Presenters

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Handouts

- Slideshow (3)

3

Handouts

- Slideshow (3)
- Example and exercises

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Handouts

- Slideshow (3)
- Exercises
- "Classic" Wall Bracing Spreadsheet

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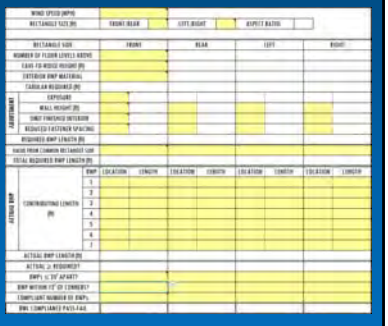
Handouts

- Slideshow (3)
- Exercises
- "Classic" Wall Bracing Spreadsheet
- Practical Wall Bracing Spreadsheet



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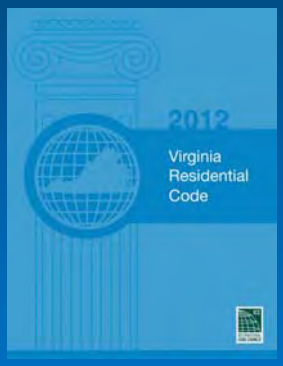
Handouts

- Slideshow (3)
- Exercises
- "Classic" Wall Bracing Spreadsheet
- Practical Wall Bracing Spreadsheet
- Code Excerpt



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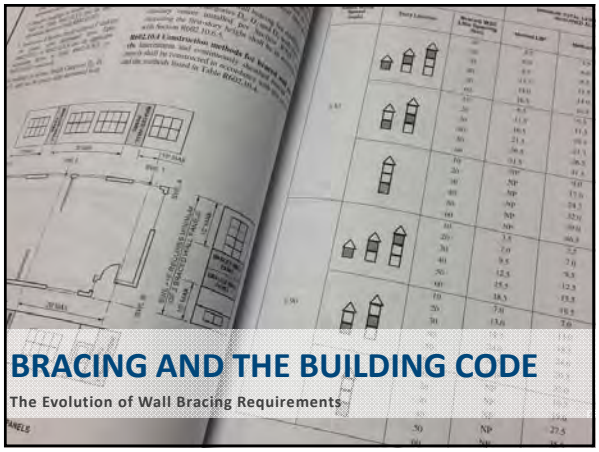
PART 1
INTRODUCTION TO WALL BRACING

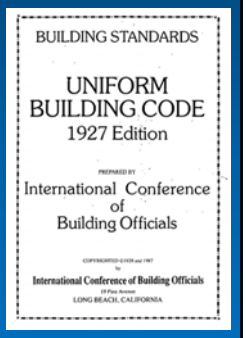


BRACING AND THE BUILDING CODE

The Evolution of Wall Bracing Requirements

1927 – UBC

"Buildings…shall be of sufficient strength to support the estimated or actual imposed dead and live…"



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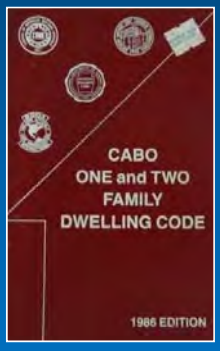
1986 - CABO

- Wall bracing methods
  - Let in bracing
  - 48" structural sheathing
    - Plywood
    - Particleboard
    - Fiberboard
    - Gypsum board



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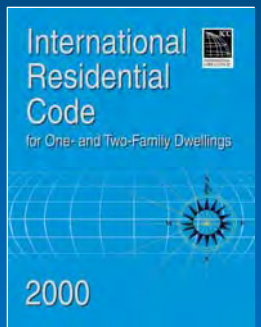
2000 – IRC

- Wall bracing
- 8 bracing methods
- Exception for "continuous sheathing"
- Wind bracing amounts based on seismic loads



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2007-2010 - ICC Ad Hoc Committee

- Resolve discrepancies:
  - Make easier to understand
  - Provide flexibility
  - Separate wind and seismic
- Members representing:
  - Academics
  - Code officials
  - Industry representatives
  - Home builders
- Proposed changes first appeared in the 2009 IRC

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2012 – IRC

- 16 bracing methods
- 4 narrow panels
- Wind and seismic separated
- Increased flexibility (with increased complexity)
- Simplified approach added

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Why Change?
The Evolution of House Size

1950s 1960s

1970s 1980s

1990s 2000s

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Why Change?
Design Trends

Open Concept

High Ceilings

Two story Walls

Natural Light Windows

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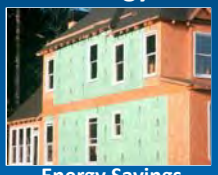
Why Change?
New Methods and Technology

Narrow Walls



Energy Savings

Hardware

Materials

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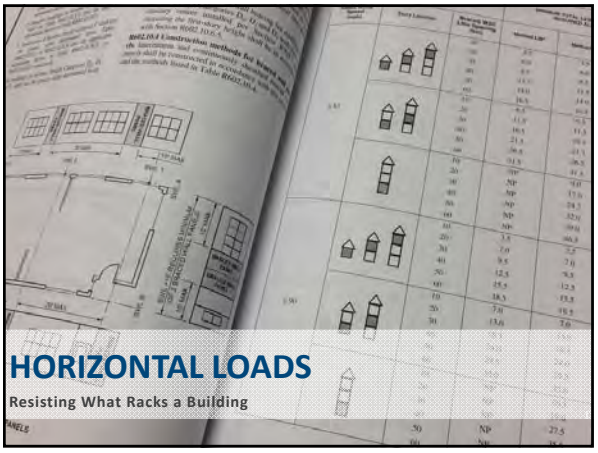
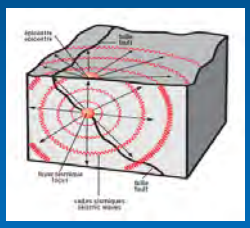


Seismic Load



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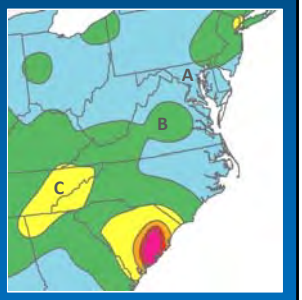
Seismic Design Category

- Based on:
  - Ground movement severity
  - Occupancy category



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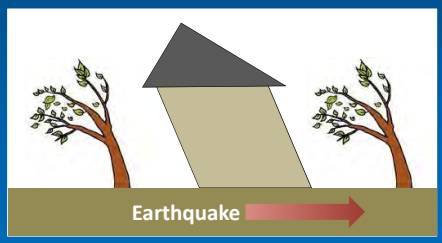
Seismic Forces



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Seismic Forces

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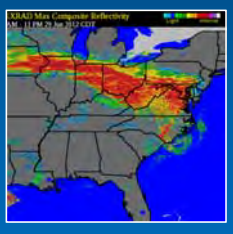
Wind Load

Hurricane Isabel 2003



Derecho 2012

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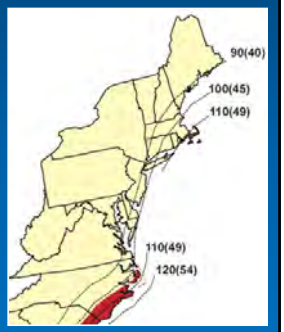
Wind Speed

- Wind speed based on:
  - 3 second gust
  - 50 year storm
  - 30 feet above grade
- Regional wind speed: 90 100 mph
- Equivalent to mid grade Category 1 hurricane



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Spreadsheet – Wind Speed

WIND SPEED (MPH)	90
BWL DESIGNATION	
NUMBER OF FLOORS ABOVE BWL	
BWP METHOD	
AVERAGE BWL SPACING (ft)	
TABULAR REQUIREMENT (ft)	

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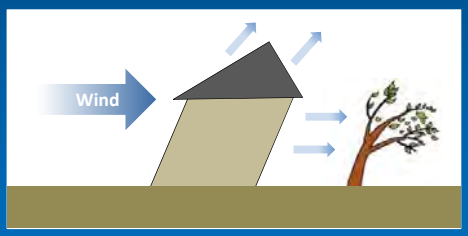
Wind Load



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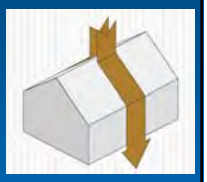
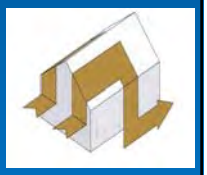
Load Path

DEFINITION: The route a force travels from the area where it is applied to the ground.

Vertical forces



Horizontal forces



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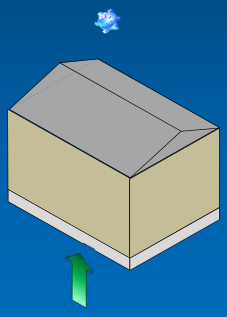
Vertical Load Path

Vertical load path transfers gravity load:

- to roof sheathing
- to rafters/trusses
- to walls
- to foundation
- to ground



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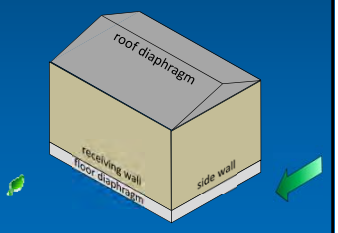
Horizontal Load Path

Horizontal load path transfers wind load:

- to receiving wall
- to diaphragms
- to side walls
- to foundation
- to ground



DIAPHRAGM: the sheathing of the roof or floor which acts as a thin, deep beam delivering lateral forces to the main wind force resisting system (MWFRS).

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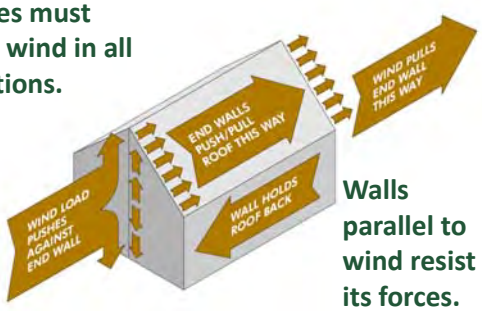
Horizontal Load Path

Houses must resist wind in all directions.



Walls parallel to wind resist its forces.

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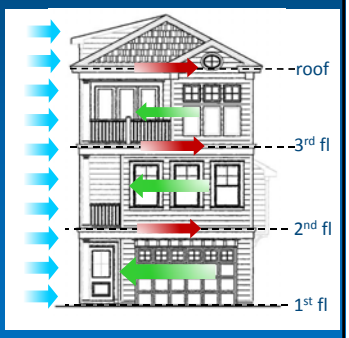
Multi-story House

- Wind load accumulates from top to bottom
- 1st floor walls resist greatest load
- Largest openings in 1st floor



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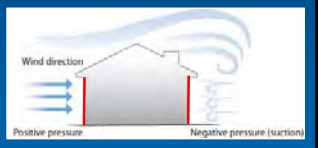
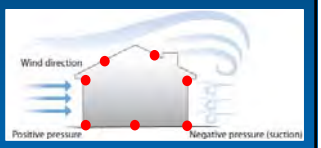
Critical Element of Load Path
Receiving wall, suction wall

- Purpose:
  - Captures load
  - Delivers load to diaphragm
- Area of focus:
  - Sheathing/siding
  - Sheathing to stud fasteners



Critical Element of Load Path
Connections

- Purpose:
  - Transfers load
- Area of focus:
  - Fasteners
  - Anchor bolts



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Critical Element of Load Path
Diaphragms

- Purpose:
  - Delivers load to side walls
- Area of focus:
  - Sheathing to rafter/truss fasteners
  - Sheathing to joists fasteners

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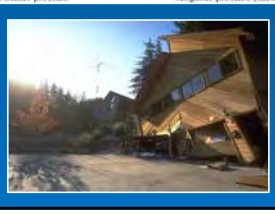
Critical Element of Load Path
Wall Bracing

- Purpose:
  - Resists load
  - Transfers load to foundation



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Critical Element of Load Path
Wall Bracing

- Purpose:
  - Resists load
  - Transfers load to foundation
- Failure modes:
  - Sliding
  - Overturning
  - Racking

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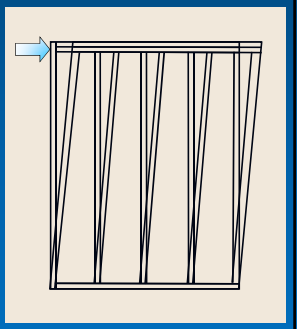
How Bracing Works

- Load at top plate
- No bracing, no stiffness



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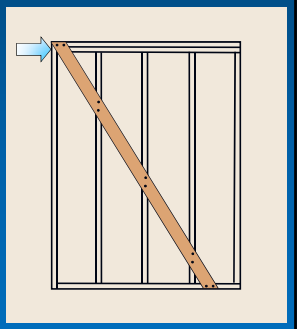
How Bracing Works

- Load at top plate
- No bracing, no stiffness
- Bracing stiffness
  - Let in



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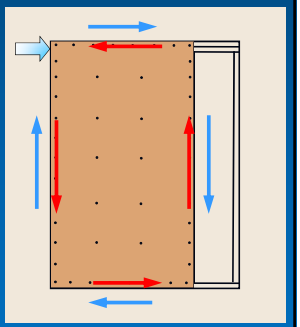
How Bracing Works

- Load at top plate
- No bracing, no stiffness
- Bracing stiffness
  - Let in
  - Solid panels
- Edge nails resist load, narrow spacing
- Field nails resist buckling, wide spacing



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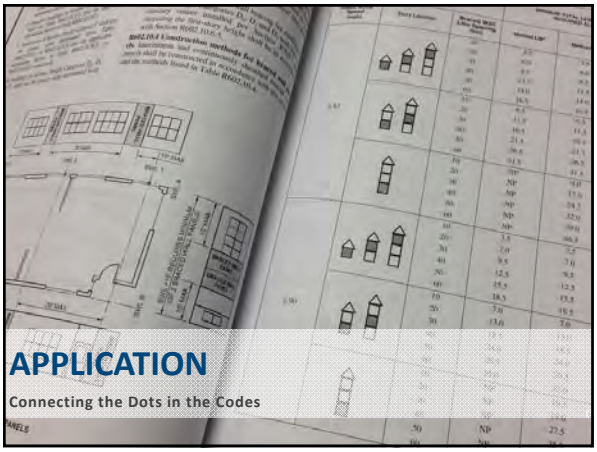

APPLICATION

Connecting the Dots in the Codes

The Prescriptive Code

- IRC is a “cookbook”
- Recipes based on
  - Historical performance
  - Common materials
  - Nationwide application
- Follow recipe no RDP
- Fall outside recipe RDP required

The worst house you can build by law!

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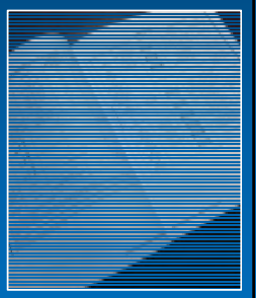
IRC Project Types

- New detached single family dwellings
- Townhouses
- Additions
- Alterations:
  - Decks to sunrooms
  - Carports to garages
  - Porches to living spaces

IRC Wall Bracing Limitations

- Wood framed construction
- Maximum 3 stories
- Wind speeds < 110 mph
- SDC A D_2
- Wall height ≤ 12 feet
- Roof height (from eave to ridge) ≤ 20 feet



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Alternate Prescription Solutions

- Wood Frame Construction Manual 2012
- WFCM Guide for high wind areas
- ICC 400 (for log structures)
- IBC Chapter 23

R301.1.1 44

Engineered Design

- Shear walls
- When design exceeds limits of IRC
- "Accepted engineering practice"
- May be portion or entire structure
- Reference IBC

R301.1.3 45

Shear Wall Standards

- ASCE 7 to determine wind load on MWRS

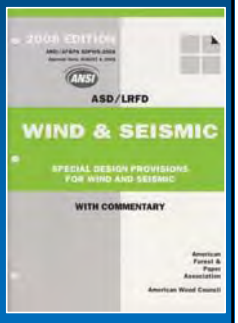
MWFRS: (main wind force resisting system) the structural elements in the horizontal load path which resist load.

