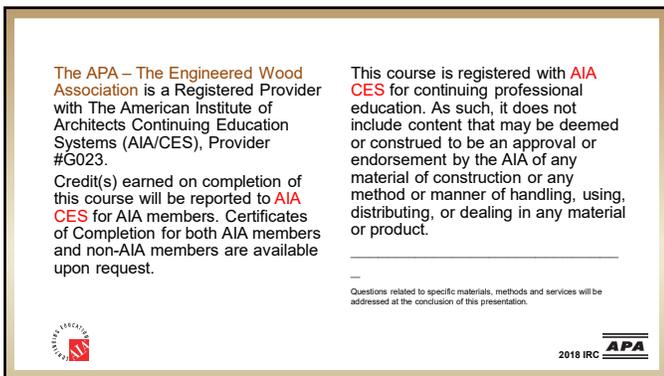


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2



3

Learning Objectives

- ❑ Appreciate the differences designing with the IRC versus the IBC.
- ❑ Understand the limits of IRC wall bracing in high seismic regions.
- ❑ Be able to design IRC wall bracing for seismic forces in SDC D₀-D₂.
- ❑ Understand when mixing IRC wall bracing types is allowed and prohibited.

2018 IRC **APA**

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High Seismic

Load Path	Limits	High Seismic	Bracing	Seismic Details
Load Path Basics	Wall Bracing vs. Shear Walls	Definition	Wall Bracing Types	Connections
Lateral Forces	Limitations	Seismic & Wind	BWL Spacing vs. BWP Spacing	Foundation
Failure Modes	Stud vs. Story HT	Dead Load Limits	Required Length	Anchorage
	Irregularities	Seismic Design Category E	Contributing Length	Cripple Walls & Crawl Spaces
			Mixing Wall Bracing Types	Plate Splice
				Collector

2018 IRC **APA**

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Limits

Load Path	Limits	High Seismic	Bracing	Seismic Details
	Wall Bracing vs. Shear Walls			
	Limitations			
	Stud vs. Story HT			
	Irregularities			

2018 IRC **APA**

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Wall Bracing vs. Shear Walls

BWP (Prescriptive)	Shear Walls (Engineered)
<ul style="list-style-type: none"> ▪ Limitations ▪ 3-story maximum ▪ Ultimate design wind speed < 140 mph⁽¹⁾ ▪ SDC limitations ▪ Maximum story height = 11'-7" (R301.3) ▪ Townhome configuration ▪ Others per Chapter 3 	<ul style="list-style-type: none"> ▪ Applications ▪ Any building size/shape ▪ Wind – no limit ▪ SDC – no limit ▪ Calculations required ▪ Typically with hold-downs

vs.

(1) Areas requiring wind design in Table R301.2(5)A may not use the Residential Code for lateral provisions.

2018 IRC

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Limits

Load Path	Limits	High Seismic	Bracing	Seismic Details
	Wall Bracing vs. Shear Walls Limitations Stud vs. Story Ht. Irregularities			

2018 IRC

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Limitations

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

2018 IRC

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Limitations

Seismic Design Category	One- and two-family	Townhouses
A & B	Wind Only	Wind Only
C	Wind Only	Wind + Seismic
D ₀	Wind + Seismic	Wind + Seismic
D ₁	Wind + Seismic	Wind + Seismic
D ₂	Wind + Seismic	Wind + Seismic

R301.2.2
2018 IRC **APA**

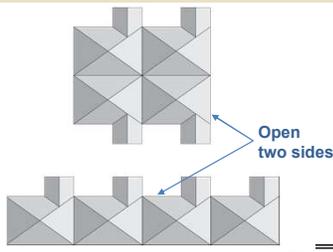
10

Limitations

R202 Townhouse

- Three or more attached units
- Units extend from foundation to roof
- Open space on at least two sides

These townhomes can be designed using the prescriptive bracing of the Residential Code



R202
2018 IRC **APA**

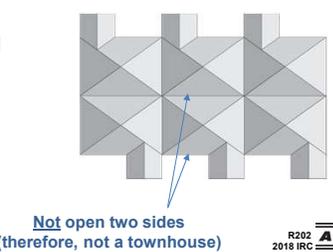
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Limitations

R202 Townhouse

- Three or more attached units
- Units extend from foundation to roof
- Open space on at least two sides

These townhomes cannot be designed using the prescriptive bracing of the Residential Code



R202
2018 IRC **APA**

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Limits

Load Path
Limits
High Seismic
Bracing
Seismic Details

Wall Bracing vs. Shear Walls

Limitations

Stud vs. Story Ht.

Irregularities

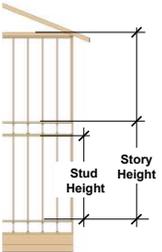


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Stud vs. Story Height

In-plane lateral forces
Requirements for story height exist to limit the wind and seismic provisions

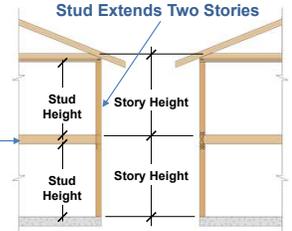
- Story height limit – 11'-7"
- Stud height – 10 ft. per Table R602.3(5) – does not include thickness of top & bottom plates
- Table R602.3(6) allows stud heights up to 12 ft. – a lot of restrictions and requirements – read the footnotes and R602.3.1



R301.3
2018 IRC 

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Stud vs. Story Ht.



Balloon Framing
Platform Framing

R301.1.2
2018 IRC 

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Limits

Load Path
Limits
High Seismic
Bracing
Seismic Details

Wall Bracing vs. Shear Walls
 Limitations
 Stud vs. Story Ht.
 Irregularities

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Irregularities

R301.2.2.6 Irregular buildings

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

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Irregularities

R301.2.2.6 Irregular buildings

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

Wind Requirements Irregular building provisions do not apply	Seismic Requirements Irregular building provisions apply
---	--

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Irregularities

Seismic Requirements Irregular Buildings (R301.2.2.6)

- 1 Setbacks & Cantilevers
- 2 Unsupported Floors & Roofs
- 3 Panel & Window Locations
- 4 Floor or Roof Opening
- 5 Vertical Floor Offset
- 6 Non-perpendicular Walls
- 7 Concrete or Masonry Construction

R301.2.2.6
2018 IRC **APA**

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R301.2.2.6
2018 IRC **APA**

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Irregularities

1 Setbacks & Cantilevers

Vertically in plane

R301.2.2.6
2018 IRC **APA**

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Irregularities

R6 Vertical Floor Cuts

Partial perimeter supported by continuous foundation or lap-joint floor framing

ENGINEER

All perimeter supported by continuous foundation or lap-joint floor framing

Photo: Nam Goong Sun

Photo from GoRepro.com

R301.2.2.6
2018 IRC

APA

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Irregularities

R6 Non-perpendicular Walls

ENGINEER

6 Non-Perpendicular Walls

Not perpendicular

R301.2.2.6
2018 IRC

APA

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Irregularities

R6 Non-perpendicular Walls

ENGINEER

6 Non-Perpendicular Walls

The Prahran House by Nervegna Reed

Photo by John Gollings

R301.2.2.6
2018 IRC

APA

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Irregularities

```

graph TD
    A["#7 Concrete or Masonry Construction"] --> B["Isolated to Foundations, Fireplaces, Chimneys"]
    B --> C["Structural Concrete or Masonry Walls"]
    C --> D["Stone or masonry veneer > 5' thick"]
    D --> E["ENGINEER"]
    E --> F["below 1st story"]
    E --> G["above 1st story"]
    F --> H["BWP length < max. per Table R602.10.3(1) & Table R602.10.3(3)"]
    G --> I["BWP length < max. per Table R602.10.3(1) & Table R602.10.3(3)"]
    I --> J["ENGINEER"]
    I --> K["BWP length < R602.10.6.5"]
    K --> L["ENGINEER"]
    K --> M["BWP length > R602.10.6.5"]
    M --> N["ENGINEER"]
    
```

