (1) (c) ; 10 (2) (a) 15 (5), J-118, 150, 208	None	None	None	None	-
6	Weak Storey	7 (1) (c) ; 10 (1), (2) (b) J-118, 150	None	None	None	None	-
7	Torsional Sensitivity	7 (1) ; 10 (2) (a) 11 (10) ; 11 (11) (b) J-120, 150, 173-5	n/a	n/a	n/a	n/a	d
8	Non-orthogonal	7 (1) (c) J-120	n/a	n/a	n/a	n/a	c
9	Gravity-Induced	7 (1) ; 10 (2), (5-7) J-150	n/a	n/a	n/a	n/a	b

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SHEARWALLS

Lateral Design

Seismic Irregularity

Table 4.1.8.6.
Structural Irregularities⁽¹⁾⁽²⁾
Forming Part of Sentence 4.1.8.6.(1)

Elevation

Plan

Gravity

Type	Irregularity Type and Definition
1	Vertical Stiffness Irregularity Vertical stiffness irregularity shall be considered to exist when the lateral stiffness of the SFRS in a storey is less than 70% of the stiffness of any adjacent storey, or less than 80% of the average stiffness of the three storeys above or below.
2	Weight (mass) Irregularity Weight irregularity shall be considered to exist where the weight, W_i , of any storey is more than 150% of the weight of an adjacent storey. A roof that is lighter than the floor below need not be considered.
3	Vertical Geometric Irregularity Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the SFRS in any storey is more than 130% of that in an adjacent storey.
4	In-Plane Discontinuity in Vertical Lateral-Force-Resisting Element Except for braced frames and moment-resisting frames, an in-plane discontinuity shall be considered to exist where there is an offset of a lateral-force-resisting element of the SFRS or a reduction in lateral stiffness of the resisting element in the storey below.
5	Out-of-Plane Offsets Discontinuities in a lateral force path, such as out-of-plane offsets of the vertical elements of the SFRS.
6	Discontinuity in Capacity - Weak Storey A weak storey is one in which the storey shear strength is less than that in the storey above. The storey shear strength is the total strength of all seismic-resisting elements of the SFRS sharing the storey shear for the direction under consideration.
7	Torsional Sensitivity (to be considered when diaphragms are not flexible) Torsional sensitivity shall be considered to exist when the ratio B calculated according to Sentence 4.1.8.11.(10) exceeds 1.7.
8	Non-orthogonal Systems A non-orthogonal system irregularity shall be considered to exist when the SFRS is not oriented along a set of orthogonal axes.
9	Gravity-Induced Lateral Demand Irregularity ~~Gravity-induced lateral demand irregularity on the SFRS shall be considered to exist where the ratio, α, calculated in accordance with sentence 4.1.8.10.(5), exceeds 0.1 for an SFRS with self-centering characteristics and 0.03 for other systems.~~

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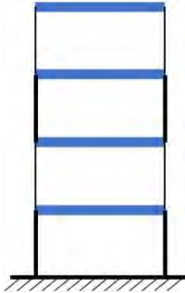


SHEARWALLS
Lateral Design

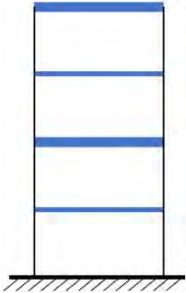
Irregularities (Table 4.1.8.6)

Type	Irregularity Type and Definition
1	Vertical Stiffness Irregularity Vertical stiffness irregularity shall be considered to exist when the lateral stiffness of the SFRS in a storey is less than 70% of the stiffness of any adjacent storey, or less than 80% of the average stiffness of the three storeys above or below.
2	Weight (mass) Irregularity Weight irregularity shall be considered to exist where the weight, W_i , of any storey is more than 150% of the weight of an adjacent storey. A roof that is lighter than the floor below need not be considered.

Type 1



Type 2



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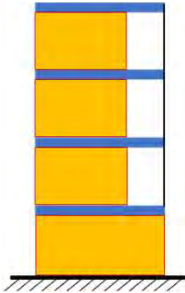


SHEARWALLS
Lateral Design

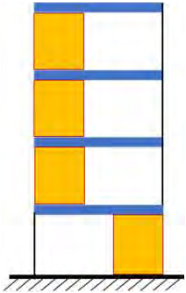
Irregularities (Table 4.1.8.6)

3	Vertical Geometric Irregularity Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the SFRS in any storey is more than 130% of that in an adjacent storey.
4	In-Plane Discontinuity in Vertical Lateral-Force-Resisting Element Except for braced frames and moment-resisting frames, an in-plane discontinuity shall be considered to exist where there is an offset of a lateral-force-resisting element of the SFRS or a reduction in lateral stiffness of the resisting element in the storey below.