IBC 1609.1.1 46

Shear Wall Standards

- SDPWS as design standard
- Design requirements for shear walls, diaphragms
- Table 4.3.4:

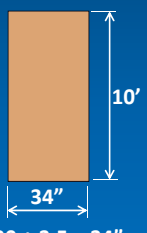
Shear Wall Sheathing Type (blocked, unless noted otherwise)	Maximum Aspect Ratio
Wood structural panels, unblocked	2:1
Wood structural panels	3.5:1
Particleboard	2:1
Diagonal sheathing, conventional	2:1
Gypsum wallboard	2:1
Portland cement plaster	2:1
Structural fiberboard	3.5:1



IBC 2305.1 47

Shear Wall Standards

Wood Structural Panels
aspect ratio 3.5:1



120 ÷ 3.5 34"

Height	8'	9'	10'	11'	12'
Length	27"	31"	34"	38"	41"

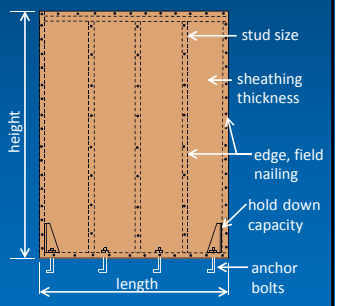
Portland Cement Plaster Panels
aspect ratio 2:1

120 ÷ 2.0 60"

Height	8'	9'	10'	11'	12'
Length	48"	54"	60"	66"	72"

Engineered Shear Walls

- Stud size, spacing
- Sheathing type, thickness
- Fastening schedule
- Hold down requirement, capacity
- Anchor bolt location, capacity



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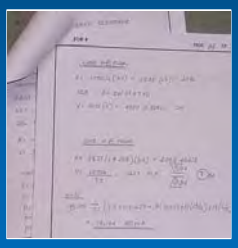
Engineered Shear Walls

TIP: When submitting or reviewing engineered calculations, look for…

- Wind load determination (13 18 psf in 90 mph, V_{ult} 115 mph)
- Seal of registered design professional
- Minimum aspect ratio



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Engineered Moment Frame

- Engineered solution
- Requires calculations
- Types:
  - Custom
  - Pre designed
    - Hardy Frame
    - Simpson Strong Tie
- Used often in townhouses

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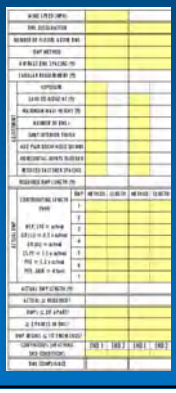
Bracing Information

- Bracing elements shown on plans
  - BWPs
  - BWLs
  - Circumscribed rectangles
- Analysis may be required
  - Forms
  - Calculations
  - Spreadsheet



VCC 109.3, R602.10 & R602.12

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Relaxed Plan Review

- At discretion of the building official
- No review of 2nd floor wall bracing if:
  - 1st floor analysis correct, and
  - 2nd floor openings less than walls directly below

R602.10 & R602.12

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Relaxed Plan Review

R602.10 & R602.12

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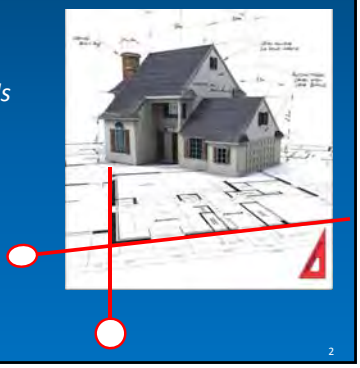
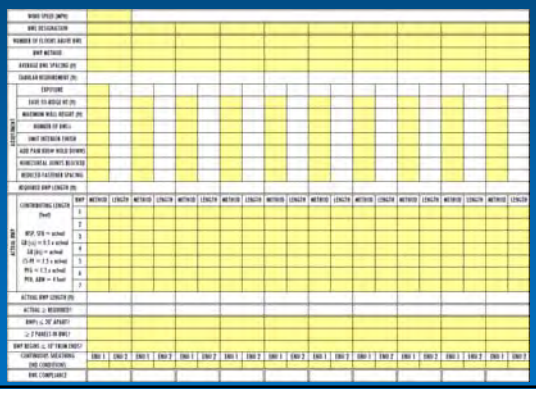
"Classic" Wall Bracing

- *Braced Wall Lines* (BWL)
- *Braced Wall Panels* (BWP)
- Greater flexibility
- More complex



R602.10 2

"Classic" Spreadsheet



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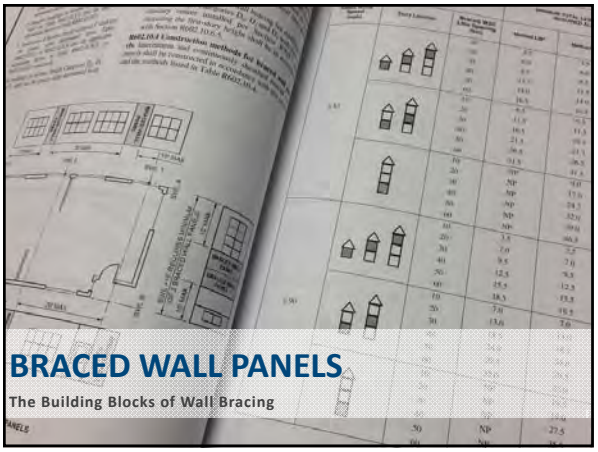
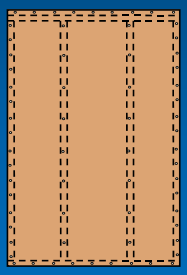


Braced Wall Panel

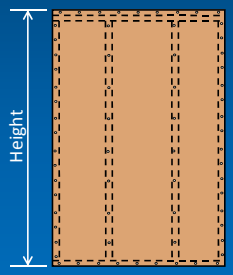
DEFINITION: A full height section of wall constructed to resist horizontal loads with a minimum panel length.



R602.10.2 5

Braced Wall Panel

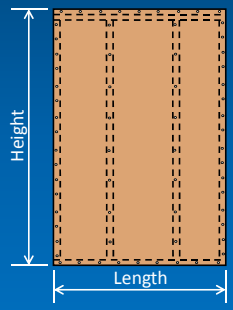
- Full height, 12' maximum



R602.10.2 6

Braced Wall Panel

- Full height, 12’ maximum
- Minimum length based on bracing method



R602.10.2 7

Braced Wall Panel

- Full height, 12’ maximum
- Minimum length based on bracing method
- No horizontal offsets

Not the same BWP

R602.10.2 8

Braced Wall Panel

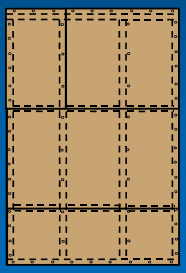
- Full height, 12’ maximum
- Minimum length based on bracing method
- No horizontal offsets
- No vertical offsets

Not the same BWP

R602.10.2 9

Braced Wall Panel

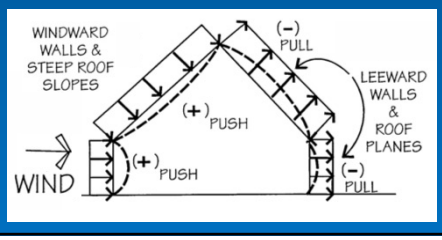
- Full height, 12’ maximum
- Minimum length based on bracing method
- No horizontal offsets
- No vertical offsets
- Vertical, horizontal joints permitted (same material)
  - Studs at vertical joints
  - Blocking at horizontal joints



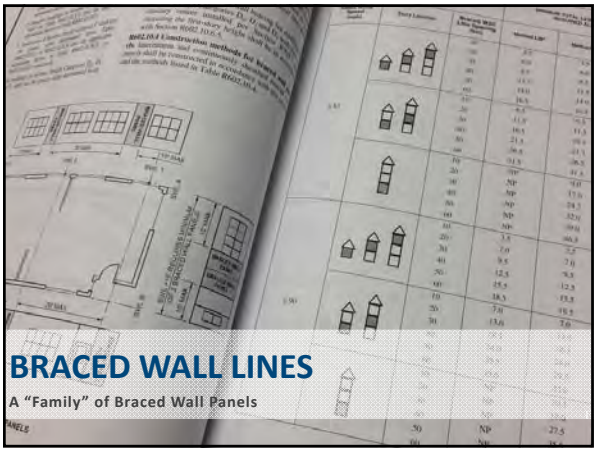
R602.10.10 10

Uplift Load Path

- Wind speeds > 90 mph calculate uplift forces
- For forces > 100 plf :
  - Install hurricane clips or similar connectors, or
  - Designed per RDP

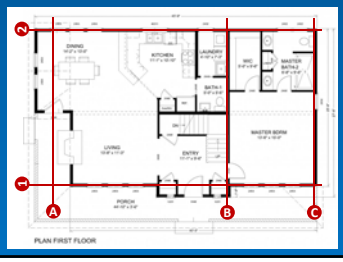


R602.3.5 11



Braced Wall Line

DEFINITION: An imaginary straight line though the building which represents the centerline of lateral resistance provided by parallel BWPs.



R602.10.1 13

Six Rules for BWLs

1. **STRAIGHT LINES:**
   BWLs cannot curve, bend or jog
2. **EACH PLAN DIRECTION:**
   BWLs go up/down and left/right
3. **ALL FLOORS:**
   Each floor level requires BWLs
4. **PERMITTED TO FLOAT:**
   BWLs are not required to be on actual walls
5. **DEFINED ENDS:**
   BWLs have a starting and ending point
6. **MAXIMUM SPACING:**
   Spacing between parallel BWLs is limited

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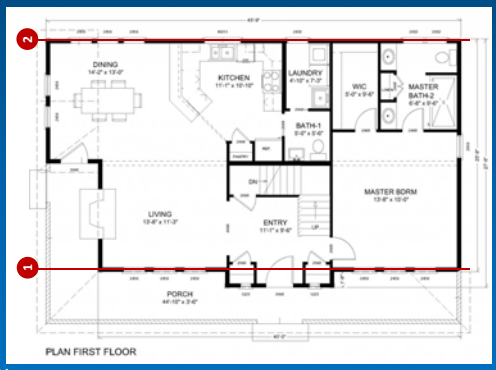
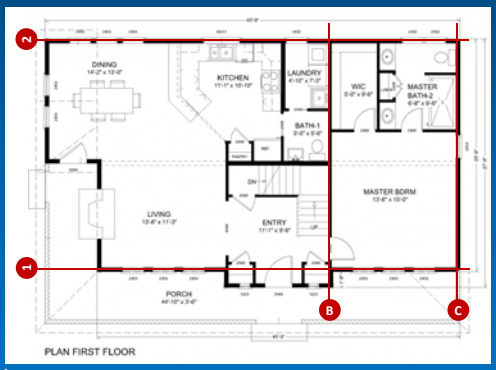
Rule 1: Straight line



R602.10.1 15

Rule 2: Each Plan Direction

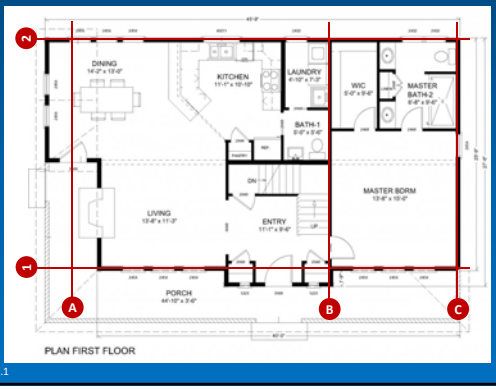


R602.10.1 16

Rule 3: All Floors

R602.10.1 17

Rule 4: Permitted to Float

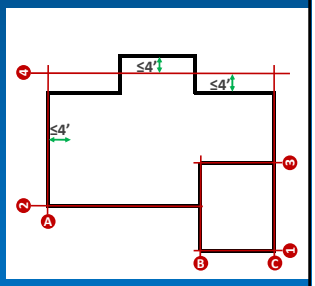


R602.10.1 18

Rule 4: Permitted to Float

BWLs are not required to align with actual walls such that…

- BWLs can "float" between walls
- Parallel BWPs within 4' apply to BWL
- BWLs can be offset from entire wall

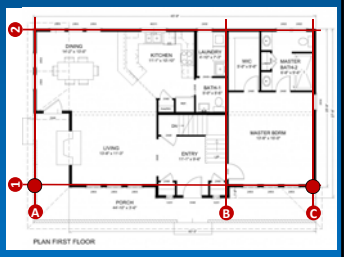


R602.10.1.2 19

Rule 5: Defined Ends

DEFINITION: The end of a BWL is defined as the…

- Intersection with another BWL



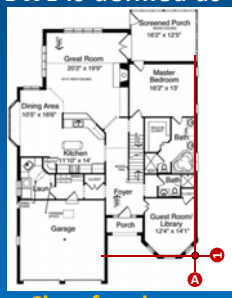
Intersection

R602.10.1.1 20

Rule 5: Defined Ends

DEFINITION: The end of a BWL is defined as the…

- Intersection with another BWL
- Projected intersection at chamfered corner



Chamfered corner (8' max.)

R602.10.1.1 21

Rule 5: Defined Ends

DEFINITION: The end of a BWL is defined as the…

- Intersection with another BWL
- Projected intersection at chamfered corner
- Intersecting basement walls

Walkout basement

R602.10.1.1 22

Rule 5: Defined Ends

DEFINITION: The end of a BWL is defined as the…

- Intersection with another BWL
- Projected intersection at chamfered corner
- Intersecting basement walls
- Farthest exterior wall

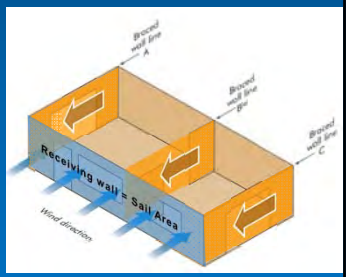
Discontinuous floor

R602.10.1.1 23

Rule 6: Maximum Spacing

DEFINITION: The average distance between parallel BWLs.

- Sail area governs BWL spacing
- Parallel BWLs resist load



R602.10.1.3 24

Rule 6: Maximum Spacing

TABLE R602.10.1.3
BRACED WALL LINE SPACING

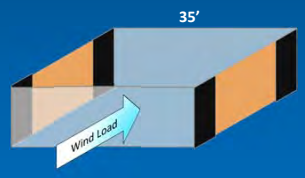
APPLICATION	CONDITION	BUILDING TYPE	BRACED WALL LINE SPACING CRITERIA	
			Maximum Spacing	Exception to Maximum Spacing
Wind bracing	85 mph to < 110 mph	Detached, townhouse	60 feet	None
Seismic bracing	SDC A – C	Detached	Use wind bracing	
	SDC A – B	Townhouse	Use wind bracing	
	SDC C	Townhouse	35 feet	Up to 50 feet when length of required bracing per Table R602.10.3(3) is adjusted in accordance with Table R602.10.3(4).
	SDC D_0, D_1, D_2	Detached, town-houses, one- and two-story only	25 feet	Up to 35 feet to allow for a single room not to exceed 900 square feet. Spacing of all other braced wall lines shall not exceed 25 feet.
	SDC D_0, D_1, D_2	Detached, townhouse	25 feet	Up to 35 feet when length of required bracing per Table R602.10.3(3) is adjusted in accordance with Table R602.10.3(4).

- Local wind zones: 90 mph, 100 mph
- Maximum spacing between parallel BWLs 60’
- SDC A and B: design for wind

R602.10.1.3 25

Braced Wall Line Spacing

Larger sail areas require more bracing.



R602.10.1.3 26

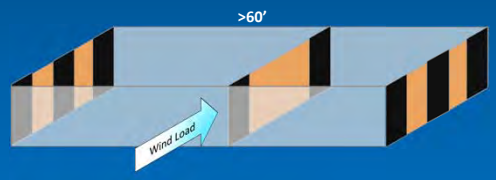
Braced Wall Line Spacing

Larger sail areas require more bracing.

R602.10.1.3 27

Braced Wall Line Spacing

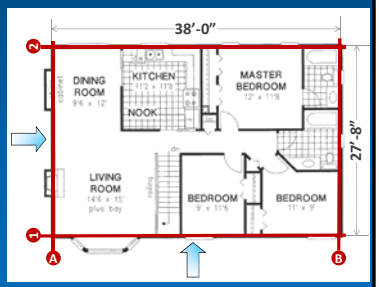
Larger sail areas require more bracing.



R602.10.1.3 28

Braced Wall Line Spacing

- BWLs share load
- Example:
  - A & B share load in N/S direction
  - 1 & 2 share load in E/W direction



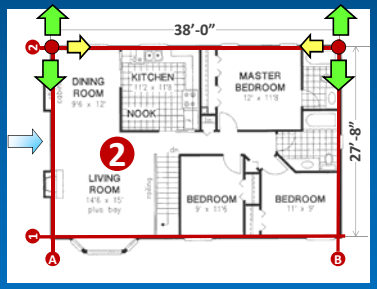
R602.10.1.3 29

How to Determine BWL Spacing

- Use average spacing if adjacent BWLS have differing dimensions
  - Check the spacing from both sides at each end
  - Average the values measured

Tab e R602.10.3(1), Footnote C 30

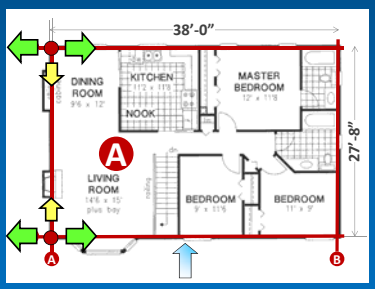
BWL Spacing: "Where's my help?"



BWL spacing = 27.67'

R602.10.1.3 31

BWL Spacing: "Where's my help?"



BWL spacing = 38'

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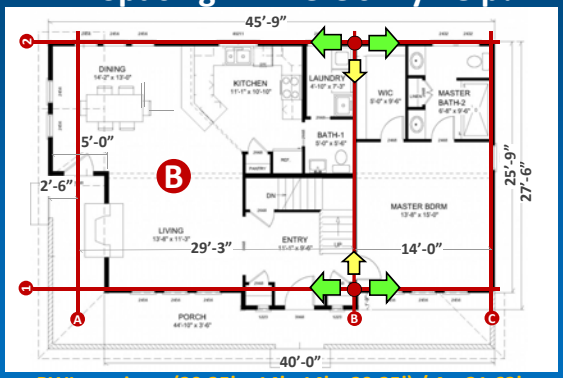
BWL Spacing: "Where's my help?"

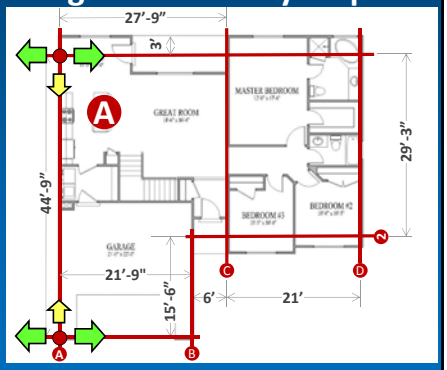


BWL spacing = (29.25' + 14'+ 14' + 29.25') / 4 = 21.63'

33

BWL Spacing: "Where's my help?"