7

Masonry or Concrete

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



R301.2.2.6
2018 IRC **APA**

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Irregularities

```

graph TD
    A["#7 Concrete or Masonry Construction"] --> B["Isolated to Foundations, Fireplaces, Chimneys"]
    B --> C["Structural Concrete or Masonry Walls"]
    C --> D["Stone or masonry veneer > 5' thick"]
    D --> E["ENGINEER"]
    E --> F["below 1st story"]
    E --> G["above 1st story"]
    F --> H["BWP length < max. per Table R602.10.3(1) & Table R602.10.3(3)"]
    G --> I["BWP length < max. per Table R602.10.3(1) & Table R602.10.3(3)"]
    I --> J["ENGINEER"]
    I --> K["BWP length < R602.10.6.5"]
    K --> L["ENGINEER"]
    K --> M["BWP length > R602.10.6.5"]
    M --> N["ENGINEER"]
    
```



R301.2.2.6
2018 IRC **APA**

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Irregularities

Irregular building definitions
1
2
3
4
5
6
7

R301.2.2.2.5 Irregular buildings review

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

R301.2.2.6
2018 IRC **APA**

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High Seismic

Load Path
Limits
High Seismic
Bracing
Seismic Details

Definition

Seismic & Wind

Dead Load Limits

Seismic Design Category E



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Definition

What do you mean “high seismic”?

- All one- and two-family dwelling units in Seismic Design Category D₀, D₁, D₂ & E
- Townhomes in Seismic Design Category C

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High Seismic

Load Path
Limits
High Seismic
Bracing
Seismic Details

Definition

Seismic & Wind

Dead Load Limits

Seismic Design Category E



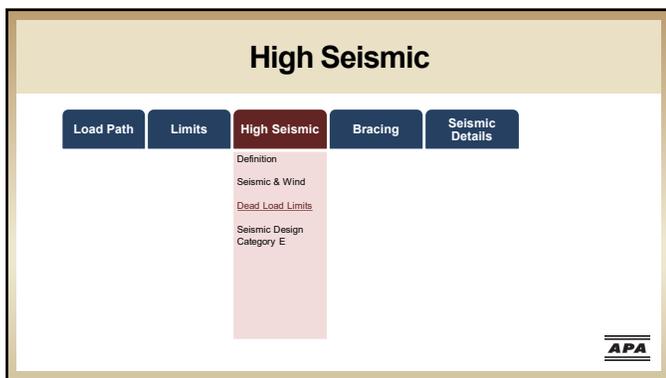
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Seismic & Wind

Seismic Design Category	One- and two-family	Townhouses
A & B	Wind Only	Wind Only
C	Wind Only	Wind + Seismic
D ₀	Wind + Seismic	Wind + Seismic
D ₁	Wind + Seismic	Wind + Seismic
D ₂	Wind + Seismic	Wind + Seismic

R301.2.2
2018 IRC **APA**

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Dead Load Limits

R301.2.2.2 Weight of Materials

- Average dead loads shall not exceed:
 - 15 or 25* psf for roofs/ceiling assemblies
 - 10 psf for floor assemblies
 - 15 psf for exterior wall assemblies

*25 psf allowed with increased wall bracing per Table R602.10.3(4)

Wind Requirements

Weight of materials provisions do not apply

Seismic Requirements

Weight of materials provisions apply

R301.2.2.2
2018 IRC **APA**

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Roof Dead Loads

Example Roof Dead Loads:

▪ 3-tab shingles & felt	3.0 psf
▪ Re-roof allowance	3.0 psf
▪ 7/16" OSB sheathing	1.5 psf
▪ Roof truss (no beams)	2.5 psf
▪ Insulation, R-49	0.8 psf
▪ 1/2" gypsum board	2.2 psf
▪ Misc. & electrical	1.5 psf
Total Estimate Roof DL =	14.5 psf

▪ Slate 10-17 psf
 ▪ 5/8" OSB Sheathing 1.8 psf

This is a quick list of dead loads only. Do not rely on this list for design of any roof system. Verify loads independently.

Residential Code:
 R301.2.2.2 – Average dead loads shall not exceed 15 psf for the combined roof and ceiling assemblies...

Exception – Roof and ceiling dead loads not exceeding 25 psf shall be permitted provided the wall bracing amounts are adjusted in accordance with Table R602.10.3(4):

- 2- or 3-story building, adj. = 1.1
- 1-story building or any top story = 1.2

R301.2.2.2
2018 IRC **APA**

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Floor Dead Loads

Example Floor Dead Loads:

▪ Carpet and pad	1.5 psf
▪ 23/32" OSB sheathing	2.2 psf
▪ 11-7/8" I-joists @16" o.c.	1.8 psf
▪ Floor beams	0.5 psf
▪ 1/2" gypsum board	2.2 psf
▪ Misc. & MPE	1.0 psf
Total Estimate Floor DL =	9.0 psf

▪ Hardwood flooring 4.0 psf
 ▪ 3/4" ceramic or quarry tile 16 psf

This is a quick list of dead loads only. Do not rely on this list for design of any roof system. Verify loads independently.

Residential Code:
 R301.2.2.2 – Average dead loads shall not exceed ...10 psf for floor assemblies...

R301.2.2.2
2018 IRC **APA**

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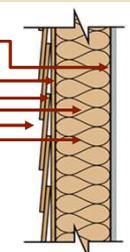
Wall Dead Loads

Example Exterior Wall Dead Loads:

▪ 1/2" gypsum board	2.2 psf
▪ 2x6 studs 16" o.c.	1.7 psf
▪ 15/32" OSB sheathing	1.5 psf
▪ Insulation, R-21	0.6 psf
▪ Exterior lap siding	3.0 psf
▪ Misc. & electrical	1.0 psf
Total Estimate wall DL =	10 psf

Residential Code Code:
 R301.2.2.2 – Dead loads for walls above grade shall not exceed 15 psf for exterior light-frame walls and 10 psf for interior light-frame walls.

This is a quick list of dead loads only. Do not rely on this list for design of any roof system. Verify loads independently.



R301.2.2.2
2018 IRC **APA**

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Wall Dead Loads

Residential Code Code:
 R301.2.2.2 – Dead loads for walls above grade shall not exceed 15 psf for exterior light-frame walls and 10 psf for interior light-frame walls.

Example Interior Wall Dead Loads:

- 2 x 1/2" gypsum 4.5 psf
- 2x4 studs 16" o.c. 1.0 psf
- Misc. & electrical 1.0 psf

Total Estimate wall DL = 6.5 psf

This is a quick list of dead loads only. Do not rely on this list for design of any roof system. Verify loads independently.

R301.2.2.2
2018 IRC **APA**

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High Seismic

Load Path	Limits	High Seismic	Bracing	Seismic Details
		Definition Seismic & Wind Dead Load Limits Seismic Design Category E		

APA

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Seismic Design Category E

Reclassify to D₂ if...
 SDC D per the IBC

OR

The building meets all of these:

- No out-of-plane offsets for exterior shear wall lines or BWP
- No floors can cantilever past the exterior walls
- (In addition to meeting other irregularity requirements)

R301.2.2.1.2
2018 IRC **APA**

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Bracing

Load Path
Limits
High Seismic
Bracing
Seismic Details

Wall Bracing Types

BWL Spacing vs. BWP Spacing

Required Length

Contributing Length

Mixing Wall Bracing Types



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Wall Bracing Types

Intermittent Bracing Methods:

- ~~LIB*~~ - ~~Let in diagonal brace~~
- DWB - 3/4" Diagonal wood boards
- WSP - 3/8" Wood structural panel
- BV-WSP - 7/16" Wood structural panel with stone or masonry veneer
- SFB - 1/2" Structural fiberboard
- GB - 1/2" Interior gypsum wallboard or gypsum sheathing particleboard, nailed

WILL REQUIRE HOLD-DOWNS!

