Earthquakes and Single Family Homes

2021 International Residential Code® (IRC®)
Description

• Mid-career residential inspectors and plans examiners will find this seminar insightful as will designers looking for a review of seismic requirements for single family homes.

• With a focus on wood construction, this seminar dives into the details for designing and inspecting a home built to resist large earthquakes.

• Minimum requirements for foundations, walls, roofs and floors are covered as well as a discussion of beyond code minimum options.
Objectives

• Understand how seismic resistance is developed using the IRC to build a structurally safe dwelling.

• Explain how framing and nailing are different in high seismic regions.

• Describe which structural members should be considered when designing for earthquakes.

• Identify structural members requiring additional detailing for earthquakes in a residential example.
About Me

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Product Development
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About You

What is your primary job function?

- Plans Reviewer
- Inspector
- Building or Fire Official
- Permit Tech
- Designer/Engineer
- Contractor/Builder
About You

Where in the United States do you work?

- East coast
- West coast
- Mid-west
- Central
- South
- Alaska
- Hawaii, US Territories
- Canada
- Other country
About You

How many years have you worked in the construction industry?

- 0-5
- 6-10
- 11-20
- 21-30
- 30+
Outline

- Overview
- Building Planning and Construction
  - Loads and Load Path
  - Walls and Wall Coverings
  - Roof-Ceilings and Assemblies
- Two-story Residential Examples
  - 115 mph Winds, Exposure B
  - 160 mph Winds, Exposure B
Overview
IRC – International Residential Code

- Regulates 1- and 2-family dwellings and townhouse structures, existing structures and accessory buildings
- Combines all regulations for building, energy, mechanical, fuel gas, plumbing and electrical into one document
Dwellings and Townhouses

- Habitable attic is a story
- Maximum 3 stories above grade plane
- Allows a full basement in addition to 3 stories
Habitable Attics

• Floor area per Section R304
• Ceiling height per Section R305
• Considered a story above grade plane

• Not a story above grade plane if all the following are met:
  • Total area < \(\frac{1}{3}\) floor area of the story below, or < \(\frac{1}{2}\) floor area of the story below with fire sprinkler system
  • Occupiable space enclosed by roof assembly, knee walls, and floor-ceiling assembly
  • Floor does not extend beyond exterior walls of story below
  • Where located above a 3rd story, the unit must have a fire sprinkler system
Habitable Attics

- Habitable attic
- 3rd story
- 2nd story
- 1st story
- Basement (Not a story above grade plane)

(Not a story above grade plane)

Grade plane

Three stories above grade plane
Dwelling protected by fire sprinkler system per section P2904

Area not greater than 50 percent of story below

Floor plan of habitable attic
Dwellings

• Separate means of egress for each dwelling unit
  • 1 exterior exit door
  • Egress travel distance not regulated
• No size limit
• 2-family dwellings require fire-resistant separations
Townhouses

- Minimum of 3 units
- No maximum number of units
- Fire-resistant separations between units
- Open on at least 2 sides

Units not open on 2 sides cannot be constructed under IRC
Accessory Buildings

• IRC regulates accessory buildings
  • Use incidental and accessory to dwelling
  • On same lot as dwelling
  • Unlimited area
  • ≤ 3 stories AGP
Existing Buildings

- Existing buildings may continue without change
  - Maintained per code under which constructed
- IRC regulates additions, alterations and repairs to an existing building
- Appendix J offers construction compliance alternatives for existing buildings
  - Work categorized as repair, renovation, alteration or reconstruction
Seismic Loads
Lateral Forces

**Wind**

Force = Pressure x Area

**Seismic**

Force = Mass x Acceleration
Climatic and Geographic Design Criteria

IRC adoption: jurisdiction completes table with data applicable to the jurisdiction – for example:

<table>
<thead>
<tr>
<th>Ground Snow Load</th>
<th>Speed (mph) ( V )</th>
<th>Topographic Effects</th>
<th>Special Wind Region</th>
<th>Wind-borne Debris Zone</th>
<th>Seismic Design Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 psf</td>
<td>115 mph</td>
<td>No</td>
<td>No</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

Table R301.2(1)
Lateral Forces - Earthquakes
**ATC Hazards Tool**
hazards.atcouncil.org

- **$S_{DS}$ value**
- **Site Class D**
- $0.462g = SDC C$ per Table R301.2.2.1.1
Table R301.2.2.1.1
Seismic Design Category Determination

<table>
<thead>
<tr>
<th>Seismic Design Category</th>
<th>$S_{DS}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>$S_{DS} &lt; 0.167g$</td>
</tr>
<tr>
<td>A</td>
<td>$0.167g \leq S_{DS} &lt; 0.33g$</td>
</tr>
<tr>
<td>B</td>
<td>$0.33g \leq S_{DS} &lt; 0.50g$</td>
</tr>
<tr>
<td>C</td>
<td>$0.50g \leq S_{DS} &lt; 0.67g$</td>
</tr>
<tr>
<td>D₀</td>
<td>$0.67g \leq S_{DS} &lt; 0.83g$</td>
</tr>
<tr>
<td>D₁</td>
<td>$0.83g \leq S_{DS} &lt; 1.25g$</td>
</tr>
<tr>
<td>D₂</td>
<td>$1.25g \geq S_{DS}$</td>
</tr>
</tbody>
</table>

Las Vegas Strip
0.462g
**ATC Hazards Tool**

**hazards.atcouncil.org**

**Structural Loads and Load Paths**

- **SDS value**
- Site Class E
- 0.462g = SDC $D_0$
- per Table R301.2.2.1.1
Lateral Forces - Earthquakes

**ASCE HAZARD TOOL**

- Location: Las Vegas Strip, Nevada
- Elevation: 0 ft with respect to North American Vertical Datum of 1988 (NAVD 88)
- Lat: 36.11479
- Long: -115.17281
- Standard: ASCE/SEI 7-16
- Risk Category: II
- Soil Class: D - Stiff Soil

**REPORT SUMMARY**

<table>
<thead>
<tr>
<th>Seismic</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_S$</td>
<td>0.493</td>
</tr>
<tr>
<td>$S_L$</td>
<td>0.171</td>
</tr>
<tr>
<td>$F_L$</td>
<td>1.405</td>
</tr>
<tr>
<td>$F_T$</td>
<td>2.288</td>
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<tr>
<td>$S_{25}$</td>
<td>0.693</td>
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<tr>
<td>$S_{34}$</td>
<td>0.385</td>
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<td>$S_D$</td>
<td>0.462</td>
</tr>
<tr>
<td>$S_{MT}$</td>
<td>0.257</td>
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</table>

$S_D$ value
0.462g = SDC C per Table R301.2.2.1.1
### TABLE R301.2(1) CLIMATIC AND GEOGRAPHIC DESIGN CRITERIA

<table>
<thead>
<tr>
<th>COUNTY</th>
<th>GROUND SNOW LOAD, ( P_g )</th>
<th>BASIC DESIGN WIND SPEED, ( V )(mph)(^b)</th>
<th>SPECIAL WIND REGION BASIC DESIGN WIND SPEED, ( V )(mph)(^b)</th>
<th>SEISMIC DESIGN CATEGORY</th>
<th>SUBJECT TO DAMAGE</th>
<th>AIR FREEZING INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baker</td>
<td>Note a</td>
<td>103</td>
<td>—</td>
<td>Note c</td>
<td>Severe</td>
<td>24</td>
</tr>
<tr>
<td>Benton</td>
<td>Note a</td>
<td>96</td>
<td>—</td>
<td>Note c</td>
<td>Moderate</td>
<td>12</td>
</tr>
<tr>
<td>Clackamas</td>
<td>Note a</td>
<td>98</td>
<td>120</td>
<td>Note c</td>
<td>Moderate</td>
<td>12</td>
</tr>
<tr>
<td>Clatsop</td>
<td>Note a</td>
<td>97</td>
<td>135</td>
<td>Note c</td>
<td>Moderate</td>
<td>12</td>
</tr>
<tr>
<td>Columbia</td>
<td>Note a</td>
<td>97</td>
<td>120</td>
<td>Note c</td>
<td>Moderate</td>
<td>12</td>
</tr>
<tr>
<td>Coos</td>
<td>Note a</td>
<td>95</td>
<td>120(^i)</td>
<td>Note c</td>
<td>Moderate</td>
<td>12</td>
</tr>
<tr>
<td>Crook</td>
<td>Note a</td>
<td>98</td>
<td>110</td>
<td>Note c</td>
<td>Severe</td>
<td>18</td>
</tr>
<tr>
<td>Curry</td>
<td>Note a</td>
<td>95</td>
<td>135</td>
<td>Note c</td>
<td>Moderate</td>
<td>12</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

a. The ground snow load, \( P_g \) shall be determined in accordance with Section R301.2.3.1.

b. Sites located within a special wind region as determined from Figure R301.2.1 shall use the special wind speed values indicated in the special wind region column.

c. The seismic design category shall be determined in accordance with Section R301.2.2.1.
Oregon Residential Code
Building Department Website
Seismic Forces

• Seismic (earthquake) forces are:
  • Dynamic; loading direction changes during an earthquake with forces reversing rapidly.
  • Able to shake or slide buildings off their foundations, overturn the entire structure, or force walls out of vertical similar to wind forces.
Seismic Forces

• Seismic forces vary due to:
  • Geometry of the building (regular/irregular).
  • Strength and stiffness distribution (soft/weak story).
  • Weight (mass) and height of the building.
  • Location (SDC and proximity to faults).
  • Construction materials (type/strength/ductility)
Vertical Loads