- Side a
  NA
- Side b
  21.75
- Side c
  27.75
- Side d
  NA

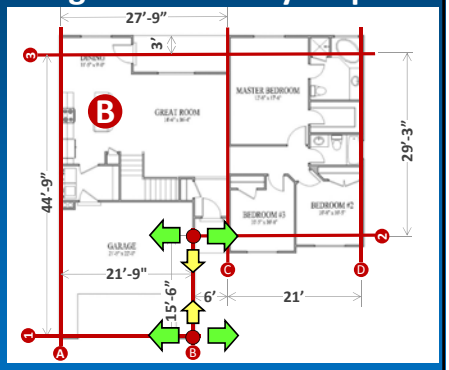


BWL spacing = (21.75 + 27.75) / 2 = 24.75'

34

BWL Spacing: "Where's my help?"

- Side a
  21.75
- Side b
  NA
- Side c
  6
- Side d
  21.75

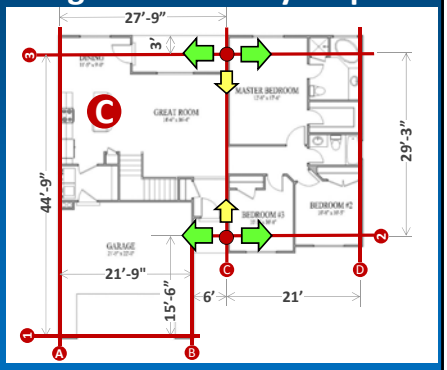


BWL spacing = (21.75 + 6 + 21.75) / 3 = 16.5'

35

BWL Spacing: "Where's my help?"

- Side a
  6
- Side b
  21
- Side c
  21
- Side d
  27.75

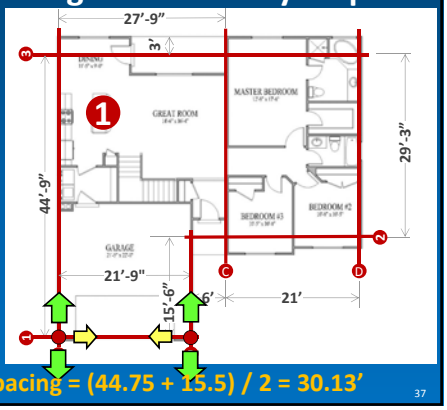


BWL spacing = (6 + 21 + 21 + 27.75) / 4 = 18.94'

36

BWL Spacing: "Where's my help?"

- Side a
  44.75
- Side b
  NA
- Side c
  NA
- Side d
  15.5

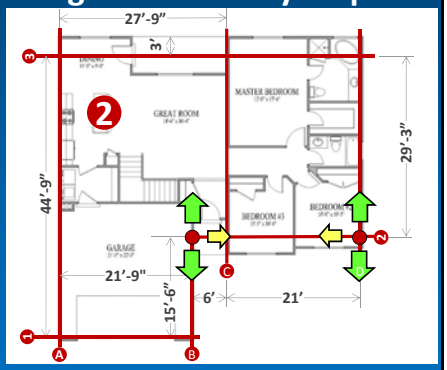


BWL spacing = (44.75 + 15.5) / 2 = 30.13'

37

BWL Spacing: "Where's my help?"

- Side a
  29.25
- Side b
  15.5
- Side c
  NA
- Side d
  29.25

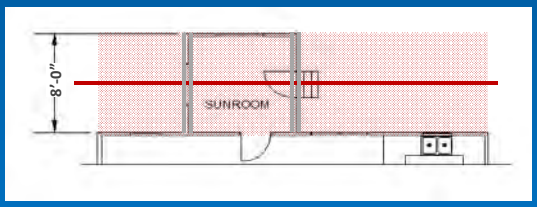


BWL spacing = (29.25 + 15.5 + 29.25) / 3 = 24.67'

38

Braced Wall Lines

- **TIP: Consider a BWL to be the centerline of an 8' wide "braced wall band" where any perpendicular walls located completely within the band are not required to be braced.**



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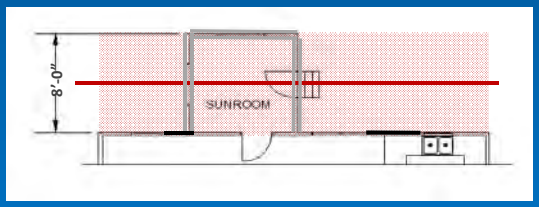
Braced Wall Lines

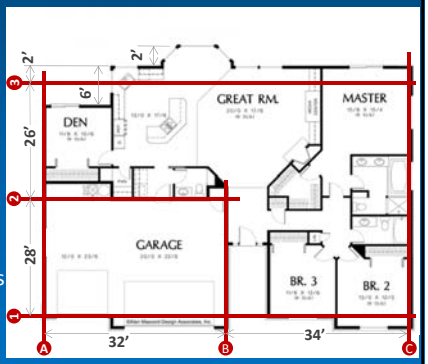
- **TIP: If placing BWPs strategically, all walls in a sunroom can be glass.**



40

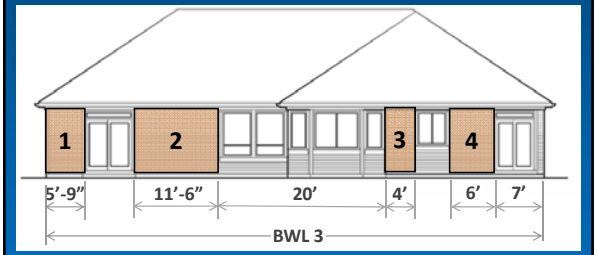
Example – BWL 3

- 100 mph
- Farm house
- 15' eave to ridge
- 10' walls
- Finished interior
- CS WSP
- All joints blocked
- No hold downs
- Standard fastener spacing



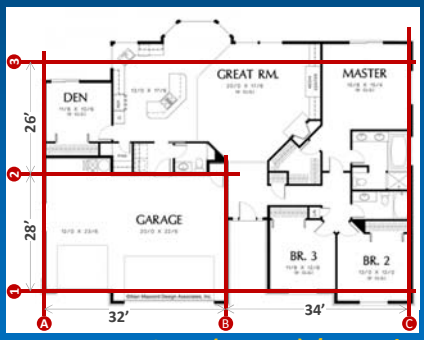
41

Example – BWL 3



42

Example – Average BWL Spacing?



BWL spacing = (26 + 54) / 2 = 40'

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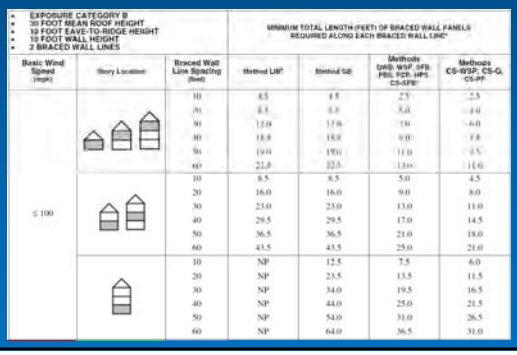
Spreadsheet – Average BWL Spacing

WIND SPEED (MPH)	100
BWL DESIGNATION	3
NUMBER OF FLOORS ABOVE BWL	0
BWP METHOD	CS-WSP
AVERAGE BWL SPACING (ft)	40
TABULAR REQUIREMENT (ft)	

44

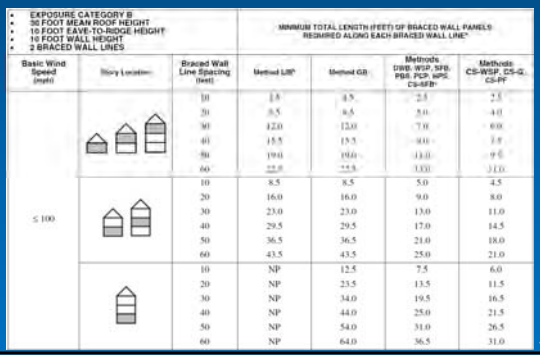
Tabular Requirement

- Use Table R602.10.3(1)



45

Example – BWL 3



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Spreadsheet – Tabular Requirement

WIND SPEED (MPH)	100
BWL DESIGNATION	3
NUMBER OF FLOORS ABOVE BWL	0
BWP METHOD	CS-WSP
AVERAGE BWL SPACING (ft)	30
TABULAR REQUIREMENT (ft)	7.5

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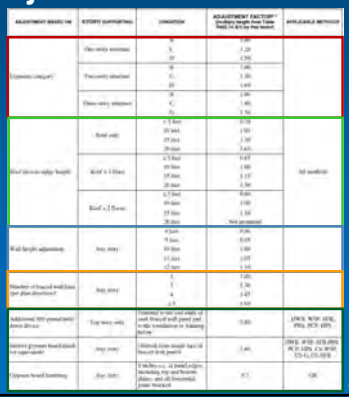
Adjustments

- Use Table R602.10.3(2)
- Choose adjustments for:
  - Wind exposure
  - Roof height
  - Wall height
  - No. of BWLs
  - More



R602.10.3

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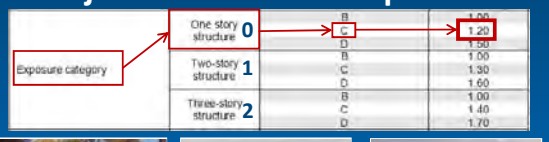
Adjustments - Wind Exposure



Category B
Urban suburban
Wooded

Category C
Open terrain
Grasslands, flat plains
Wind flows over open water for 1,500 feet

Category D
Unobstructed, flat
Wind flows over open water for 1 mile

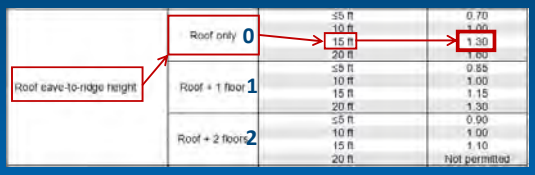
Spreadsheet - Adjustments

ADJUSTMENT	EXPOSURE	C	1.20
	EAVE-TO-RIDGE HT (ft)		
	MAXIMUM WALL HEIGHT (ft)		
	NUMBER OF BWLs		
	OMIT INTERIOR FINISH		
	ADD PAIR 800# HOLD DOWNS		
	HORIZONTAL JOINTS BLOCKED		
	REDUCED FASTENER SPACING		
	REQUIRED BWP LENGTH (ft)		

Adjustments - Wind Exposure

TIP: Houses located on a lake or reservoir with open water for 1,500 feet or more, requires Exposure Category C.

Adjustments – Eave-to-Ridge Height



Flat, very low slope

Low slope, up to 10 feet

Steep slope

Example – BWL 3

ADJUSTMENT	EXPOSURE	C	1.20
	EAVE-TO-RIDGE HT (ft)	15	1.30
	MAXIMUM WALL HEIGHT (ft)		
	NUMBER OF BWLs		
	OMIT INTERIOR FINISH		
	ADD PAIR 800# HOLD DOWNS		
	HORIZONTAL JOINTS BLOCKED		
	REDUCED FASTENER SPACING		
	REQUIRED BWP LENGTH (ft)		

Adjustments – Wall Height

Shorter walls

10-foot walls

Tall walls

Example – BWL 3

ADJUSTMENT			
	EXPOSURE	C	1.20
	EAVE-TO-RIDGE HT (ft)	15	1.30
	MAXIMUM WALL HEIGHT (ft)	10	1.00
	NUMBER OF BWLs		
	OMIT INTERIOR FINISH		
	ADD PAIR 800# HOLD DOWNS		
	HORIZONTAL JOINTS BLOCKED		
	REDUCED FASTENER SPACING		
REQUIRED BWP LENGTH (ft)			

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Adjustments

TIP: When a BWL has more than one wall height, eave to ridge height, etc., adjust to the highest value for the required length of bracing.

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Adjustments – Number of BWLs

Number of braced wall lines (per plan direction)[c]	Any story	2	1.00
		3	1.30
		4	1.45
		≥5	1.60

- Number of BWLs in <u>one</u> plan direction
- Value adjusts for larger building with more BWLs.

2 BWLs 1.00 **3 BWLs** 1.30 **4 BWLs** 1.45 **≥5 BWLs** 1.60

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Example – BWL 3

ADJUSTMENT			
	EXPOSURE	C	1.20
	EAVE-TO-RIDGE HT (ft)	15	1.30
	MAXIMUM WALL HEIGHT (ft)	10	1.00
	NUMBER OF BWLs	3	1.30
	OMIT INTERIOR FINISH		
	ADD PAIR 800# HOLD DOWNS		
	HORIZONTAL JOINTS BLOCKED		
	REDUCED FASTENER SPACING		
REQUIRED BWP LENGTH (ft)			

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Adjustments – Number of BWLs

TIP: When placing BWLs, consider the following:

- **Place as few BWLs as possible**
- **BWLs that penetrate the entire house are the most efficient**
- **Placing BWLs can be an iterative process**

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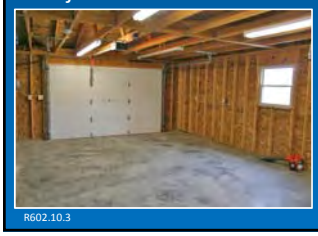
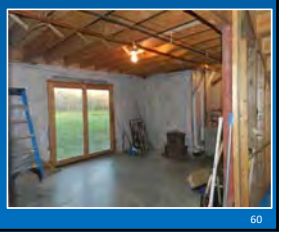
Adjustments – No Interior Finish

Interior gypsum board finish (or equivalent)	Any story	Omitted from inside face of braced wall panels	1.40	DWB, WSP, SFB, PBS, PCP, HPS, CS-WSP, CS-G, CS-SFB

- For unfinished areas
- Limited methods
- Adjustment factor 1.40





R602.10.3

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Example – BWL 3

ADJUSTMENT			
	EXPOSURE	C	1.20
	EAVE-TO-RIDGE HT (ft)	15	1.30
	MAXIMUM WALL HEIGHT (ft)	10	1.00
	NUMBER OF BWLs	3	1.30
	OMIT INTERIOR FINISH	No	1.00
	ADD PAIR 800# HOLD DOWNS		
	HORIZONTAL JOINTS BLOCKED		
	REDUCED FASTENER SPACING		
REQUIRED BWP LENGTH (ft)			

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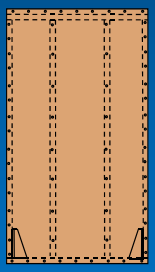
Adjustments – Hold-Down

Additional 800-pound hold-down device	Top story only	Fastened to the end studs of each braced wall panel and to the foundation or framing below	0.80	DWB, WSP, SFB, PBS, PCP, HPS

- Limited methods
- Top story only
- Add hold down
- Adjustment factor 0.8
- Not applicable to continuous sheathing



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Example – BWL 3

ADJUSTMENT			
	EXPOSURE	C	1.20
	EAVE-TO-RIDGE HT (ft)	15	1.30
	MAXIMUM WALL HEIGHT (ft)	10	1.00
	NUMBER OF BWLs	3	1.30
	OMIT INTERIOR FINISH	No	1.00
	ADD PAIR 800# HOLD DOWNS	No	1.00
	HORIZONTAL JOINTS BLOCKED		
	REDUCED FASTENER SPACING		
REQUIRED BWP LENGTH (ft)			

63

Adjustments – Omit Horiz. Blocking

Horizontal blocking	Any story	Omit blocking from horizontal joints	2.0	WSP, SFB, GB, PBS, HPS, CS-WSP, CS-SFB

R602.10.10

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Example – BWL 3

ADJUSTMENT			
	EXPOSURE	C	1.20
	EAVE-TO-RIDGE HT (ft)	15	1.30
	MAXIMUM WALL HEIGHT (ft)	10	1.00
	NUMBER OF BWLs	3	1.30
	OMIT INTERIOR FINISH	No	1.00
	ADD PAIR 800# HOLD DOWNS	No	1.00
	HORIZONTAL JOINTS BLOCKED	Yes	1.00
	REDUCED FASTENER SPACING		
REQUIRED BWP LENGTH (ft)			

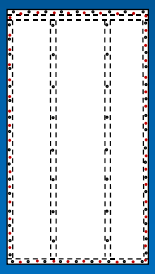
65

Adjustments – Fastener Spacing

Fastener spacing	Any story	4 in. o.c. at panel edges, including top and bottom plates, an all horizontal joints blocked	0.7	GB
			0.83	WSP, CS-WSP

- Limited methods
- Reduce edge spacing to 4” o.c.
- Adjustment factor:
  - 0.7 for GB
  - 0.83 for WSP, CS WSP when supporting floor(s) above*

*Virginia interpretat on only



R602.10.3

66

Example – BWL 3

ADJUSTMENT	EXPOSURE	C	1.30
	EAVE-TO-RIDGE HT (ft)	15	1.20
	MAXIMUM WALL HEIGHT (ft)	10	1.00
	NUMBER OF BWLs	3	1.30
	OMIT INTERIOR FINISH	No	1.00
	ADD PAIR 800# HOLD DOWNS	No	1.00
	HORIZONTAL JOINTS BLOCKED	Yes	1.00
	REDUCED FASTENER SPACING	No	1.00
REQUIRED BWP LENGTH (ft)			

67

Required Length of Bracing

- Multiply tabular requirement by each adjustment factor:

Required BWP Length = (tabular requirement) x (adjustment factor) x (adjustment factor) x (adjustment factor)…

Required BWL Length = 6' x 1.30 x 1.20 x 1.00 x 1.30 x 1.00 x 1.00 x 1.00 x 1.00 = 12.17'

