Presenters

Chuck Bajnai
Chesterfield County
Chief Residential Plan Reviewer
Licensed Architect
bajnaic@chesterfield.gov

Brian Foley
Fairfax County
Building Official
Professional Engineer
brian.foley@fairfaxcounty.gov

Handouts

- Slideshow (3)
- Exercises
- “Classic” Wall Bracing Spreadsheet
- Practical Wall Bracing Spreadsheet

Handouts

- Slideshow (3)
- Example and exercises
Handouts

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

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...”

1986 - CABO
- Wall bracing methods
  - Let in bracing
  - 48” structural sheathing
    - Plywood
    - Particleboard
    - Fiberboard
    - Gypsum board

2000 – IRC
- Wall bracing
- 8 bracing methods
- Exception for “continuous sheathing”
- Wind bracing amounts based on seismic loads
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

2012 – IRC

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

Why Change?
The Evolution of House Size

1950s 1960s 1970s 1980s 1990s 2000s

Why Change?
Design Trends

- Open Concept
- High Ceilings
- Two story Walls
- Natural Light  Windows

Why Change?
New Methods and Technology

- Narrow Walls
- Energy Savings
- Hardware
- Materials
**Seismic Load**

- Based on:
  - Ground movement severity
  - Occupancy category

**Seismic Design Category**

- Based on:
  - Ground movement severity
  - Occupancy category

**Seismic Forces**

- 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

**Wind Load**

- Hurricane Isabel 2003
- Derecho 2012

**Wind Speed**

- Regional wind speed: 90 100 mph
  - Equivalent to mid grade Category 1 hurricane
Spreadsheet – Wind Speed

<table>
<thead>
<tr>
<th>WIND SPEED (MPH)</th>
<th>90</th>
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<tbody>
<tr>
<td>BWL DESIGNATION</td>
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<tr>
<td>NUMBER OF FLOORS ABOVE BWL</td>
<td></td>
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<tr>
<td>BWP METHOD</td>
<td></td>
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<tr>
<td>AVERAGE BWL SPACING (ft)</td>
<td></td>
</tr>
<tr>
<td>TABULAR REQUIREMENT (ft)</td>
<td></td>
</tr>
</tbody>
</table>

Wind Load

Load Path

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

**Vertical Load Path**
Vertical load path transfers gravity load:
- to roof sheathing
- to rafters/trusses
- to walls
- to foundation
- to ground

**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).
Multi-story House

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

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

Critical Element of Load Path
Diaphragms

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

Critical Element of Load Path
Wall Bracing

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

- Load at top plate
- No bracing, no stiffness

- Load at top plate
- Bracing stiffness
- Let in
- Solid panels
- Edge nails resist load, narrow spacing
- Field nails resist buckling, wide spacing

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!

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 D2
- Wall height ≤ 12 feet
- Roof height (from eave to ridge) ≤ 20 feet

Alternate Prescription Solutions

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

Engineered Design

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

Shear Wall Standards

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

<table>
<thead>
<tr>
<th>Shear Wall Sheathing Type (blocked, unless noted otherwise)</th>
<th>Maximum Aspect Ratio</th>
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<td>Wood structural panels, unblocked</td>
<td>2:1</td>
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<tr>
<td>Wood structural panels</td>
<td>3.5:1</td>
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<tr>
<td>Particleboard</td>
<td>2:1</td>
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<td>Diagonal sheathing, conventional</td>
<td>2:1</td>
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<tr>
<td>Gypsum wallboard</td>
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<tr>
<td>Portland cement plaster</td>
<td>2:1</td>
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<tr>
<td>Structural fiberboard</td>
<td>3.5:1</td>
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</tbody>
</table>

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

Engineered Shear Walls
TIP: When submitting or reviewing engineered calculations, look for...
- Wind load determination (13 18 psf in 90 mph, \( V_{ref} \) 115 mph)
- Seal of registered design professional
- Minimum aspect ratio

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

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

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
PART 2
R602.10 – “CLASSIC” WALL BRACING

“Classic” Wall Bracing

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

“Classic” Spreadsheet

Braced Wall Panel

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

Braced Wall Panel

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

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

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

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

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

BRACED WALL LINES
A “Family” of Braced Wall Panels
DEFINITION: An imaginary straight line though the building which represents the centerline of lateral resistance provided by parallel BWPs.