Vertical (Gravity) Load Path

1. Ridge Beam
2. Post
3. Header
4. Jack Studs
5. Sill Plate
6. Foundation
7. Ground
Load Path

Lateral (Sideways) Load Path

1. Sheathing
2. Floor
3. Studs
4. Foundation
5. Ground
Lateral Forces
Lateral Forces

Effects of Forces

Racking
- Resisted by Bracing

Base Shear
- Resisted by Anchors

Overturning
- Resisted by hold-downs & Dead Load
Lateral Forces – Effects of Forces

Racking

Resisted by Bracing
Lateral Forces – Effects of Forces
Lateral Forces – Effects of Forces

Base Shear

Resisted by Anchors

Anchors
Lateral Forces – Effects of Forces

Base Shear
Lateral Forces – Effects of Forces

Overturning

Resisted by hold-downs & Dead Load
Lateral Forces – Effects of Forces

Overturning

Earthquakes and Single-Family Homes
Lateral Forces – Effects of Forces

Racking
Resisted by Bracing

Base Shear
Resisted by Anchors

Overturning
Resisted by hold-downs & Dead Load

Earthquakes and Single-Family Homes
Stiffened Walls

BWP (Prescriptive)

- Limitations
  - 3-Stories Maximum
  - Wind: $V_{ult} < 140\text{mph}^1$
  - SDC A-D
  - Others (see IRC Chap. 3)

- Typically without hold-downs

Shear Walls (Engineered)

- Applications
  - Any building size/shape
  - Wind – no limit
  - SDC – no limit
  - Calculations required

- Typically with hold-downs

---

1. Limitation: $V_{ult}$ is the ultimate wind speed.
Stiffened Walls

Prescribed material & nailing

Calculated load, material & nailing

Braced Wall Panel (BWP)

Shear Wall

Hold-down capacity calculated

Earthquakes and Single-Family Homes
Stiffened Walls

Wall Framing
Stiffened Walls

Wall Framing

Braced Wall Panel imparts resistance to wall framing (Prevents hinging)
Limits - Seismic

R301.2.2 Seismic provisions.

The seismic provisions of this code shall apply to...

- Townhouses in SDC C, D₀, D₁ and D₂
- Detached one- and two-family dwellings in SDC D₀, D₁ and D₂
Limits - Seismic

Seismic Design Category C

One- & two-family
Seismic requirements don't apply

Townhouse
Seismic requirements apply
Limits – Weight

R301.2.2.2 Weight of Materials

Average dead loads shall not exceed:

• 15 psf for roofs/ceiling assemblies, (exception for up to 25 psf)
• 10 psf for floor assemblies
• 15 psf for exterior wall assemblies
Limits – Irregular Buildings

R301.2.2.6 Irregular buildings

Irregular building definitions

Seismic Requirements
Irregular building provisions apply
R301.2.2.6 Irregular buildings

“The seismic provisions of this code shall not be used for structures... located in Seismic Design Categories C, D₀, D₁, and D₂ and considered to be irregular... Irregular structures, or irregular portions...shall be designed ... with accepted engineering practice... design of the remainder of the building shall be permitted to use the provisions of this code.”

<table>
<thead>
<tr>
<th>Irregular building definitions</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
</table>

Wind Requirements

Irregular building provisions do not apply

Seismic Requirements

Irregular building provisions apply

Additional building shape and structural requirements apply
### Limits – Irregular Buildings

<table>
<thead>
<tr>
<th>Seismic Requirements</th>
<th>Structural Requirements for Irregular Shape</th>
<th>If Irregular Shape Limit Exceeded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irregular Buildings, R301.2.2.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1 2 3 4 5</td>
<td>Engineering</td>
</tr>
<tr>
<td>2</td>
<td>Ex</td>
<td>Engineering</td>
</tr>
<tr>
<td>3</td>
<td>1 2 3 4 5</td>
<td>Engineering</td>
</tr>
<tr>
<td>4</td>
<td>N/A (Eng. Req.)</td>
<td>Engineering</td>
</tr>
<tr>
<td>5</td>
<td>1 2</td>
<td>Engineering</td>
</tr>
<tr>
<td>6</td>
<td>N/A (Eng. Req.)</td>
<td>Engineering</td>
</tr>
<tr>
<td>7</td>
<td>Ex</td>
<td>Engineering</td>
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<tr>
<td>8</td>
<td>N/A (Eng. Req.)</td>
<td>Engineering</td>
</tr>
</tbody>
</table>
Limits – Irregular Buildings

- Setbacks & Cantilevers
- Unsupported Floors & Roofs
- Panel & Window Locations
- Floor or Roof Opening

Earthquakes and Single-Family Homes
Limits – Irregular Buildings

Vertical Floor Offsets

Non-perpendicular Walls

Brick or Masonry Walls

Hillside Structures

Earthquakes and Single-Family Homes
Limits – Irregular Buildings

Vertically in plane

R301.2.2.6
Limits – Irregular Buildings

Setback

Cantilever

\[ \leq 4X \]
Limits – Irregular Buildings

1. 2 x 10 joists min. @ 16" max. (Cantilever & Setback)

2. Back span to cantilever = 2:1 (Cantilever)
Limits – Irregular Buildings

1. Uniform loads & 8' max. header clear span

2. ≤4X

3. Doubled Joists

4. Continuous rim or approved splice

5. R301.2.2.6

Earthquakes and Single-Family Homes
Limits – Irregular Buildings

1. **Summary**
   
   **Setback or Cantilever**
   
   1. 2" x 10" Joists @ 16" Max.
   2. Back span to cantilever = 2:1
   3. Doubled joists at BWP ends
   4. Continuous rim or approved splice
   5. Uniform load & 8' max header
Limits – Irregular Buildings
Limits – Irregular Buildings

Unsupported roof or floor

6' Max.

R301.2.2.6

Earthquakes and Single-Family Homes
Limits – Irregular Buildings

2

Lateral Support:
When a section of floor or roof is not laterally supported by shear walls or braced wall lines on all edges.

R301.2.2.6
Limits – Irregular Buildings

1' Max.

BWP

R301.2.2.6
Limits – Irregular Buildings

3. Entire BWP length shall not occur over opening below.

BWP & window not in line

8' Max.

Header requirement

1 2 3 4

R301.2.2.6
## Limits – Irregular Buildings

<table>
<thead>
<tr>
<th>Maximum Opening length</th>
<th>Minimum Header Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>4'</td>
<td>Qty 1 – 2&quot; x 12&quot; Qty 2 – 2&quot; x 10&quot;</td>
</tr>
<tr>
<td>6'</td>
<td>Qty 2 – 2&quot; x 12&quot; Qty 3 – 2&quot; x 10&quot;</td>
</tr>
<tr>
<td>8'</td>
<td>Qty 3 – 2&quot; x 12&quot; Qty 4 – 2&quot; x 10&quot;</td>
</tr>
</tbody>
</table>
Limits – Irregular Buildings

Floor or roof opening

W/2 12' max.

Least dimension

W/2 12' max.

W
Floor or Roof Opening:
When an opening in a floor or roof exceeds the lesser of 12 feet or 50% of the least floor dimension it must be engineered in high seismic regions.
Limits – Irregular Buildings

Vertical offset permitted if:

1. Floor framing supported over continuous foundation at building perimeter,  
or

2. Floor framing lapped or connected per R502.6.1

Vertically offset

R301.2.2.6
Limits – Irregular Buildings

Not perpendicular
Limits – Irregular Buildings

Masonry or Concrete:

When stories above-grade...include masonry or concrete construction.

Entire story must be designed by engineer.

Exception:

Fireplaces, chimneys, and masonry veneer are permitted by this code.
Limits – Irregular Buildings

Hillside Construction:

Grade slope > 1:5; Engineering required for cripple walls or posts and beams, floor above and foundation.

Exception:

Basement with concrete or masonry walls on three sides
R301.2.2.6 Irregular buildings review

Irregular portions of structures shall be designed in accordance with accepted engineering practice unless specific exceptions are met.
Limits – Story Height

In-plane lateral forces
- Requirements for story height exist to limit the wind and seismic provisions
- In-plane forces (lateral forces along a wall line)
  - Story height limit – 11 ft. 7 in.
    - Exception: 13 ft. 7 in. with limits (R602.3.1)
  - Bearing stud height – 10 ft.
    - Exception: 12 ft with limits (Table R602.3(5) footnote a)
- When wall heights do exceed the limit, the walls are designed using the IBC
Limits – Story vs Stud Height

10' = Max. Bearing Stud Height
20' = Max. Nonbearing Stud Height
(Table R602.3(5))
Limits – Story Height

No max floor framing depth

10' = Max. Bearing Stud Height  
(Table R602.3(5))

Stud Height

Story Height

Story Height
Limits – Story Height

Out-of-plane lateral forces

Requirements for story height exist to limit the wind forces pressing against a wall.