R602.10.3

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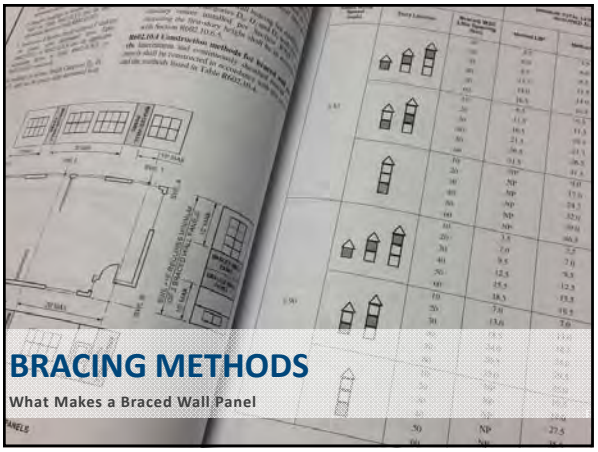
Example – BWL 3

TABULAR REQUIREMENT (ft)		7.5	
ADJUSTMENT	EXPOSURE	C	1.20
	EAVE-TO-RIDGE HT (ft)	15	1.30
	MAXIMUM WALL HEIGHT (ft)	10	1.00
	NUMBER OF BWLs	3	1.30
	OMIT INTERIOR FINISH	No	1.00
	ADD PAIR 800# HOLD DOWNS	No	1.00
	HORIZONTAL JOINTS BLOCKED	Yes	1.00
	REDUCED FASTENER SPACING	No	1.00
REQUIRED BWP LENGTH (ft)		15.21	

69

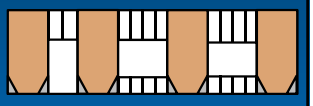


BRACING METHODS

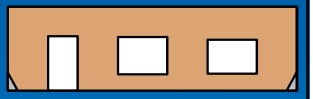
What Makes a Braced Wall Panel

Engineered Bracing Types

- Segmented shear walls
  - Separate shear walls
  - Hold down at each end



- Perforated shear walls
  - One large shear wall
  - Hold down at each end
  - Openings permitted



R602.10.4

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Prescriptive Bracing Types

- Intermittent bracing
  - Based on segmented
  - Sheath at BWP locations only
- Continuous sheathing
  - Based on perforated
  - Sheath all exposed areas

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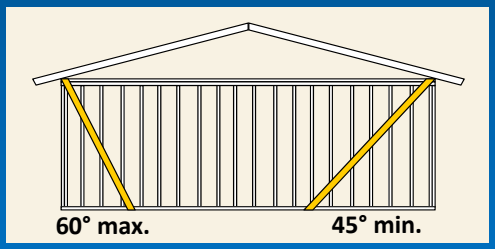
Intermittent Bracing Methods

- LIB: let in bracing
- WSP: wood structural panels
- SFB: structural fiberboard
- GB: gypsum board
- PFH: portal frame with hold downs
- PFG: portal frame at garages

R602.10.4 73

LIB: Let-in Bracing

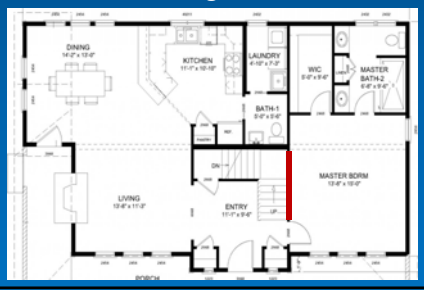
- 1x4 wood or metal strap
- 45° to 60° angle
- 2 8d nails per stud



R602.10.4 74

LIB: Let-in Bracing

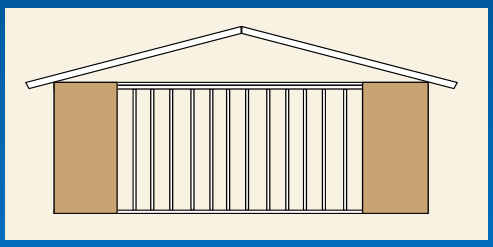
TIP: Place LIB bracing in an interior wall that does not have full height gypsum board is an easy way to provide "hidden" bracing.



75

WSP: Wood Structural Panels

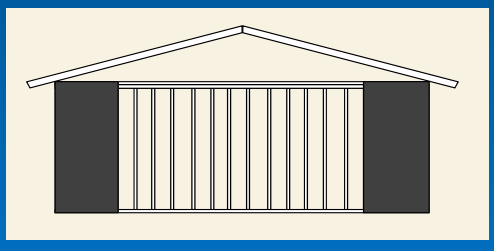
- $^{7}/_{16}$" thick OSB or plywood
- Fasteners: 6d nails @ 6" o.c. edges, 12" o.c. field
- 48" minimum length



R602.10.4 76

SFB: Structural Fiberboard

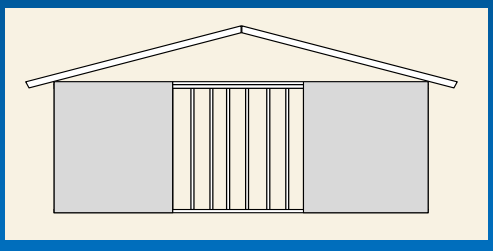
- $^{1}/_{2}$" thick @ 16" o.c. stud spacing only
- Fasteners: 8d nails @ 3" o.c. edges, 6" o.c. field
- 48" minimum length



R602.10.4 77

GB: Gypsum Board

- $^{1}/_{2}$" thick
- Fasteners: nails or screws @ 7" o.c. edges and field
- 48" minimum length



R602.10.4 78

GB: Gypsum Board

TIP: The fire separation between the garage and living space is an efficient way to get added bracing.

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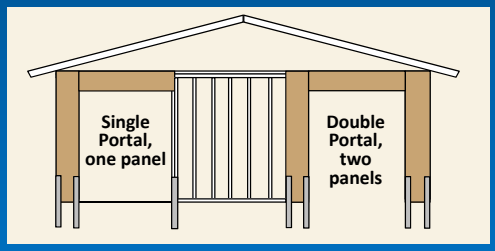
PFH: Portal Frame with Hold-down

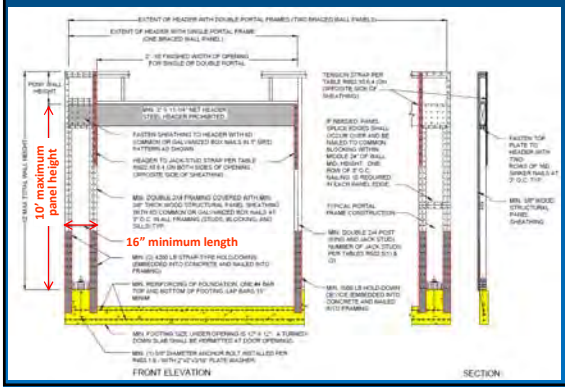
- $^{7}/_{16}$" thick OSB or plywood
- Cast in place hold downs required



R602.10.6.2

80

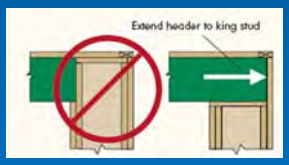
PFH: Portal Frame with Hold-down

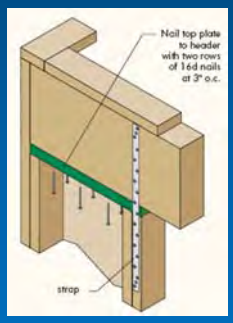


81

TIP: Portal Frames

- Tested assembly
- Cannot be engineered
- Field deviations prohibited





R602.10.6.2

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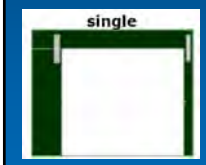
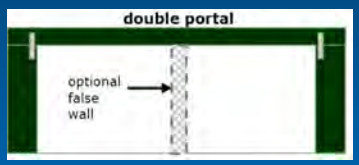
TIP: Portal Frames at Garages



One Opening

83

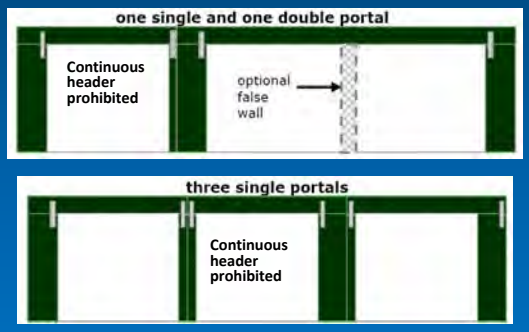
TIP: Portal Frames at Garages



Two Openings

84

TIP: Portal Frames at Garages

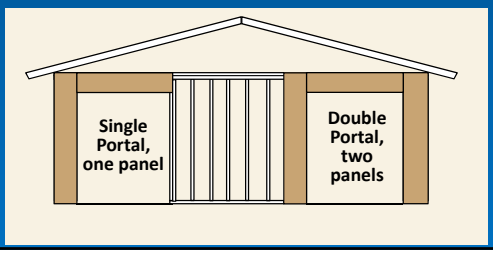


Three Openings

85

PFG: Portal Frame at Garage Opening

- $^{7}/_{16}$" thick OSB or plywood
- At garage only
- No hold downs



R602.10.6.3

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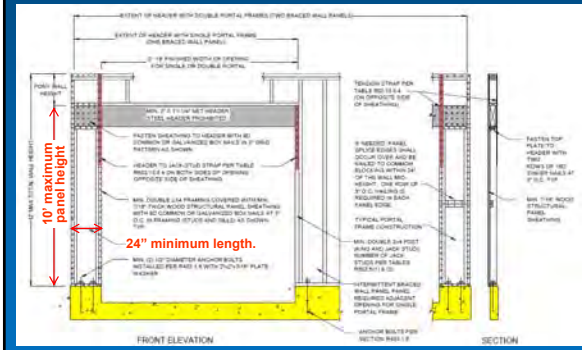
PFG: Portal Frame at Garage Opening



87

Equivalent Products

- Equivalent to BWP
- Per ICC ES Evaluation Report
- Simpson Strong Tie:
  - Steel Strong Wall
  - Wood Strong Wall
  - SB Shearwall
- Hardy HFX Series Panels

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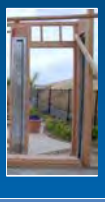
Equivalent Products

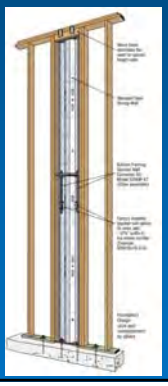



Product	Manufacturer	Minimum Available Width	ICC ES ESR Number
Steel Strong Walls	Simpson Strong-Tie	12"	1679
Wood Strong Walls	Simpson Strong-Tie	16"	1267
SB Shearwalls	Simpson Strong-Tie	12"	2652
HFX Panels	Hardy Frame	9" (nailer not included)	2089

89

Two-Story Walls

TIP: Some approved equivalent products can be stacked to brace two story, balloon framed walls.



90

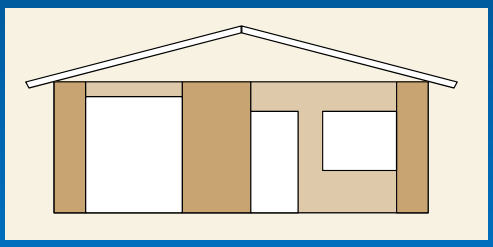
Continuous Sheathing Bracing Methods

- CS WSP: wood structural panels
- CS SFB: structural fiberboard
- CS G: wood structural panels adjacent garage openings
- CS PF: continuous sheathing portal frame

R602.10.4 91

CS-WSP: Wood Structural Panels

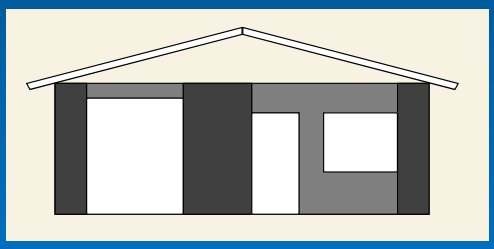
- $^{7}/_{16}$" thick OSB or plywood
- Fasteners: 8d nails @ 6" o.c. edges, 12" o.c. field
- 24" minimum length



R602.10.4 92

CS-SFB: Structural Fiberboard

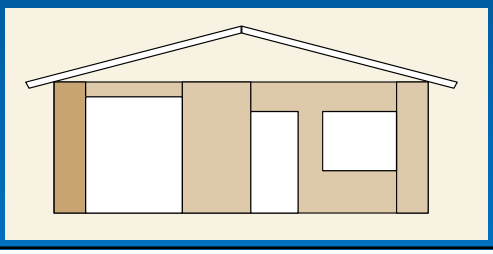
- $^{1}/_{2}$" thick structural fiberboard
- Fasteners: 8d nails @ 3" o.c. edges, 6" o.c. field
- 24" minimum length



R602.10.4 93

CS-G: Wood Structural Panels at Garage

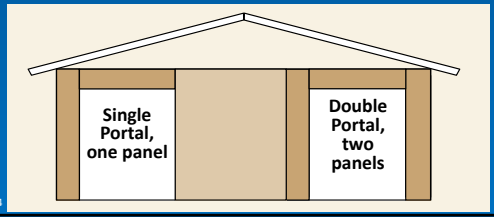
- $^{7}/_{16}$" thick OSB or plywood
- Fasteners: 6d nails @ 6" o.c. edges, 12" o.c. field
- 24" minimum length; one opening only
- No floors above



R602.10.4 94

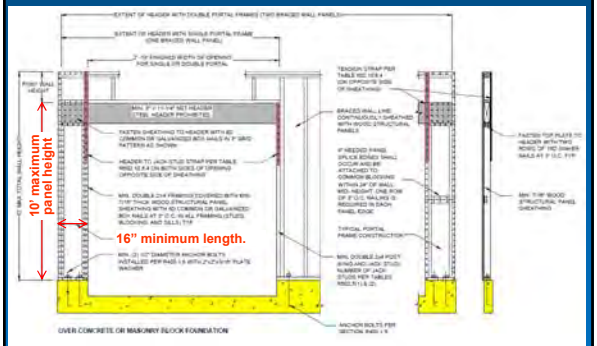
CS-PF: Continuous Sheathing Portal Frame

- $^{7}/_{16}$" thick OSB or plywood
- No hold downs
- Can be constructed on wood floor
- 4 panels maximum in one BWL



R602.10.6.3.4 95

CS-PF: Continuous Sheathing Portal Frame



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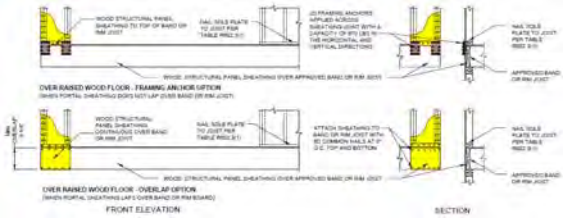
CS-PF: Continuous Sheathing Portal Frame



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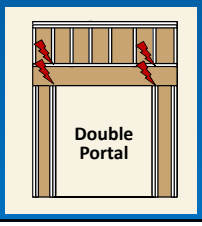
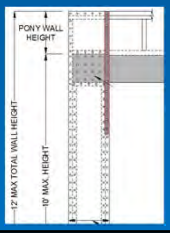
Pony Walls on Portal Frames

- Creates hinges
- Strap resists hinge forces
- Table R602.10.6.4 determines strap capacity





R602.10.6.4

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Pony Walls on Portal Frames

MINIMUM WALL STUD FRAMING NOMINAL SIZE AND GRADE	MAXIMUM PONY WALL HEIGHT (feet)	MAXIMUM TOTAL WALL HEIGHT (feet)	MAXIMUM OPENING WIDTH (feet)	TENSION STRAP CAPACITY REQUIRED (pounds)[a, b]					
				Basic Wind Speed (mph)					
				85	90	100	85	90	100
				Exposure B			Exposure C		
2 × 4 No. 2 Grade	4	12	9	1,000	1,000	1,000	1,000	1,000	1,000
			16	1,000	1,000	1,750	1,800	2,325	3,500
			18	1,000	1,000	2,100	2,175	2,725	DR
			9	1,000	1,000	1,025	1,075	1,550	2,500
			16	1,525	2,025	3,125	3,200	3,900	DR
			18	1,575	2,400	3,575	3,700	DR	DR
			9	1,000	1,700	2,075	2,125	2,750	4,000
			16	2,600	3,200	DR	DR	DR	DR
			18	3,175	3,500	DR	DR	DR	DR
			9	1,000	2,350	3,500	3,550	DR	DR
			16	4,175	DR	DR	DR	DR	DR

Tab e R602.10.6.4

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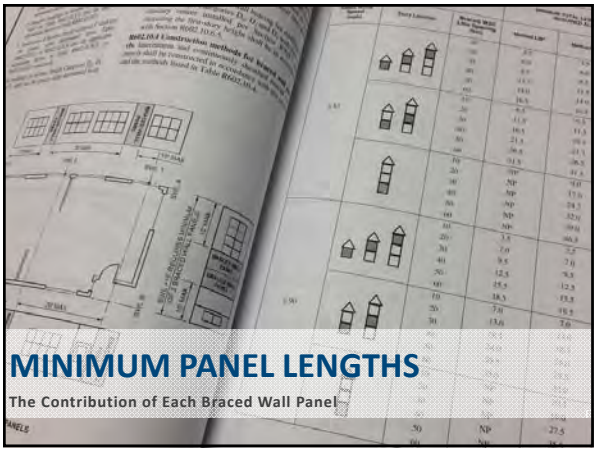
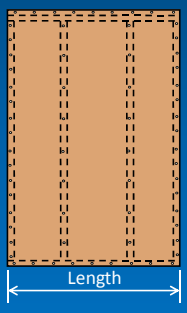


MINIMUM PANEL LENGTHS

The Contribution of Each Braced Wall Panel

BWP Minimum Length

DEFINITION: The dimension required for a length of sheathed wall to be considered a braced wall panel which contributes to the MWFRS.