Table R602.10.4
2018 IRC



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Wall Bracing Types

Intermittent Bracing Methods:

- PBS - 3/8" Particleboard sheathing
- PCP - Portland cement plaster on studs
- HPS - 7/16" Hardboard panel siding
- ABW - Alternate braced wall
- PFH - Portal frame with hold-downs
- ~~PFG*~~ - ~~Portal frame at garage door openings in SDC A-C~~

Table R602.10.4
2018 IRC

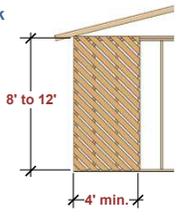


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Wall Bracing Types

Method DWB – Diagonal Wood Boards

- Wood boards 3/4" (1" nominal) thick applied diagonally
- Studs spaced 24" max.



8' to 12'

4' min.

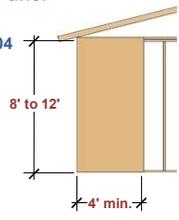
Table R602.10.4
2018 IRC **APA**

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Wall Bracing Types

Method WSP – Wood Structural Panel

- 3/8" min. thickness
- Wood structural panel defined in R604



8' to 12'

4' min.

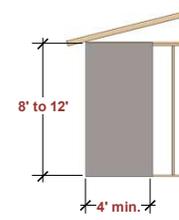
Table R602.3(3)
2018 IRC **APA**

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Wall Bracing Types

Method SFB – Structural Fiberboard Sheathing

- 1/2" or 25/32" thick
- Studs spaced 16" o.c. max.
- Must conform to ASTM C 208
- Nailing 3" o.c. edge, 6" o.c. field



8' to 12'

4' min.

Table R602.10.4
2018 IRC **APA**

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Wall Bracing Types

Method GB – Gypsum Board

- 1/2" min. thick for studs spaced at 24" o.c. max.
- 4' minimum length
- Nailing at 7" o.c.
- Bracing length:
 - Single sided = 0.5 x actual length
 - Double sided = 1x actual length

No floating corners!

Table R602.10.4
2018 IRC **APA**

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Wall Bracing Types

Method PBS – Particleboard Sheathing

- 3/8" or 1/2" min. thickness
- Studs 16" o.c. max.
- 4' minimum length
- Nailing at 3" edge, 6" field
- Minimum 8d nails for 1/2" thick sheathing

Table R602.10.4
2018 IRC **APA**

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Wall Bracing Types

Method PCP – Portland Cement Plaster

- Studs 16" o.c. max.
- Installed in accordance with R703.7
- Nailing 6" o.c. nailing

Table R602.10.4
2018 IRC **APA**

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Wall Bracing Types

Method HPS – Hardboard Panel Siding

- 7/16" minimum thickness
- Studs 16" on center
- Nailing 4" o.c. edge and 8" o.c. field

Table R602.10.4
2018 IRC **APA**

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Wall Bracing Types

Method ABW - Alternate Braced Wall

Wind
8' to 12'

SDC C, D₀, D₁, and D₂
8' to 10'

- Min. 3/8" thick wood structural panel sheathing
- Anchor bolts 1/2" (2)
- Hold-down capacity per Table R602.10.6.1
- #4 bars top and bottom for bracing
- 12" x 12" min. footing

	Wall Height (ft.)				
	8	9	10	11	12
SDC A-C	28	32	34	38	42
SDC D ₀ -D ₂	32	32	34	NP	NP

Table R602.10.5
2018 IRC **APA**

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Wall Bracing Types

Method PFH – Intermittent Portal Frame

10' Max.

- Extended header
- 1,000-lb strap capacity (opposite side from sheathing)
- 3" o.c. nailing
- Min. 3/8" thick wood structural panel
- 3,500-lb strap-type hold-down
- (1) 5/8" anchor bolt

Figure R602.10.6.2
2018 IRC **APA**

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Wall Bracing Types

Method PFH with taller walls

- Wall height up to 12 ft. tall
- Portal height limited to 10 ft. (top of header)
- Pony wall built above portal header
- 4 ft. max pony wall height
- Pony walls require tension straps (Table R602.10.6.4)
- Number of jack studs required for single portal post in Table R602.7(1) & (2)

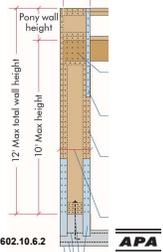


Figure R602.10.6.2 **APA**

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Wall Bracing Types

Continuous Sheathing Bracing Methods:

CS-WSP	Continuously sheathed wood structural panel
CS-G*	Continuously sheathed wood structural panel adjacent to garage openings
CS-PF	Continuously sheathed portal frame
CS-SFB	Continuously sheathed structural fiberboard

Table R602.10.4
2018 IRC **APA**

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Bracing

Load Path	Limits	High Seismic	Bracing	Seismic Details
-----------	--------	--------------	---------	-----------------

Wall Bracing Types

BWL Spacing vs. BWP Spacing

Required Length

Contributing Length

Mixing Wall Bracing Types

APA

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BWL Spacing vs. BWP Spacing

BWL vs. BWP

- The Residential Code defines a **BWL** as a series of **BWPs** in a single story
- The code (R602.10.2) defines a **Braced Wall Panel (BWP)** as a full height section of a **Braced Wall Line (BWL)** with no vertical or horizontal offsets.

R602.10.2
2018 IRC **APA**

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BWL Spacing vs. BWP Spacing

<p style="text-align: center;">SDC C (townhouses only)</p> <p>BWL Spacing = 35 ft. max. Permitted to be = 50 ft. max. when bracing length increased per Table R602.10.3(4).</p>	
<p style="text-align: center;">SDC D₀, D₁, & D₂ (all dwellings)</p> <p>BWL Spacing = 25 ft. max. Permitted to be = 35 ft. max. 1. To accommodate one room not exceeding 900 ft² 2. When required length of bracing is adjusted per Table R602.10.3(4)</p>	

Table R602.10.1.3
2018 IRC **APA**

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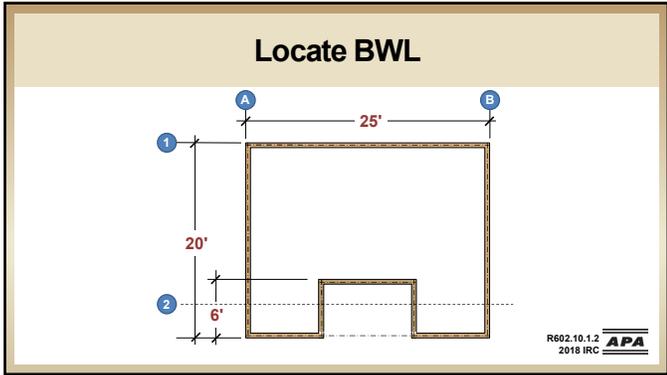
BWL Spacing vs. BWP Spacing

Braced Wall Lines R602.10.1

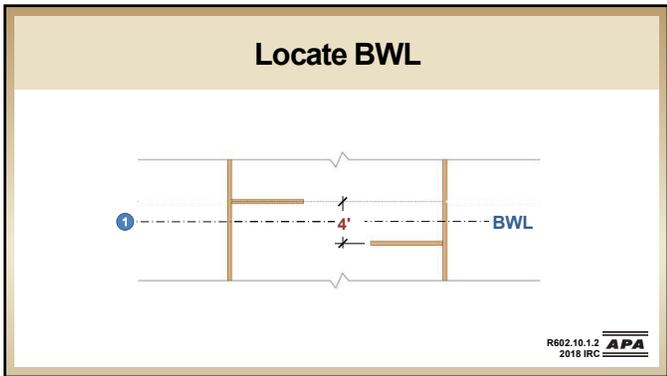
- Straight
- Run in each plan direction
- Required on each floor
- 4' offset each side of BWL allowed
- BWL not required to align with physical walls
- Angled walls allowed
- Aspect ratio (Length:Width) ≤ 3:1 per Table R602.10.3(4) footnote c

