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Understanding Braced Wall Lines per the 2018 IRC

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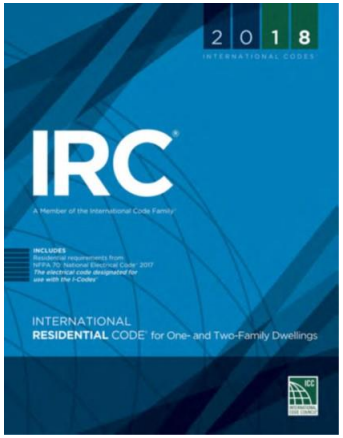
American Wood Council



- Participants may download the presentation here: http://www.awc.org/education/resources

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- Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Who am I?

- AWC's NE Regional Manager
- Building Code Official-PA
- A classically trained draftsman & landscape designer
- 15 years experience in civil/site/land development & inspection
- Framed over 30 wood decks & 20 houses, and worked in the trades as a framer.
- A teacher **and** a student.
- Army veteran and Eagle Scout
- Stick burner and a really good BBQ Cook…just ask!

What is the AWC?

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- Represents about 85% of wood industry
- Engages in the consensus based model code development (IRC, IBC, IFC, IECC, etc.)
- Writes wood standards referenced in the I-Codes
- Participates in other standards (ASCE, ASTM, ICC-ES, ASHRAE, USGBC, etc.)
- Develops technical papers
- ICC/AIA Preferred Provider of Continuing Education

Course Description

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There are various methods to achieve compliance with the prescriptive wall bracing provisions in the 2018 International Residential Code (IRC). The presentation will provide a systematic overview of the various methods of compliance, while focusing on commonly used structural panel and continuously sheathed options. Requirements for braced wall lines, braced wall panel length and location, materials, fasteners, load path, and connections to roof and floor framing are among the topics that will be discussed.

Please note that the 2018 IRC has not been adopted by New York as of January 2018.

Learning Objectives

Upon completion, participants will:

1 Define Braced Wall Lines

Identify minimum requirements for braced wall lines.

2 Load Path

Understand how compliance with the requirements provides a continuous load path for resisting lateral forces.

3 Methods and Materials

Identify requirements for braced wall panels, including materials, fastening, connections, and support.

4 Code Compliance & Additional Resources

Understand specific requirements for typical braced wall line methods, requirements specific to certain methods, cripple wall bracing, and anchorage, among others.

Outline

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- **BWL's: mimimum requirements**
- **Load Path & resisting lateral loads**
- **BWL methods**
- **Combining BWL methods**
- **Summary**
- **Questions?**

Why design for high wind or lateral loads?

Tornado and hurricane resistance!

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Damage from Hurricane Opal in Florida. This deck was designed to meet State of Florida Coastal Construction Control Line (CCCL) requirements. The house predated the CCCL and was not.

Structure on left can withstand 250 m.p.h. winds and a 15 lbs. 2” x 4” missile fired at the structure at 100 m.p.h.! https://www.fema.gov/wall-sections-passed-previous-missile-impact-tests

Wall Bracing-Braced Wall Lines?

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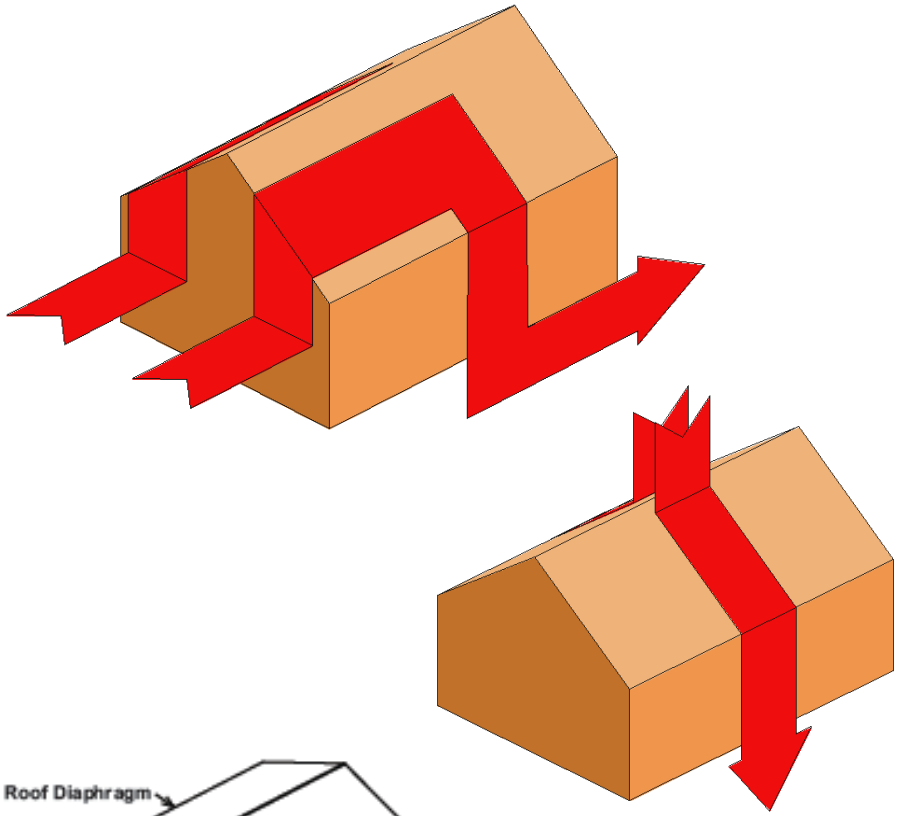
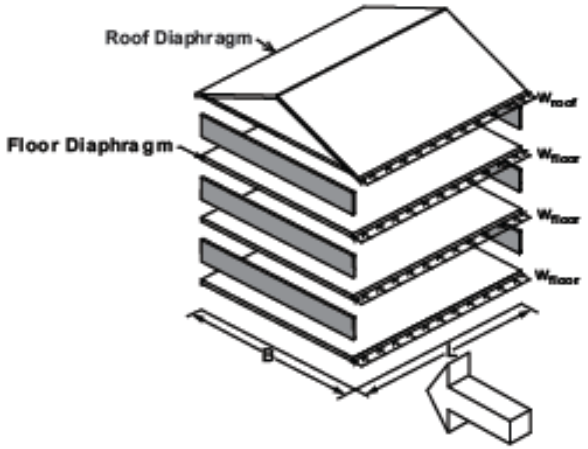
- **Supports vertical loads on the horizontal diaphragms and transfers the resultant lateral forces from wind and seismic loads into the foundation**
- **Constitutes the vertical elements in the lateral force resisting system for many structures**
- **Wind, seismic, dynamic snow loads**





Why are Braced Wall Lines Important?

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Shear Wall Test-typical nailed sheathing failure

- **Nail yielding at adjoining panel edge (left)**
- **Nail yielding and head pull through at panel to bottom plate location (right)**

Load Path

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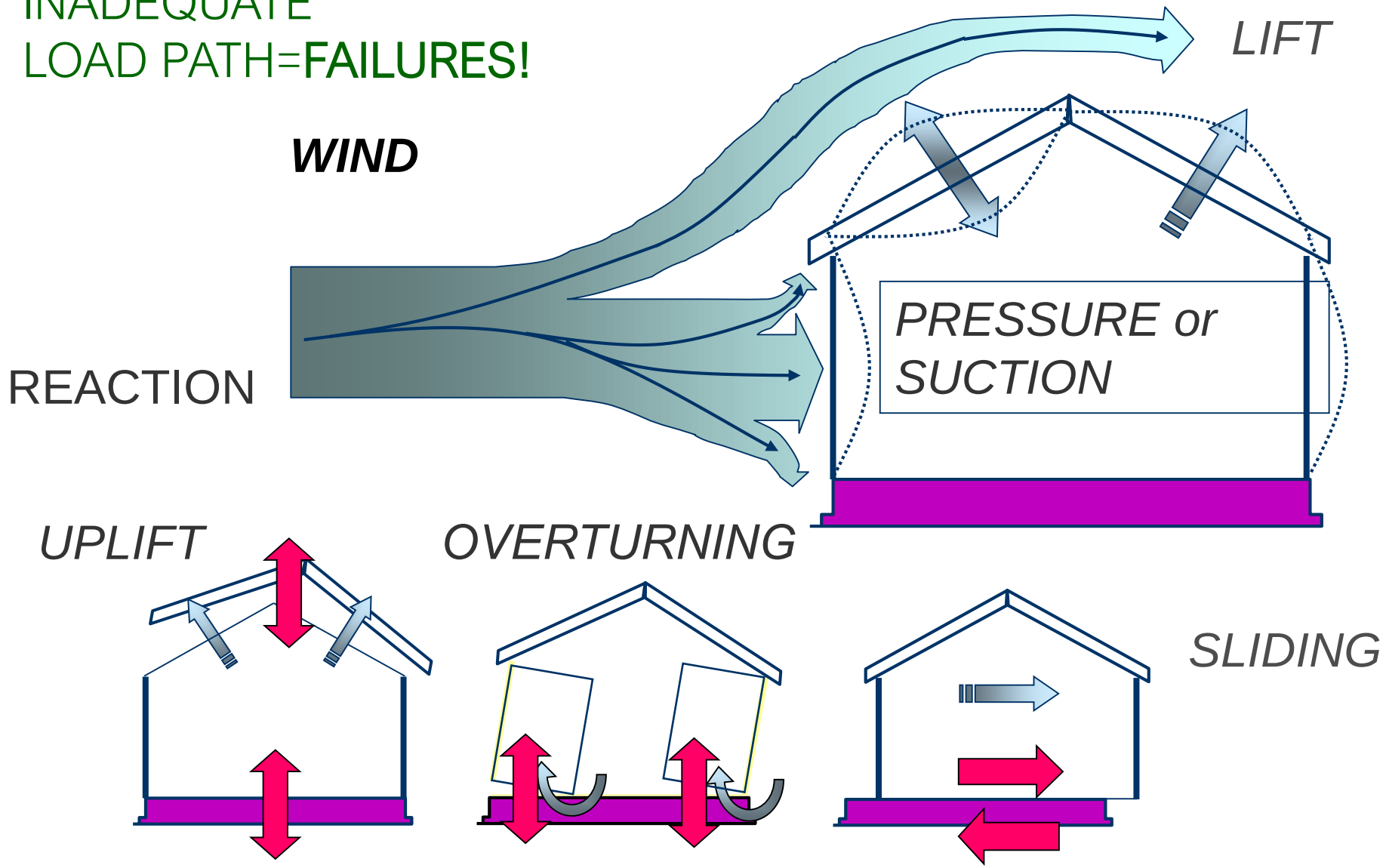
INADEQUATE
LOAD PATH=**FAILURES!**



Lateral Loads

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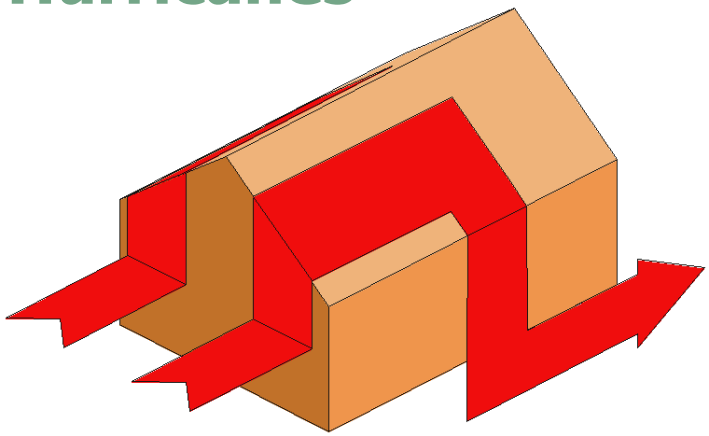
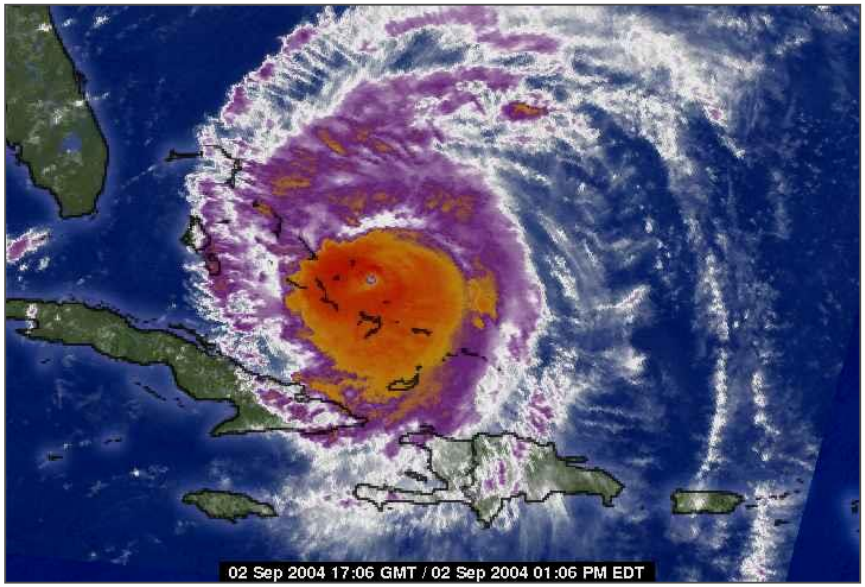
- **Wind Loads –**
- **produced by extreme**
- **weather:**
  - **Thunderstorms**
  - **Tornadoes**
  - **Tropical storms**
  - **Hurricanes**