R602.10.5

101

Minimum Length of Intermittent BWPs

METHOD (See Table R602.10.4)	MINIMUM LENGTH[a] (inches)				
	Wall Height				
	8 feet	9 feet	10 feet	11 feet	12 feet
DWB, WSP, SFB, PBS, PCP, HPS, BV-WSP	48	48	48	53	58
GB	48	48	48	53	58
LIB (based on 60° angle)	55	62	69	NP	NP

Tab e R602.10.5

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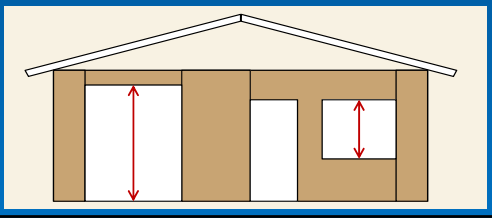
Minimum Length of Narrow Methods

METHOD (See Table R602.10.4)		MINIMUM LENGTH* (inches) Wall Height				
		8 feet	9 feet	10 feet	11 feet	12 feet
PFH	Supporting roof only	16	16	16	18	20
	Supporting one story and roof	24	24	24	27	29
PFG		24	27	30	33	36
CS-G		24	27	30	33	36
CS-PF		16	18	20	22	24

Tab e R602.10.5

Minimum Length of CS-WSP, CS-SFB

- Based on height of adjacent opening(s)
- Where opening on both sides, use taller



Minimum Length of Continuous Sheathing

Adjacent clear opening height (inches)	8 feet	9 feet	10 feet	11 feet	12 feet
≤ 64	24	27	30	33	36
68	26	27	30	33	36
72	27	27	30	33	36
76	30	29	30	33	36
80	32	30	30	33	36
84	35	32	32	33	36
88	38	35	33	33	36
92	43	37	35	35	36
96	48	41	38	36	36
100	—	44	40	38	38
104	—	49	43	40	39
108	—	54	46	43	41
112	—	—	50	45	43
116	—	—	55	48	45
120	—	—	60	52	48
124	—	—	—	56	51
128	—	—	—	61	54
132	—	—	—	66	58
136	—	—	—	—	62
140	—	—	—	—	66
144	—	—	—	—	72

27" minimum

Tab e R602.10.5

Minimum Length of Continuous Sheathing

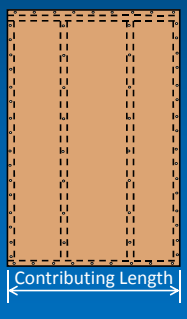
Adjacent clear opening height (inches)	8 feet	9 feet	10 feet	11 feet	12 feet
≤ 64	24	27	30	33	36
68	26	27	30	33	36
72	27	27	30	33	36
76	30	29	30	33	36
80	32	30	30	33	36
84	35	32	32	33	36
88	38	35	33	33	36
92	43	37	35	35	36
96	48	41	38	36	36
100	—	44	40	38	38
104	—	49	43	40	39
108	—	54	46	43	41
112	—	—	50	45	43
116	—	—	55	48	45
120	—	—	60	52	48
124	—	—	—	56	51
128	—	—	—	61	54
132	—	—	—	66	58
136	—	—	—	—	62
140	—	—	—	—	66
144	—	—	—	—	72

30" minimum

Tab e R602.10.5

BWP Contributing Length

DEFINITION: The dimension a BWP contributes towards a BWL's required length of bracing.



R602.10.5.1

BWP Contributing Length

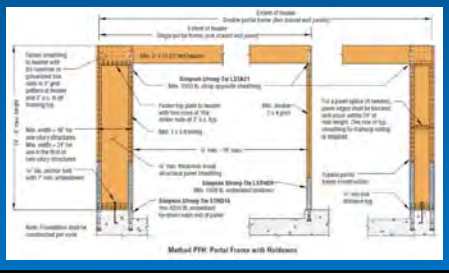
METHOD (See Table R602.10.4)		MINIMUM LENGTH* (inches) Wall Height					CONTRIBUTING LENGTH (inches)
		8 feet	9 feet	10 feet	11 feet	12 feet	
DWB, WSP, SFB, PBS, PCP, HPS, BV-WSP		48	48	48	53	58	Actual
GB		96	96	96	96	96	Double sided = Actual Single sided = 0.5 × Actual
LIB		55	62	69	NP	NP	Actual
ABW	SDC A, B and C, 3-second gust speed < 110 mph	28	32	34	38	42	48
	SDC D_0, D_1 and D_2, 3-second gust speed < 110 mph	32	32	34	NP	NP	
PFH	Supporting roof only	16	16	16	18	20	48
	Supporting one story and roof	24	24	24	27	29	48
PFG		24	27	30	33	36	1.5 × Actual
CS-G		24	27	30	33	36	Actual
CS-PF		16	18	20	22	24	1.5 × Actual

*Virginia 2012, IRC 2015

Tab e R602.10.5

BWP Contributing Length

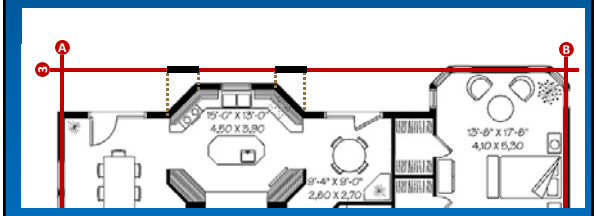
TIP: Narrow methods PFH, PFG, CS PF and equivalent products are a way to provide more bracing than the actual wall length.



109

BWP Projected Length

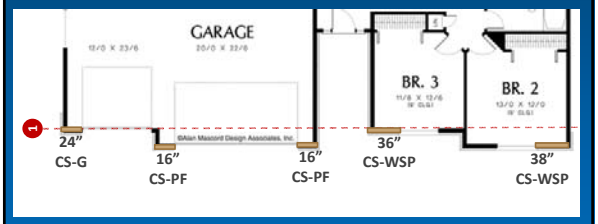
- Angled BWPs contribute projected length only
- Can project to one BWL only



R602.10.3

110

BWP Contributing Length

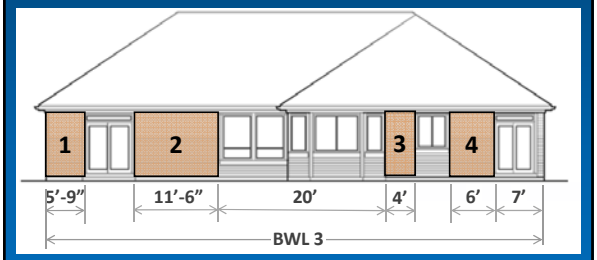


The cumulative length of all BWPs in BWL 1 =
24 + (16 x 1.5) + (16 x 1.5) + 36 + 38 = 146" = 12'-2"

R602.10.5.1

111

Example – BWL 3



112

Example – BWL 3

ACTUAL BWP	BWP	METHOD	LENGTH
CONTRIBUTING LENGTH (feet) WSP, SFB = actual GB (ss) = 0.5 x actual GB (ds) = actual CS-PF = 1.5 x actual PFG = 1.5 x actual PFH, ABW = 4 feet	1	CS-WSP	5.75
	2	CS-WSP	11.5
	3	CS-WSP	4
	4	CS-WSP	6
	5		
	6		
	7		
ACTUAL BWP LENGTH (ft)			27.25

113

Rules for BWPs on a BWL

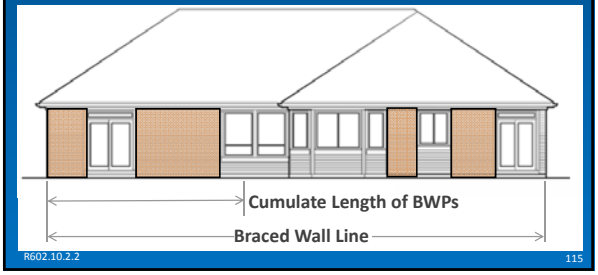
1. **LENGTH:**
   Total contributing length of BWPs must exceed Required BWP Length
2. **SPACING:**
   BWPs cannot exceed a maximum spacing
3. **QUANTITY:**
   BWLs require a minimum number of BWPs
4. **LOCATION:**
   BWPs must be located at each end
5. **END CONDITIONS:**
   Ends of BWLs with continuous sheathing must be stiffened

R602.10.2, R602.10.3

114

Length

- Cumulative length of all BWPs' contributing length
- Cumulative length ≥ Required BWP Length



R602.10.2.2

115

Example – BWL 3

REQUIRED BWP LENGTH (ft)			12.17
ACTUAL BWP	CONTRIBUTING LENGTH (feet) WSP, SFB = actual GB (ss) = 0.5 x actual GB (ds) = actual CS-PF = 1.5 x actual PFG = 1.5 x actual PFH, ABW = 4 feet	BWP	METHOD / LENGTH
		1	CS-WSP 5.75
		2	CS-WSP 11.5
		3	CS-WSP 4
		4	CS-WSP 6
		5	
		6	
		7	
ACTUAL BWP LENGTH (ft)			27.25

116

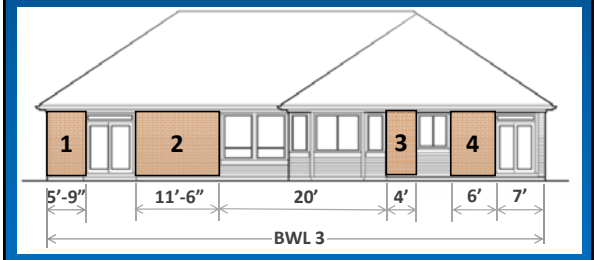
Example – BWL 3

ACTUAL ≥ REQUIRED?	Pass	
BWPs ≤ 20' APART?		
≥ 2 PANELS IN BWL?		
BWP BEGINS ≤ 10' FROM ENDS?		
CONTINUOUS SHEATHING END CONDITIONS	END 1	END 2
BWL COMPLIANCE		

117

Spacing

- BWPs cannot exceed a distance of 20' edge to edge.



R602.10.2.2

118

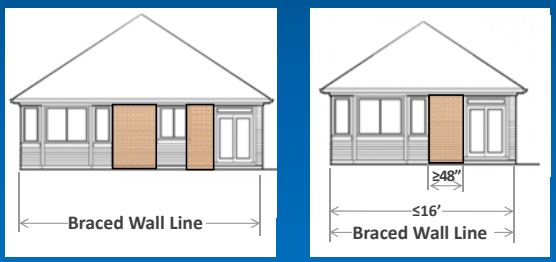
Example – BWL 3

ACTUAL ≥ REQUIRED?	Pass	
BWPs ≤ 20' APART?	Yes	
≥ 2 PANELS IN BWL?		
BWP BEGINS ≤ 10' FROM ENDS?		
CONTINUOUS SHEATHING END CONDITIONS	END 1	END 2
BWL COMPLIANCE		

119

Number

- BWLs must have a minimum of two BWPs
- Exception: BWLs ≤ 16' can have one 48" BWP



R602.10.2.3

120

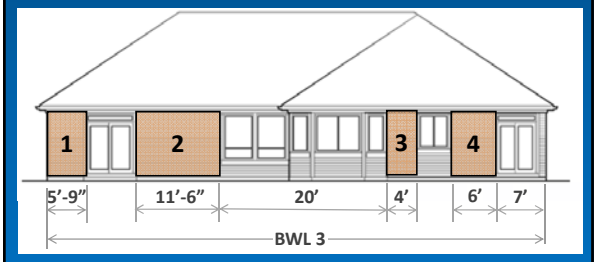
Example – BWL 3

ACTUAL ≥ REQUIRED?	Pass	
BWPs ≤ 20' APART?	Yes	
≥ 2 PANELS IN BWL?	Yes	
BWP BEGINS ≤ 10' FROM ENDS?		
CONTINUOUS SHEATHING END CONDITIONS	END 1	END 2
BWL COMPLIANCE		

121

Location

- Located at BWL end , or
- Begins within 10' of BWL end



R602.10.2.2

122

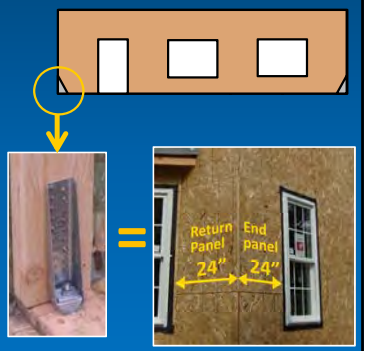
Example – BWL 3

ACTUAL ≥ REQUIRED?	Pass	
BWPs ≤ 20' APART?	Yes	
≥ 2 PANELS IN BWL?	Yes	
BWP BEGINS ≤ 10' FROM ENDS?	Yes	
CONTINUOUS SHEATHING END CONDITIONS	END 1	END 2
BWL COMPLIANCE		

123

End Conditions

- Perforated shear walls: hold downs at each end
- Continuous sheathing: 24" panels each side of corner

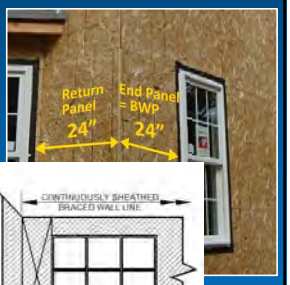


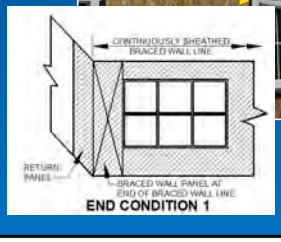
R602.10.7

124

End Conditions

- End panel BWP since…
  - ≤ 64" opening
  - 8' tall wall
  - BWP 24" panel length
- Return panel
- End Condition 1



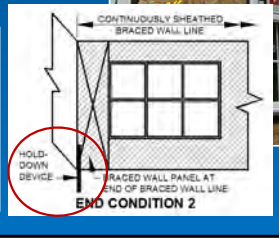


R602.10.7

125

End Conditions

- End panel BWP
- No return panel
- End Condition 2
- Add 800 lbs. hold down device

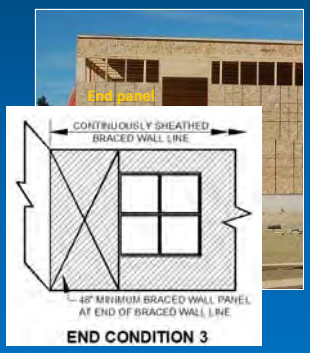


R602.10.7

126

End Conditions

- 48” sheathing at end also equivalent to hold down device
- End panel BWP
- No return panel or hold down
- End Condition 3

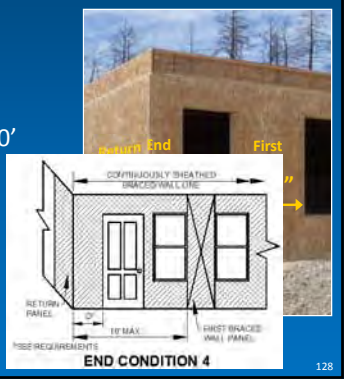


R602.10.7

127

End Conditions

- End panel ≠ BWP
- End panel 24”
- Return panel
- First BWP begins ≤ 10’ from end
- End Condition 4

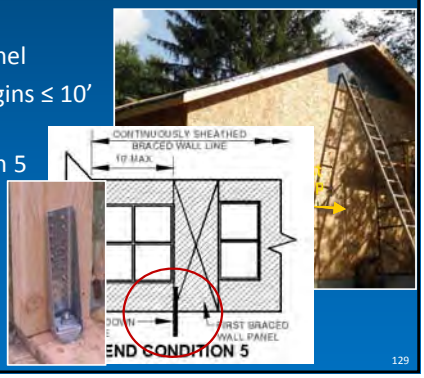


R602.10.7

128

End Conditions

- No end panel
- No return panel
- First BWP begins ≤ 10’ from end
- End Condition 5
- Add 800 lbs. hold down device

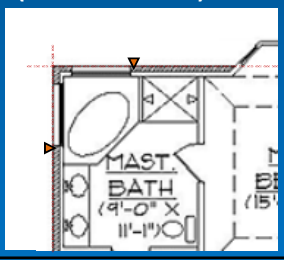


R602.10.7

129

End Conditions

TIP: Where 2 BWLs with continuous sheathing meet at a corner and one side requires a hold down, the opposite side will usually require a hold down or 48” end panel (End Condition 3).