Type 3



Type 4



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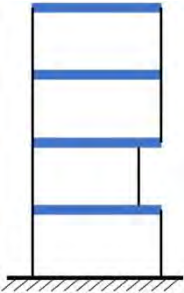


SHEARWALLS
Lateral Design

Irregularities (Table 4.1.8.6)

5	Out-of-Plane Offsets Discontinuities in a lateral force path, such as out-of-plane offsets of the vertical elements of the SFRS.
6	Discontinuity in Capacity - Weak Storey A weak storey is one in which the storey shear strength is less than that in the storey above. The storey shear strength is the total strength of all seismic-resisting elements of the SFRS sharing the storey shear for the direction under consideration.

Type 5



Type 6



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111



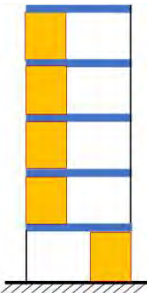
SHEARWALLS
Lateral Design

Additional restrictions – Article 4.1.8.10

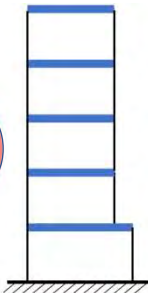
$I_E F_a S_a(0.2) \geq 0.35$ (SC3, SC4)

Type 4 and 5 not permitted for timber buildings more than 4 storeys

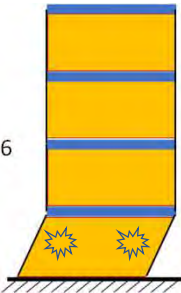
Type 4



Type 5



Type 6



Type 6 permitted for $I_E F_a S_a(0.2) < 0.2$ (SC1) and elastic design ($R_d R_o = 1$).

Not permitted for Post-disaster buildings (NBC 2015 and 2020).

Not permitted for High-importance buildings (NBC 2020).

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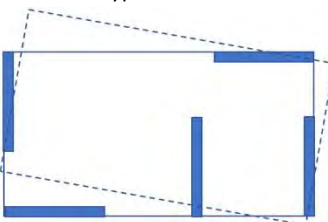
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Irregularities (Table 4.1.8.6)

7	Torsional Sensitivity (to be considered when diaphragms are not flexible) Torsional sensitivity shall be considered to exist when the ratio B calculated according to Sentence 4.1.8.11.(10) exceeds 1.7.
8	Non-orthogonal Systems A non-orthogonal system irregularity shall be considered to exist when the SFRS is not oriented along a set of orthogonal axes.
9	Gravity-Induced Lateral Demand Irregularity Gravity-induced lateral demand irregularity on the SFRS shall be considered to exist where the ratio, α , calculated in accordance with Sentence 4.1.8.10.(5), exceeds 0.1 for an SFRS with self-centering characteristics and 0.03 for other systems.

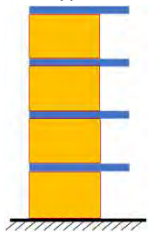
Type 7



Type 8



Type 9



Type 7 (torsional irregularity) not permitted when $I_E S_a(0.2) > 0.35$ (SC3, SC4)

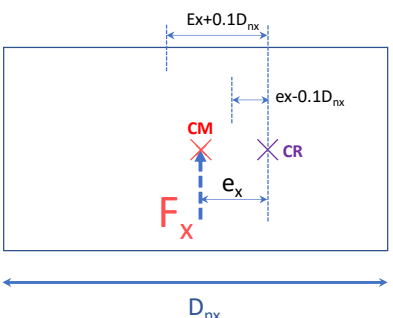
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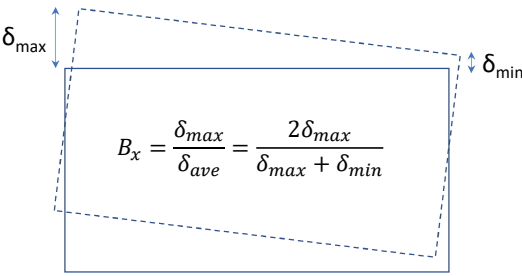