Lateral Loads

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- **Tornados**

Enhanced Fujita **Damage** Scale
- revised in 2007

80%

Light – EF0
(65-85 mph)

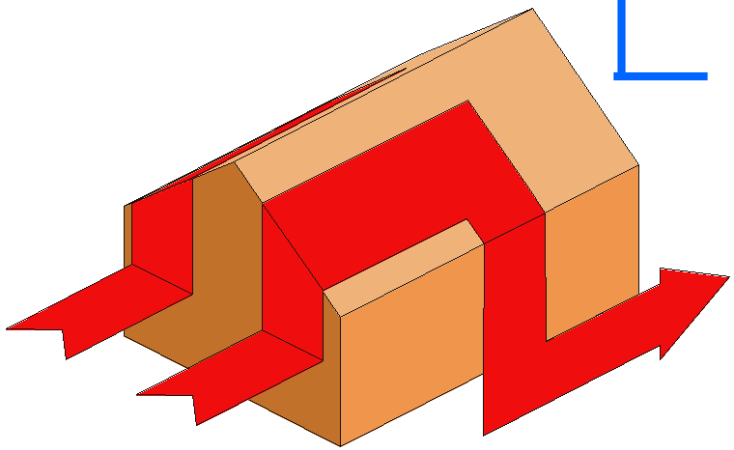
Moderate – EF1
(86-110 mph)

Considerable – EF2
(111-135 mph)

Severe – EF3
(136-165 mph)

Devastating – EF4
(166-200 mph)

Incredible – EF5
200 mph +)



Lateral Loads

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- Tornados

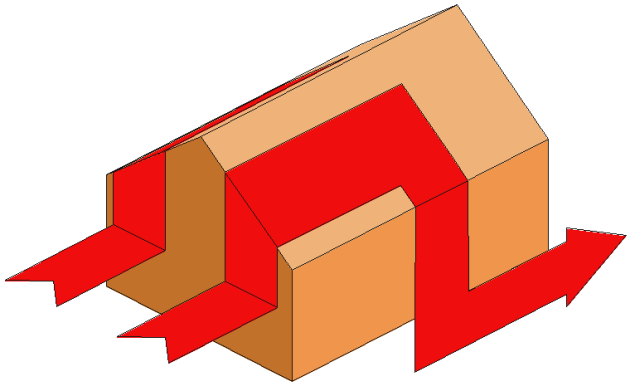
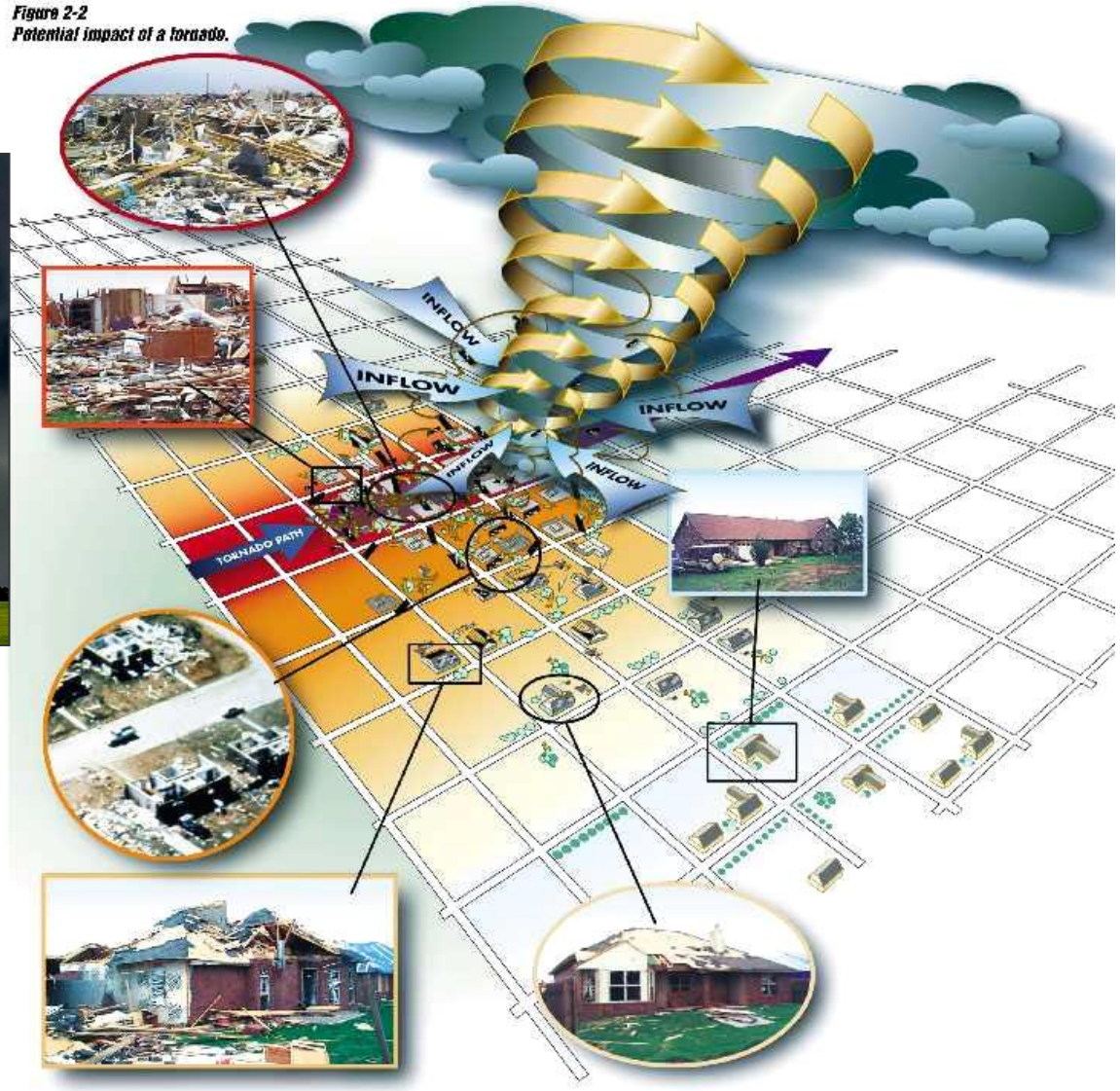


Figure 2-2
Potential impact of a tornado.



Code Compliant=LESS DAMAGE!

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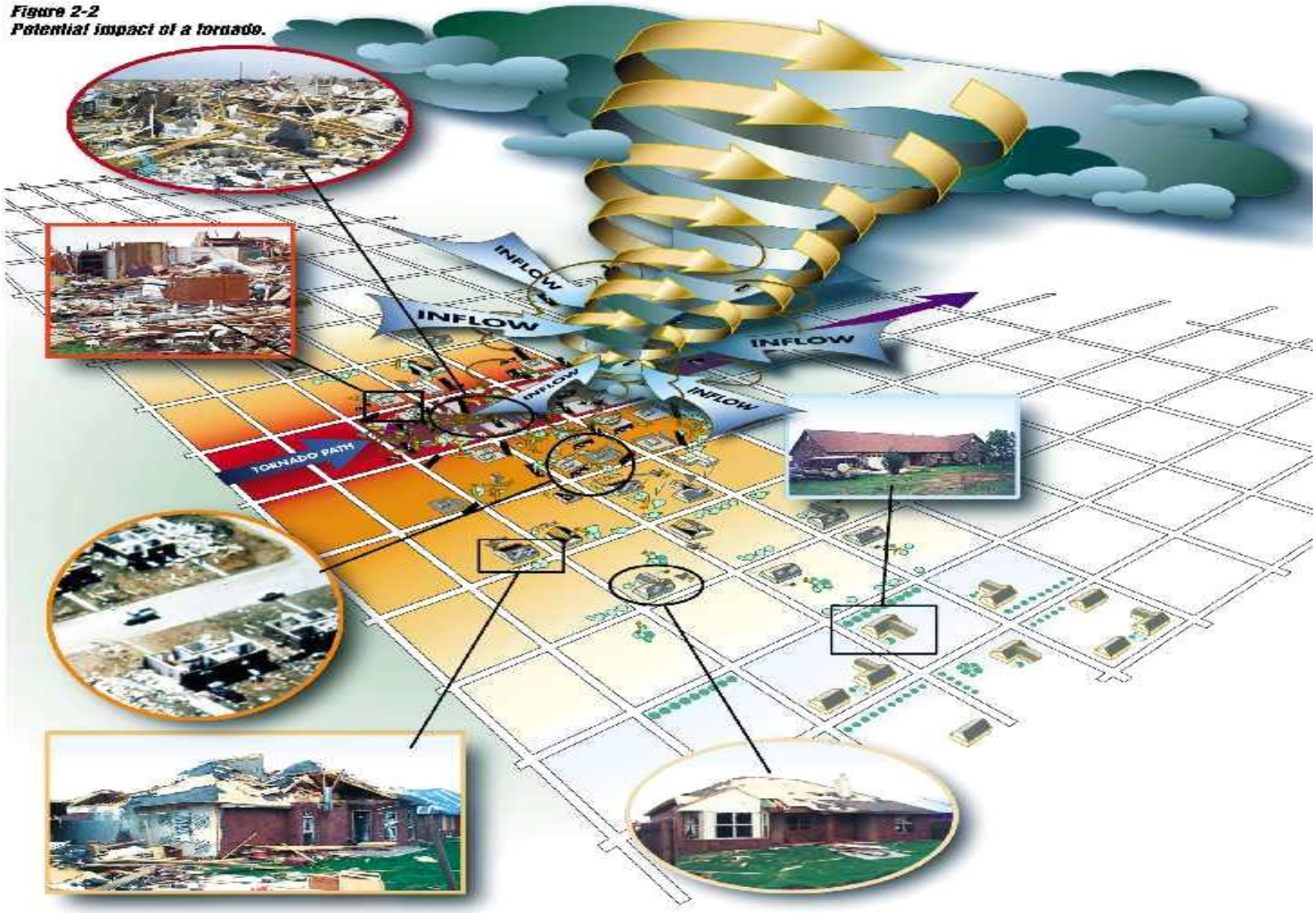

The Basic Concept…

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… is to tie it all together, regardless of where the building is located.

An engineer once told me: "Picture an angry giant picking up your house, turning it upside down and then shaking it…..

NOTHING SHOULD FALL OFF THE HOUSE!

Wall Bracing

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Old & New School:
Still fully sheathed!