Out-of-plane forces (wind on sail area):
- Stud height limit: 10 ft (bearing wall)
- 20 ft (nonbearing wall)

Stud height may be increased to 20 ft. for bearing walls, if the building and wall line meet the requirements of Section R602.3.1.
# Limits – Stud Height

Size, Height and Spacing of Wood Studs - Table R602.3(5)\(^a\)

<table>
<thead>
<tr>
<th>Stud Size (Inches)</th>
<th>Laterally unsupported stud height (feet)(^a)</th>
<th>Maximum spacing when supporting roof-ceiling assembly or habitable attic, only (inches)</th>
<th>Maximum spacing when supporting one floor, plus a roof-ceiling assembly or habitable attic (inches)</th>
<th>Maximum spacing when supporting two floors, a roof-ceiling assembly or habitable attic (inches)</th>
<th>Maximum spacing when supporting one floor height (inches)(^a)</th>
<th>Laterally unsupported stud height (feet)(^a)</th>
<th>Maximum spacing (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x 3(^b)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>10</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>2 x 4</td>
<td>10</td>
<td>24</td>
<td>16</td>
<td>--</td>
<td>24</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>3 x 4</td>
<td>10</td>
<td>24</td>
<td>24</td>
<td>16</td>
<td>24</td>
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<td>2 x 5</td>
<td>10</td>
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<td>24</td>
<td>--</td>
<td>24</td>
<td>16</td>
<td>24</td>
</tr>
<tr>
<td>2 x 6</td>
<td>10</td>
<td>24</td>
<td>24</td>
<td>16</td>
<td>24</td>
<td>20</td>
<td>24</td>
</tr>
</tbody>
</table>
Limits – Stud Height

Table R602.3(5) footnote a

1. Listed heights are distances between points of lateral support placed perpendicular to the plane of the wall.

2. Bearing walls shall be sheathed on not less than one side or bridging shall be installed not greater than 4 feet apart measured vertically from either end of the stud.

3. Increases in unsupported height are permitted where in compliance with Exception 2 of Section R602.3.1 or designed in accordance with accepted engineering practice.
Limits – Stud Height

Table R602.3(5) footnotes b and c

b. [2x3 studs] shall not be used in exterior walls.

c. A habitable attic assembly supported by 2 × 4 studs is limited to a roof span of 32 feet. **Where the roof span exceeds 32 feet, the wall studs shall be increased to 2 × 6** or the studs shall be designed in accordance with accepted engineering practice.
Limits – Stud Height

Stud Size, Height and Spacing - Section R602.3.1 footnote b

An exception in Section R602.3.1 allows stud heights greater than 10 feet tall for very limited circumstances in bearing walls.

- Snow loads $\leq 25$ psf
- $V_{ult} \leq 130$ mph
- 2-inch by 6-inch studs
- Roof load $\leq 6$ feet of tributary length
- Min. No. 2 grade studs

Maximum height
- 18 feet @ 16 inches o.c.
- 20 feet @ 12 inches o.c.
Limits – Stud Height

Two Point Truss

Three Point Truss

6' Max.

Tall walls
Limits – Stud Height

Stud Size, Height and Spacing - Section R602.3.1 footnote c

- An exception in Section R602.3.1 allows stud heights to 12 feet tall in bearing walls.
- Studs must meet the requirements of Table R602.3(6).

Limits
- Snow loads ≤ 30 psf
- Wind Exposure B
- Min. No. 2 grade studs and plates

Maximum height
- 12 feet
## Limits – Stud Height

Alternate Wood Bearing Wall Stud Size, Height and Spacing – Table R602.3(6) excerpt

<table>
<thead>
<tr>
<th>Stud Height</th>
<th>Supporting</th>
<th>Stud Spacing&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Ultimate Design Wind Speed</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>115 mph</td>
<td>130 mph&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Maximum roof/floor span&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Maximum roof/floor span&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12 ft.</td>
<td>24 ft.</td>
<td>12 ft.</td>
</tr>
<tr>
<td>11 ft.</td>
<td>Roof Only</td>
<td>12 in.</td>
<td>2 x 4</td>
<td>2 x 4</td>
<td>2 x 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 in.</td>
<td>2 x 4</td>
<td>2 x 4</td>
<td>2 x 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 in.</td>
<td>2 x 6</td>
<td>2 x 6</td>
<td>2 x 6</td>
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<tr>
<td>12 ft.</td>
<td>Roof and One Floor</td>
<td>12 in.</td>
<td>2 x 4</td>
<td>2 x 4</td>
<td>2 x 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 in.</td>
<td>2 x 6</td>
<td>2 x 6</td>
<td>2 x 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 in.</td>
<td>2 x 6</td>
<td>2 x 6</td>
<td>2 x 6</td>
</tr>
<tr>
<td></td>
<td>Roof Only</td>
<td>12 in.</td>
<td>2 x 4</td>
<td>2 x 4</td>
<td>2 x 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 in.</td>
<td>2 x 4</td>
<td>2 x 6</td>
<td>2 x 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 in.</td>
<td>2 x 6</td>
<td>2 x 6</td>
<td>2 x 6</td>
</tr>
</tbody>
</table>

---

<sup>a</sup> Refer to IRC 2021 for detailed stud size, height, and spacing guidelines.

<sup>b</sup> Ultimate design wind speed for 130 mph areas needs additional considerations.

<sup>c</sup> Maximum roof/floor span varies based on thickness and support conditions.
Limits – Stud Height

Alternate Wood Bearing Wall Stud Size, Height and Spacing – Table R602.3(6)

DR = Design Required

a. Wall studs ≤ 16 in. o.c. shall be sheathed with minimum ½-inch GB on the interior and ⅜-inch WSP sheathing on the exterior. WSP sheathing shall be attached with 8d (2.5" x 0.131") nails ≤ 6 in. o.c. along panel edges and 12 in. o.c. at intermediate supports, and all panel joints shall occur over studs or blocking.

b. Where $V_{ult} > 115$ mph, studs shall be attached to top and bottom plates with connectors having a min. 300-pound lateral capacity.

c. The max. span is applicable to both single- and multiple-span roof and floor conditions. The roof assembly shall not contain a habitable attic.
Foundations
Foundation styles

Basement

Crawl Space

Slab on Grade
Wall Anchorage to Foundations

**Sliding**
Resisted by soil friction and lateral bearing capacity of soil.

**Overturning**
Resisted by weight of structure and footing, weight of soil on footing, and bearing capacity of soil.
Footings

**Table R403.1 Concrete Footings**

<table>
<thead>
<tr>
<th>Ground Snow Load or Roof Live Load</th>
<th>Story and Type of Structure with Light Frame</th>
<th>Load-Bearing Value of Soil (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1,500</td>
</tr>
<tr>
<td>20 psf roof live load or 25 psf ground snow load</td>
<td>1 story—slab-on-grade</td>
<td>12 x 6</td>
</tr>
<tr>
<td></td>
<td>1 story—with crawl space</td>
<td>12 x 6</td>
</tr>
<tr>
<td></td>
<td>1 story—plus basement</td>
<td>16 x 6</td>
</tr>
<tr>
<td></td>
<td>2 story—slab-on-grade</td>
<td>13 x 6</td>
</tr>
<tr>
<td></td>
<td>2 story—with crawl space</td>
<td>15 x 6</td>
</tr>
<tr>
<td></td>
<td>2 story—plus basement</td>
<td>19 x 6</td>
</tr>
<tr>
<td></td>
<td>3 story—slab-on-grade</td>
<td>16 x 6</td>
</tr>
<tr>
<td></td>
<td>3 story—with crawl space</td>
<td>18 x 6</td>
</tr>
<tr>
<td></td>
<td>3 story—plus basement</td>
<td>22 x 7</td>
</tr>
<tr>
<td></td>
<td>1 story—slab-on-grade</td>
<td>12 x 6</td>
</tr>
<tr>
<td></td>
<td>1 story—with crawl space</td>
<td>13 x 6</td>
</tr>
</tbody>
</table>
# Footings and Foundations

## Concrete Reinforced Footing Requirements (R403)

<table>
<thead>
<tr>
<th>Code Section</th>
<th>Provision</th>
<th>SDC A-C</th>
<th>High Seismic Regions SDC D₀-D₂</th>
</tr>
</thead>
</table>
| R403.1.3.1   | Concrete stem wall Construction Joint | No reinforcement requirements, unless required by other sections of code | 1-#4 horizontal within 12” of the top of wall  
1-#4 horizontal located 3” to 4” from bottom of footing  
1-#4 vertical at 48” o.c. with standard hook at bottom bars with minimum 14” into stem wall |
| R403.1.3.2   | Masonry stem wall                   | No reinforcement requirements, unless required by other sections of code | 1-#4 horizontal within 12” of the top of wall and  
1-#4 at 3” to 4” from bottom of footing  
1-#4 vertical at 48” o.c. with standard hook at bottom bar with minimum 14” into stem wall |
| R403.1.3.3   | Slab with turned down footing       | No reinforcement requirements, unless required by other sections of code | 1-#4 horizontal at top and bottom or 2-#4 or 1-#5 in middle third  
1-#3 vertical at 48” o.c. with standard hook to top and bottom bars when slab and footing cast separately |
Footings and Foundations

Construction Joint Reinforcement
# Footings and Foundations

## Continuous Footings in SDC D₀, D₁, D₂ (R403.1.2)

<table>
<thead>
<tr>
<th>Braced Wall Panel</th>
<th>Number of Stories</th>
<th>Plan Dimension ≤ 50 ft.</th>
<th>Plan Dimension &gt; 50 ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exterior</strong></td>
<td>All Stories</td>
<td>Supported by continuous footings</td>
<td>Supported by continuous footings</td>
</tr>
<tr>
<td><strong>Interior</strong></td>
<td>Single Story</td>
<td>No requirement for continuous footing</td>
<td>Continuous footings below all required interior BWPs</td>
</tr>
<tr>
<td></td>
<td>Two Story</td>
<td>No requirement for continuous footing</td>
<td>Continuous footings below all required interior BWPs</td>
</tr>
<tr>
<td></td>
<td>Two Story Exception</td>
<td>No requirement for continuous footing</td>
<td>Exception – allows interior BWP support every 50 feet or less with additional requirements</td>
</tr>
</tbody>
</table>
Footings and Foundations