R602.10.1
2018 IRC **APA**

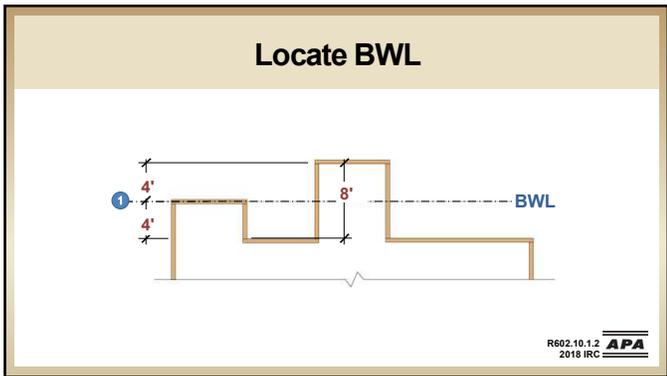
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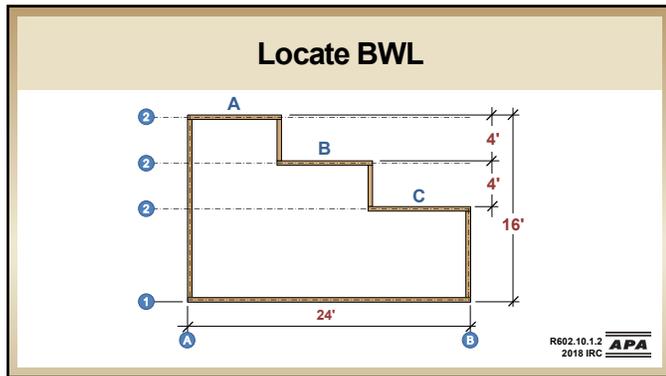
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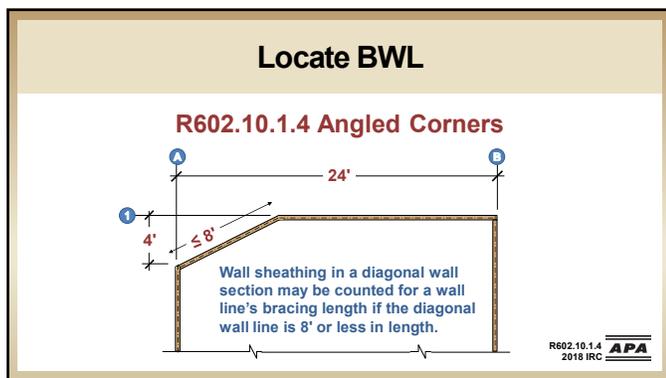
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BWL Spacing vs. BWP Spacing

R602.10.2.2.1 Location of Braced Wall Panels in SDC D₀, D₁ and D₂

Placement Requirements

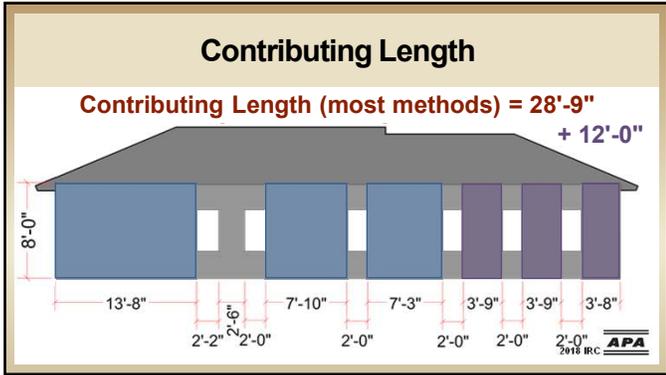
BWPs to begin at each end of a BWL.

Exceptions:

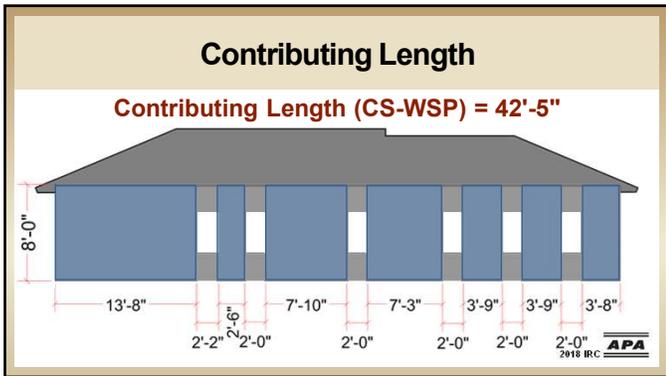
1. **Methods WSP, CS-WSP, CS-G and CS-PF**
 - Panels may begin up to 10 ft. from wall end
 - A minimum 24" corner return at end of the braced wall line or a 1,800-lb hold-down at the corner stud is required.
2. **Method BV-WSP**
 - Panel may move up to 10 ft. from BWL end.
 - Requires use of BV-WSP hold-downs.

R602.10.2.2.1
2018 IRC **APA**

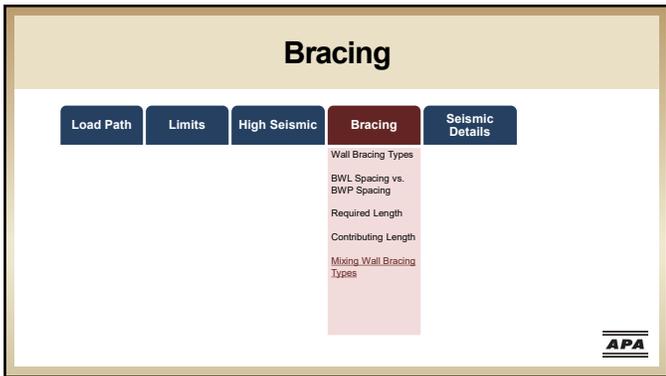
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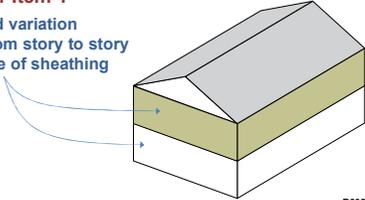
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Mixing Wall Bracing Types

R602.10.4.1 Item 1
BWP method variation permitted from story to story with any type of sheathing

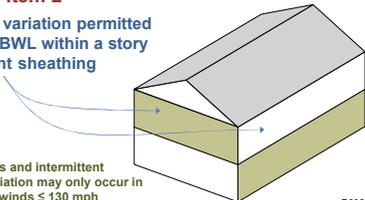


R602.10.4.1 Item 1
2018 IRC **APA**

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Mixing Wall Bracing Types

R602.10.4.1 Item 2
BWP method variation permitted from BWL to BWL within a story for intermittent sheathing



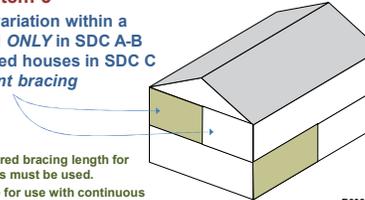
- For continuous and intermittent sheathing, variation may only occur in SDC A-C with winds \leq 130 mph

R602.10.4.1 Item 2
2018 IRC **APA**

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Mixing Wall Bracing Types

R602.10.4.1 Item 3
BWP method variation within a BWL permitted *ONLY* in SDC A-B and for detached houses in SDC C with *intermittent bracing*



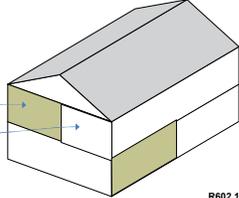
- Greatest required bracing length for panel materials must be used.
- Not applicable for use with continuous sheathing OR dwellings in SDC D_v/D₂

R602.10.4.1 Item 3
2018 IRC **APA**

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Mixing Wall Bracing Types

R602.10.4.1 Item 4
 Mixing of CS-WSP, CS-G and CS-PF along a BWL is permitted in any SDC

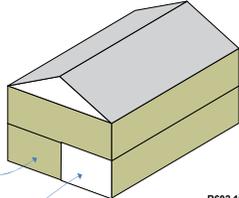


R602.10.4.1 Item 4
2018 IRC **APA**

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Mixing Wall Bracing Types

R602.10.4.1 Item 4
 Mixing ABW, PFH and PFG with continuous sheathed methods is permitted, provided the required length used is the highest value of the bracing methods used.