Wall Bracing…

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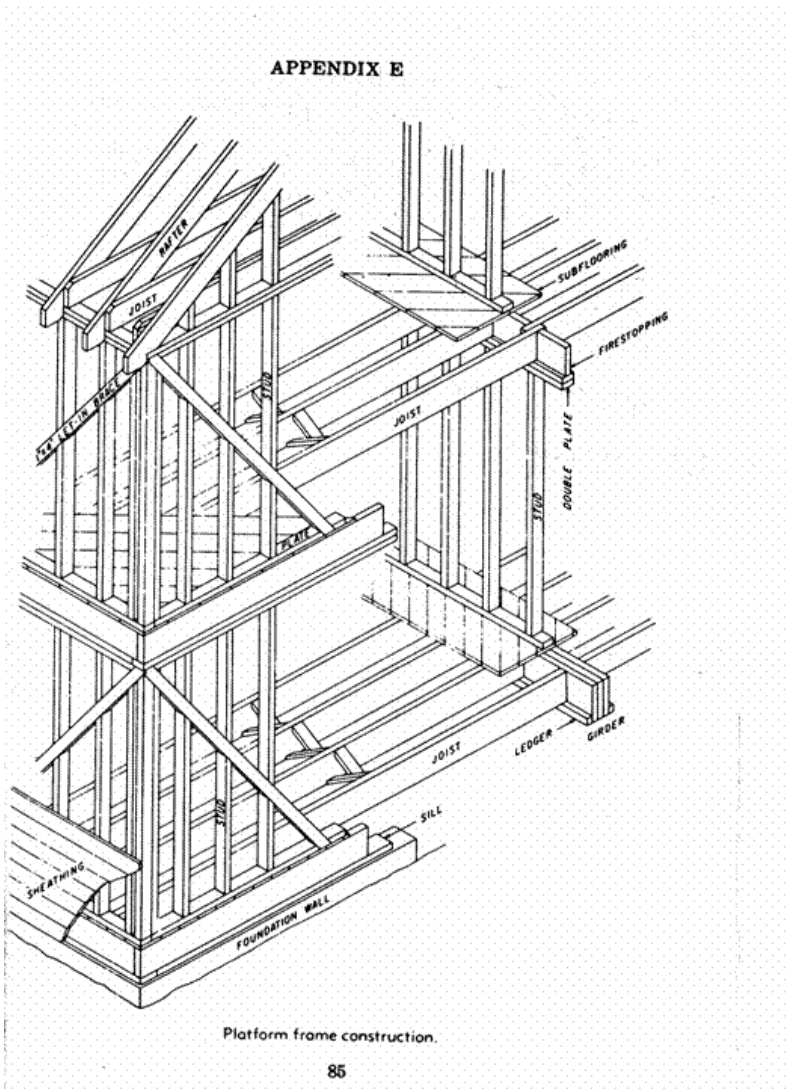
- **… comprises the vertical elements in the lateral force resisting system for many structures.**
- **… supports the horizontal diaphragms and transfers the resultant forces from the applied lateral loads into the foundation**
  - **Seismic loads**
  - **Settlement loads**
  - **Wind loads**



Wall Bracing

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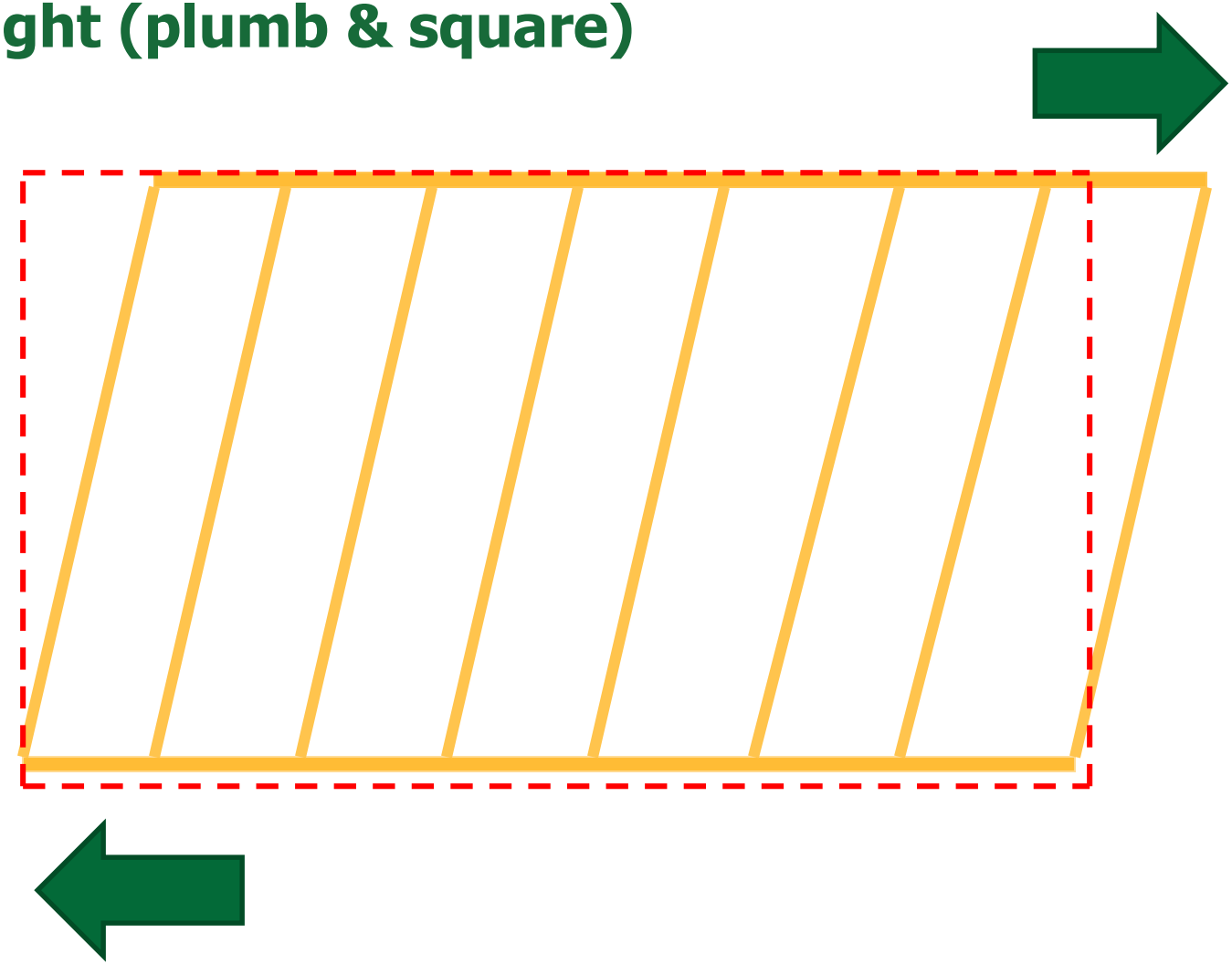
- **Bracing resists tendency to rack and keeps walls upright (plumb & square)**



Wall Bracing Methodologies

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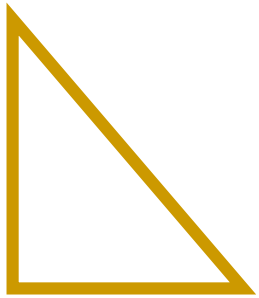
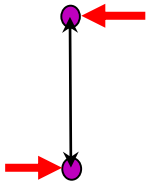
- **Three concepts:**
  - **Triangle geometry**



  - **Fastener moment couples**



  - **Rigid joints**

All of the bracing materials and systems, even in low-load areas, involve some version of what you see here.

Bracing: Triangle Geometry

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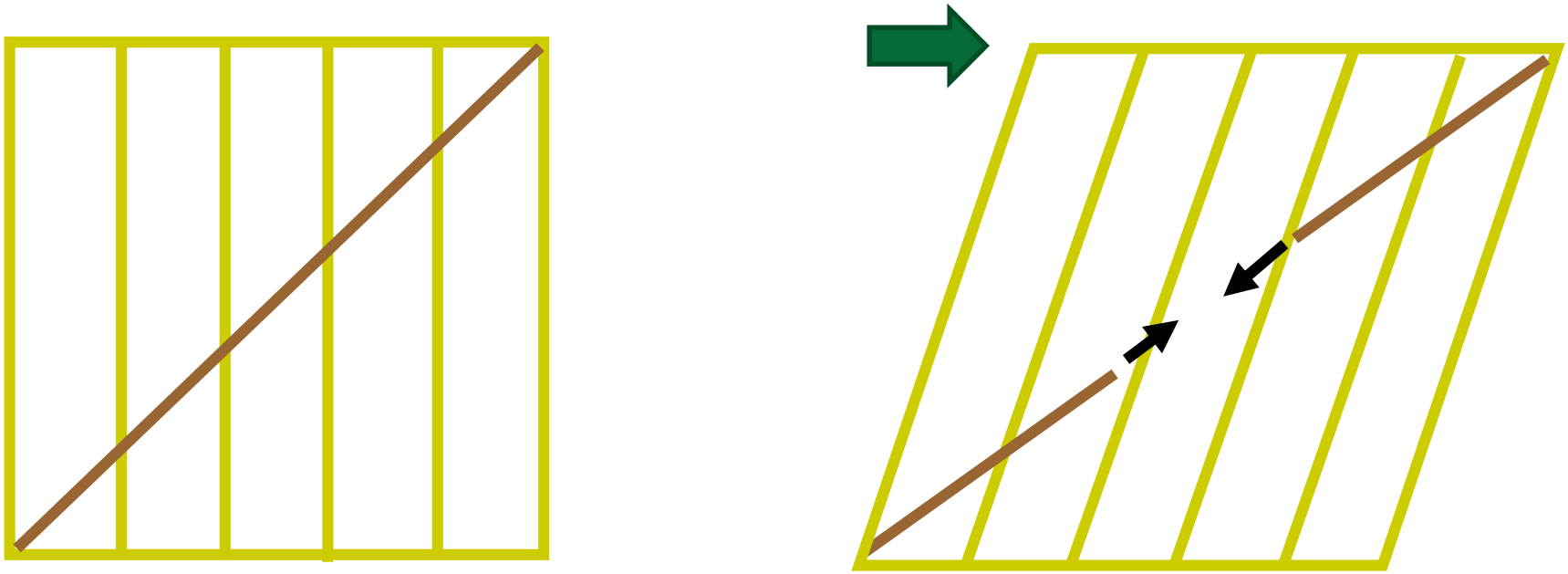

Diagonal tension tie

Bracing Triangle Geometry

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Let-in wall bracing….HELPS, but not really enough due to nail placement and quantity.

Bracing: Triangle Geometry

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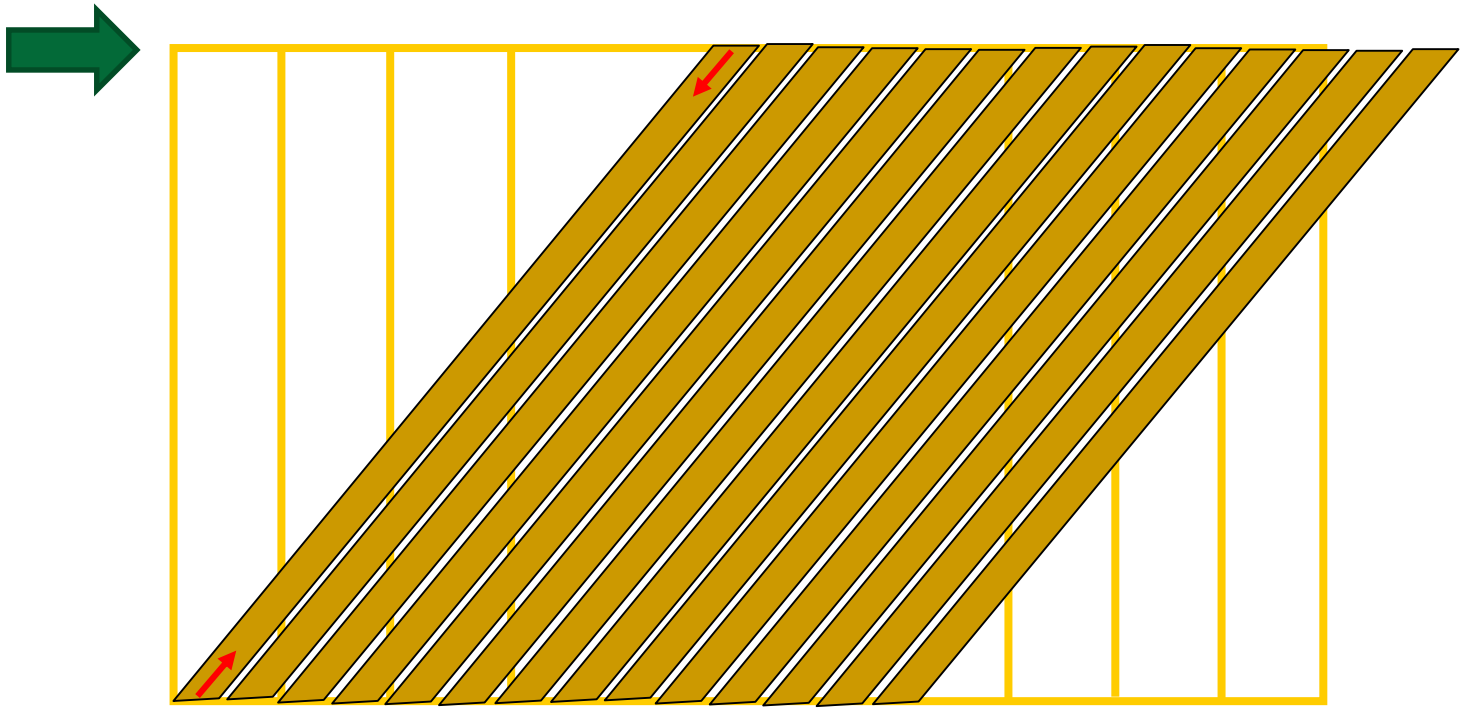
- **Diagonally sheathed wall**



A very efficient way to brace walls, and one that was common years ago, is to sheath the wall in diagonally oriented boards. What would this be if it was horizontal?