SDC $D_0$ and $D_1$

Two-story exception to allow 50' interval between continuous foundation segments

1. Cripple walls not more than 4' in height
2. First floor BWP's are supported on double floor joists, continuous blocking or floor beams
3. The distance between BWL's does not exceed twice the building width measure parallel to the BWL
## Footings and Foundations

### Continuous Footings SDC $D_2$

<table>
<thead>
<tr>
<th>Braced Wall Panel</th>
<th>Number of Stories</th>
<th>Plan Dimension $\leq 50$ ft.</th>
<th>Plan Dimension $&gt; 50$ ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exterior</strong></td>
<td>All Stories</td>
<td>Supported by continuous footings</td>
<td>Supported by continuous footings</td>
</tr>
<tr>
<td><strong>Interior</strong></td>
<td>Single Story</td>
<td>No requirement for continuous footing</td>
<td>Continuous footings below all interior BWPs</td>
</tr>
<tr>
<td></td>
<td>Two Story</td>
<td>Requires continuous foundation below all interior BWPs</td>
<td>Requires continuous foundation below all interior BWPs</td>
</tr>
</tbody>
</table>
Footings and Foundations

Continuous footing

SDC D, one-story, continuous footing at 50' intervals
Footings and Foundations

SDC D₂, 2-story continuous footings at all interior BWPs
Footings and Foundations

Footings

Anchor bolt placement

• Bolts embedded 7 inches
• Total length = 7" + plate(s) depth + threaded end
• Placed at 6 feet on center
• Bolts shall be located in the middle third of the width of the plate
• Bolts can be wet-set

Footing depth

• Minimum 12 inches (R403.1.4)
• Frost depth controls in many areas
Footings and Foundations

1/2" bolt with 7" min. embedment in concrete or masonry

7 bolt dia. min. to 12" max.

6' max.

End of Plate

R403.1.6
Footings and Foundations

Anchor bolt spacing
## Footings and Foundations

### Wall Bracing – Foundation Requirements (R602.10)

<table>
<thead>
<tr>
<th>Code Section</th>
<th>Provision</th>
<th>SDC A-C</th>
<th>SDC $D_0$-$D_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>R602.10.6, Figures R602.10.6.1 and R602.10.6.2</td>
<td>Alternate wall bracing (ABW, PFH)</td>
<td>Methods ABW and PFH required 1-#4 horizontal top and bottom of footing</td>
<td>Methods ABW and PFH required 1-#4 horizontal at top and bottom of footing</td>
</tr>
<tr>
<td>R602.10.9, Figure R602.10.9</td>
<td>Short concrete or masonry walls below BWPs</td>
<td>Rebar required complying with Figure R602.10.9 if wall length, height, and thickness are $L \leq 48''$ AND $H &gt; 12''$ AND $T &lt; 6''$</td>
<td>Rebar required complying with Figure R602.10.9 if wall length, height, and thickness are $L \leq 48''$ AND $H &gt; 12''$ AND $T &lt; 6''$</td>
</tr>
</tbody>
</table>
Wall Anchorage to Foundations

Wall Bracing Section Requirements

For footings supporting an ABW or PFH panel

#4 bars at top & bottom

R602.10.6.1 and R602.10.6.2
Footings and Foundations

Narrow Masonry Wall Requirements

Only required for walls less than 48" long.
# Footings and Foundations

## Anchorage Requirements (R403.1.6, R403.1.6.1, R602.11)

<table>
<thead>
<tr>
<th>Section</th>
<th>Provision</th>
<th>SDC A-C</th>
<th>SDC D₀-D₂, SDC C (townhouses)</th>
</tr>
</thead>
</table>
| R403.1.6, R403.1.6.1 | Foundation anchorage | • Wood sole and sill plates attached to foundation with anchor bolts 6' o.c.  
 • ½” bolt w/ min. 7” embedment  
 • 2 bolts per plate with bolts located 7 bolt diameters to 12” from each end | • Wood sole and sill plates attached to foundation with anchor bolts 4' o.c. for 3-stories  
 • Interior and exterior BWLs require plate washers  
 • Wall lines without BWPs may use cut washers in lieu of plate washers  
 • ½” bolt w/ min. 7” embedment and 3” by 3” plate washers  
 • 2 bolts per plate with bolts located 7 bolt diameters to 12” from each end |

**Exception:**  
• 24” and shorter walls require 1 anchor bolt  
• 12” and shorter walls do not require anchor bolts
Footings and Foundations

Anchorage Requirements (R602.11)

<table>
<thead>
<tr>
<th>Code Section</th>
<th>Provision</th>
<th>SDC A-C</th>
<th>SDC D₀-D₂, SDC C (townhouses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R602.11</td>
<td>Wall anchorage</td>
<td>No additional requirements, use Section R403.1.6</td>
<td>Plate washers 0.229&quot; by 3&quot; by 3&quot; minimum between sill plate and nut on braced wall lines</td>
</tr>
</tbody>
</table>
Wall Anchorage to Foundations

- **Exterior Stem Wall on Footing**
  - #4 bars at top & bottom
  - 3-4" min.
  - #4 bars at 4' o.c. (extend 14" into stem wall)

- **Interior Stem Wall on Footing**
  - #4 bars at top & bottom
  - 3-4" min.
  - 12" max

- **SDC D₀, D₁ and D₂**

**Notes:**
- SDC D₀, D₁ and D₂
- R403.1.3, R403.1.3.1

**Images:**
- Exterior Stem Wall on Footing
- Interior Stem Wall on Footing
Wall Anchorage to Foundations

**SDC** $D_0$, $D_1$ and $D_2$

Seismic reinforcing

- **Exterior Turned-down Slab Footing**
  - #4 bars at top & bottom

- **Interior Turned-down Slab Footing**
  - $3\text{"}$
  - $7\text{"}$ min.
  - $3\text{-}1/2\text{"}$
Wall Anchorage to Foundations

- Construction Joint
- #4 bars at top & bottom
- Exterior Turned-down Slab Footing
- Interior Turned-down Slab Footing

**SDC D₀, D₁ and D₂**

- #3 bars at 4' o.c. (if const. joint used)

- R403.1.3.3, R403.1.3.4
# Footings and Foundations

## Concrete Foundation Walls (Basement Walls)  R404

<table>
<thead>
<tr>
<th>Code Section</th>
<th>Provision</th>
<th>SDC A-C</th>
<th>High Seismic Regions SDC D₀-D₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table R404.1.2(1)</td>
<td>Horizontal Reinforcement</td>
<td>1-#4 required at top and mid-height (or third points)</td>
<td>1-#4 horizontal required within 12 inches of top and near mid-height</td>
</tr>
<tr>
<td>Tables R404.1.2(2) thru R404.1.2(9)</td>
<td>Vertical Reinforcement</td>
<td>Rebar required according to table used, read footnotes for additional requirements</td>
<td>Rebar required according to table used, read footnotes for additional requirements</td>
</tr>
<tr>
<td>R404.1.4.2</td>
<td>Concrete foundation walls in SDC D₀-D₂</td>
<td>No additional reinforcement requirements</td>
<td>Walls less than or equal to 7.5&quot; thick require 1-#4 vertical bar at 48&quot; o.c.</td>
</tr>
</tbody>
</table>
Stepped Foundation Base

Connection per R403.1

Stepped at bottom
Intermittent Cripple Walls

- If \( A \geq 8' \), wall line considered braced
- If \( A < 8' \), not considered braced, bracing required

SDC D₀, D₁ and D₂
Stepped foundations

- If \( A \geq 8' \), provide metal tie

2x Plate Splice

2' min.

Footing
Section "A"

3" x 3" Plate Washer

Earthquakes and Single-Family Homes
Walls
## Connections – Wall

<table>
<thead>
<tr>
<th>Item</th>
<th>Description of Building Elements</th>
<th>Number and Type of Fastener</th>
<th>Spacing of Fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Stud to Stud (not at braced wall panels)</td>
<td>16d common (3½&quot; x 0.162&quot;)</td>
<td>24” o.c. face nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10d box (3&quot; x 0.128&quot;); or 3&quot; x 0.131&quot; nails</td>
<td>16” o.c. face nail</td>
</tr>
<tr>
<td>9</td>
<td>Stud to stud and abutting studs at intersecting wall corners (at braced wall panels)</td>
<td>16d box (3½&quot; x 0.135&quot;); or 3&quot; x 0.131&quot; nails</td>
<td>12” o.c. face nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16d common (3½&quot; x 0.162&quot;)</td>
<td>16” o.c. face nail</td>
</tr>
</tbody>
</table>

**NOTE:**

16d common (3½" x 0.162")
16d sinker (3¾" x 0.148");
16d box (3½" x 0.135")
Pneumatic nails (3½" x 0.12" - 0.131")
Connections – Wall

- Studs at corners
- Abutting studs = Built-up column
# Connections – Wall

<table>
<thead>
<tr>
<th>Item</th>
<th>Description of Building Elements</th>
<th>Number and Type of Fastener</th>
<th>Spacing of Fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Built-up header (2&quot; to 2&quot; header with ½&quot; spacer)</td>
<td>16d common (3½&quot; x 0.162&quot;)</td>
<td>16&quot; o.c. along each edge face nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16d box (3½&quot; x 0.135&quot;)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Continuous header to stud</td>
<td>5-8d box (2½&quot; x 0.113&quot;); or 4-8d common (2½&quot; x 0.131&quot;); or 4-10d box (3&quot; x 0.128&quot;)</td>
<td>Toe nail</td>
</tr>
</tbody>
</table>