R602.10.4.1 Item 4
2018 IRC **APA**

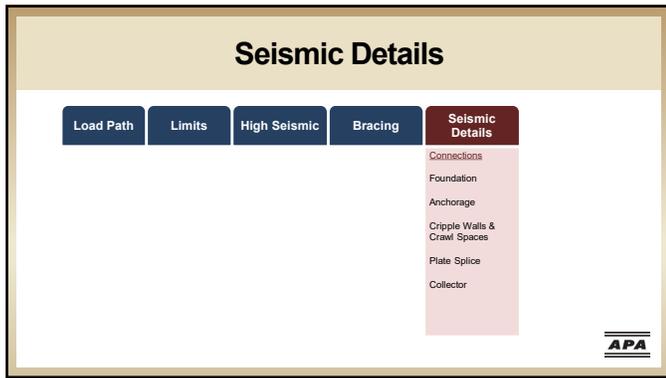
89

Mixing Wall Bracing Types

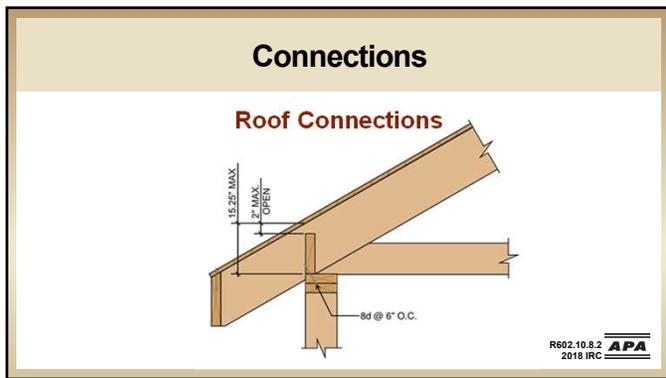
Table 3.27
 from "A Guide to the 2018 IRC Wood Wall Bracing Provisions"

Mixing Locations	Mixing Limitations	SDC A-B	SDC C Detached	SDC C Townhomes	SDC D ₁ -D ₂
Story to Story	Mixing continuous and intermittent methods	•	•	•	•
BWL to BWL	Mixing intermittent methods	•	•	•	•
BWL to BWL	Mixing continuous and intermittent methods	•	•	•	
Within BWL	Mixing intermittent methods	•	•		
Within BWL	Mixing CS-WSP, CS-G and CS-PF	•	•	•	•
Within BWL	Mixing ABW, PFH and PFG with continuous sheathing methods	•	•	•	•
Within BWL	Mixing an intermittent method on an interior portion and CS-WSP, CS-G or CS-PF on an exterior portion of a wall line	•	•		

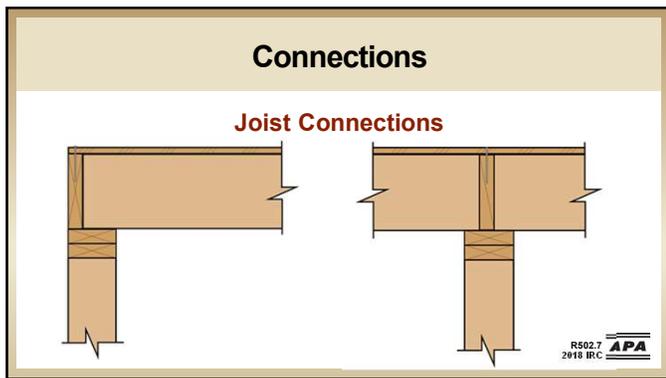
90



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Connections

Panel Connections



Table R602.10.4
Footnote a
2018 IRC



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Seismic Details

Load Path	Limits	High Seismic	Bracing	Seismic Details
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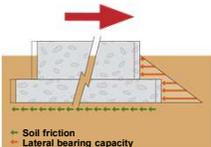
- Connections
- Foundation
- Anchorage
- Cripple Walls & Crawl Spaces
- Plate Splice
- Collector

R403.1
2018 IRC

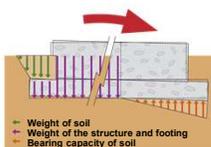


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Bracing: Foundation



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.

R403.1
2018 IRC



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Bracing: Foundation

Braced Wall Panel Support Requirements – SDC D₀-D₁ Continuous Footings/Foundation

Braced Wall Panels	Plan Dimension ≤ 50 ft.	Plan Dimension > 50 ft.
Exterior	Supported by continuous concrete or fully grouted masonry footing	
Interior	No requirement for continuous footing	Requires continuous concrete or fully grouted masonry footing, or exception*

* See future slides

R403.1.2
2018 IRC 

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Bracing: Foundation

Braced Wall Panel Support Requirements – SDC D₂
(R403.1.2 & R602.10.9.1)

BWP Location	Number of Stories	Plan Dimension ≤ 50 ft.	Plan Dimension > 50 ft.
Exterior	All	Supported by continuous foundation/footing	
Interior	One Story	No requirement for continuous foundation/footing	Supported by continuous foundation/footing or exception*
	Two Story	Supported by continuous foundation/footing, or exception*	

* See future slides

R403.1.2, R602.10.9.1
2018 IRC 

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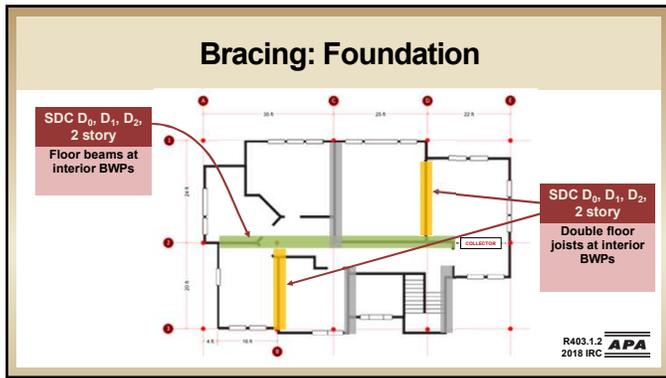
Bracing: Foundation

R403.1.2 – The SDC D₀-D₂ two-story exception can allow interior wall lines with braced wall panels to be supported according to the three-criteria listed below if footings below interior braced wall panels are spaced a maximum of 50 ft.:

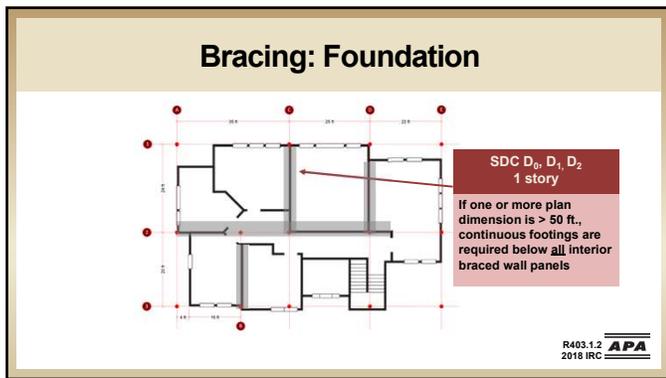
1. Cripple walls not more than 4 ft. in height.
2. First floor BWPs are supported on double floor joists, continuous blocking or floor beams.
3. The distance between BWLs does not exceed twice the building width measure parallel to the BWL.