Bracing: Triangle Geometry

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- **Diagonally sheathed wall**

- **How it was done in the old school!**

Bracing: Fastener Moment Couples (WSP's)

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Bracing: Fastener Moment Couples

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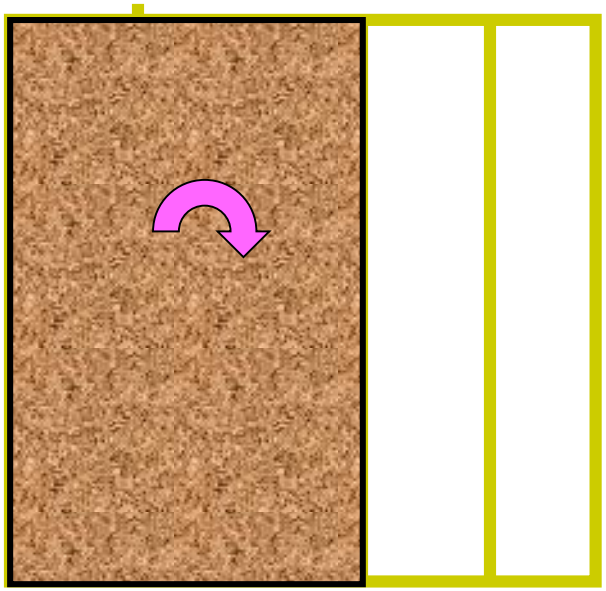

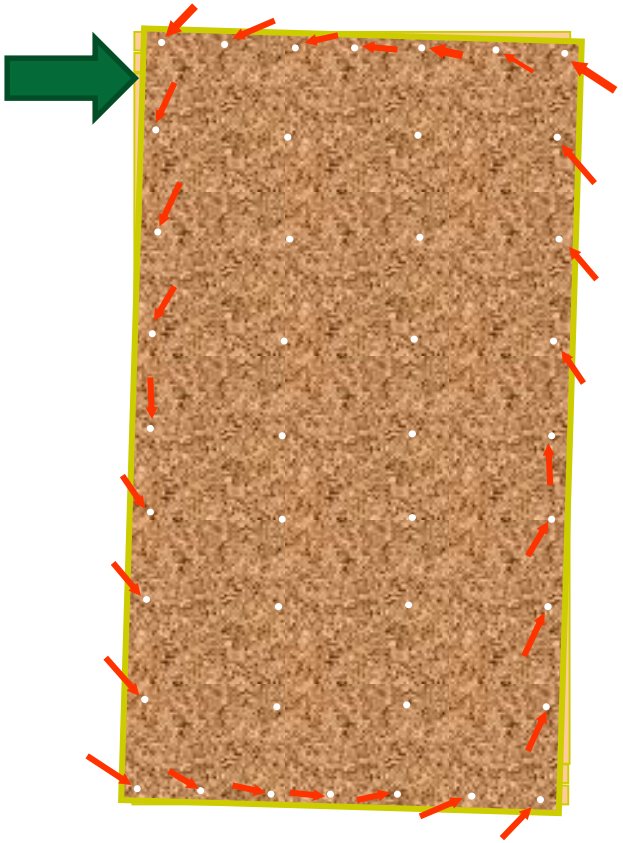

The perimeter-nailed panel resists racking through the resisting action of the perimeter nails to the applied racking moment on the panel.

Bracing: Fastener Moment Couples

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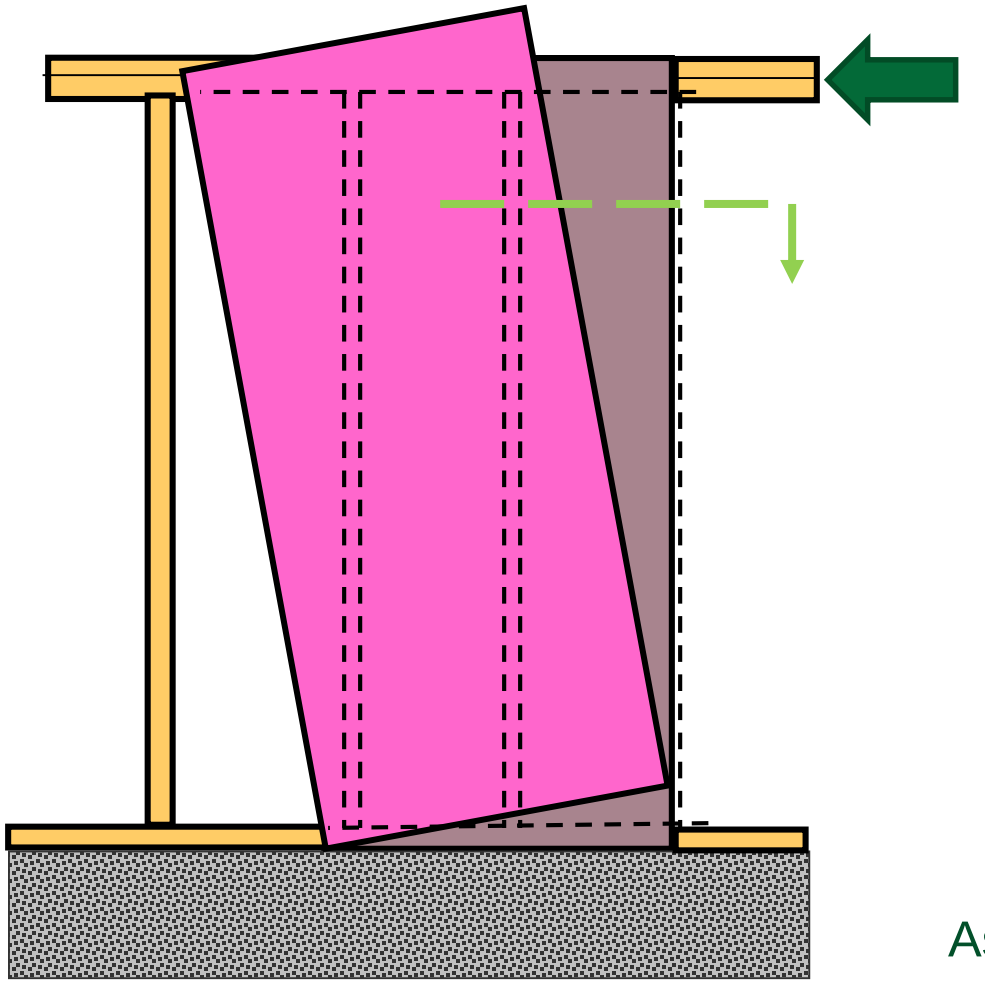
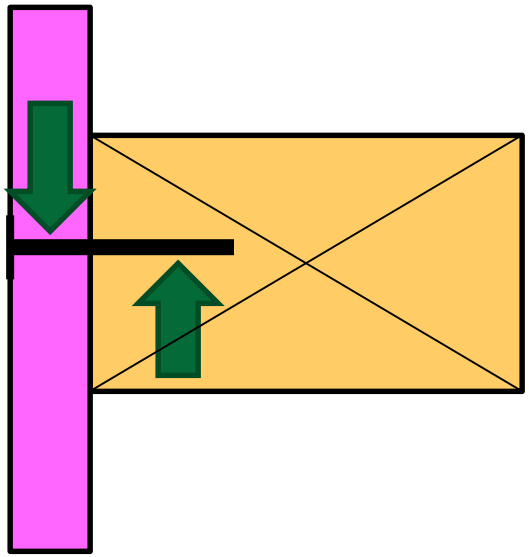


IBC 2304.9.2 Sheathing fasteners. *Sheathing nails or other approved sheathing connectors shall be driven so that their head or crown is **flush** with the surface of the sheathing.*



Assuming that the panel is fastened properly to the studs, this is happening at every nail, both on the perimeter and in the field of the panel.

Bracing: Overdriven nails?

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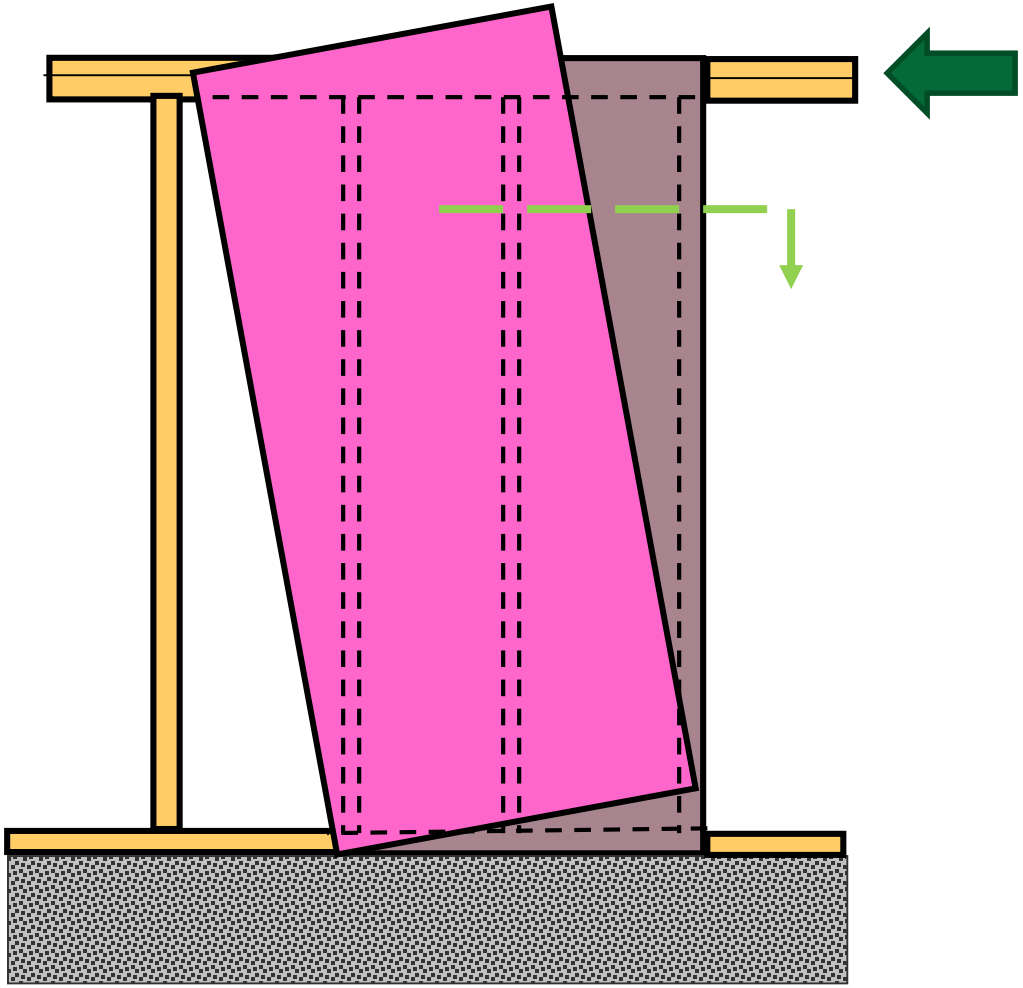