130

Example – BWL 3

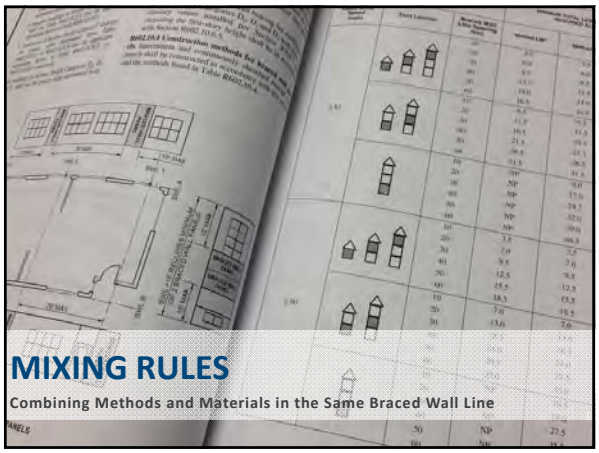
ACTUAL ≥ REQUIRED?	Pass	
BWPs ≤ 20' APART?	Yes	
≥ 2 PANELS IN BWL?	Yes	
BWP BEGINS ≤ 10' FROM ENDS?	Yes	
CONTINUOUS SHEATHING END CONDITIONS	END 1	END 2
	1	1
BWL COMPLIANCE		

131

Example – BWL 3

ACTUAL ≥ REQUIRED?	Pass	
BWPs ≤ 20' APART?	Yes	
≥ 2 PANELS IN BWL?	Yes	
BWP BEGINS ≤ 10' FROM ENDS?	Yes	
CONTINUOUS SHEATHING END CONDITIONS	END 1	END 2
	1	1
BWL COMPLIANCE	Pass	

132



MIXING RULES

Combining Methods and Materials in the Same Braced Wall Line

Mixing Methods

- Mixing methods from BWL to BWL is permitted

BWL must include return panels, if applicable

R602.10.4

134

Mixing Methods

- Mixing intermittent methods along a BWL is permitted

BWL must be designed for weakest method

R602.10.4

135

Mixing Methods

- Any narrow method can mix with CS WSP
- No other methods can mix with CS SFB

NO mixing in CS-SFB

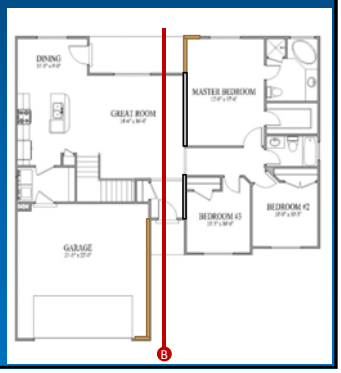
ABW, PFH, PFG, CS-PF permitted in CS-WSP

R602.10.4

136

Mixing Methods

- Mixing intermittent and continuous permitted
  - CS on exterior
  - Intermittent on interior
  - Design for weakest methods
- End conditions required



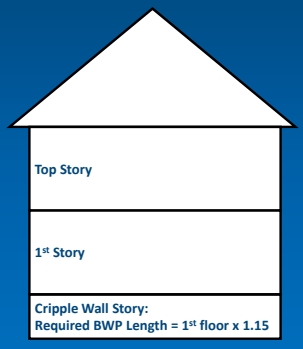
R602.10.4

Cripple Walls

DEFINITION: A framed wall extending from the top of the foundation to the underside of the floor framing of the first story above grade.

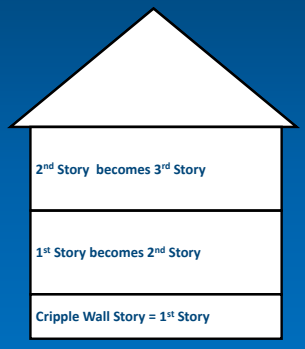
138

Cripple Wall Bracing – Option 1



R602.10.11 139

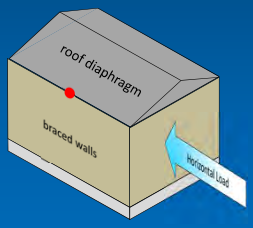
Cripple Wall Bracing – Option 2



R602.10.11.3 140

Completing the Load Path: Roof

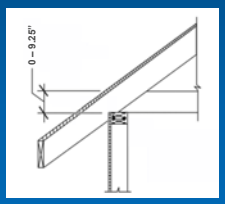
- Roof diaphragm to BWPs



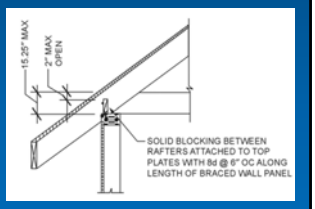
R602.10.8.1 141

Roof Blocking

- Roof diaphragm to BWPs



≤ 9.25"
No blocking required

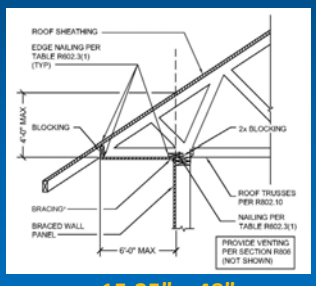


> 9.25" – 15.25"
2x blocking

R602.10.8.1 142

Roof Blocking

- Roof diaphragm to BWPs

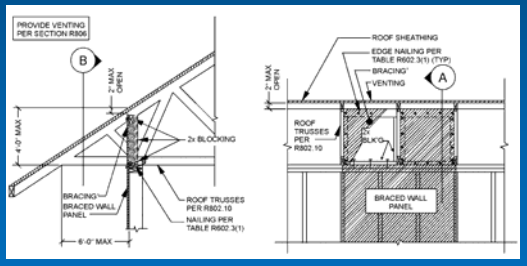


15.25" – 48"
Soffit panel or…

R602.10.8.1 143

Roof Blocking

- Roof diaphragm to BWPs

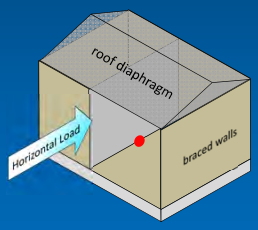


15.25" – 48"
Vertical blocking panel

R602.10.8.1 144

Completing the Load Path: Interior BWPs

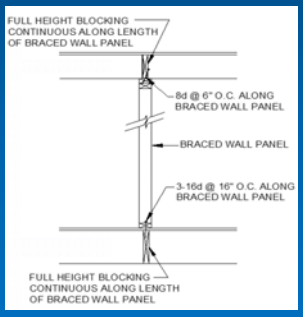
- Interior BWPs to floors



R602.10.8.1 145

Interior BWP Blocking

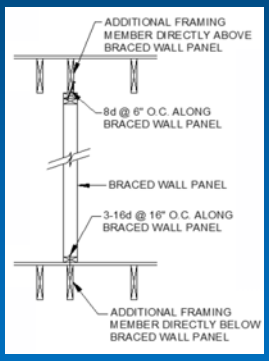
- Interior BWPs to floors
- Where joists are perpendicular:
  - Full height blocking
  - Between joists
  - Full length of BWP



R602.10.8 146

Interior BWP Blocking

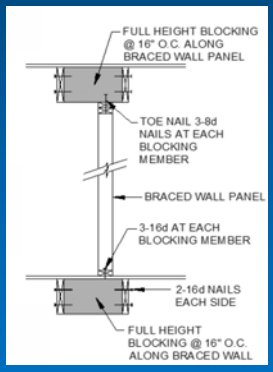
- Where joists are parallel:
  - Option 1: provide additional joists



R602.10.8 147

Interior BWP Blocking

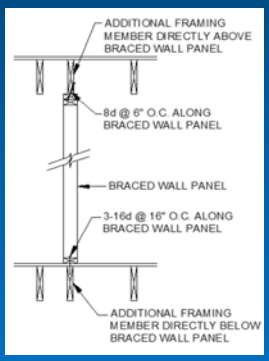
- Where joists are parallel:
  - Option 1: provide additional joists
  - Option 2: provide additional blocking
    - Perpendicular @ 16" o.c.
    - Full length of BWP



R602.10.8 148

Interior BWP Blocking

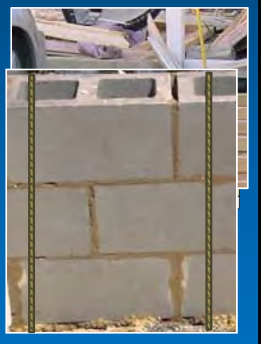
TIP: Placing an interior BWP within a bearing wall will eliminate the need for added blocking.



R602.10.8 149

Completing the Load Path: Stem Walls

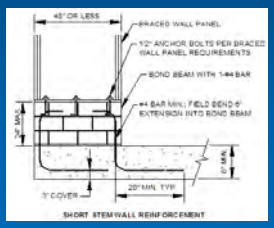
- Masonry or concrete
- BWPs to stem walls
- Reinforce stem walls
  - < 48" long BWPs
  - Stem walls up to 48" high
  - Stem walls > 48" high require RDP design



R602.10.9 150

Completing the Load Path: Stem Walls

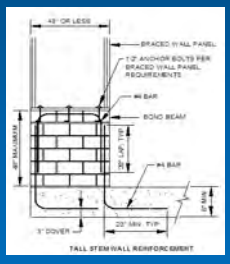
- Stem wall height ≤ 24”
- Cast in place #4 dowels
- Bend dowels into bond beam



R602.10.9 151

Stem Walls

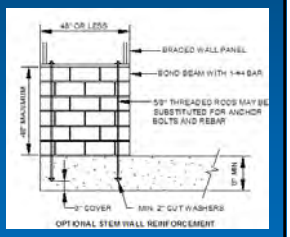
- Stem wall up to 48” high
- Cast in place #4 dowels
- Additional “hair pin” #4 rebar lapped to dowels



R602.10.9 152

Stem Walls

- Non rebar option
- Stem wall up to 48” high
- Cast in place $^{5}/_{8}$” threaded rod
- Epoxy option with 5,000 lbs. pull out value (V rg nia amendment)
- 2” cut washers



R602.10.9 153

Completing the Load Path: Cantilevers

- Short cantilevered diaphragms can transfer load to BWPs
- Cantilevers per R502.3.3 permissible

R602.10.9 154

Completing the Load Path: Piers

- Walls above piers per R602.10
- Piers by RDP
- Common error: sunrooms on posts
- Common solution: cross bracing

R602.10.9 155

Wall Bracing Omissions

- Construction conditions not addressed in IRC
- Sheath the following:
  - Gable end walls
  - Gable dormers
  - Narrow shed dormers
- Treat the following as full wall or part of BWL:
  - Full width shed dormers

156

"Practical" Wall Bracing

- Virginia only
- Simpler
- *Braced wall panels* (BWP)
- *Circumscribed rectangles*
- Based on "Classic"

R602.12 2

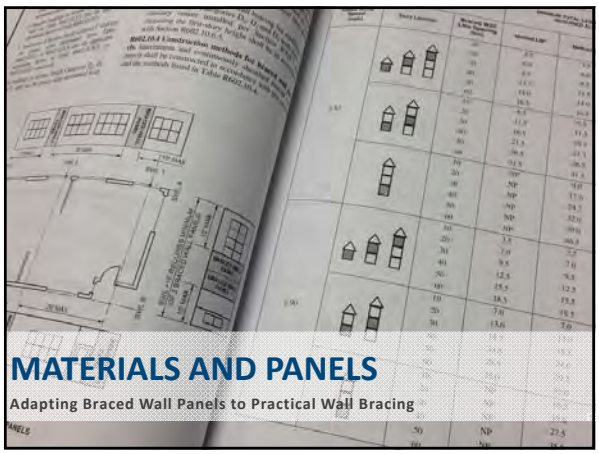
Alternate Prescription Solutions

- APA Simplified Wall Bracing
- IRC Simplified Wall Bracing (national version)

3

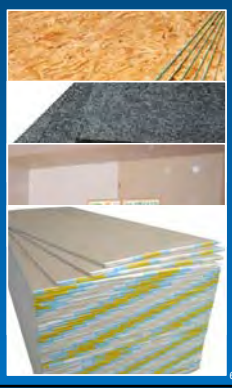
Practical Spreadsheet

4



Sheathing Materials

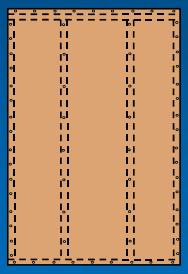
- Exterior
  - $^{7}/_{16}$ OSB or plywood (fasten 6" edge, 12" field)
  - $^{1}/_{2}$ structural fiberboard (fasten 3" edge, 6" field)
  - Sheath entire exterior (continuous sheathing)
  - Cannot mix materials
- Interior
  - $^{1}/_{2}$ gypsum board (fasten 7" edge, field)



R602.12.1 6

Braced Wall Panel

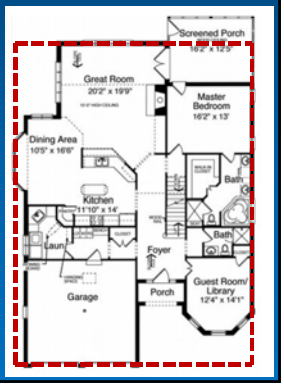
- Same as "classic"
  - Full height
  - No offsets
  - Splices permitted
- Minimum Length:
  - Interior: 48"
  - Exterior, per Table R602.12.2
- "Classic" carryovers:
  - Narrow methods: ABW, PFH, PFG, CS PF



R602.10.2 7

Circumscribed Rectangle

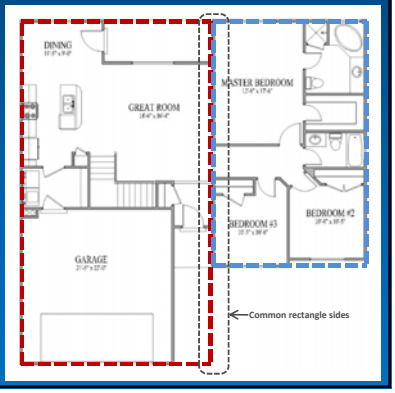
DEFINITION: A rectangle that surrounds a building or portions thereof with a minimum length of bracing assigned to each side.



R602.12.3

Circumscribed Rectangles

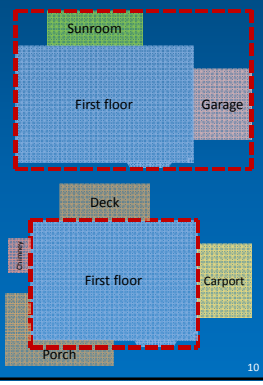
- Unlimited rectangles permitted
- Identify common rectangle sides



R602.10.1.1

Circumscribed Rectangles

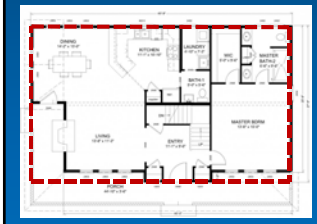
- Include enclosed offsets and projections
  - Sunrooms
  - Garages
  - Bay windows
- Exclude open structures
  - Decks
  - Carports
  - Screened porches
- Exclude chimneys



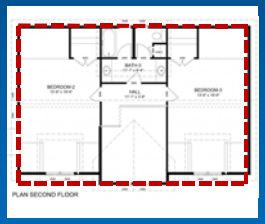
R602.12.3 10

Circumscribed Rectangles

- Different rectangle(s) for each floor



First Floor

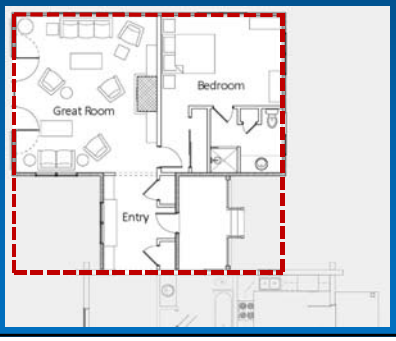


Second Floor

R602.12.3 11

Circumscribed Rectangles

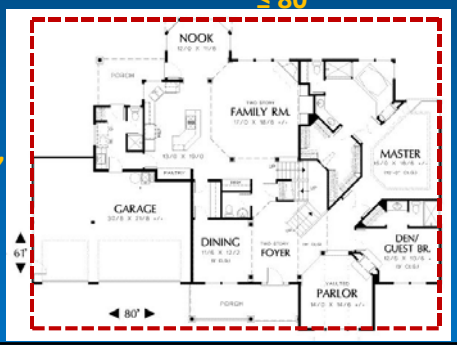
- Can be applied to additions



R602.12.3 12

Circumscribed Rectangles

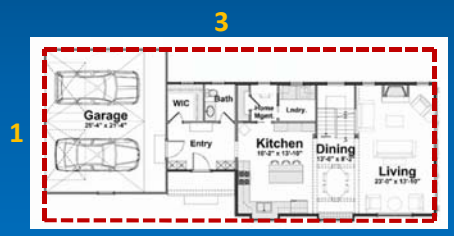
- Maximum size: 80’ x 80’



R602.12.3 13

Circumscribed Rectangles

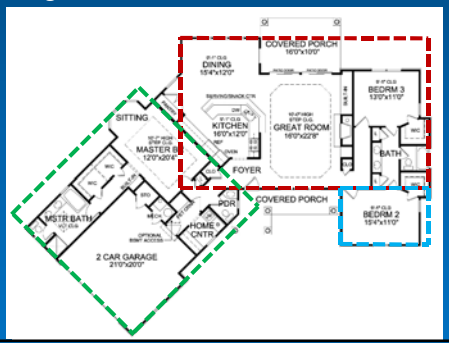
- Maximum aspect ratio: long side / short side 3:1



R602.12.3 14

Circumscribed Rectangles

- Rectangles can be skewed



R602.12.3 15

Circumscribed Rectangles

- Applies to walk out conditions

R602.12.3 16

Circumscribed Rectangles

TIP: One rectangle relies solely on exterior bracing. Multiple rectangles results in complicated interiors. Deciding the most efficient number of rectangle may be an iterative process.