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

Rule 1: Straight line

Rule 2: Each Plan Direction

Rule 3: All Floors

Rule 4: Permitted to Float
**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

**Rule 5: Defined Ends**

**DEFINITION:** The end of a BWL is defined as the...
- Intersection with another BWL
- Projected intersection at chamfered corner

**Rule 6: Maximum Spacing**

**DEFINITION:** The average distance between parallel BWLS.
- Sail area governs BWL spacing
- Parallel BWLS resist load
Rule 6: Maximum Spacing

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<tr>
<th>APPLICATION</th>
<th>ZONE</th>
<th>MAXIMUM TYP</th>
<th>PROJECT WALL LINE SPACING</th>
<th>FOOTNOTE</th>
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<td>Tornado</td>
<td>50 ft</td>
<td>up to 30 ft if side lengths ofM</td>
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<tr>
<td>SDG C</td>
<td>Tornado</td>
<td>50 ft</td>
<td>up to 30 ft if side lengths ofM</td>
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<td>SDG D, E, F</td>
<td>Damage, heavy</td>
<td>35 ft</td>
<td>up to 30 ft if side lengths ofM</td>
<td></td>
</tr>
<tr>
<td>SDG G, H, I</td>
<td>Damage, heavy</td>
<td>50 ft</td>
<td>up to 30 ft if side lengths ofM</td>
<td></td>
</tr>
</tbody>
</table>

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

Braced Wall Line Spacing

Larger sail areas require more bracing.

- 35'
- 60'
- >60'

Braced Wall Line Spacing

Larger sail areas require more bracing.

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

BWLS share load

Example:
- A & B share load in N/S direction
- 1 & 2 share load in E/W direction
BWL Spacing: “Where’s my help?”

BWL spacing = 27.67’

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

BWL Spacing: “Where’s my help?”

BWL spacing = 38’

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

BWL Spacing: “Where’s my help?”

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

BWL Spacing: “Where’s my help?”

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

**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'

---

**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.

---

**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

---

**Braced Wall Lines**

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

---

**Example – BWL 3**
Example – Average BWL Spacing?

Example – Average BWL Spacing?

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

Spreadsheet – Average BWL Spacing

Tabular Requirement

- Use Table R602.10.3(1)

Example – BWL 3

Spreadsheet – Tabular Requirement

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

Adjustments

Example

BWLSpacing = (26 + 54) / 2 = 40'
### 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

**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

### Adjustments - Wall Height

- Shorter walls
- 10-foot walls
- Tall walls
Example – BWL 3

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.

Adjustments – Number of BWLs

Number of BWLs in one plan direction
Value adjusts for larger building with more BWLs.

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

Adjustments – No Interior Finish

- For unfinished areas
- Limited methods
- Adjustment factor 1.40
### Example – BWL 3

<table>
<thead>
<tr>
<th>EXPOSURE</th>
<th>C</th>
<th>1.20</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAVE-TO-RIDGE HT (ft)</td>
<td>15</td>
<td>1.30</td>
</tr>
<tr>
<td>MAXIMUM WALL HEIGHT (ft)</td>
<td>10</td>
<td>1.00</td>
</tr>
<tr>
<td>NUMBER OF BWLs</td>
<td>3</td>
<td>1.30</td>
</tr>
<tr>
<td>OMIT INTERIOR FINISH</td>
<td>No</td>
<td>1.00</td>
</tr>
<tr>
<td>ADD PAIR #90° HOLD DOWNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HORIZONTAL JOINTS BLOCKED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REDUCED FASTENER SPACING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQUIRED BWP LENGTH (in)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Adjustments – Hold-Down