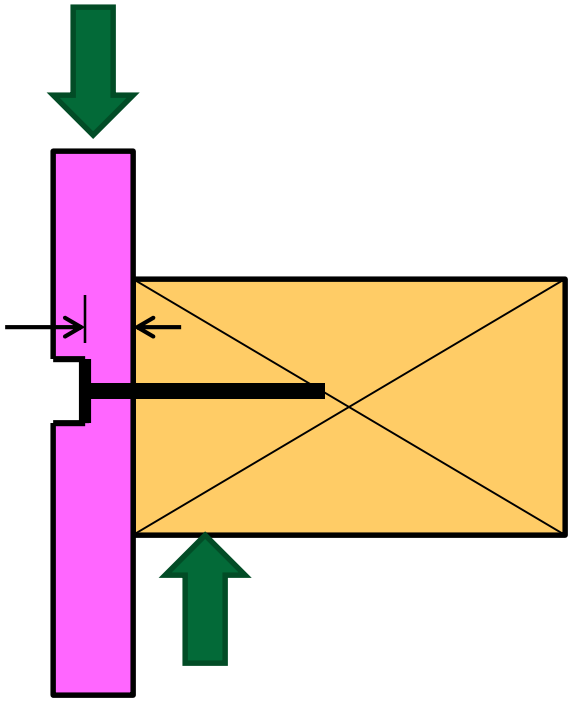

Connecting Wood- Philosophy

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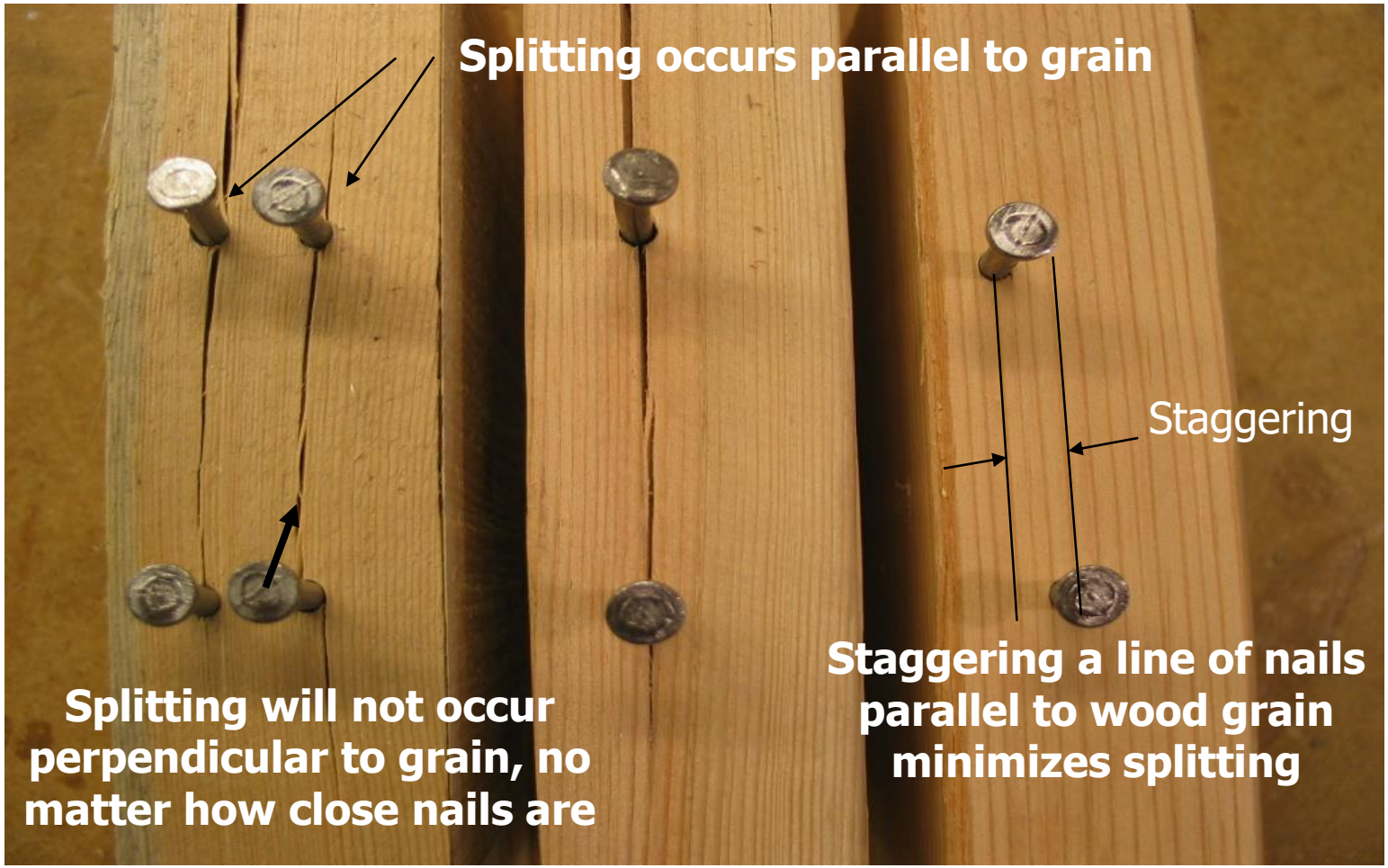

Bracing: Overdriven nails

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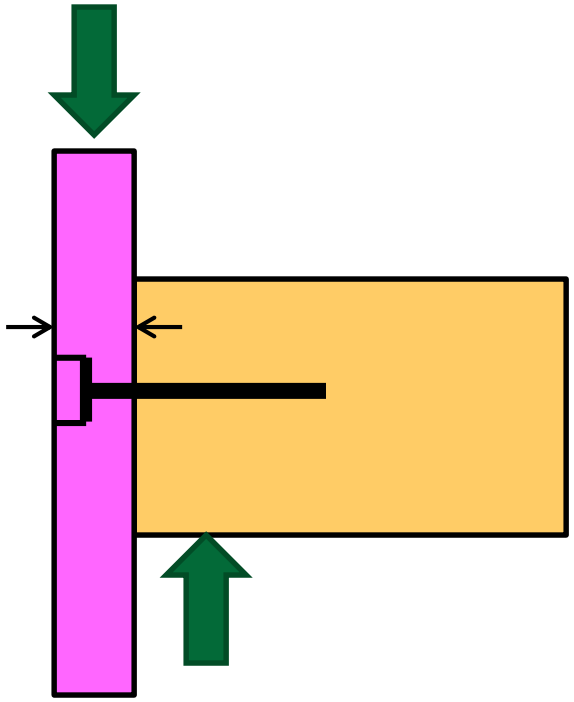
Over-driving the fasteners reduces the strength of the connection because there is less wood in contact with the fastener.

Example: If 20% or more of the nails are overdriven by 1/8”, shear capacity is reduced.

For every two (2) nails overdriven, one (1) nail must be correctly installed to address the overdriven fastener.

APA-The Engineered Wood Association has a great Technical Topic, TT-012B regarding overdriven fasteners and the resulting loss of strength.

Check this and fastener size in the field!



Bracing: Fastener Moment Couples

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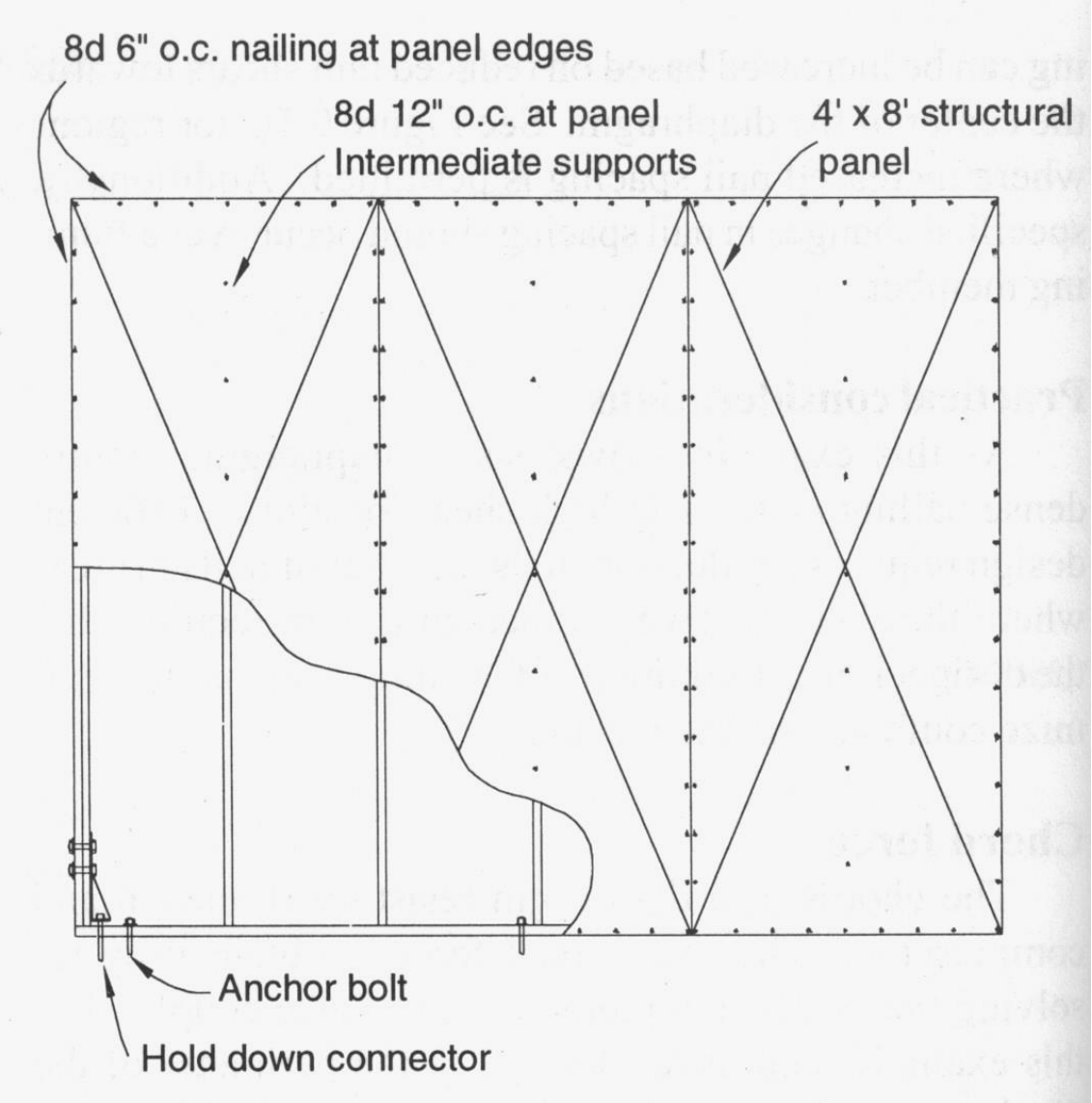
Shear wall (engineered)

Minimum wall aspect ratios apply in order to develop “shear wall action” as opposed to “cantilever beam action” when the wall panel aspect ratios become very slim.