R403.1.2 Exception
2018 IRC 

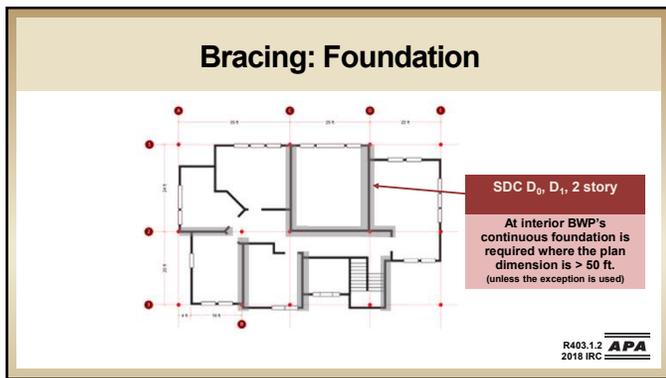
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Bracing: Foundation

R403.4.2
2018 IRC **APA**

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Continuous Footing Requirements in High SDCs D₀ – D₂

SDC	NUMBER OF STORES	WALL LOCATION	LENGTH OF PLAN DIMENSIONS	
			Both dimensions ≥ 20 ft.	One or more dimensions ≥ 10 ft.
D ₀ , D ₁ , D ₂	One story	Exterior walls	Continuous footings required.	
		Interior walls	No continuous footings required.	Continuous footings required below all interior braced wall panels.
D ₁ , D ₂	Two stories	Exterior walls	Continuous footings required.	
		Interior walls	No continuous footings required.	Continuous footings are required below all interior braced wall panels unless the Section R403.1.2 exception is used. Then interior wall lines with braced wall panels may be supported according to the exception with footings below interior braced wall panels spaced a maximum of 50 feet.
D ₂	Two stories	Exterior walls	Continuous footings required.	
		Interior walls	Continuous footings are required below all interior braced wall panels unless the Section R403.1.2 exception is used.	Continuous footings are required below all interior braced wall panels unless the Section R403.1.2 exception is used. Then interior wall lines with braced wall panels may be supported according to the exception with footings below interior braced wall panels spaced a maximum of 50 feet.

Commentary Figure R403.1.2
CONTINUOUS FOOTING REQUIREMENTS IN HIGH-SEISMIC REGIONS

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Foundation Sizes

CLASS OF MATERIAL	LOAD-BEARING PRESSURE (pounds per square foot)
Crystalline bedrock	12,000
Sedimentary and foliated rock	4,000
Sandy gravel and/or gravel (GW and GP)	3,000
Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000
Clay, sandy, silty clay, clayey silt, silt and sandy silt/clay (CL, ML, MH and CH)	1,500 ^b

For SI: 1 pound per square foot = 0.0479 kPa.

a. Where soil tests are required by Section R401.4, the allowable bearing capacities of the soil shall be part of the recommendations.

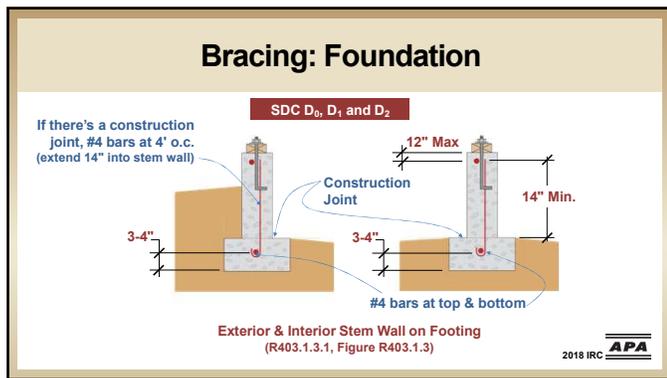
b. Where the building official determines that in-place soils with an allowable bearing capacity of less than 1,500 psf are likely to be present at the site, the allowable bearing capacity shall be determined by a soils investigation.

Establishing the soil capacity:

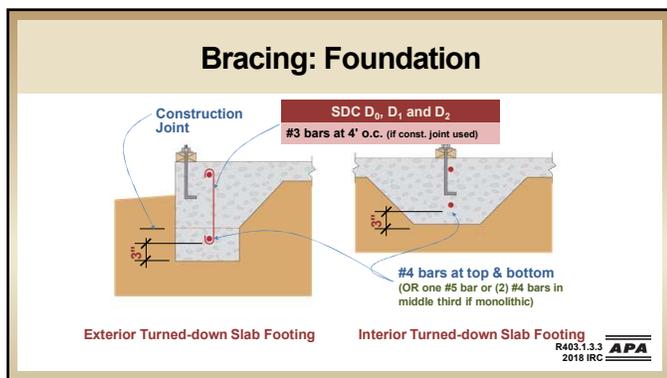
- Minimum footing width based on load bearing value of the soil per Table R401.4.1
- Minimum footing size for piers and columns per tributary load and allowable soil pressure per R401.4.1

R401.4.1
2018 IRC **APA**

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Bracing: Foundation

Concrete Foundation Walls (Basement Walls) R404

Code Section	Provision	High Seismic Regions SDC D ₀ -D ₂
R404.1.3.3.1 & R404.1.3.3.7.1	Compressive Strength & Reinforcement Grade	3,000 psi minimum & 60ksi
Table R404.1.2(1)	Horizontal Reinforcement	Walls ≤ 8' - 1-#4 horizontal required within 12 inches of top and near mid-height, ≥ 8' top and middle third
Tables R404.1.2(2) thru R404.1.2(9)	Vertical Reinforcement	Rebar required according to table used, read footnotes for additional requirements
R404.1.4.2	Concrete foundation walls	Walls less than or equal to 7.5" thick require 1-#4 vertical bar at min. 48" o.c.

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Bracing: Foundation

Wall Bracing – Additional Foundation Requirements (R602.10)

Code Section	Provision	All SDC
R602.10.6, Figures R602.10.6.1 and R602.10.6.2	Alternate wall bracing (ABW, PFH)	Methods ABW and PFH required 1-#4 horizontal at top and bottom of footing and lap bars minimum of 15"
R602.10.9, Figure R602.10.9	Short concrete or masonry walls below BWPs	Rebar required complying with Figure R602.10.9 if wall length, height and thickness are: L ≤ 48" AND H > 12" AND T < 6"

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2018 IRC

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Bracing: Foundation

Narrow Masonry Wall Requirements

Only required for walls less than 48" long.

Figure R602.10.9
2018 IRC **APA**

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Seismic Details

Load Path

Limits

High Seismic

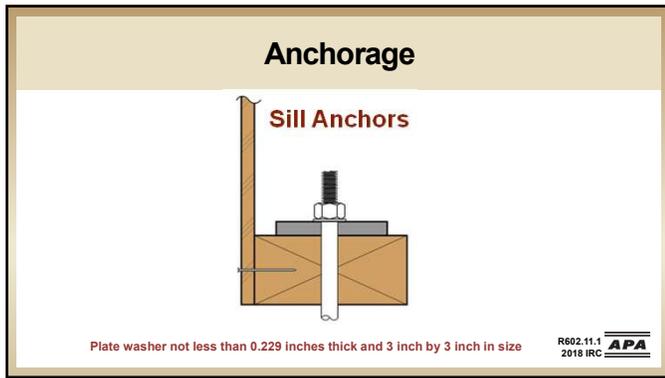
Bracing

Seismic Details

- Connections
- Foundation
- Anchorage
- Cripple Walls & Crawl Spaces
- Plate Splice
- Collector

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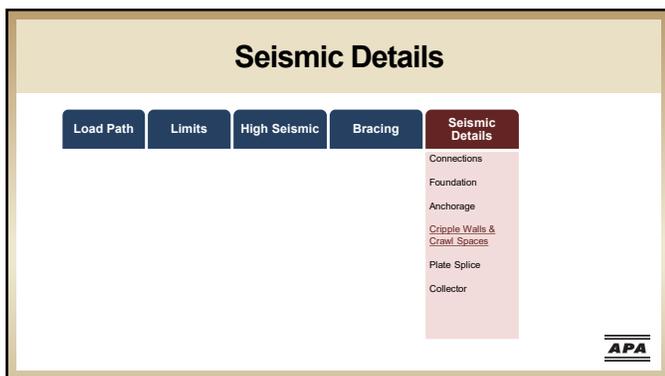
Anchorage