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

### Adjustments – Omit Horiz. Blocking

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

### Adjustments – Fastener Spacing

- 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*
Example – BWL 3

| EXPOSURE | 15 | 1.20 |
| EAVE-TO-RIDGE HT (ft) | 1.00 |
| MAXIMUM WALL HEIGHT (ft) | 3 | 1.30 |
| NUMBER OF BWLs | No | 1.00 |
| OMIT INTERIOR FINISH | No | 1.00 |
| ADD PAIR BDGF HOLD DOWNS | Yes | 1.00 |
| HORIZONTAL JOINTS BLOCKED | Yes | 1.00 |
| REDUCED FASTENER SPACING | No | 1.00 |

**Required BWP Length (ft)**

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

Required BWP 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'

---

**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

---

**Prescriptive Bracing Types**

- Intermittent bracing
  - Based on segmented
  - Sheath at BWP locations only

- Continuous sheathing
  - Based on perforated
  - Sheath all exposed areas
**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

**LIB: Let-in Bracing**

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

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

**WSP: Wood Structural Panels**

- 7/16” thick OSB or plywood
- Fasteners: 6d nails @ 6” o.c. edges, 12” o.c. field
- 48” minimum length

**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

**GB: Gypsum Board**

- 1/2” thick
- Fasteners: nails or screws @ 7” o.c. edges and field
- 48” minimum length
GB: Gypsum Board

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

PFH: Portal Frame with Hold-down

- 7/16” thick OSB or plywood
- Cast in place hold downs required

TIP: Portal Frames

- Tested assembly
- Cannot be engineered
- Field deviations prohibited

TIP: Portal Frames at Garages

One Opening

Double Portal, one panel

Double Portal, two panels

Two Openings

Continuous header prohibited

optional face wall
**TIP: Portal Frames at Garages**

- One single and one double portal
- Continuous header prohibited
- Three single portals
- Continuous header prohibited

Three Openings

**PFG: Portal Frame at Garage Opening**

- 7/16" thick OSB or plywood
- At garage only
- No hold downs

**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

**Equivalence Products**

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
<th>Minimum Available Width</th>
<th>ICC ES ESR Number</th>
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<tbody>
<tr>
<td>Steel Strong Walls</td>
<td>Simpson Strong Tie</td>
<td>12&quot;</td>
<td>1679</td>
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<tr>
<td>Wood Strong Walls</td>
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<td>SB Shearwalls</td>
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<tr>
<td>HFX Panels</td>
<td>Hardy Frame</td>
<td>5&quot; (nailer not included)</td>
<td>2089</td>
</tr>
</tbody>
</table>

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

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

CS-SFB: Structural Fiberboard

- 1/2” thick structural fiberboard
- Fasteners: 8d nails @ 3” o.c. edges, 6” o.c. field
- 24” minimum length

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

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
CS-PF: Continuous Sheathing Portal Frame

Pony Walls on Portal Frames

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

Pony Walls on Portal Frames

<table>
<thead>
<tr>
<th>MINIMUM WALL-TO-WALL BRACING NORMAL TO SHEATH</th>
<th>MINIMUM TOTAL WALL-TO-WALL BRACING</th>
<th>MINIMUM SHEATHING TO WALL PROTECTIVE</th>
<th>TENSION STRAP CAPACITY REQUIRED</th>
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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.

**Minimum Length of Intermittent BWPs**

<table>
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<th>UNMINIMUM LENGTH (COMBINED)</th>
<th>MINIMUM LENGTH (COMBINED)</th>
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<td>8 ft</td>
<td>5 ft</td>
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<td>10</td>
<td>8</td>
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Minimum Length of Narrow Methods

<table>
<thead>
<tr>
<th>METHOD</th>
<th>MINIMUM LENGTH (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFH</td>
<td>Supporting end only: 18, 20, 22, 24</td>
</tr>
<tr>
<td>FFH</td>
<td>Supporting one story and over: 24, 25, 26, 28</td>
</tr>
<tr>
<td>TSD</td>
<td>24, 26, 28, 30</td>
</tr>
<tr>
<td>CS-WP</td>
<td>24, 26, 28, 30</td>
</tr>
<tr>
<td>CS-SFB</td>
<td>24, 26, 28, 30</td>
</tr>
</tbody>
</table>