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Example

- 100 mph
- Farm house
- 15’ eave to ridge
- 10’ walls
- Exterior walls sheathed in OSB
- Finished interior
- Standard fastener spacing

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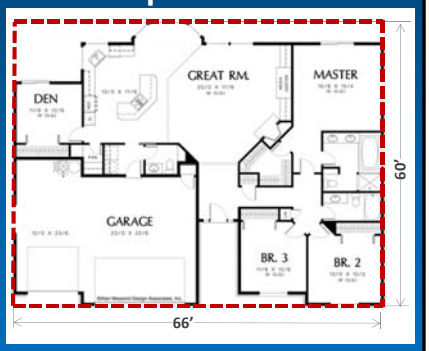
Example

- Draw rectangle
- Determine aspect ratio



WIND SPEED (MPH)	100				
RECTANGLE SIZE (ft)	FRONT/REAR	66	LEFT/RIGHT	60	ASPECT RATIO: 1.10

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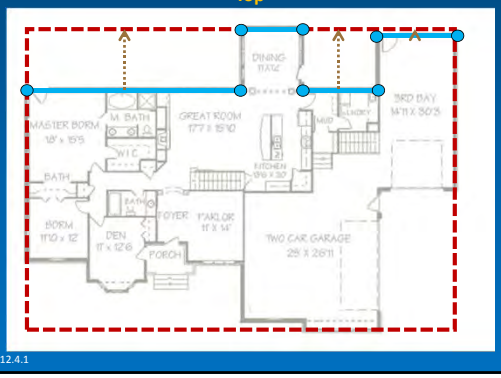
Exterior BWPs on or Facing Rectangle Side

Top



R602.12.4.1

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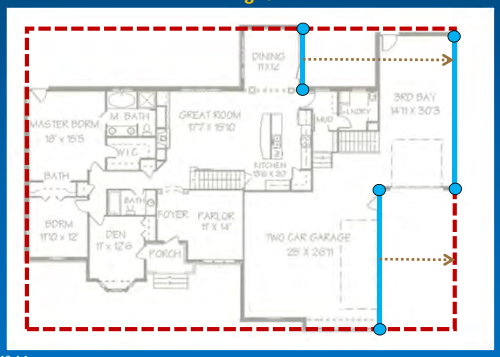
Exterior BWPs on or Facing Rectangle Side

Right

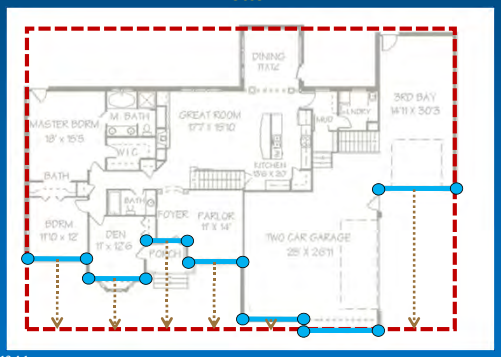


R602.12.4.1

21

Exterior BWPs on or Facing Rectangle Side

Bottom



R602.12.4.1

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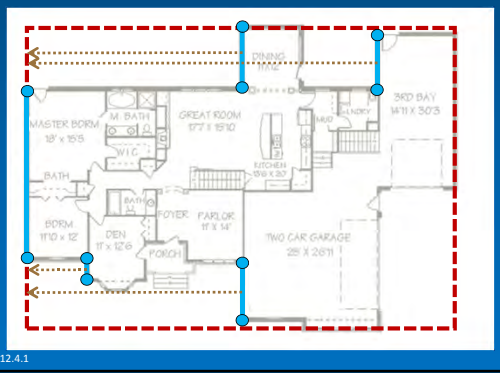
Exterior BWPs on or Facing Rectangle Side

Left



R602.12.4.1

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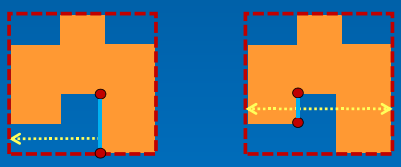
Exterior BWPs on or Facing Rectangle Side

TIP 1: Assign a partially obscured BWP to the parallel rectangle side it's unobscured portion faces.

TIP 2: Assign an wholly obscured BWP to either parallel rectangle side.



Partially Obscured Obscured

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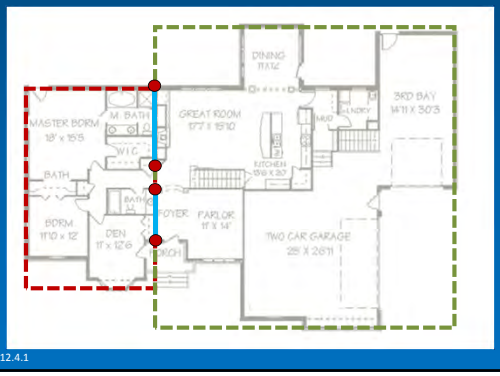
Interior BWP on Rectangle Side

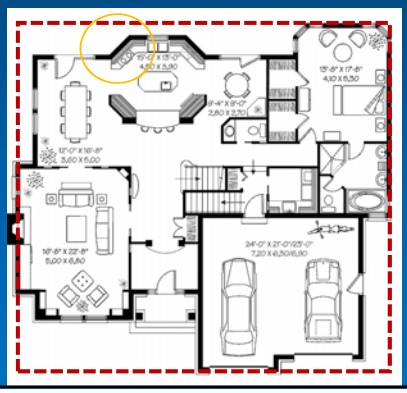


R602.12.4.1 25

Interior BWP Facing Rectangle Side

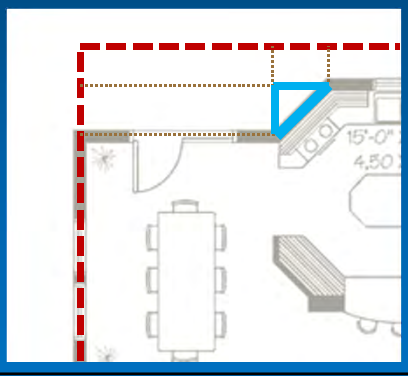
R602.12.4.1 26

Projections of Angled BWPs



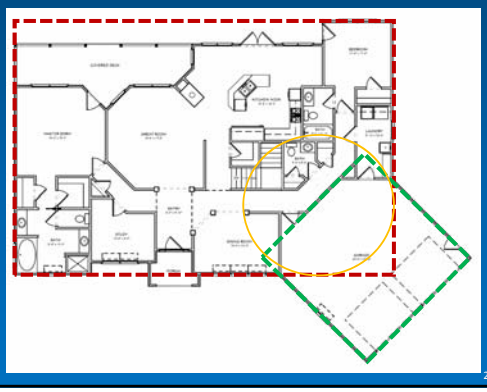
R602.12.4.1 27

Projections of Angled BWPs



R602.12.4.1 28

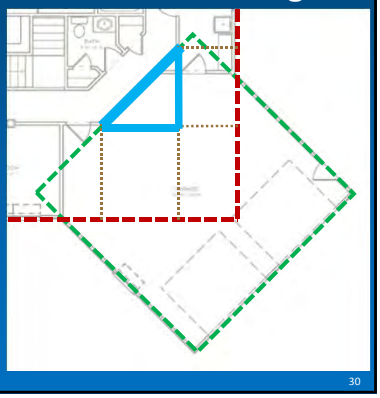
Shared BWPs at Skewed Rectangles



R602.12.4.3 29

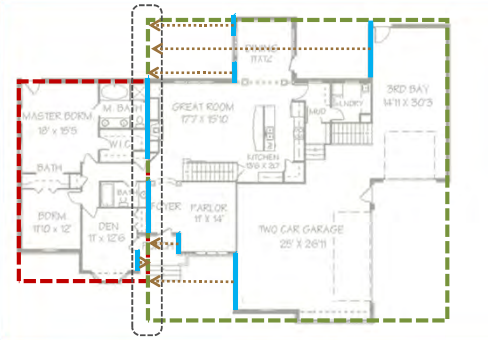
Shared BWPs at Skewed Rectangles

- Apply BWP to skewed rectangle (green) it is located on
- Apply BWL projections to non skewed rectangle (red)



R602.12.4.3 30

BWP on Common Rectangle Sides



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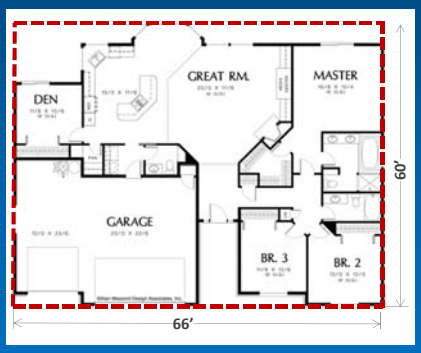
Example – Rear Rectangle Side



32

Example – Rear Rectangle Side

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Tabular Requirement

- Use Table R602.12.4

TABLE R602.12.4
REQUIRED LENGTH OF BRACING ALONG EACH SIDE OF A CIRCUMSCRIBED RECTANGLE

WIND SPEED	EAVE-TO RIDGE HEIGHT (FEET)	NUMBER OF FLOOR LEVELS ABOVE	REQUIRED LENGTH OF BRACING ON FRONT/REAR SIDE (feet)							REQUIRED LENGTH OF BRACING ON LEFT/RIGHT SIDE (feet)						
			Length of left/right side (feet)							Length of front/rear side (feet)						
			10	20	30	40	50	60	70	80	10	20	30	40	50	60	70	80
90	10	0	2.0	3.5	5.0	6.0	7.5	9.0	10.5	12.0	2.0	3.5	5.0	6.0	7.5	9.0	10.5	12.0
		1	3.5	6.5	9.0	12.0	14.5	17.0	19.8	22.6	3.5	6.5	9.0	12.0	14.5	17.0	19.8	22.6
		2	5.0	9.5	13.5	17.5	21.5	25.0	29.2	33.4	5.0	9.5	13.5	17.5	21.5	25.0	29.2	33.4
	15	0	2.6	4.6	6.5	7.9	9.8	11.7	13.7	15.7	2.6	4.6	6.5	7.9	9.8	11.7	13.7	15.7
		1	4.0	7.5	10.4	13.8	16.7	19.6	22.9	26.2	4.0	7.5	10.4	13.8	16.7	19.6	22.9	26.2
		2	5.5	10.5	14.9	19.3	23.7	27.5	32.1	36.7	5.5	10.5	14.9	19.3	23.7	27.5	32.1	36.7
	20	0	2.9	5.2	7.3	8.8	11.1	13.2	15.4	17.6	2.9	5.2	7.3	8.8	11.1	13.2	15.4	17.6
		1	4.5	8.5	11.8	15.6	18.9	22.1	25.8	29.5	4.5	8.5	11.8	15.6	18.9	22.1	25.8	29.5
		2	6.2	11.9	16.8	21.8	27.3	31.1	36.3	41.5	6.2	11.9	16.8	21.8	27.3	31.1	36.3	41.5
100	10	0	2.5	4.0	6.0	7.5	9.5	11.0	12.8	14.6	2.5	4.0	6.0	7.5	9.5	11.0	12.8	14.6
		1	4.5	8.0	11.0	14.5	18.0	21.0	24.5	28.0	4.5	8.0	11.0	14.5	18.0	21.0	24.5	28.0
		2	6.0	11.5	16.5	21.5	26.5	31.0	36.2	41.4	6.0	11.5	16.5	21.5	26.5	31.0	36.2	41.4
	15	0	3.4	5.2	7.8	9.8	12.4	14.3	16.7	19.1	3.4	5.2	7.8	9.8	12.4	14.3	16.7	19.1
		1	5.2	9.2	12.7	16.7	20.7	24.2	28.2	32.2	5.2	9.2	12.7	16.7	20.7	24.2	28.2	32.2
		2	6.6	12.7	18.2	23.7	29.2	34.1	39.8	45.5	6.6	12.7	18.2	23.7	29.2	34.1	39.8	45.5
	20	0	3.8	5.9	8.8	11.1	14.0	16.2	18.9	21.6	3.8	5.9	8.8	11.1	14.0	16.2	18.9	21.6
		1	5.8	10.4	14.4	18.9	23.4	27.3	31.8	36.3	5.8	10.4	14.4	18.9	23.4	27.3	31.8	36.3
		2	7.5	14.4	20.6	26.8	33.0	38.5	44.9	51.3	7.5	14.4	20.6	26.8	33.0	38.5	44.9	51.3

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Example – Rear Rectangle Side

TABLE R602.12.4
REQUIRED LENGTH OF BRACING ALONG EACH SIDE OF A CIRCUMSCRIBED RECTANGLE

WIND SPEED	EAVE-TO RIDGE HEIGHT (FEET)	NUMBER OF FLOOR LEVELS ABOVE	REQUIRED LENGTH OF BRACING ON FRONT/REAR SIDE (feet)							REQUIRED LENGTH OF BRACING ON LEFT/RIGHT SIDE (feet)						
			Length of left/right side (feet)							Length of front/rear side (feet)						
			10	20	30	40	50	60	70	80	10	20	30	40	50	60	70	80
90	10	0	2.0	3.5	5.0	6.0	7.5	9.0	10.5	12.0	2.0	3.5	5.0	6.0	7.5	9.0	10.5	12.0
		1	3.5	6.5	9.0	12.0	14.5	17.0	19.8	22.6	3.5	6.5	9.0	12.0	14.5	17.0	19.8	22.6
		2	5.0	9.5	13.5	17.5	21.5	25.0	29.2	33.4	5.0	9.5	13.5	17.5	21.5	25.0	29.2	33.4
	15	0	2.6	4.6	6.5	7.9	9.8	11.7	13.7	15.7	2.6	4.6	6.5	7.9	9.8	11.7	13.7	15.7
		1	4.0	7.5	10.4	13.8	16.7	19.6	22.9	26.2	4.0	7.5	10.4	13.8	16.7	19.6	22.9	26.2
		2	5.5	10.5	14.9	19.3	23.7	27.5	32.1	36.7	5.5	10.5	14.9	19.3	23.7	27.5	32.1	36.7
	20	0	2.9	5.2	7.3	8.8	11.1	13.2	15.4	17.6	2.9	5.2	7.3	8.8	11.1	13.2	15.4	17.6
		1	4.5	8.5	11.8	15.6	18.9	22.1	25.8	29.5	4.5	8.5	11.8	15.6	18.9	22.1	25.8	29.5
		2	6.2	11.9	16.8	21.8	27.3	31.1	36.3	41.5	6.2	11.9	16.8	21.8	27.3	31.1	36.3	41.5
100	10	0	2.5	4.0	6.0	7.5	9.5	11.0	12.8	14.6	2.5	4.0	6.0	7.5	9.5	11.0	12.8	14.6
		1	4.5	8.0	11.0	14.5	18.0	21.0	24.5	28.0	4.5	8.0	11.0	14.5	18.0	21.0	24.5	28.0
		2	6.0	11.5	16.5	21.5	26.5	31.0	36.2	41.4	6.0	11.5	16.5	21.5	26.5	31.0	36.2	41.4
	15	0	3.4	5.2	7.8	9.8	12.4	14.3	16.7	19.1	3.4	5.2	7.8	9.8	12.4	14.3	16.7	19.1
		1	5.2	9.2	12.7	16.7	20.7	24.2	28.2	32.2	5.2	9.2	12.7	16.7	20.7	24.2	28.2	32.2
		2	6.6	12.7	18.2	23.7	29.2	34.1	39.8	45.5	6.6	12.7	18.2	23.7	29.2	34.1	39.8	45.5
	20	0	3.8	5.9	8.8	11.1	14.0	16.2	18.9	21.6	3.8	5.9	8.8	11.1	14.0	16.2	18.9	21.6
		1	5.8	10.4	14.4	18.9	23.4	27.3	31.8	36.3	5.8	10.4	14.4	18.9	23.4	27.3	31.8	36.3
		2	7.5	14.4	20.6	26.8	33.0	38.5	44.9	51.3	7.5	14.4	20.6	26.8	33.0	38.5	44.9	51.3

R602.10.3

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Example – Rear Rectangle Side

RECTANGLE SIDE	FRONT
NUMBER OF FLOOR LEVELS ABOVE	0
EAVE-TO-RIDGE HEIGHT (ft)	15
EXTERIOR BWP MATERIAL	Wood Structural Panels
TABULAR REQUIRED (ft)	14.3

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Adjustments

- Use footnotes from Table R602.12.4:
  - Exposure Category C
  - Wall heights
  - Fastener spacing

a. Interpolation shall be permitted, extrapolation shall be prohibited.
b. For Exposure Category C, multiply the required length of bracing by a factor of 1.20 for a one-story building, 1.30 for a two-story building and 1.40 for a three-story building.
c. For wall height adjustments multiply the required length of bracing by the following factors: 0.90 for 8 feet (2438 mm), 0.95 for 9 feet (2743 mm), 1.0 for 10 feet (3048 mm), 1.05 for 11 feet (3353 mm) and 1.10 for 12 feet (3658 mm).
d. Where braced wall panels supporting stories above have been sheathed in wood structural panels with edge fasteners spaced at 4 inches (102 mm) on center, multiply the required length of bracing by 0.83.
e. A floor level, habitable or otherwise, contained wholly within the roof rafters or trusses shall not be considered a floor level for purposes of determining the required length of bracing.
f. A rectangle side with differing number of floor levels above shall use the greatest number when determining the required length of bracing.

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Adjustments - Wind Exposure

Category C

Open terrain

Grasslands, flat plains

Wind flows over open water for 1,500 feet

1.20 one-story

1.30 two-story

1.40 three-story

Tab e R602.12.4, Footnote b 38

Example – Rear Rectangle Side

TABULAR REQUIRED (ft)		14.3	
ADJUSTMENT	EXPOSURE	C	1.20
	WALL HEIGHT (ft)		
	OMIT FINISHED INTERIOR		
	REDUCED FASTENER SPACING		
REQUIRED BWP LENGTH (ft)			
VALUE FROM COMMON RECTANGLE SIDE			
TOTAL REQUIRED BWP LENGTH (ft)			

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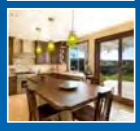
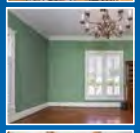
Adjustments – Wall Height

0.90 8' wall



0.95 9' wall

1.00 10' wall



1.05 11' wall

1.10 12' wall

Tab e R602.12.4, Footnote c 40

Adjustments

TIP: When walls assigned to a rectangle side have more than one wall height, eave to ridge height, etc., adjust to the highest value for the required length of bracing.