Anchorage Requirements
(R403.1.6, R403.1.6.1, R602.11.1)

Code Section	Provision	SDC D ₁ -D ₂ , SDC C (townhouses)
R403.1.6 & R403.1.6.1	Foundation anchorage (for all SDC categories except where noted in bullet 1)	<ul style="list-style-type: none"> •Wood sole and sill plates attached to foundation with anchor bolts minimum of 6 ft. o.c. located within 12" of the ends of each plate section. However, for SDC D₁ - D₂, the maximum anchor bolt spacing shall be 4 ft. for buildings over two stories •Minimum 1/2" diameter anchor bolt with 7" embedment •Minimum of 2 bolts per plate section with bolts located 7 bolt diameters to 12" from each end of the plate section
R403.1.6.1	Miscellaneous of Note	<ul style="list-style-type: none"> •Wall lines without BWP may use cut washers in lieu of plate washers •Interior BWLs require plate washers •Stepped cripple walls must meet R602.11.2 requirements
R602.11.1	Wall anchorage	Plate washers a minimum 0.229" by 3" by 3" between sill plate and nut on braced wall lines except where approved anchor straps are used.

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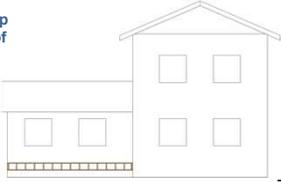
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Cripple Walls & Crawl Spaces

Cripple Wall Definition:
 A **framed** wall extending from the top of the foundation to the underside of the floor framing of the **first story above grade plane** (R202).



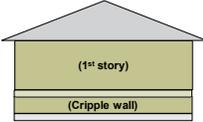
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Cripple Walls & Crawl Spaces

Main Concepts:

- Cripple walls shall be supported on continuous foundations. (R602.9)
- There are 2 methods for determining the required braced panel length for cripple walls. (R602.10.10 & R602.10.10.3)
- Cripple walls shall be braced with same length and method of bracing used for wall above multiplied by appropriate adjustments:
 - 1.15 (cripple wall bracing factor, except for SDC D₂ - Use Tables)
 - 1.5 or 1.4 (if gypsum is eliminated from the inside face)
 - 1.5 (if 1st floor interior BWLs are not supported on continuous footings)
 - 0.7 (if fasteners are decreased to 4" o.c., except for SDC D₂)

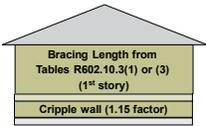


R602.10.10, R602.10.10.1, R602.10.1.2, R602.10.10.3 **APA**

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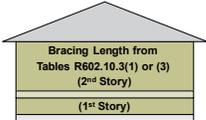
Cripple Walls

Cripple wall supporting one story **or** Redesignation of cripple walls: optional if all cripple walls are < 48", mandatory if any cripple wall **segment** is > 48"



Bracing Length from Tables R602.10.3(1) or (3) (1st story)
Cripple wall (1.15 factor)

14' BWP edge to edge max. for SDC C in Townhomes and SDC D₁-D₂ in SF dwellings



Bracing Length from Tables R602.10.3(1) or (3) (2nd Story)
(1st Story)

20' BWP edge to edge max.

R602.10.10 & R602.10.10.3 2018 IRC **APA**

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Cripple Walls

Seismic Design Categories D₀-D₁ & Townhomes C

Cripple wall supporting two stories

Bracing Length from Tables R602.10.3(1) or (3) (2nd Story)

Bracing Length from Tables R602.10.3(1) or (3) (1st Story)

Cripple wall (1.15 factor)

14' BWP edge to edge

or

Redesignated as a Three Story

Bracing Length from Tables R602.10.3(1) or (3) (3rd Story)

Bracing Length from Tables R602.10.3(1) or (3) (2nd Story)

Cripple wall (1.15 factor)

20' BWP edge to edge

R602.10.10.3
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Cripple Walls

Specific to SDC D₂

Cripple Wall Supporting One Story

Bracing Length from Tables R602.10.3(3) or (4) (1st Story)

Cripple wall (1.15 factor)

14' BWP edge to edge distance

R602.10.10.2

or

Re-designated as a Two Story

Bracing Length from Tables R602.10.3(3) and (4) (2nd Story)

(1st Story)

20' BWP edge to edge

R602.10.10.3

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Cripple Walls

Specific for SDC D₂

Cripple wall supporting two stories

Bracing Length from Tables R602.10.3(3) (2nd Story)

Bracing Length from Tables R602.10.3(3) (1st story)

Cripple wall (from Table R602.10.3(3))

14' BWP edge to edge distance

or

If trying to re-designate as a three story

For SDC D₂ - The bottom story of a three story is not permitted "NP" Per Table R602.10.3(3) (also referenced in R602.10.10.2)

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Cripple Walls

For SDC D₀, D₁, and Townhomes C only per R602.10.10.1

Cripple wall bracing

If interior BWL's are not supported by a continuous foundation (i.e. BWL "B"):

1. The adjacent parallel cripple walls, where provided, shall be braced with Method WSP or Method CS-WSP in accordance with R602.10.4
2. Increase exterior cripple wall's length of bracing by factor of 1.5 (i.e., BWL's A & C).
3. You can increase panel edge fastener nailing to 4" oc and adjust the bracing length by 0.7

Currently, conditions 2 and 3 above are not addressed in the APA wall bracing calculator

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Cripple Walls & Crawl Spaces

SDC D₀, D₁, and D₂

Stepped foundations

Anchor bolts shall be located not more than 1 ft. and 3 ft. from the step foundation

2x plate splice

2' Min.

If "A" > 8 ft., provide metal tie

If > 4' refer to R602.11.2 (3 conditions)

3" x 3" plate washer

Footing Section "A"

- If "A" ≥ 8 ft. in a 25' wall line, the cripple wall is considered braced
- If "A" < 8 ft. in a 25' wall line, bracing is required at cripple stud wall

R602.11.2
2018 IRC **APA**

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Cripple Walls & Crawl Spaces

SDC D₀, D₁, and D₂

Stepped foundations

VS.

Wind

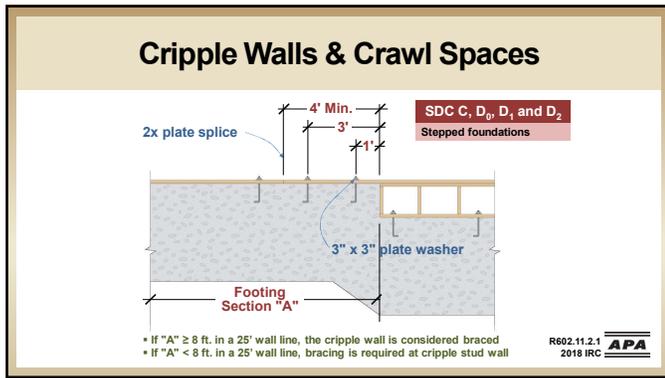
Stepped foundations

If footing section ≥ 8 ft. per R602.11.2.1, the BWL considered braced

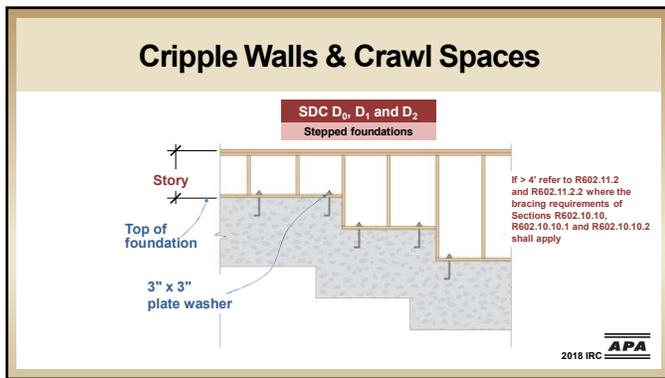
Can this provision be used in low seismic areas?