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

Minimum Length of Continuous Sheathing

<table>
<thead>
<tr>
<th>Height of Adjacent Opening(s)</th>
<th>Minimum Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>9' tall wall 62&quot; window</td>
<td>27&quot; minimum</td>
</tr>
<tr>
<td>9' tall wall 80&quot; door</td>
<td>30&quot; minimum</td>
</tr>
</tbody>
</table>

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

BWP Projected Length

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

Example – BWL 3

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

Example – BWL 3

<table>
<thead>
<tr>
<th>Actual ≥ Required?</th>
<th>Pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWPs ≤ 20’ Apart?</td>
<td></td>
</tr>
<tr>
<td>≥ 2 Panels in BWL?</td>
<td></td>
</tr>
<tr>
<td>BWP Begins ≤ 10’ from Ends?</td>
<td></td>
</tr>
<tr>
<td>Continuous Sheathing End Conditions</td>
<td>END 1 END 2</td>
</tr>
<tr>
<td>BWL Compliance</td>
<td></td>
</tr>
</tbody>
</table>

Spacing
- BWPs cannot exceed a distance of 20’ edge to edge.

Number
- BWLs must have a minimum of two BWPs
- Exception: BWLs ≤ 16’ can have one 48” BWP
Example – BWL 3

<table>
<thead>
<tr>
<th>ACTUAL ≥ REQUIRED?</th>
<th>Pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWPs ≤ 20’ APART?</td>
<td>Yes</td>
</tr>
<tr>
<td>≥ 2 PANELS IN BWL?</td>
<td>Yes</td>
</tr>
<tr>
<td>BW PENS ≤ 10’ FROM ENDS?</td>
<td>Yes</td>
</tr>
<tr>
<td>CONTINUOUS SHEATHING END CONDITIONS</td>
<td>END 1</td>
</tr>
<tr>
<td>BWL COMPLIANCE</td>
<td></td>
</tr>
</tbody>
</table>

Location

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

Example – BWL 3

<table>
<thead>
<tr>
<th>ACTUAL ≥ REQUIRED?</th>
<th>Pass</th>
</tr>
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<tbody>
<tr>
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</tr>
<tr>
<td>CONTINUOUS SHEATHING END CONDITIONS</td>
<td>END 1</td>
</tr>
<tr>
<td>BWL COMPLIANCE</td>
<td></td>
</tr>
</tbody>
</table>

End Conditions

- End panel BWL since...
  - ≤ 64” opening
  - 8’ tall wall
  - BW L 24” panel length
- Return panel
- End Condition 1

End Conditions

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

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

End Conditions

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

End Conditions

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

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).

Example – BWL 3

<table>
<thead>
<tr>
<th>ACTUAL ≥ REQUIRED?</th>
<th>Pass</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
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</tr>
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<td>END 1 END 2</td>
</tr>
</tbody>
</table>

Example – BWL 3

<table>
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<tbody>
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<tr>
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<td>Yes</td>
</tr>
<tr>
<td>CONTINUOUS SHEATHING END CONDITIONS</td>
<td>END 1 END 2</td>
</tr>
</tbody>
</table>

BWL COMPLIANCE | Pass
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

Mixing Methods
- Mixing intermittent methods along a BWL is permitted
- BWL must be designed for weakest method

Mixing Methods
- Any narrow method can mix with CS WSP
- No other methods can mix with CS SFB
- ABW, PFH, PFG, CS-PF permitted in CS-WSP

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

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.
**Cripple Wall Bracing – Option 1**