Tab e R602.12.4, Footnote f 41

Example – Rear Rectangle Side

TABULAR REQUIRED (ft)		14.3	
ADJUSTMENT	EXPOSURE	C	1.20
	WALL HEIGHT (ft)	10	1.00
	OMIT FINISHED INTERIOR		
	REDUCED FASTENER SPACING		
REQUIRED BWP LENGTH (ft)			
VALUE FROM COMMON RECTANGLE SIDE			
TOTAL REQUIRED BWP LENGTH (ft)			

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Adjustments – No Interior Finish

1.40

R602.12.2 #4

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Example – Rear Rectangle Side

TABULAR REQUIRED (ft)		14.3	
ADJUSTMENT	EXPOSURE	C	1.20
	WALL HEIGHT (ft)	10	1.00
	OMIT FINISHED INTERIOR	NO	1.00
	REDUCED FASTENER SPACING		
REQUIRED BWP LENGTH (ft)			
VALUE FROM COMMON RECTANGLE SIDE			
TOTAL REQUIRED BWP LENGTH (ft)			

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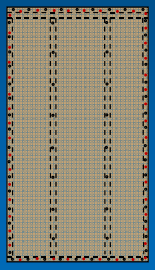
Adjustments – Fastener Spacing



4" fastener spacing

0.83

OSB or plywood (exterior) when supporting floor(s) above

0.7

gypsum board (interior)*

*Virginia nterpretat on

R602.10.3, Footnote d

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Example – Rear Rectangle Side

TABULAR REQUIRED (ft)		14.3	
ADJUSTMENT	EXPOSURE	C	1.20
	WALL HEIGHT (ft)	10	1.00
	OMIT FINISHED INTERIOR	NO	1.00
	REDUCED FASTENER SPACING	NO	1.00
REQUIRED BWP LENGTH (ft)			
VALUE FROM COMMON RECTANGLE SIDE			
TOTAL REQUIRED BWP LENGTH (ft)			

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Required Length of Bracing

- Multiply tabular requirements by each adjustment factor:

***Adjusted length* = *(tabular value)* x *(adjustment factor)* x *(adjustment factor)* x *(adjustment factor)*…**

Required BWL Length = 14.3' x 1.20 x 1.00 x 1.00 x 1.00 = 17.2'

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Example – Rear Rectangle Side

TABULAR REQUIRED (ft)		14.3	
ADJUSTMENT	EXPOSURE	C	1.20
	WALL HEIGHT (ft)	10	1.00
	OMIT FINISHED INTERIOR	NO	1.00
	REDUCED FASTENER SPACING	NO	1.00
REQUIRED BWP LENGTH (ft)		17.2	
VALUE FROM COMMON RECTANGLE SIDE			
TOTAL REQUIRED BWP LENGTH (ft)			

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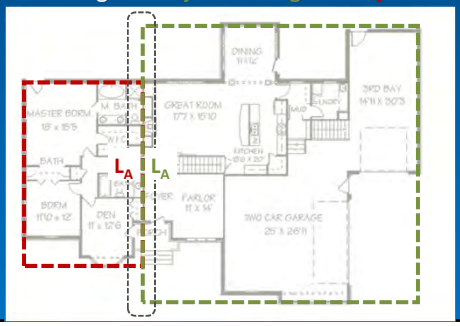
Common Rectangle Sides

- Add Required BWP Length for each side:

Adjusted length Adjusted length + Adjusted length



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Example – Rear Rectangle Side

- Repeat for common rectangle side and add required value here.

TABULAR REQUIRED (ft)		14.3	
ADJUSTMENT	EXPOSURE	C	1.20
	WALL HEIGHT (ft)	10	1.00
	OMIT FINISHED INTERIOR	NO	1.00
	REDUCED FASTENER SPACING	NO	1.00
REQUIRED BWP LENGTH (ft)		17.2	
VALUE FROM COMMON RECTANGLE SIDE		0	
TOTAL REQUIRED BWP LENGTH (ft)		17.2	

R602.12.4

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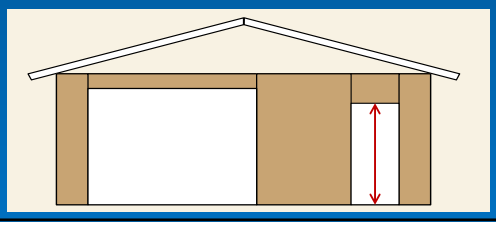
Exterior BWP Minimum Length

- Based on adjacent opening(s)
  - Adjacent garage opening or
  - Height of adjacent opening



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Exterior BWP Minimum Length

TABLE R602.12.2
BRACED WALL PANEL LENGTHS

Location		Minimum Panel Length (inches) Wall Height (feet)				
		8	9	10	11	12
Adjacent garage door of one-story garage[b]		24	27	30	33	36
Adjacent all other openings[b]	Clear opening height (inches)					
	≤ 64	24	27	30	33	36
	≤ 72	27	27	30	33	36
	≤ 80	30	30	30	33	36
	> 80	36	36	36	40	40

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. Braced wall panels supporting a gable end wall or roof load only.
b. Interpolation shall be permitted.

R602.12.2

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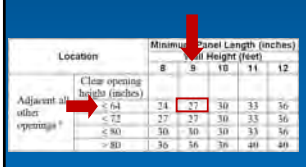
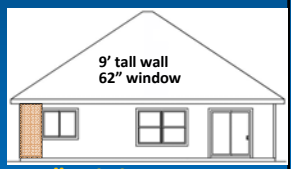
Exterior BWP Minimum Length





27" minimum

Tab e R602.10.5

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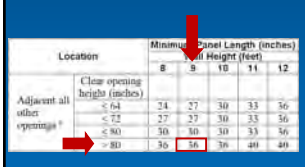
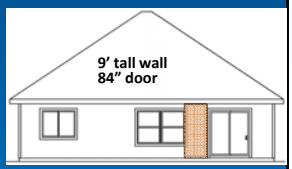
Exterior BWP Minimum Length





36" minimum

Tab e R602.10.5

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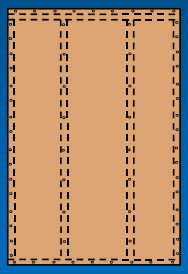
Braced Wall Panel

- Contributing Length
  - Exterior actual
  - Interior 0.5 x actual
  - "Classic" narrow methods:
    - PFH 48"
    - PFG, CS PF 1.5 x actual
    - Equivalent products 48"



R602.10.2

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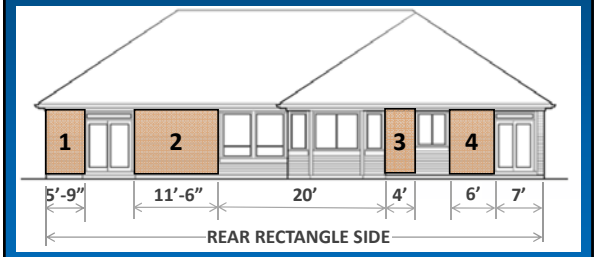
Example – Rear Rectangle Side



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Example – Rear Rectangle Wall

TOTAL REQUIRED BWP LENGTH (ft)			17.6
ACTUAL BWP	CONTRIBUTING LENGTH (ft)	BWP	LOCATION	LENGTH
		1	EXTERIOR	5.75
		2	EXTERIOR	11.5
		3	EXTERIOR	4
		4	EXTERIOR	6
		5		
		6		
		7		
ACTUAL BWP LENGTH (ft)			27.25
ACTUAL ≥ REQUIRED?			PASS

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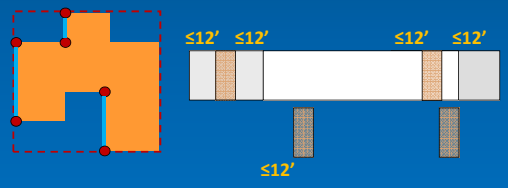
Distribution Rule 1

- BWPs located ≤ 12' from house corner



R602.12.6 #1

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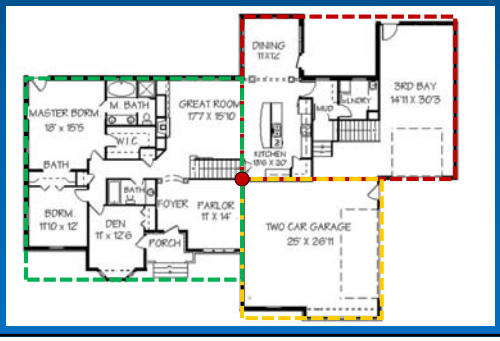
Distribution Rule 1

- BWPs located ≤ 12' from interior rectangle corner



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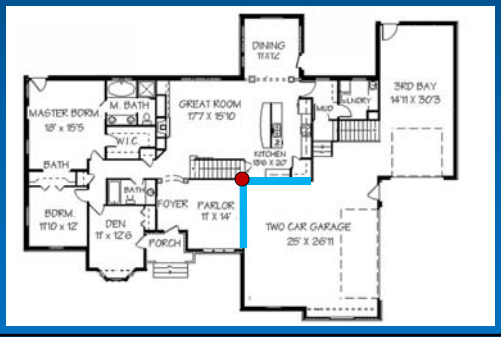
Distribution Rule 1

- BWPs located ≤ 12' from interior rectangle corner



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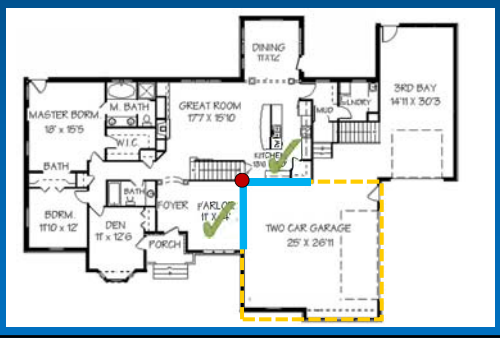
Distribution Rule 1

- BWPs located ≤ 12’ from interior rectangle corner



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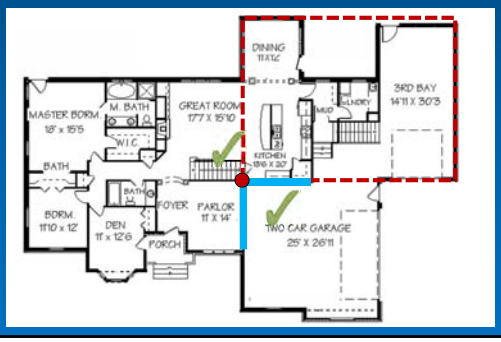
Distribution Rule 1

- BWPs located ≤ 12’ from interior rectangle corner



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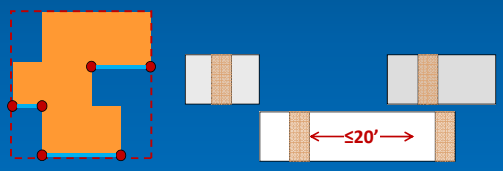
Distribution Rule 2

- Edge to edge distance between adjacent BWPs ≤ 20’



R602.12.6 #2

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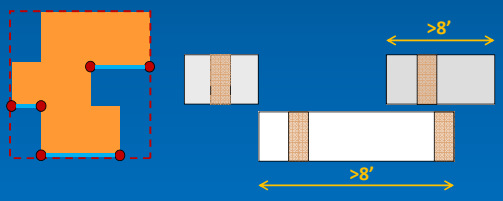
Distribution Rule 3

- Wall > 8’ require at least one BWP



R602.12.6 #3

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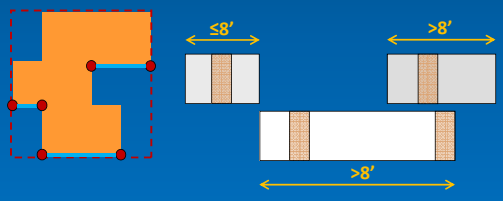
Distribution Rule 3

- Wall > 8’ require at least one BWP
- Walls ≤ 8’ are permitted no BWPs



R602.12.6 #4

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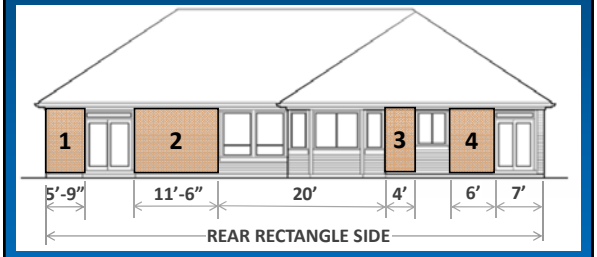
Example – Rear Rectangle Side



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Example – Rear Rectangle Side

ACTUAL ≥ REQUIRED?	PASS
BWPs ≤ 20' APART?	YES
BWP WITHIN 12' OF CORNERS?	YES
COMPLIANT NUMBER OF BWPs	YES
BWL COMPLIANCE PASS-FAIL	PASS

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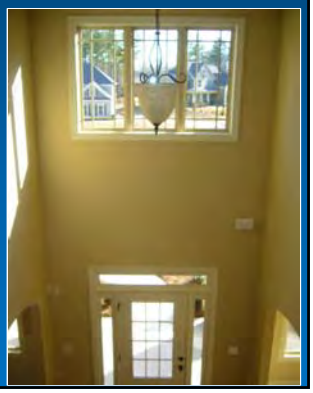
BWPs Adjacent Balloon-Framed Walls

- Balloon framed walls:
  - Two story foyers
  - Family rooms
- BWP locations
  - Each side of two story portion
  - Each floor



R602.12.6.1

BWPs Adjacent Balloon-Framed Walls

R602.12.6.1

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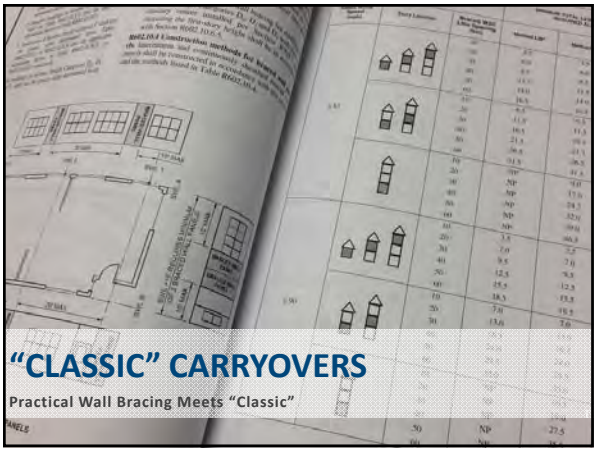
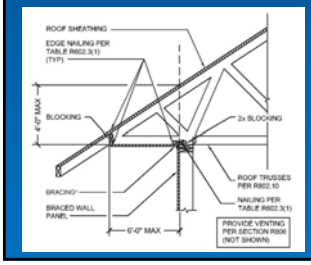
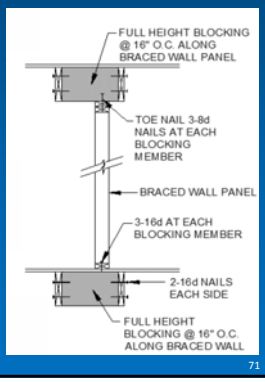


BWP Connections

- Refer to R602.10.8
- Connections to framing
- Connections to roof





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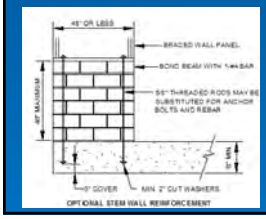
BWP Support

- Refer to R602.10.9
- Cantilevered floor restriction
- Masonry stem walls



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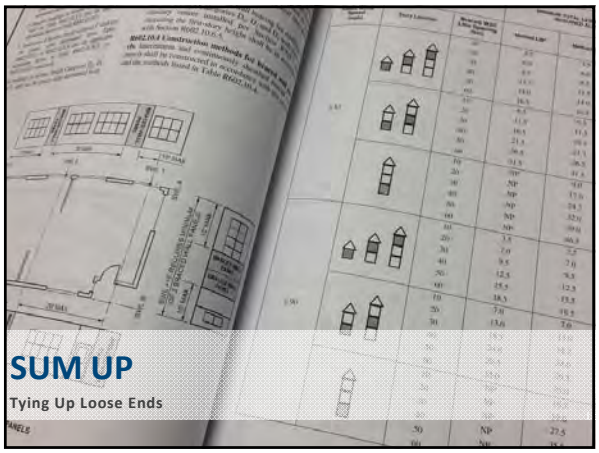

Classic vs. Practical

R602.10	R602.12
8 materials	3 materials
4 narrow methods	4 narrow methods
Unlimited size houses	Unlimited size houses
Braced wall panels	Braced wall panels
Braced wall lines	Circumscribed rectangles
All detached homes	All detached homes
All townhouses	Townhouses in SDC A & B only
End conditions	No end conditions
BWPs 10' from BWL end	BWPs 12' from all house/rectangle corners
Greater flexibility	Easier application
Nationwide	Virginia only

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Publications

- *Guide to the 2012 IRC Wall Bracing Provisions* (APA)
- *Wind Bracing* (Fairfax County)
- *Prescriptive Design Guide* (Simpson Strong Tie)
- *IRC Wall Bracing Guide for Builders, Designers and Plan Reviewers* (Foam Sheathing Coalition)
- Notes from this class (available *on fairfaxcounty.gov*)

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Resources

- Chuck Bajnai, 804 717 6428, *bajnaic@chesterfield.gov*
- Brian Foley, 703 324 1842, *brian.foley@fairfaxcounty.gov*
- APA – The Engineered Wood Association, 253 620 7400, *apawood.org*
- Simpson Strong Tie, (800) 999 5099, *strongtie.com*
- ICC ES, 1 800 423 6587 x66546, *icc es.org*

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