Bracing: Fastener Moment Couples

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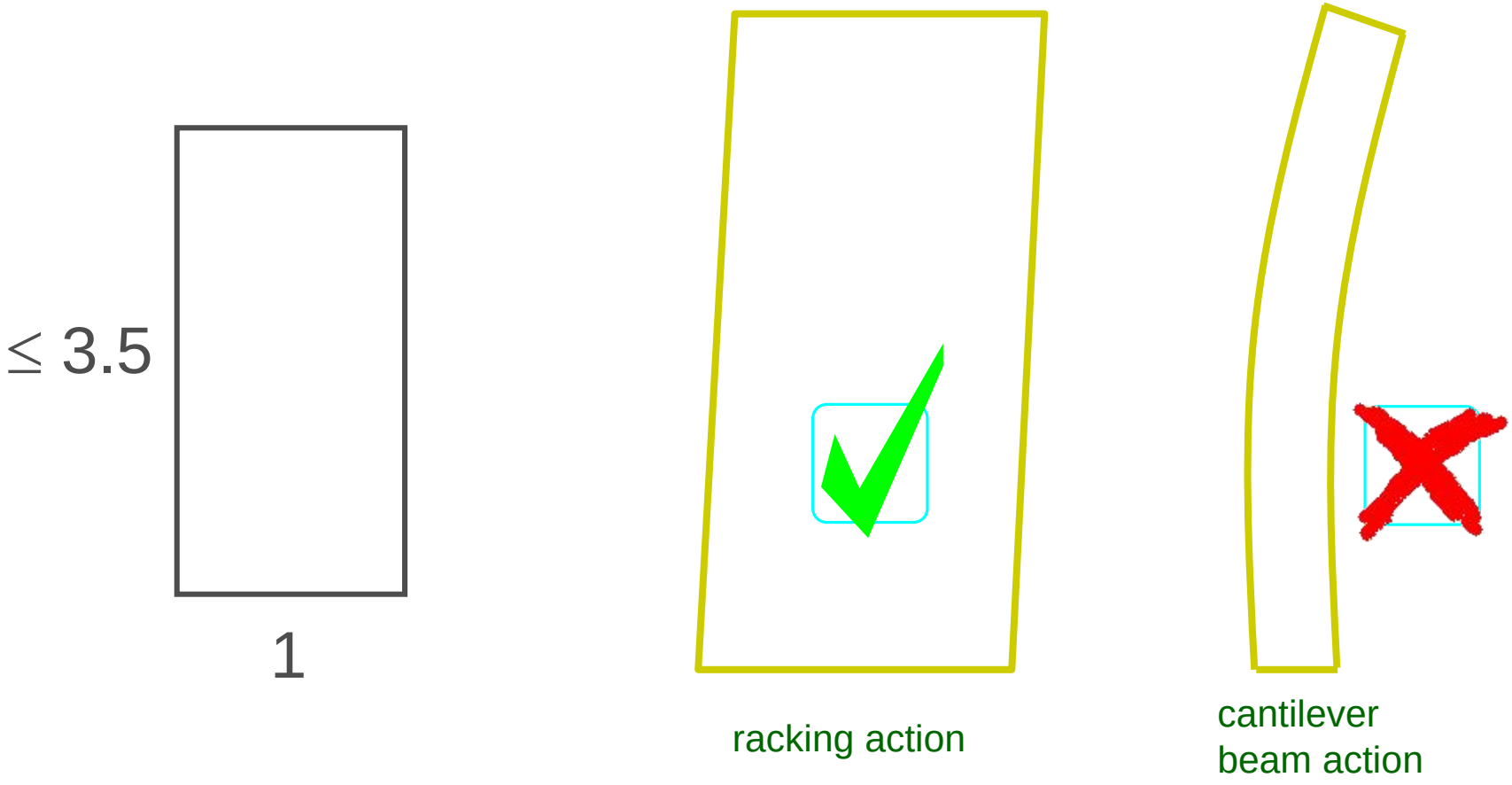
Aspect ratio critical for
prescriptive & engineered bracing



Bracing: Fastener Moment Couples

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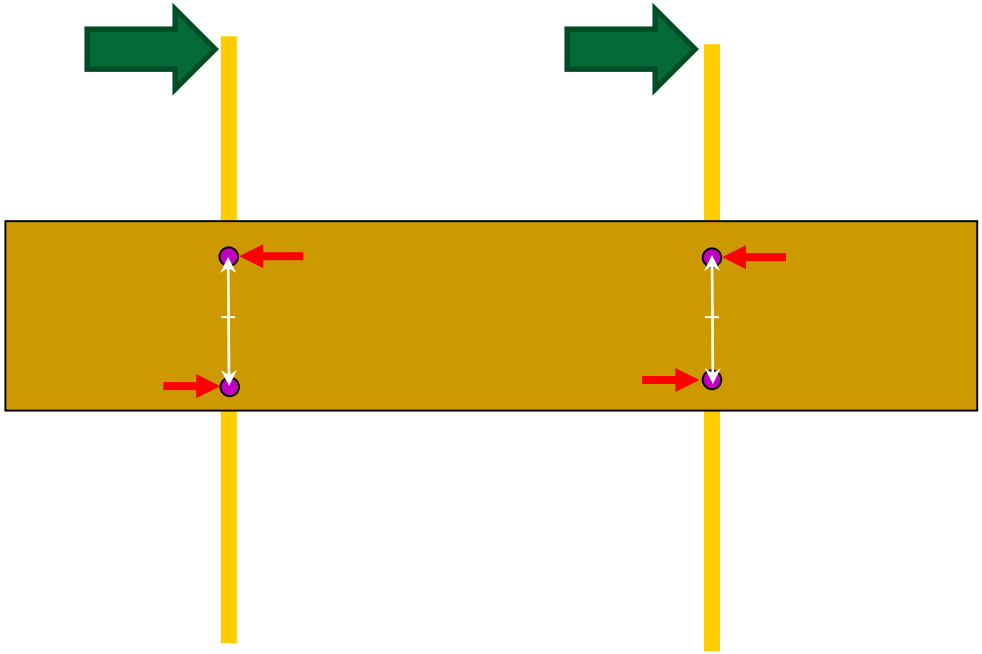

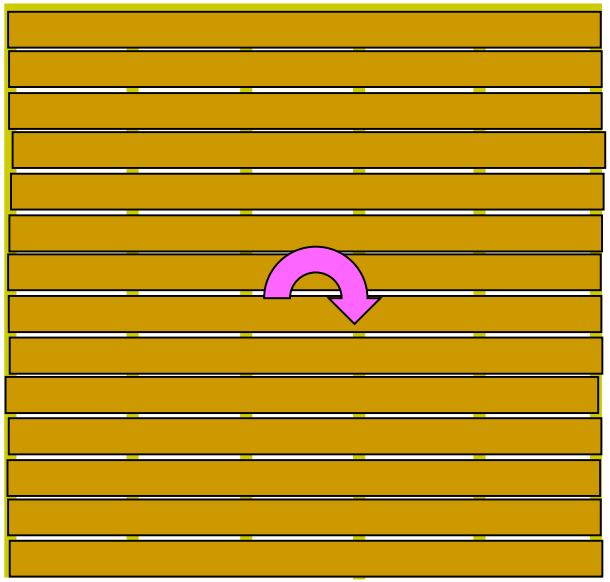

Horizontal board sheathing (minimum 2 fasteners per stud) – Same affect as panel product but to a lesser degree. The nails do the heavy work.

Bracing: Fastener Moment Couples

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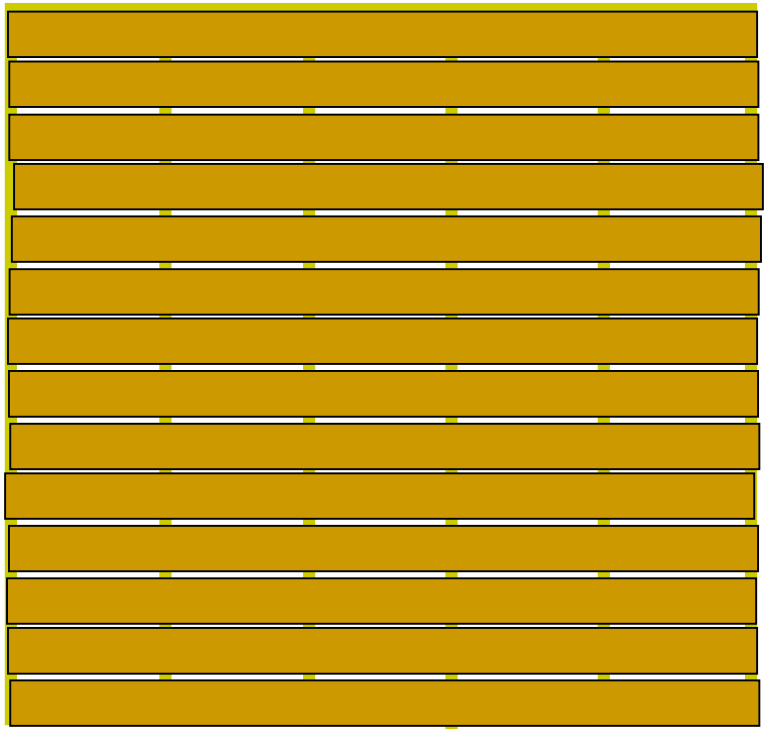

Horizontal board sheathing (minimum 2 fasteners per stud)….

How does this compare to plywood or OSB panel attachment?

Bracing: Rigid Joints

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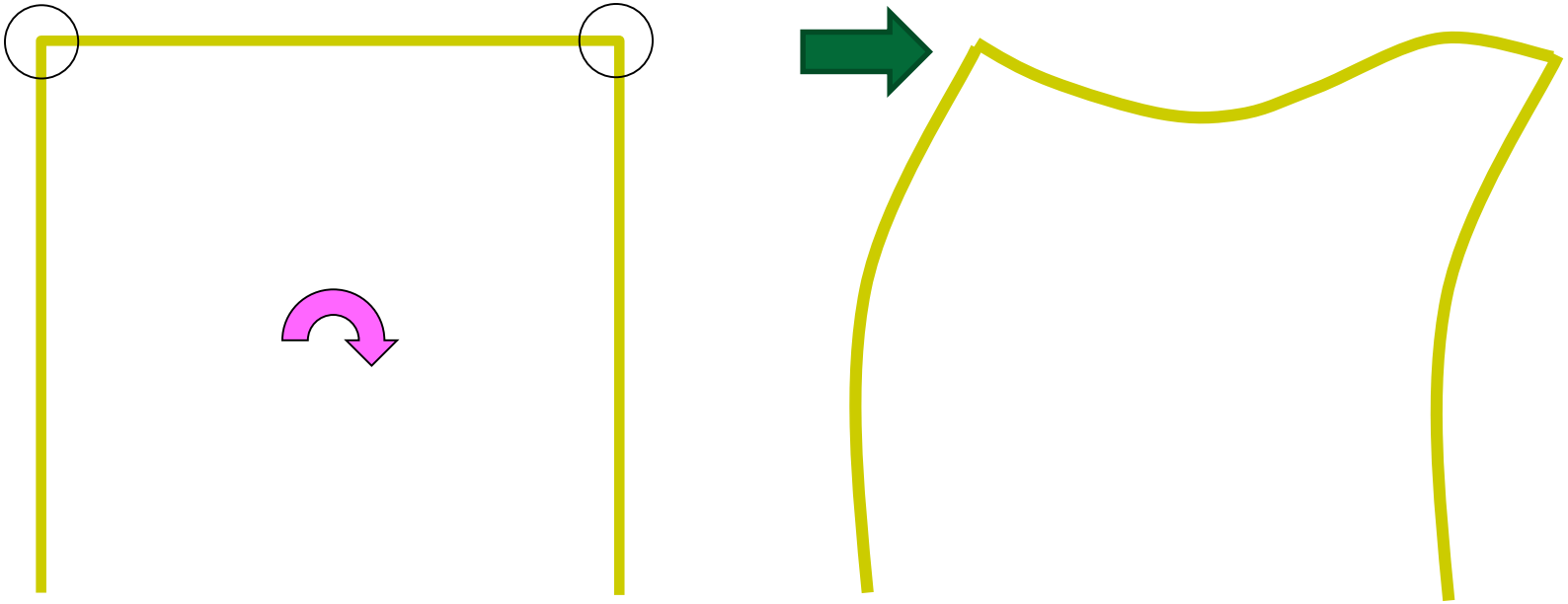
Moment frame (rigid corners)



A third method absorbs the racking moment directly in the rigid joints in the corners

Bracing: Rigid Joints

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Moment Frame

Bracing: Rigid Joints

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Bracing: Rigid Joints – portal frame with hold downs