Table R602.3(1)
## Connections – Wall

<table>
<thead>
<tr>
<th>Item</th>
<th>Description of Building Elements</th>
<th>Number and Type of Fastener</th>
<th>Spacing of Fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Adjacent full-height stud to end of header</td>
<td>4-16d box (3-1/2&quot; x 0.135&quot;); or 3-16d common (3-1/2&quot; x 0.0162&quot;); or 4-10d box (3&quot; x 0.128&quot;); or 4-3&quot; x 0.131&quot; nails</td>
<td>End nail</td>
</tr>
<tr>
<td>13</td>
<td>Top plate to top plate</td>
<td>16d common (3½&quot; x 0.162&quot;)</td>
<td>16&quot; o.c. face nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10d box (3&quot; x 0.128&quot;); or 3&quot; x 0.131&quot; nails</td>
<td>12&quot; o.c. face nail</td>
</tr>
</tbody>
</table>

Table R602.3(1)
## Connections – Wall

<table>
<thead>
<tr>
<th>Item</th>
<th>Description of Building Elements</th>
<th>Number and Type of Fastener</th>
<th>Spacing of Fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Double top plate splice for SDCs A-D₂ with seismic braced wall line spacing &lt; 25’</td>
<td>8-16d common (3½” x 0.162”); or 12-16d box (3½” x 0.135”); or 12-10d box (3” x 0.128”); or 12-3” x 0.131” nails</td>
<td>Face nail on each side of end joint (minimum 24” lap splice length each side of end joint)</td>
</tr>
<tr>
<td></td>
<td>Double top plate splice SDCs D₀, D₁, or D₂; and braced wall line spacing ≥ 25’</td>
<td>12-16d (3½” x 0.135”)</td>
<td></td>
</tr>
</tbody>
</table>

Table R602.3(1)

![Diagram of Connections – Wall](image-url)

Earthquakes and Single-Family Homes
## Connections – Wall

<table>
<thead>
<tr>
<th>Item</th>
<th>Description of Building Elements</th>
<th>Number and Type of Fastener</th>
<th>Spacing of Fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Bottom plate to joist, rim joist, band joist or blocking (not at braced wall panels)</td>
<td>16d common (3½&quot; x 0.162&quot;)</td>
<td>16&quot; o.c. face nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16d box (3½&quot; x 0.135&quot;); or 3&quot; x 0.131&quot; nails</td>
<td>12&quot; o.c. face nail</td>
</tr>
<tr>
<td>16</td>
<td>Bottom plate to joist, rim joist, band joist or blocking (at braced wall panel)</td>
<td>3-16d box (3½&quot; x 0.135&quot;); or 2-16d common (3½&quot; x 0.162&quot;); or 4-3&quot; x 0.131&quot; nails</td>
<td>16&quot; o.c. face nail</td>
</tr>
</tbody>
</table>
Connections – Wall

Blocking for interior BWP placed between 2 joists

Blocking for interior BWL

Table R602.3(1)
When braced wall panels are perpendicular to joists above or below, blocking shall be provided in line with the BWPs...
Connections

BWP Perpendicular to Framing

Toenail at 6" o.c. with 8d common (2-1/2" × 0.131") or 10d box (3" × 0.128") or 3" × 0.131" nails

Nail at 16" o.c. along BWP with 3-16d box (3-1/2" × 0.135") or 2-16d com. (3-1/2" × 0.162") or 4-3" × 0.131" nails

Figure R602.10.8(1) & Table R602.3(1) Items 16, 23
Connections

Where joists are parallel to BWPs above or below... where a parallel framing member cannot be located... full-depth blocking at 16 inch spacing shall be provided...

R602.10.8 Item 2, Figure R602.10.8(2)
Connections

BWP Parallel to Framing

Figure R602.10.8(2) & Table R602.3(1)
Bracing Topics

- Forces & History
- Related Provisions
- Bracing
  - Locate BWL
  - BWL Spacing
  - Locate BWPs
  - Required Length
  - Sufficient Length
  - Panel Material & Ends
  - Connections
  - Simplified Wall Bracing
- Examples
Wall Bracing

R602.10 Wall Bracing

"... Where a building, or portion thereof, does not comply with one or more of the bracing requirements in this section, those portions shall be designed and constructed in accordance with Section R301.1."
R301 Design Criteria

Engineered design

- Where a building of otherwise conventional construction contains structural elements not conforming to the IRC, these elements shall be designed in accordance with accepted engineering practice.
- The extent of design must show equal or better capacity to requirements of the IRC and be compatible with the performance of the conventional system.
- Engineered design in accordance with the *International Building Code* is permitted.
Definitions

Definitions from the IRC have been copied into the wall bracing guide, including

**BRACED WALL LINE**

A straight line through the building plan that represents the location of the lateral resistance provided by the wall bracing.
Locating Braced Wall Lines

Braced Wall Lines (BWL)

- Braced wall lines are straight lines drawn on a building plan

Figure R602.10.1.1

Earthquakes and Single-Family Homes

R602.10.1

Figure
R602.10.1.1
Locating Braced Wall Lines

**Braced Wall Lines (BWL)**

- Each BWL shall be located such that no more than 2/3 of the required braced wall panel length is located to one side of the BWL.
- Bracing on walls within 4 feet of the designated BWL may be counted as bracing for that BWL.
Locating Braced Wall Lines
Braced Wall Line Spacing

How many BWL's?
Braced Wall Line Spacing

Loaded wall versus resisting walls

Length

Width

RESISTANCE

LOAD

Earthquakes and Single-Family Homes
Braced Wall Line Spacing

Loaded wall versus resisting walls

Length

Resistances

Load
Braced Wall Line Spacing

Wall lines with BWP offset limitations

- Wall lines with BWP that are counted as part of a BWL must be parallel to the BWL
- Offsets out-of-plane up to 4' are permitted for any wall line
- There is an angle wall exception which will be discussed later
Braced Wall Line Spacing

Table R602.10.1.3

Wind

BWL Spacing = 60' max.
# Braced Wall Line Spacing

## Table R602.10.1.3

<table>
<thead>
<tr>
<th>Seismic</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC D₀, D₁, &amp; D₂ (all dwellings)</td>
<td></td>
</tr>
<tr>
<td>BWL Spacing = 25' max. Permitted to be = 35' max.</td>
<td></td>
</tr>
<tr>
<td>1. To accommodate one room not exceeding 900 ft²</td>
<td></td>
</tr>
<tr>
<td>2. For all BWLs when bracing length is increased and L/W &lt; 3:1</td>
<td></td>
</tr>
</tbody>
</table>

![Diagram](image.png)
Braced Wall Line Spacing

SDC D₀ to D₂
25' or 35' Spacing

Add interior BWL,
max. spacing = 25'

No bracing length
Adjustment needed
Braced Wall Line Spacing

35' x 20' = 700 s.f. < 900 s.f.; okay
No increase in bracing length required

SDC D₀, D₁ & D₂
Up to 35' BWL Spacing, First Exception

Earthquakes and Single-Family Homes
Braced Wall Line Spacing

Increase required bracing length by factor of 1.4 on BWLs 1 and 2

Table R602.10.1.3 & R602.10.3(4)

SDC D₀, D₁ & D₂
Up to 35' BWL Spacing, Second Exception

Add interior BWL?
Locate Braced Wall Panels

R602.10.2.2 Location of Braced Wall Panels

Placement Requirements

• BWP begins no more than 10' feet from the end of a BWL.
• BWP located not more than 20' o.c. from edge to edge
Locate Braced Wall Panels

Wind
Panel begins up to 10 ft. from the corner

Braced Panel Starting Location

Distance from Corner

8' to 12'

Corner (end of wall line)

R602.10.2.2

Earthquakes and Single-Family Homes
Walls – Required Bracing Length
Both wind speed and seismic risk must be considered when defining required wall bracing.

The required bracing length is the greater of the two bracing lengths.
Required Length

When considering whether wind or seismic requirements control, a number of factors must be considered.

- Wall bracing length - either wind or seismic requirements may control. Use the longest required length.
- Hold-downs, Roof Ties, Limits – if wind or seismic requirements require additional connections or limits, they must be applied regardless of which bracing length controls.

Seismic Requirements

- Wall length
- Braced wall line spacing
- Hold-downs
- Material weight limits
Required Length

Bracing Length Tables

Two bracing length tables

- Wind  Table R602.10.3(1)
- Seismic  Table R602.10.3(3)

Required bracing length is the maximum of the two tables’ bracing length x all adjustment factors
Required Length

Decision Tree for Determining Required Bracing Length

- **Bracing Required?**
  - Wind Table R602.10.3(1)
  - All detached dwellings and townhouses
  - Seismic Table R602.10.3(3)
  - Detached dwellings in SDC D₀-D₂
  - Townhouses in SDC C-D₂
## Required Length

### Bracing Requirements Based on Seismic Design Category

Seismic Bracing Table based on:
- Soil Class D
- Wall height of 10 ft.
- Floor dead load of 10 psf
- Roof/ceiling dead load of 15 psf
- Braced wall line spacing ≤ 25 ft.