- Top Story
- 1st Story

Cripple Wall Story:
Required BWP Length = 1st floor x 1.15

---

**Cripple Wall Bracing – Option 2**

- 2nd Story becomes 3rd Story
- 1st Story becomes 2nd Story

Cripple Wall Story = 1st Story

---

**Completing the Load Path: Roof**

- Roof diaphragm to BWPs

---

**Roof Blocking**

- Roof diaphragm to BWPs

- ≤ 9.25”
  No blocking required

- > 9.25” – 15.25”
  2x blocking

- 15.25” – 48”
  Soffit panel or…

---

**Roof Blocking**

- Roof diaphragm to BWPs

- 15.25” – 48”
  Vertical blocking panel
Completing the Load Path: Interior BWPs

- Interior BWPs to floors

Interior BWP Blocking

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

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

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

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
Completing the Load Path: Stem Walls
- Stem wall height ≤ 24"
- Cast in place #4 dowels
- Bend dowels into bond beam
- Stem wall up to 48” high
- Cast in place #4 dowels
- Additional “hair pin” #4 rebar lapped to dowels

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
- 2” cut washers

Completing the Load Path: Cantilevers
- Short cantilevered diaphragms can transfer load to BWPs
- Cantilevers per R502.3.3 permissible

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

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
PART 3
R602.12 – “PRACTICAL” WALL BRACING

“Practical” Wall Bracing

- Virginia only
- Simpler
- Braced wall panels (BWP)
- Circumscribed rectangles
- Based on “Classic”

Alternate Prescription Solutions

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

Practical Spreadsheet

<table>
<thead>
<tr>
<th>SHEATHING MATERIAL</th>
<th>EDGE FASTEN</th>
<th>FIELD FASTEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSB or plywood</td>
<td>6”</td>
<td>12”</td>
</tr>
<tr>
<td>Structural fiberboard</td>
<td>3”</td>
<td>6”</td>
</tr>
</tbody>
</table>

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)

MATERIALS AND PANELS
Adapting Braced Wall Panels to Practical Wall Bracing
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

Circumscribed Rectangle

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

Circumscribed Rectangles

- Unlimited rectangles permitted
- Identify common rectangle sides

Circumscribed Rectangles

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

Circumscribed Rectangles

- Different rectangle(s) for each floor

Circumscribed Rectangles

- Can be applied to additions
Circumscribed Rectangles

- Maximum size: 80' x 80'

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

Rectangles can be skewed

Applies to walk out conditions

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.

Example

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

100 mph Farm house 15’ eave to ridge 10’ walls Exterior walls sheathed in OSB Finished interior Standard fastener spacing
Example
- Draw rectangle
- Determine aspect ratio

Exterior BWPs on or Facing Rectangle Side
- Top
- Right
- Bottom
- Left

TIP 1: Assign a partially obscured BWP to the parallel rectangle side its unobscured portion faces.
TIP 2: Assign an wholly obscured BWP to either parallel rectangle side.

Partially Obscured

Obscured
1. **Interior BWP on Rectangle Side**

2. **Interior BWP Facing Rectangle Side**

3. **Projections of Angled BWPs**

4. **Projections of Angled BWPs**

5. **Shared BWPs at Skewed Rectangles**

- Apply BWP to skewed rectangle (green) if it is located on.
- Apply BWL projections to non skewed rectangle (red).
BWP on Common Rectangle Sides

Example – Rear Rectangle Side

Example – Rear Rectangle Side

Tabular Requirement

- Use Table R602.12.4

Example – Rear Rectangle Side

Example – Rear Rectangle Side

Example – Rear Rectangle Side

Example – Rear Rectangle Side

Table 602.10.3

<table>
<thead>
<tr>
<th>RECTANGLE SIDE</th>
<th>FRONT</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER OF FLOOR LEVELS ABOVE</td>
<td>0</td>
</tr>
<tr>
<td>EAVE-TO-RIDGE HEIGHT (H)</td>
<td>15</td>
</tr>
<tr>
<td>EXTERIOR BWP MATERIAL</td>
<td>Wood Structural Panels</td>
</tr>
<tr>
<td>TABULAR REQUIRED (H)</td>
<td>14.3</td>
</tr>
</tbody>
</table>
Adjustments