Torsional sensitivity

Accidental torsion & torsional sensitivity



NBC 4.1.8.11. (10)



$B_x = \frac{\delta_{max}}{\delta_{ave}} = \frac{2\delta_{max}}{\delta_{max} + \delta_{min}}$

$B = \max (B_x)$ of all levels

SHEARWALLS checks for torsional sensitivity and warns the user when $B > 1.7$

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Resolving failures

Design Summary

SHEARWALL DESIGN

Wind Shear Loads, Flexible Diaphragm

All shearwalls have sufficient design capacity.

Storey drift (NBC 4.1.3.5.(3)) Within limits. Refer to Storey Drift table.

Wind Shear Loads, Rigid Diaphragm

All shearwalls have sufficient design capacity.

Storey drift (NBC 4.1.3.5.(3)) Within limits. Refer to Storey Drift table.

Components and Cladding Wind Loads, Out-of-plane Sheathing

All shearwalls have sufficient design capacity.

Components and Cladding Wind Loads, Nail Withdrawal

All shearwalls have sufficient design capacity.

Seismic Loads, Flexible Diaphragm

The following under-capacity shear walls were found:
Level 1: B-3, B-4

Percentage gypsum wallboard (O86 11.8.8) Within limits. Refer to Gypsum Wallboard Percentage table.

Storey drift (NBC 4.1.8.13.(3)) Within limits. Refer to Storey Drift table.

Over-capacity ratio (O86 11.8.3.2) Within allowable range. Refer to Seismic Information table.

Irregularities (NBC 4.1.8.6) No violations of design code provisions due to irregularities. Refer to Seismic Irregularities table.

Seismic Loads, Rigid Diaphragm

All shearwalls have sufficient design capacity.

Percentage gypsum wallboard (O86 11.8.8) Within limits. Refer to Gypsum Wallboard Percentage table.

Storey drift (NBC 4.1.8.13.(3)) Within limits. Refer to Storey Drift table.

Over-capacity ratio (O86 11.8.3.2) Within allowable range. Refer to Seismic Information table.

Irregularities (NBC 4.1.8.6) No violations of design code provisions due to irregularities. Refer to Seismic Irregularities table.

1st storey

Materials for Shearwalls B-1, B-6, level 1

Side 1Side 2☐ Both sides the same

Sheathing

MaterialOSB

Thickness11mm

Panel mark1R24/2F16

OrientationHorizontal

Gypsum underlayNonemm

Fasteners

TypePower-driven nails

Len. (in)2-1/2"3.05

Edge spacing100mm

Interior spacing300mm

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First-Storey Wood Floor Systems

WSWH-TP top connection

Maximum 1/8" shim as necessary for tight fit

Place WSWH over threaded rods and secure with heavy bearing plates and heavy hex nuts (provided). Tighten nuts to finger tight plus 1/2 turn • 1 1/2" wrench required for 1" heavy hex nut • WSWH anchor bolts extend 6 1/2" above top of floor sheathing

Field trimmable and drillable WSWH panel

CNW nuts and threaded rods (included with WSWH-RF_KT)

Simpson Strong-Tie A34 each side (sold separately)

Foundation design (size and reinforcement) by designer

WSWH-AB

First-Storey Wood Floor Installation

Strong-Wall® High-Strength Wood Shearwalls

First-Storey Wood Floor Systems

Strong-Wall High-Strength Wood Shearwall First-Storey Wood Floor System on Concrete Foundation

Strong-Wall High-Strength Wood Shearwall Model No.	Width, W		Panel Evaluation Height, H _e		Factored Vertical Resistance, P _v		Factored Shear Resistance, V _v		Drift at V _r	Service Load at H/500
	in.	mm	in.	mm	lb.	kN	lb.	kN		
WSWH12x8	12	93.25	2000	765	0.47	330				
	305	2369	8.90	3.40	11.95	1.47				
WSWH18x8	18	93.25	2000	1990	0.47	815				
	457	2369	8.90	8.85	11.95	3.63				
WSWH124x8	24	93.25	2000	3980	0.47	1625				
	610	2369	8.90	17.70	11.95	7.23				

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