Required bracing length is determined by:
- Seismic design category
- Story location
- Braced wall line length
- Bracing method

Table R602.10.3(3)
Required Length

Adjustments to the required bracing length for seismic forces:
Only required when adjustment is greater than 1.0

Adjust required bracing length using Table R602.10.3(4)

- Story Height Adjustment
- BWL Spacing Adjustments

- Omitted Interior Finish Adjustments
- Masonry Veneer Adjustment
- Wall & Roof Dead Load Adjustments
## Required Length

Bracing adjustment based on seismic bracing length

<table>
<thead>
<tr>
<th>Adjustment based on</th>
<th>Story</th>
<th>Condition</th>
<th>Adjustment Factor</th>
<th>Applies To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Story Height (R301.3)</td>
<td>Any story</td>
<td>≤ 10 ft.</td>
<td>1.0</td>
<td>All bracing methods</td>
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<tr>
<td></td>
<td></td>
<td>&gt; 10 ft. and ≤ 12 ft.</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Braced wall line spacing – townhouses in SDC C</td>
<td>Any story</td>
<td>≤ 35 ft.</td>
<td>1.0</td>
<td></td>
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<td>Braced wall line spacing – SDC D₀, D₁ or D₂</td>
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<td>&gt; 30 ft. and ≤ 35 ft.</td>
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<td>Wall dead load</td>
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<td>&gt; 8 lb and ≤ 15 lb</td>
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<tr>
<td>Roof/Ceiling dead load for wall supporting</td>
<td>1-, 2- or 3-story</td>
<td>≤ 15 psf</td>
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<td>2- or 3-story</td>
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<td></td>
<td>1-story or top story</td>
<td>&gt; 15 psf and ≤ 25 psf</td>
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#### Required Length

**Bracing adjustment based on seismic bracing length**

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<thead>
<tr>
<th>Adjustment based on</th>
<th>Adjustment Factor</th>
<th>Applies To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls with stone or masonry veneer, townhouses in SDC C</td>
<td>1.0</td>
<td>All methods, excluding BV-WSP</td>
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<td></td>
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<td></td>
<td>1.5</td>
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</tr>
<tr>
<td>Walls with stone or masonry veneer, detached dwellings in SDC D₀-D₂</td>
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Sufficient Length

Method WSP

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<tr>
<th>WSP</th>
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<th>SDC D1</th>
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<tbody>
<tr>
<td>Bottom of Two Stories</td>
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Wind Direction

42'

36'

48" WSP

126" WSP

48" WSP

36'

Tables R602.10.3(1)-(4), R602.10.4, R602.10.5
### Minimum Total Length (feet) of Braced Wall Panels Required Along Each Braced Wall Line

#### Ultimate Design Wind Speed (mph)

<table>
<thead>
<tr>
<th>Story Location</th>
<th>Braced Wall Line Spacing (feet)</th>
<th>Method LIB</th>
<th>Method GB</th>
<th>Methods WSP, SFB, ABW, BVWSP, PFH, PFG, CS-SFB</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
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Table R602.10.3(1)
**Sufficient Length**

- Wall height = 10 feet
- 10 psf floor dead load
- 15 psf roof/ceiling dead load
- Braced wall line spacing < 25 feet

<table>
<thead>
<tr>
<th>Seismic Design Category</th>
<th>Story Location</th>
<th>Braced Wall Line Length (feet)</th>
<th>Method LIB</th>
<th>Method GB</th>
<th>Methods DWB, SFB, PBS, PCP, HPS, CS-SFB</th>
<th>Method WSP</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
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Table R602.10.3(3)
Sufficient Length

Method WSP

<table>
<thead>
<tr>
<th>WSP Bottom of Two Stories</th>
<th>130 mph</th>
<th>SDC D₁</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>21.5</td>
<td>18</td>
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</tbody>
</table>

Placement Requirement

4' + 4' + 4' = 12'
Max Wind or Seismic Requirement 21.5'

Braced Length = 18.5'

4' + 10.5' + 4' = 18.5'

Tables R602.10.3(1)-(4), R602.10.4, R602.10.5

Earthquakes and Single-Family Homes
# Sufficient Length

- Exposure Category B
- 30-Foot Mean Roof Height
- 10-Foot Wall Height
- 2 Braced Wall Lines

## Minimum Total Length (feet) of Braced Wall Panels Required Along Each Braced Wall Line

<table>
<thead>
<tr>
<th>Ultimate Design Wind Speed (mph)</th>
<th>Story Location</th>
<th>Braced Wall Line Spacing (feet)</th>
<th>Method LIB</th>
<th>Method GB</th>
<th>Methods WSP, SFB, ABW, PFH, PFG, CS-SFB</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
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Table R602.10.3(1)

Earthquakes and Single-Family Homes
Sufficient Length

Method WSP

<table>
<thead>
<tr>
<th>WSP Bottom of Two Stories</th>
<th>130 mph</th>
<th>SDC D₁</th>
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</thead>
<tbody>
<tr>
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</tbody>
</table>

Braced Length = 18.5'  
4' + 10.5' + 4' = 18.5'

Interpolate for 42 ft BWL length:
30 ft: 17.5 ft required  
40 ft: 21.5 ft required

(21.5-17.5)/10 x 2 + 17.5 = 18.3 ft required  
Bracing is sufficient

---

Tables R602.10.3(1)-(4), R602.10.4, R602.10.5

Earthquakes and Single-Family Homes  
155
Sufficient Length

Method PFH

<table>
<thead>
<tr>
<th>PFH Bottom of Two Stories</th>
<th>115 mph</th>
<th>SDC D₀</th>
</tr>
</thead>
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3,500 lb hold-downs required

Portal Frame (extended header)

Wind Direction

Earthquakes and Single-Family Homes
**Sufficient Length**

**Minimum Total Length (feet) of Braced Wall Panels Required Along Each Braced Wall Line**

<table>
<thead>
<tr>
<th>Ultimate Design Wind Speed (mph)</th>
<th>Story Location</th>
<th>Method LIB</th>
<th>Method GB</th>
<th>Methods WSP, SFB, ABW, PFH, PFG, CS-SFB</th>
<th>Method CS-WSP, CS-G, CS-PF</th>
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Table R602.10.3(1)
### Sufficient Length

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<tr>
<th>Seismic Design Category (SDC)</th>
<th>Story Location</th>
<th>Braced Wall Line Length (ft.)</th>
<th>Minimum Total Length of Braced Wall Panels Required Along Each Braced Wall Line</th>
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<td>SDC D₀</td>
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Table R602.10.3(3)
Sufficient Length

Method PFH

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<th>SDC D₀</th>
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</thead>
<tbody>
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<td>10.5'</td>
<td>11.3'</td>
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</table>

Placement Requirement

4' + 4' = 8'

Max Wind or Seismic Requirement

11.3'

Braced Length = 12'

4' + 4' + 4' = 12'

Bracing is sufficient

Tables R602.10.3(1)-(4), R602.10.4, R602.10.5

Earthquakes and Single-Family Homes
Connections – Roof

Roof Uplift Load Path vs BWP Uplift Load Path

Section R602.3.5 and R802.11 both address uplift of the roof

- Section R802.11 requires hurricane clips, toe-nails or other connector to tie the rafters or trusses to the wall below
- Section R602.3.5 requires exterior wall BWPs to be connected to the rafters or trusses when in the upper story and for the connections to continue through the stories below to the foundation

In some cases, the same strap or clip may be used to meet both code provisions
## Connections

**BWP Connection Requirements to Roof Framing**

<table>
<thead>
<tr>
<th>SDC</th>
<th>Distance (bottom of roof sheathing to top of plate)</th>
<th>Blocking</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC A, B, C</td>
<td>9.25&quot; or less</td>
<td>Not required, attach per R602.3(1)</td>
</tr>
<tr>
<td></td>
<td>9.25&quot; to 15.25&quot;</td>
<td>Per R602.10.8.2.2 Item 1 and Figure R602.10.8.2(1)</td>
</tr>
<tr>
<td>SDC D₀, D₁, D₂</td>
<td>15.25&quot; or less</td>
<td>Per R602.10.8.2 Item 2 and Figure R602.10.8.2(1)</td>
</tr>
<tr>
<td>All SDCs</td>
<td>15.25&quot; to 48&quot;</td>
<td>Per R602.10.8.2 Item 3 and Figure R602.10.8.2(2) or R602.10.8.2(3) or engineered design</td>
</tr>
</tbody>
</table>
Connections

BWP Perpendicular to Rafters or Roof Trusses

For SDC D₀, D₁ and D₂,

- Where distance from top of rafters or roof trusses to perpendicular top plates is ≤ 15.25"
- Connect rafters to the top plates of braced wall panels with blocking [Figure R602.10.8.2(1) and Table R602.3(1)]
Connections
BWP Perpendicular to Rafters or Roof Trusses

Energy Trusses
- Where distance from top of rafters or roof trusses to perpendicular top plates is > 15.25"
- Connect rafters to the top plates of braced wall panels [Figure R602.10.8.2(2) or Figure R602.10.8.2(3)]

Figure R602.10.8.2(2)
Connections

BWP Perpendicular to Rafters or Roof Trusses

Figure R602.10.8.2(3)

See R602.10.8.2 Options
Whole House Example 1
Example: SDC D₂, Wind 110 mph, Exp C

Example Attributes:
- SDC D₂
- Wind 110 mph, Wind Exposure C
- Method WSP & GB
- 1 Story
- Walls 9 ft. tall
- Eave to ridge height 8 ft. tall

Example Highlights:
- Wind Exposure C adjustment
- Use of different bracing methods in one BWL
- Application of WSP, GB and PFH
North-South Braced Wall Lines

A: 17'-2"
B: 17'
C: 31'-6"
D: 12'

Assume 20 ft spacing
Assume 40 ft spacing
Assume 20 ft spacing

64'-6"
Minimum Required Length of Bracing

Table R602.10.3(1)

- Exposure Category B
- 30 ft. Mean Roof Height
- 10 ft. Eave to Ridge Height
- 10 ft. Wall Height
- 2 Braced Wall Lines

<table>
<thead>
<tr>
<th>Basic Wind Speed</th>
<th>Story Location</th>
<th>Braced Wall Line Spacing (feet)</th>
<th>Method LIB</th>
<th>Method GB (double sided)</th>
<th>Methods WSP, SFB, ABW, PFH, PFG</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
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<tr>
<td>&lt; 110 (mph)</td>
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<td>31.5</td>
<td>31.5</td>
<td>18</td>
<td>15.5</td>
</tr>
</tbody>
</table>
Braced Wall Lines  A, B & E  Assume spacing of 20 ft.