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

Adjustments - Wind Exposure

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

Example – Rear Rectangle Side

<table>
<thead>
<tr>
<th>Tabular Required (ft)</th>
<th>14.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure</td>
<td>C</td>
</tr>
<tr>
<td>Wall Height (ft)</td>
<td>1.20</td>
</tr>
<tr>
<td>Adj.</td>
<td></td>
</tr>
<tr>
<td>Reduced Fastener Spacing</td>
<td></td>
</tr>
<tr>
<td>Required BWP Length (ft)</td>
<td></td>
</tr>
<tr>
<td>Value from Common Rectangle Side</td>
<td></td>
</tr>
<tr>
<td>Total Required BWP Length (ft)</td>
<td></td>
</tr>
</tbody>
</table>

Adjustments – Wall Height

<table>
<thead>
<tr>
<th>Wall Height (ft)</th>
<th>Adj.</th>
<th>Tabular Required (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td></td>
<td>0.90</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>0.95</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>1.05</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>1.10</td>
</tr>
</tbody>
</table>

Example – Rear Rectangle Side

<table>
<thead>
<tr>
<th>Tabular Required (ft)</th>
<th>14.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure</td>
<td>C</td>
</tr>
<tr>
<td>Wall Height (ft)</td>
<td>10</td>
</tr>
<tr>
<td>Adj.</td>
<td></td>
</tr>
<tr>
<td>Reduced Fastener Spacing</td>
<td></td>
</tr>
<tr>
<td>Required BWP Length (ft)</td>
<td></td>
</tr>
<tr>
<td>Value from Common Rectangle Side</td>
<td></td>
</tr>
<tr>
<td>Total Required BWP Length (ft)</td>
<td></td>
</tr>
</tbody>
</table>

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.
**Adjustments – No Interior Finish**

1.40

---

**Example – Rear Rectangle Side**

<table>
<thead>
<tr>
<th>TABULAR REQUIRED (ft)</th>
<th>14.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPOSURE</td>
<td>C</td>
</tr>
<tr>
<td>WALL HEIGHT (ft)</td>
<td>10</td>
</tr>
<tr>
<td>OMIT FINISHED INTERIOR</td>
<td>NO</td>
</tr>
<tr>
<td>REDUCED FASTENER SPACING</td>
<td>NO</td>
</tr>
<tr>
<td>REQUIRED BWP LENGTH (ft)</td>
<td></td>
</tr>
</tbody>
</table>

**Value from Common Rectangle Side**

**Total Required BWP Length (ft)**

---

**Adjustments – Fastener Spacing**

4" fastener spacing

0.83

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

0.7

gypsum board (interior)*

*Virginia interpretation

---

**Example – Rear Rectangle Side**

<table>
<thead>
<tr>
<th>TABULAR REQUIRED (ft)</th>
<th>14.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPOSURE</td>
<td>C</td>
</tr>
<tr>
<td>WALL HEIGHT (ft)</td>
<td>10</td>
</tr>
<tr>
<td>OMIT FINISHED INTERIOR</td>
<td>NO</td>
</tr>
<tr>
<td>REDUCED FASTENER SPACING</td>
<td>NO</td>
</tr>
<tr>
<td>REQUIRED BWP LENGTH (ft)</td>
<td>17.2</td>
</tr>
</tbody>
</table>

**Value from Common Rectangle Side**

**Total Required BWP Length (ft)**

---

**Required Length of Bracing**

- Multiply tabular requirements by each adjustment factor:

  \[
  \text{Adjusted length} = (\text{tabular value}) \times (\text{adjustment factor}) \times (\text{adjustment factor}) \times (\text{adjustment factor}) \ldots
  \]

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

---

**Example – Rear Rectangle Side**

<table>
<thead>
<tr>
<th>TABULAR REQUIRED (ft)</th>
<th>14.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPOSURE</td>
<td>C</td>
</tr>
<tr>
<td>WALL HEIGHT (ft)</td>
<td>10</td>
</tr>
<tr>
<td>OMIT FINISHED INTERIOR</td>
<td>NO</td>
</tr>
<tr>
<td>REDUCED FASTENER SPACING</td>
<td>NO</td>
</tr>
<tr>
<td>REQUIRED BWP LENGTH (ft)</td>
<td>17.2</td>
</tr>
</tbody>
</table>

**Value from Common Rectangle Side**

**Total Required BWP Length (ft)**

---
Common Rectangle Sides
- Add Required BWP Length for each side:
  Adjusted length + Adjusted length

Example – Rear Rectangle Side
- Repeat for common rectangle side and add required value here.