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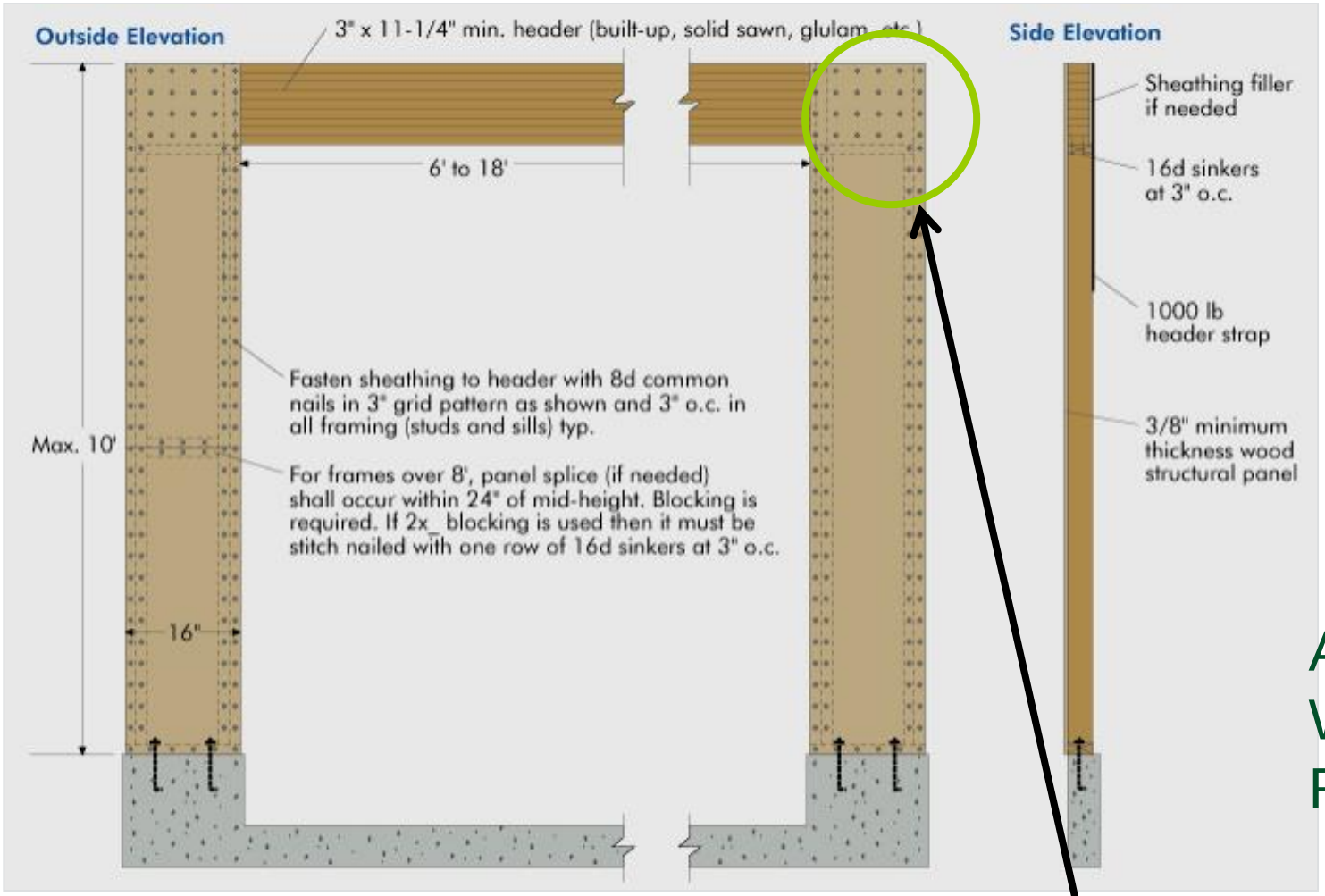

APA Narrow Wall – Figure R602.10.6.2.

Notice the attention given to making the corners rigid and the 16d Sinker nails!

General

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- **Prescriptive**
- **Bracing location – Figure R602.10.1.1**
  - **Braced wall lines composed of bracing panels & unbraced wall sections**
  - **Maximum separation between wall lines addressed**
  - **Must resist loads both directions**
  - **Allows discontinuity in wall lines**
  - **Load path**

General

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Bracing materials

- Acceptable materials listed – Table R602.10.4
- Minimum quantity needed
- Spacing of materials in the wall

- **Application**
  - ≤ 140 mph per ASCE-7-10 (2015 IRC)
  - SDC A – D2

Braced Wall Line Concept – Figure 602.10.1.1

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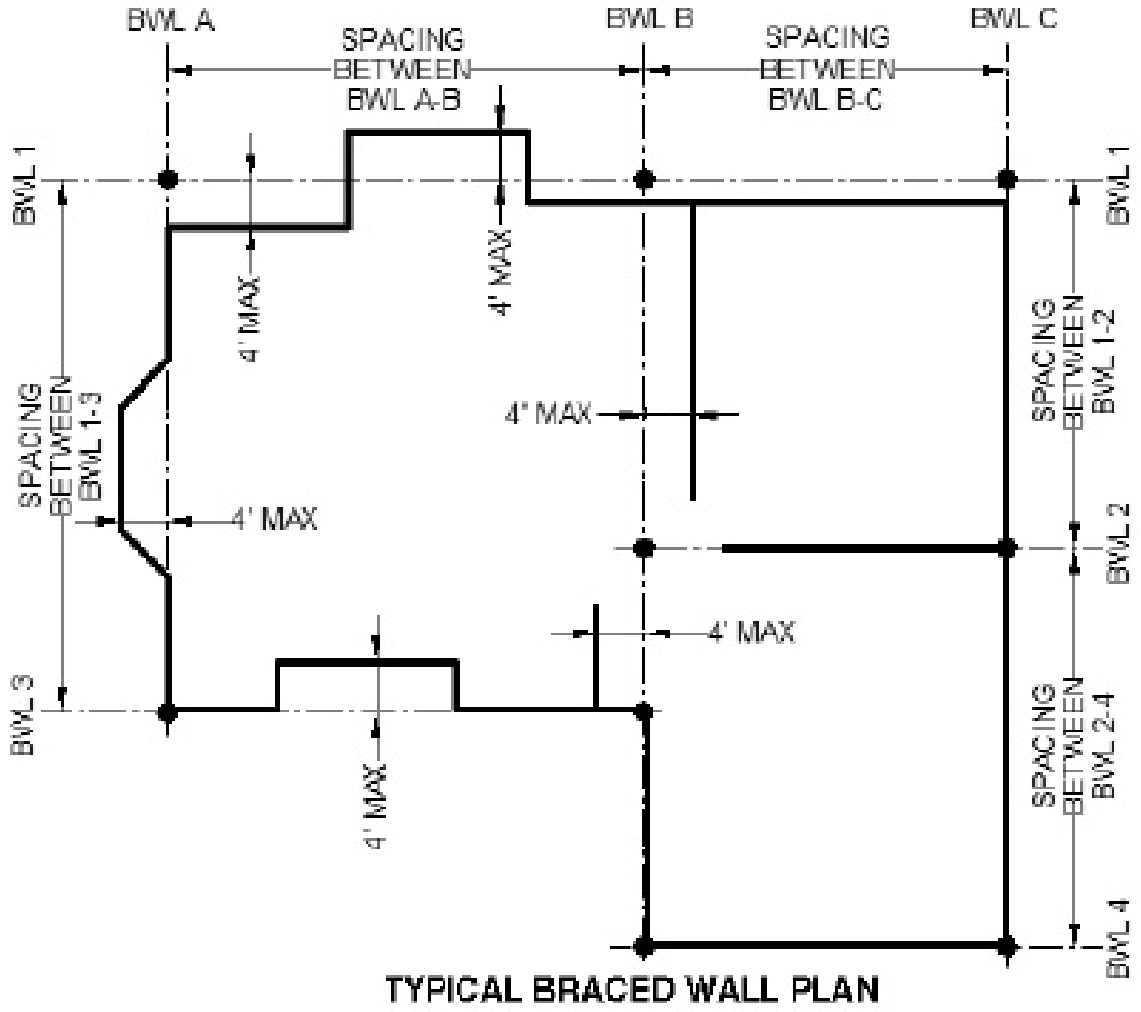
The idea is to divide the building into boxes …



TYPICAL BRACED WALL PLAN

Typical House Plan BWL Call Out

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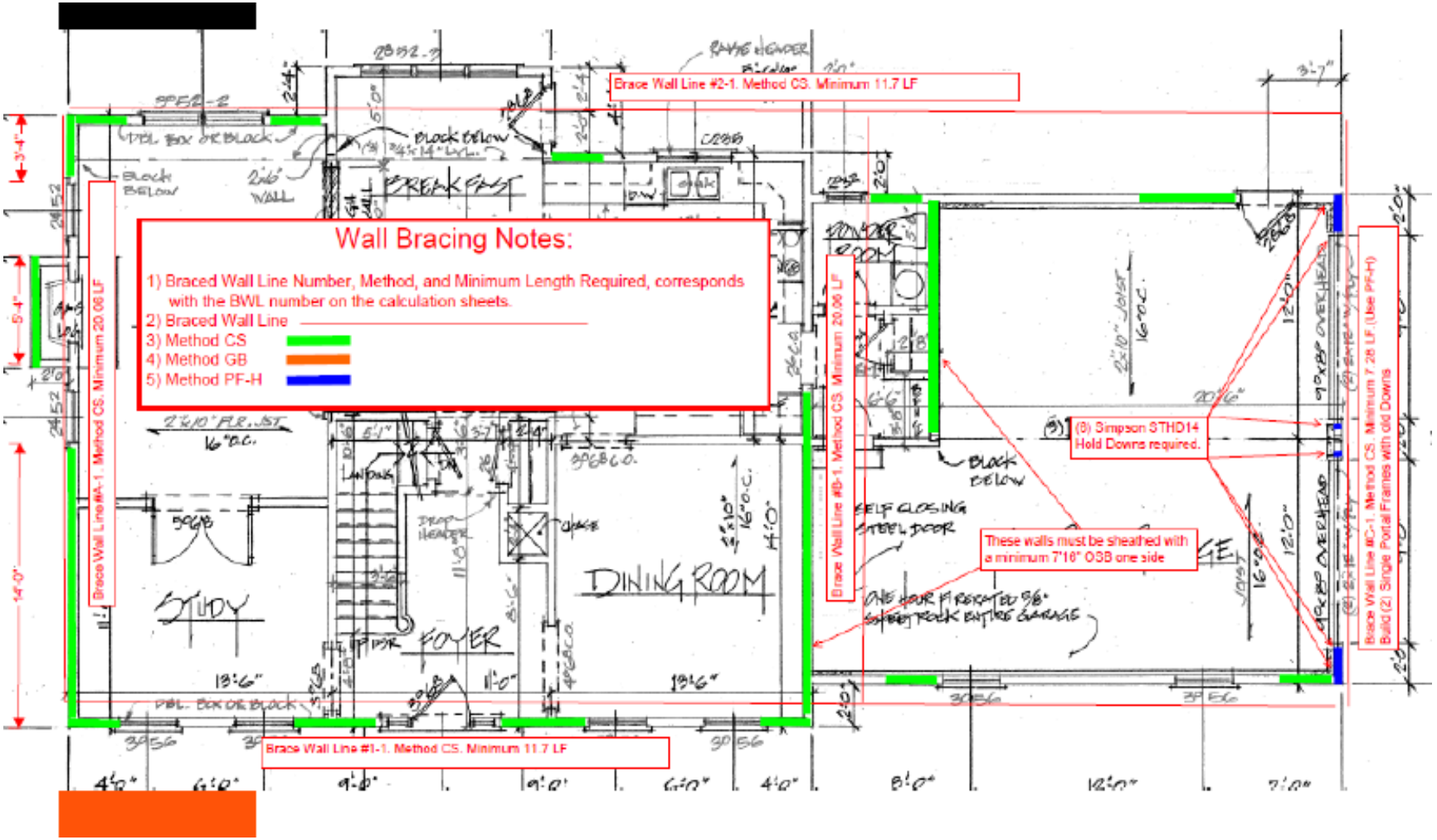

Braced Wall Lines

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Definition of "Braced Wall Lines": Straight line thru the building representing location of lateral resistance provided by wall bracing.

- **Maximum distance between lines stipulated – Table R602.10.1.3**
  - **Ranges from 60 to 10 feet.- Table 602.10.3.**
  - **More amount of bracing is required when wall spacing**

    is increased – Table R602.10.3

Braced Wall Lines

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Condition Column Revised: Ultimate design wind speed 100 mph to <140

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 â€" C	Detached	Use wind bracing	
	SDC A â€" 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, townhouses, 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).