Required bracing length
Method WSP: $3.5 \text{ ft.} \times 1.6 = 5.6 \text{ feet}$
Method GB: $6 \text{ ft.} \times 1.6 = 9.6 \text{ feet}$

Braced Wall Lines  C & D  Assume spacing of 40 ft.

Required bracing length
Method GB: $11.5 \text{ ft.} \times 1.6 = 18.4 \text{ feet}$

Adjustment Factors:
- Wind Exposure C, 1 story building = 1.2
- 5 braced wall lines = 1.6
- Walls - 9 feet tall = 0.95
- Eave to ridge height - 8 feet tall = 0.88
Total Adjustment = 1.6

<table>
<thead>
<tr>
<th>One Story</th>
<th>Wall Line</th>
<th>110 mph</th>
<th>SDC $D_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSP</td>
<td>A, E</td>
<td>5.6 ft.</td>
<td></td>
</tr>
<tr>
<td>GB</td>
<td>B, C, D</td>
<td>9.6 ft.</td>
<td>18.4 ft.</td>
</tr>
</tbody>
</table>

Earthquakes and Single-Family Homes
Minimum Required Length of Bracing Table R602.10.3(3)

- Soil Class D
- Wall Height = 10 ft.
- 10 psf Floor Dead Load
- 15 psf Roof/Ceiling Dead Load
- Braced Wall Line Spacing ≤ 25 ft.

<table>
<thead>
<tr>
<th>Seismic Design Category (SDC)</th>
<th>Braced Wall Line Length</th>
<th>Method LIB</th>
<th>Method GB</th>
<th>Method WSP</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC D2</td>
<td>10</td>
<td>NP</td>
<td>4</td>
<td>2.5</td>
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<td>NP</td>
<td>37.5</td>
<td>27.5</td>
<td>23.4</td>
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</tbody>
</table>
Braced Wall Lines A, B & E
BWL spacing less than 25 ft.
BWL Length is 64.5 ft.

Required bracing length
Method WSP: \((12.5 + 5) \times 1.0 = 17.5\) feet
Method GB: \((20 + 8) \times 1.0 = 28\) feet

Braced Wall Lines C & D
Assume BWL spacing of 35 ft.
BWL Length is 64.5 ft.

Required bracing length
Method GB: \((20 + 8) \times 1.4 = 39.2\) ft.

---

<table>
<thead>
<tr>
<th>One Story</th>
<th>Wall Line</th>
<th>110 mph</th>
<th>SDC $D_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSP</td>
<td>A, E</td>
<td>5.6 ft.</td>
<td>17.5 ft.</td>
</tr>
<tr>
<td>GB</td>
<td>B, C, D</td>
<td>9.6 ft.</td>
<td>28 ft.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18.4 ft.</td>
<td>39.2 ft.</td>
</tr>
</tbody>
</table>

Adjustment Factors:

- BWL spacing of 35 ft = 1.4
- Story height - 10 feet tall = 1.0
- Total Adjustment = 1.4
Seismic lengths insufficient
- BWL B – bracing could be determined by actual wall length
- BWL C and D – Method GB doesn’t work, use Method WSP

Braced Wall Line B  Use Method WSP
Actual length is 28 ft. 10 in., assume 30 ft. length

Braced Wall Lines C & D  Use Method WSP
Actual length is 64.5 ft., assume 70 ft.
Minimum Required Length of Bracing Table R602.10.3(3)

- Soil Class D
- Wall Height = 10 ft.
- 10 psf Floor Dead Load
- 15 psf Roof/Ceiling Dead Load
- Braced Wall Line Spacing ≤ 25 ft.

<table>
<thead>
<tr>
<th>Seismic Design Category (SDC)</th>
<th>Story Location</th>
<th>Braced Wall Line Length</th>
<th>Method LIB</th>
<th>Method GB</th>
<th>Method WSP</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC D₂</td>
<td>10</td>
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<td>4</td>
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<td>2.1</td>
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<td></td>
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<td>NP</td>
<td>8</td>
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</tr>
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<td>NP</td>
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<tr>
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<td>NP</td>
<td>37.5</td>
<td>27.5</td>
<td>23.4</td>
<td></td>
</tr>
</tbody>
</table>
Seismic lengths

Braced Wall Line B Use Method WSP
Actual length is 28 ft. 10 in., assume 30 ft. length

Required bracing length
Method WSP: 7.5 ft. x 1.0 = 7.5 ft.

Braced Wall Lines C & D Use Method WSP
BWL Length is 64.5 ft., assume 70 ft. length

Required bracing length
Method WSP: (12.5 + 5) ft. x 1.4 = 24.5 ft.
East-West Braced Wall Lines

Assume 30 ft

28'-10"
27'-8"
64'-6"
77'-8"
### Minimum Required Length of Bracing

**Table R602.10.3(1)**

- **Exposure Category B**
- **30 ft. Mean Roof Height**
- **10 ft. Eave to Ridge Height**
- **10 ft. Wall Height**
- **2 Braced Wall Lines**

<table>
<thead>
<tr>
<th>Basic Wind Speed</th>
<th>Braced Wall Line Spacing (feet)</th>
<th>Method LIB</th>
<th>Method GB (double sided)</th>
<th>Methods WSP, SFB, ABW, PFH, PFG</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 110 (mph)</td>
<td>10</td>
<td>3.5</td>
<td>3.5</td>
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<td>1.5</td>
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<td>31.5</td>
<td>31.5</td>
<td>18</td>
<td>15.5</td>
</tr>
</tbody>
</table>

**Note:** The table includes minimum total length (feet) of braced wall panels required along each braced wall line for different basic wind speeds and story locations. The methods listed are for specific structural configurations and bracing systems.
Braced Wall Lines 1, 2, 3 and 4

BWLs 3 and 4 are close enough to combine into one wall line but there is a large gap between the actual wall lines. If BWPs can’t be placed with 20 ft. edge to edge, there will need to be two separate wall lines.

<table>
<thead>
<tr>
<th>One Story Wall Line</th>
<th>110 mph</th>
<th>SDC D₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSP 1-4</td>
<td>7.25 ft.</td>
<td></td>
</tr>
<tr>
<td>GB 1-4</td>
<td>12.3 ft.</td>
<td></td>
</tr>
</tbody>
</table>

**Adjustment Factors:**
- Wind Exposure C, 1 story building = 1.2
- 4 braced wall lines = 1.45
- Walls - 9 feet tall = 0.95
- Eave to ridge height - 8 feet tall = 0.88

Total Adjustment = 1.45

Required bracing length (WSP) = 5 ft. x 1.45 = 7.25 feet
Required bracing length (GB) = 8.5 ft. x 1.45 = 12.3 feet
Minimum Required Length of Bracing
Table R602.10.3(3)

- Soil Class D
- Wall Height = 10 ft.
- 10 psf Floor Dead Load
- 15 psf Roof/Ceiling Dead Load
- Braced Wall Line Spacing ≤ 25 ft.

<table>
<thead>
<tr>
<th>Seismic Design Category (SDC)</th>
<th>Story Location</th>
<th>Braced Wall Line Length</th>
<th>Method LIB</th>
<th>Method GB</th>
<th>Method WSP</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
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<td>27.5</td>
<td>23.4</td>
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</tbody>
</table>
**Braced Wall Lines 1, 2, 3 & 4**

Assume BWL spacing of 30 ft.

BWL Length is 77 ft. 8 in., assume 80 ft.

<table>
<thead>
<tr>
<th>One Story</th>
<th>Wall Line</th>
<th>110 mph</th>
<th>SDC D₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSP</td>
<td>1-4</td>
<td>7.25 ft.</td>
<td>24 ft.</td>
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<tr>
<td>GB</td>
<td>1-4</td>
<td>12.3 ft.</td>
<td>38.4 ft</td>
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</table>

**Seismic Adjustment Factors:**

- BWL spacing of 30 ft = 1.2
- Story height - 10 feet tall = 1.0

Total Adjustment = 1.2

<table>
<thead>
<tr>
<th>Required bracing length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method WSP: (12.5 + 7.5) ft. x 1.2 = 24 feet</td>
</tr>
<tr>
<td>Method GB: (20 + 12) ft. x 1.2 = 38.4 feet</td>
</tr>
</tbody>
</table>
Seismic Adjustment Factors:

- BWL spacing of 30 ft = 1.2
- Story height - 10 feet tall = 1.0

Total Adjustment = 1.2

<table>
<thead>
<tr>
<th>One Story</th>
<th>Wall Line</th>
<th>110 mph</th>
<th>SDC D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSP 1-4</td>
<td>7.25 ft.</td>
<td>110</td>
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</tr>
<tr>
<td>GB 1-4</td>
<td>12.3 ft.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Braced Wall Lines  1, 2, 3 & 4

Determine actual braced wall line length.
East-West Braced Wall Lines

1. Assume 30 ft
   - 28'-10"
2. Assume 30 ft
   - 27'-8"
3. Assume 30 ft
   - 34'-2"
4. 12'
Braced Wall Line 1
BWL Length is 60 ft. 4 in., assume 60 ft.