R602.11.2
2018 IRC **APA**

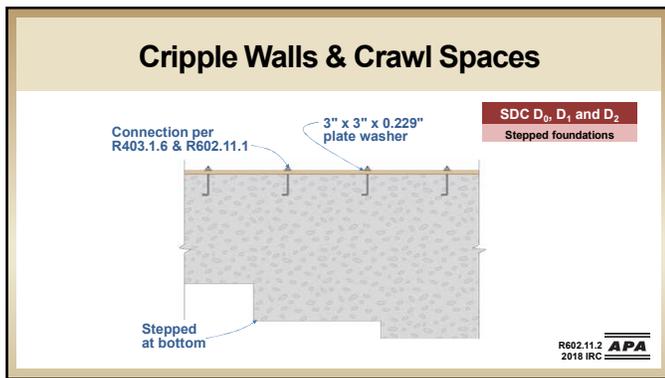
126



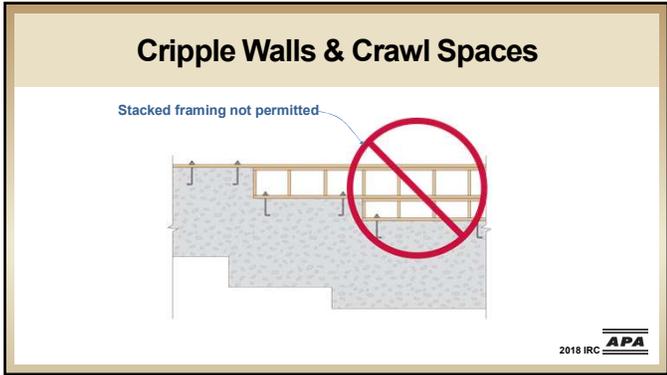
127



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Seismic Details

Load PathLimitsHigh SeismicBracingSeismic Details

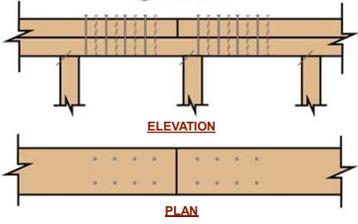
- Connections
- Foundation
- Anchorage
- Cripple Walls & Crawl Spaces
- Plate Splice
- Collector



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Plate Splice

Figure A.2



ELEVATION

PLAN

2018 IRC 

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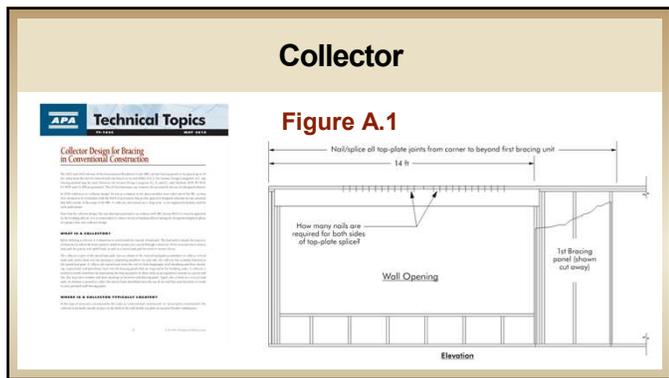
Seismic Details

Load PathLimitsHigh SeismicBracingSeismic Details

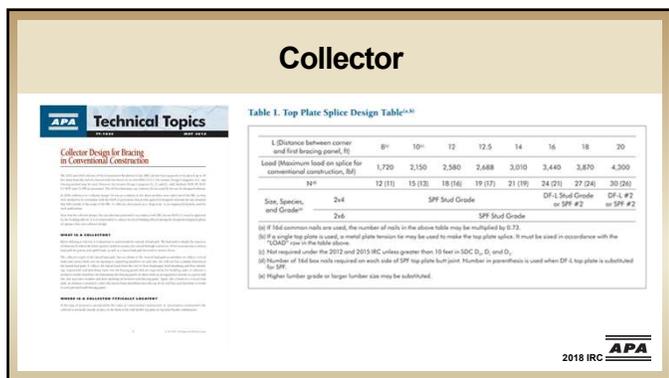
- Connections
- Foundation
- Anchorage
- Cripple Walls & Crawl Spaces
- Plate Splice
- Collector



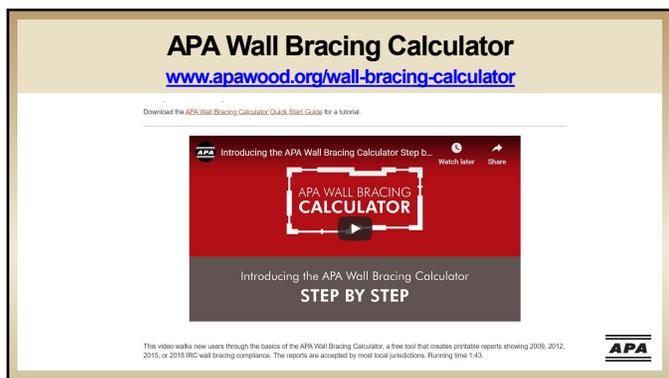
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Resources

www.apawood.org/wall-bracing

Item no. 7102S18



Form F430



APA

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What's Coming Next... (2021 IRC)

- **Hillside Irregularity Added** (R301.2.2.6)
- **Story Height Exception Added** (R301.3)
- **BWL Offset Limit Added** (R602.10.1.2)
- **PFH, ABW or BV-WSP Distance from End Clarification** (R602.10.2.2.1)
- **Masonry/Stone Veneer Limits Added For SDC D** (R602.10.6.5)
- **U1 Preservative Treatment Required for Wood Columns within 8" of the Ground** (R317.1)

2018 IRC **APA**

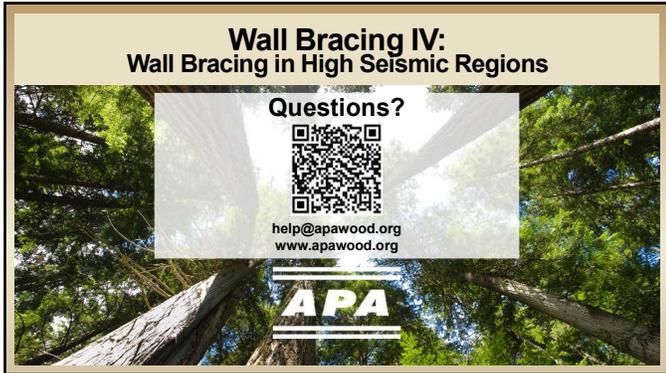
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Learning Objectives

- ✓ Appreciate the differences designing with the IRC versus the IBC.
- ✓ Understand the limits of IRC wall bracing in high seismic regions.
- ✓ Be able to design IRC wall bracing for seismic forces in SDC D₀-D₂.
- ✓ Understand when mixing IRC wall bracing types is allowed and prohibited.

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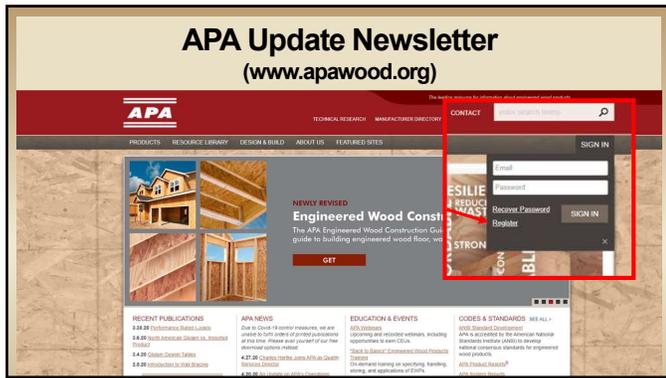
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