Exterior BWP Minimum Length
- Based on adjacent opening(s)
  - Adjacent garage opening or
  - Height of adjacent opening

Exterior BWP Minimum Length
- Based on adjacent opening(s)
  - Adjacent garage opening or
  - Height of adjacent opening

Exterior BWP Minimum Length
- Based on adjacent opening(s)
  - Adjacent garage opening or
  - Height of adjacent opening

Exterior BWP Minimum Length
- Based on adjacent opening(s)
  - Adjacent garage opening or
  - Height of adjacent opening
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"

Example – Rear Rectangle Side

Distribution Rule 1

- BWPs located ≤ 12’ from house corner

Example – Rear Rectangle Wall

### Table: Total Required BWP Length

<table>
<thead>
<tr>
<th>TOTAL REQUIRED BWP LENGTH (ft)</th>
<th>17.6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACTUAL BWP</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CONTRIBUTING LENGTH</strong> (ft)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>EXTERIOR</td>
</tr>
<tr>
<td>2</td>
<td>EXTERIOR</td>
</tr>
<tr>
<td>3</td>
<td>EXTERIOR</td>
</tr>
<tr>
<td>4</td>
<td>EXTERIOR</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>TOTAL BWP LENGTH (ft)</td>
<td>27.25</td>
</tr>
<tr>
<td>ACTUAL ≥ REQUIRED?</td>
<td>PASS</td>
</tr>
</tbody>
</table>
Distribution Rule 1
- BWPs located ≤ 12’ from interior rectangle corner

Distribution Rule 2
- Edge to edge distance between adjacent BWPs ≤ 20’

Distribution Rule 3
- Wall > 8’ require at least one BWP
- Walls ≤ 8’ are permitted no BWPs

Example – Rear Rectangle Side

1
2
3
4
Example – Rear Rectangle Side

<table>
<thead>
<tr>
<th>ACTUAL ≥ REQUIRED?</th>
<th>PASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWPs ≤ 20' APART?</td>
<td>YES</td>
</tr>
<tr>
<td>BWPs WITHIN 12' OF CORNERS?</td>
<td>YES</td>
</tr>
<tr>
<td>COMPLIANT NUMBER OF BWPS</td>
<td>YES</td>
</tr>
<tr>
<td>BWLP COMPLIANCE PASS-FAIL</td>
<td>PASS</td>
</tr>
</tbody>
</table>

BWP Support

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

BWP Connections

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

BWP Adjacent Balloon-Framed Walls

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

“CLASSIC” CARRYOVERS
Practical Wall Bracing Meets “Classic”
SUM UP
Tying Up Loose Ends

---

<table>
<thead>
<tr>
<th>Classic vs. Practical</th>
</tr>
</thead>
<tbody>
<tr>
<td>R602.10</td>
</tr>
<tr>
<td>R602.12</td>
</tr>
<tr>
<td><strong>8 materials</strong></td>
</tr>
<tr>
<td><strong>4 narrow methods</strong></td>
</tr>
<tr>
<td>Unlimited size houses</td>
</tr>
<tr>
<td>Braced wall panels</td>
</tr>
<tr>
<td>Braced wall lines</td>
</tr>
<tr>
<td>All detached homes</td>
</tr>
<tr>
<td>All townhouses</td>
</tr>
<tr>
<td>End conditions</td>
</tr>
<tr>
<td>BWPs 10’ from BWL end</td>
</tr>
<tr>
<td>Greater flexibility</td>
</tr>
<tr>
<td>Nationwide</td>
</tr>
</tbody>
</table>

---

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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THE END