Braced Wall Line 2
BWL Length is 77 ft. 8 in., assume 80 ft.

Braced Wall Line 3
BWL Length is 34 ft. 2 in., assume 40 ft.

Braced Wall Line 4
BWL Length is 12 ft., interpolate for 12 ft. or use 20 ft.

Seismic Adjustment Factors:

- BWL spacing of 30 ft = 1.2
- Story height - 10 feet tall = 1.0

Total Adjustment = 1.2

<table>
<thead>
<tr>
<th>One Story</th>
<th>Wall Line</th>
<th>110 mph</th>
<th>SDC D2</th>
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<tr>
<td>WSP</td>
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<td>7.25 ft.</td>
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</table>
Minimum Required Length of Bracing
Table R602.10.3(3)

- Soil Class D
- Wall Height = 10 ft.
- 10 psf Floor Dead Load
- 15 psf Roof/Ceiling Dead Load
- Braced Wall Line Spacing ≤ 25 ft.

<table>
<thead>
<tr>
<th>Seismic Design Category (SDC)</th>
<th>Story Location</th>
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<th>Method GB</th>
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<td>27.5</td>
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</table>
Seismic Adjustment Factors:

- BWL spacing of 30 ft = 1.2
- Story height - 10 feet tall = 1.0
- Total Adjustment = 1.2

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<thead>
<tr>
<th>One Story</th>
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<td>2</td>
<td>24 ft.</td>
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</tr>
<tr>
<td></td>
<td>3</td>
<td>12 ft.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>6 ft.</td>
<td></td>
</tr>
</tbody>
</table>

Braced Wall Line 1
BWL Length is 60 ft. 4 in., assume 60 ft.
Method WSP: \((12.5 + 2.5) \text{ ft.} \times 1.2 = 18 \text{ feet}\)

Braced Wall Line 2
BWL Length is 77 ft. 8 in., assume 80 ft.
Method WSP: \((12.5 + 7.5) \text{ ft.} \times 1.2 = 24 \text{ feet}\)

Braced Wall Line 3
BWL Length is 34 ft. 2 in., assume 40 ft.
Method WSP: \(10 \text{ ft.} \times 1.2 = 12 \text{ feet}\)

Braced Wall Line 4
BWL Length is 12 ft., assume 20 ft.
Method WSP: \(5 \text{ ft.} \times 1.2 = 6 \text{ feet}\)
Braced Wall Line 1
BWL 1 has insufficient length.
There is no more space to add braced wall panels.

Options:
1. Remove a window and add a BWP.
2. Use proprietary panels in the narrow spaces.
3. Try CS-WSP.

Braced Wall Line 4
Minimum required BWL length is 7.25 ft.
There is extra space to the right of the window. If 48 inches, add WSP, if shorter add ABW or PFH.

<table>
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<th>One Story</th>
<th>Wall Line</th>
<th>110 mph</th>
<th>SDC D₂</th>
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<td>WSP</td>
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<td>18 ft.</td>
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<td>2</td>
<td>7.25 ft.</td>
<td>24 ft.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>7.25 ft.</td>
<td>12 ft.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>7.25 ft.</td>
<td>6 ft.</td>
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</table>
Minimum Required Length of Bracing
Table R602.10.3(3)

- Soil Class D
- Wall Height = 10 ft.
- 10 psf Floor Dead Load
- 15 psf Roof/Ceiling Dead Load
- Braced Wall Line Spacing ≤ 25 ft.

<table>
<thead>
<tr>
<th>Seismic Design Category (SDC)</th>
<th>Story Location</th>
<th>Braced Wall Line Length</th>
<th>Method LIB</th>
<th>Method GB</th>
<th>Method WSP</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
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</table>

Minimum Total Length (feet) of Braced Wall Panels Required Along Each Braced Wall Line

Earthquakes and Single-Family Homes
Braced Wall Line  1 BWL length of 60.33 ft., assume 60 ft.

Adjustment Factor: 1.2

Method CS-WSP: \((10.6 + 2.1) \times 1.2 = 15.3 \text{ ft.}\)
Whole House Example 2
Example 11:
SDC D₂, Wind 129 mph, Exp C

Example Attributes:

- SDC D₂
- Wind 129 mph, Exposure Category C
- Method CS-WSP
- 1 Story
- Walls 9 ft. tall
- Eave to ridge height 8 ft. tall
Use CS-WSP to brace walls.
Braced Wall Lines  1 & 2

From Table R602.10.3(1), CS- WSP column, required bracing for the 30 ft. BWL spacing?
Minimum Required Length of Bracing Table R602.10.3(1)

- Exposure Category B
- 30 ft. Mean Roof Height
- 10 ft. Eave to Ridge Height
- 10 ft. Wall Height
- 2 Braced Wall Lines

<table>
<thead>
<tr>
<th>Basic Wind Speed</th>
<th>Story Location</th>
<th>Braced Wall Line Spacing (feet)</th>
<th>Method GB (double sided)</th>
<th>Methods WSP, SFB, ABW, PFH, PFG</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
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<td>23</td>
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<td>11</td>
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</table>
Required bracing length from table is 6 feet.

Method WSP:
6 ft x 1.09 = 6.6 ft

Wind Adjustment Factors:
- Wind Exposure C = 1.3
- 2 braced wall lines = 1.0
- Walls - 9 feet tall = 0.95
- Eave to ridge height - 8 feet tall = 0.88
Total = 1.09
### Minimum Required Length of Bracing

#### Table R602.10.3(3)

- **Soil Class D**
- **Wall Height = 10 ft.**
- **10 psf Floor Dead Load**
- **15 psf Roof/Ceiling Dead Load**
- **Braced Wall Line Spacing ≤ 25 ft.**

<table>
<thead>
<tr>
<th>Seismic Design Category (SDC)</th>
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<td>8.5</td>
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<td>12.5</td>
<td>10.6</td>
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Earthquakes and Single-Family Homes

For an assumed 40 ft BWL length:

<table>
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<th>Bottom Story</th>
<th>Wall Line</th>
<th>130 mph</th>
<th>SDC D₂</th>
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<tbody>
<tr>
<td>WSP</td>
<td>1</td>
<td>6.6 ft.</td>
<td>6.4 ft.</td>
</tr>
</tbody>
</table>

Seismic Adjustment Factors:

- Walls - 9 feet tall = 1.0
- BWL spacing < 25 ft. = 1.0
- Wall dead load of 12 psf = 1.0
- Roof dead load of 20 psf = 1.0

Total Adjustment = 1.0

BWL 1 & 2 Method WSP 1.0 x 6.4 ft = 6.4 ft minimum
Minimum Required Length of Bracing Table R602.10.3(1)

- Exposure Category B
- 30 ft. Mean Roof Height
- 10 ft. Eave to Ridge Height
- 10 ft. Wall Height
- 2 Braced Wall Lines

<table>
<thead>
<tr>
<th>Basic Wind Speed</th>
<th>Story Location</th>
<th>Braced Wall Line Spacing (feet)</th>
<th>Method GB (double sided)</th>
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<tbody>
<tr>
<td>&lt; 130 (mph)</td>
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<td>4.5</td>
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<td>11</td>
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</table>
Wind Adjustment Factors:

- Wind Exposure C = 1.3
- 3 braced wall lines = 1.3
- Walls - 9 feet tall = 0.95
- Eave to ridge height - 8 feet tall = 0.88

Total = 1.41

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<td>C</td>
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<td>GB</td>
<td>B</td>
<td>17 ft.</td>
<td>?</td>
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</table>

Braced Wall Lines A, B & C

From Table R602.10.3(1), WSP and GB columns for 30 ft and 20 ft BWL spacing

- BWL A: Method WSP
  \[7 \times 1.41 = 9.9 \text{ ft.}\]
- BWL B: Method GB
  \[12 \times 1.41 = 17 \text{ ft.}\]
- BWL C: Method WSP
  \[5 \times 1.41 = 7.1 \text{ ft.}\]
Minimum Required Length of Bracing
Table R602.10.3(3)

- Soil Class D
- Wall Height = 10 ft.
- 10 psf Floor Dead Load
- 15 psf Roof/Ceiling Dead Load
- Braced Wall Line Spacing ≤ 25 ft.

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<tr>
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<th>Methods CS-WSP, CS-G, CS-PF</th>
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<tr>
<td>SDC D₂</td>
<td>10</td>
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<td>2.5</td>
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<td>20</td>
<td>12.5</td>
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</tbody>
</table>

Minimum Total Length (feet) of Braced Wall Panels Required Along Each Braced Wall Line
For an assumed 30 ft BWL length:

- **BWL A and C**  Method WSP  \[1.0 \times 7.5 \text{ ft} = 7.5 \text{ ft minimum}\]
- **BWL B**  Method GB  \[1.0 \times 12 \text{ ft} = 12 \text{ ft minimum}\]
IRC Significant Changes

www.iccsafe.org
Item # 7101S21
IRC Essentials

www.icc-safe.org
Item # 4131S21
Wall Bracing Guide

www.iccsafe.org
Item # 7102S18

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