Braced Wall Panels

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Definition of "Panels": Full-height section of wall constructed to resist in-plane shear loads thru interaction of framing members, sheathing material, & anchors. - R602.10.2

- **Can be intermittent or continuous – Section R602.10.4**
- **Bracing methods (materials) specified –Table R602.10.4**
- **Mixing of bracing methods allowed (with limits) – Section 602.10.4.1.**
- **Minimum length of bracing materials specified – Section 602.10.5. Refer to Tables R602.10.5**

Braced Wall Lines

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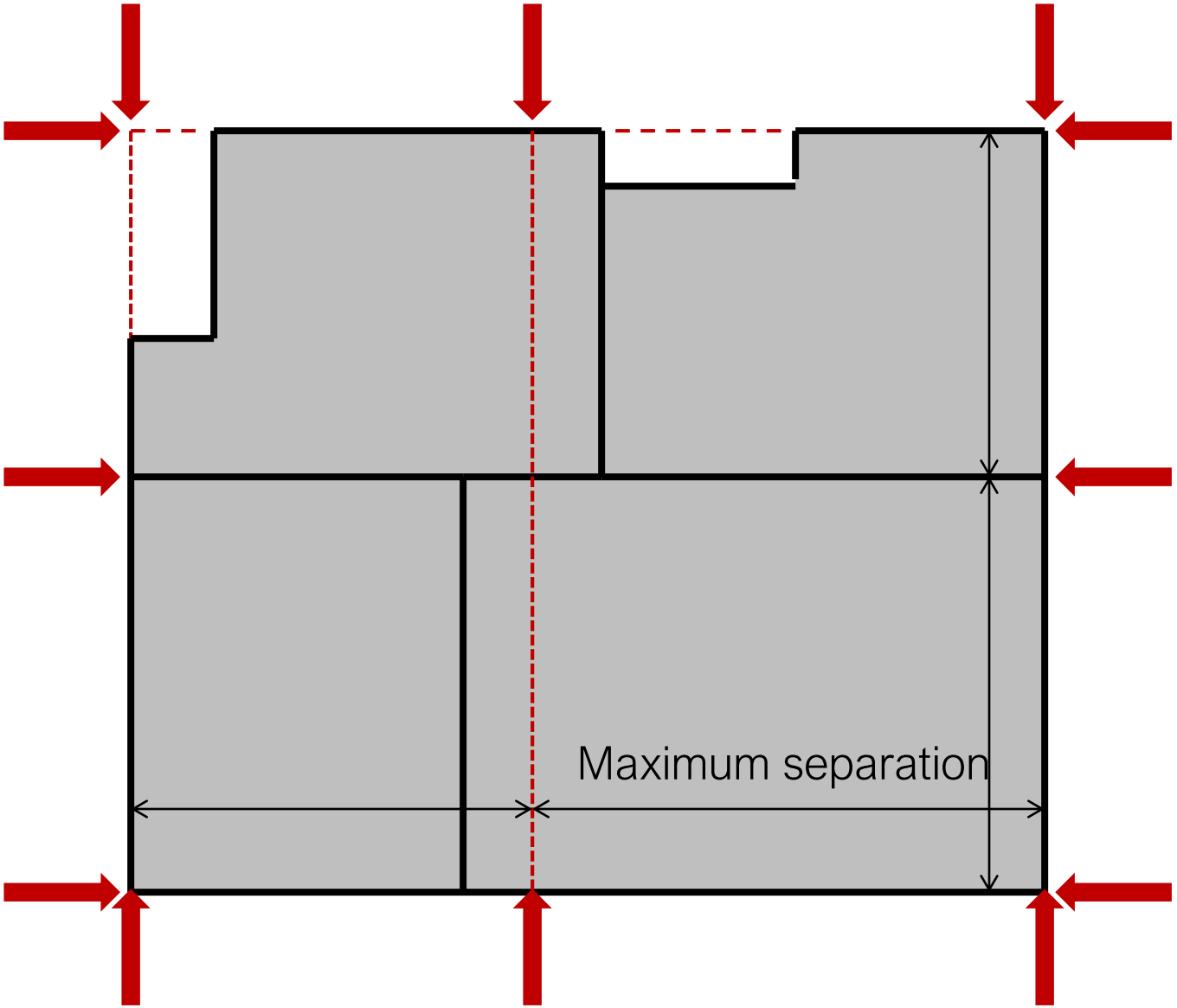

Braced Wall Panels

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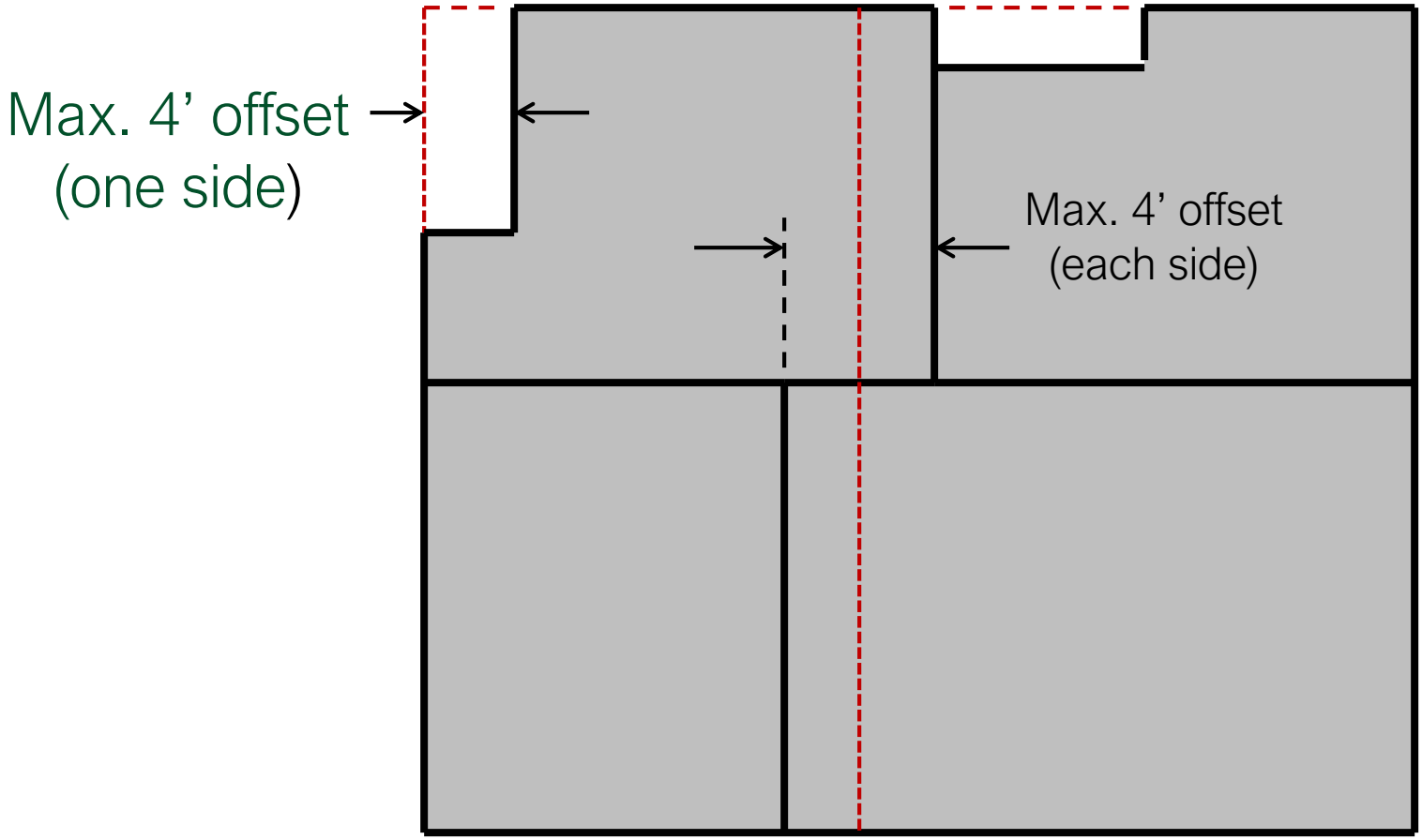

4 foot offset allowed by Section R602.10.1.2

Braced Wall Panels

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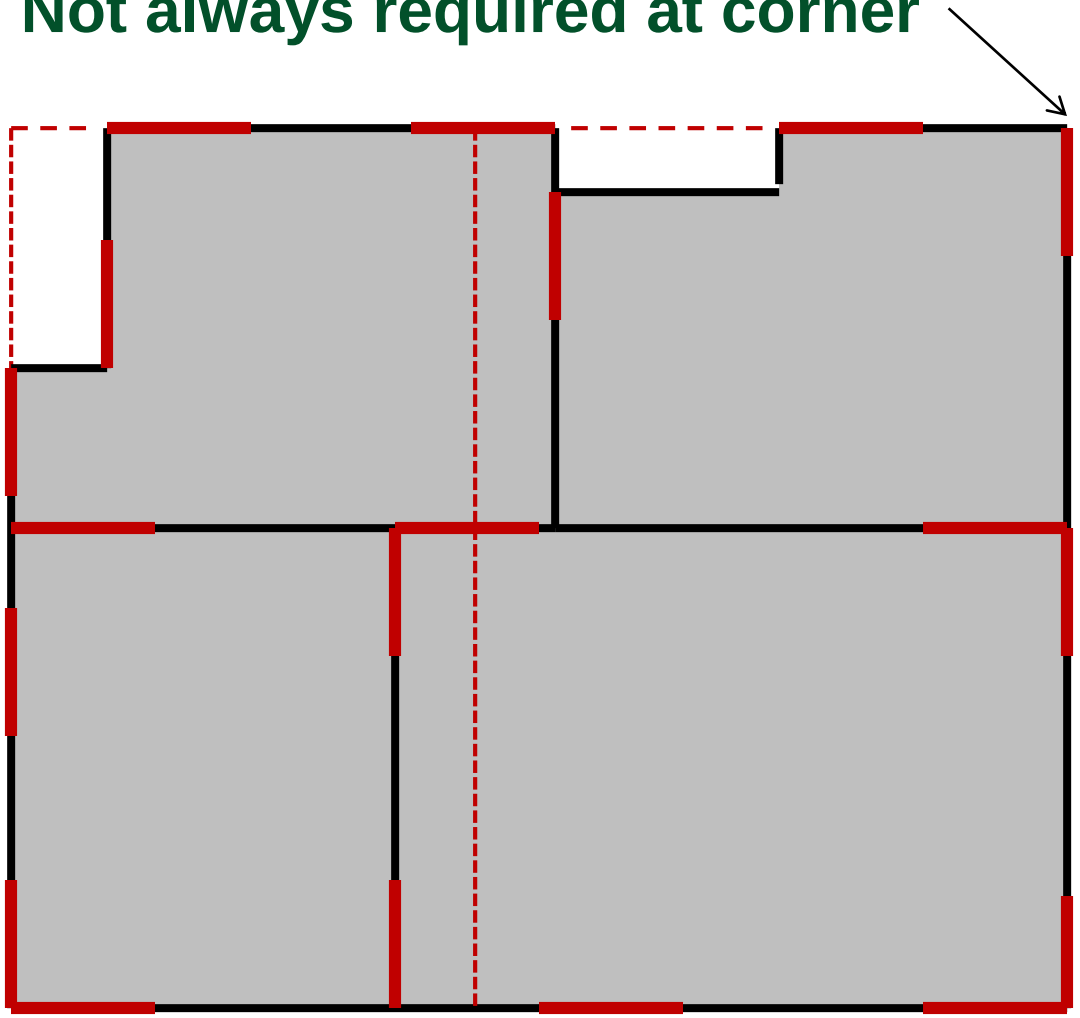
Not always required at corner



Section R602.10.2.2 allows panel to begin within 10 feet of each end of bbraced wall line.

Bracing Methods -Basic

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METHOD	MATERIAL
LIB	Let-in bracing
DWB	Diagonal wood boards
WSP	Wood structural panels (plywood/OSB)
SFB	Structural fiberboard sheathing
GB	Gypsum board
PBS	Particleboard sheathing
PCP	Portland cement plaster
HPS	Hardboard panel siding
ABW	Alternate braced wall
PFH	Intermittent portal frame (house)
PFG	Intermittent portal frame (garage)

Fasteners: Table R602.10.2

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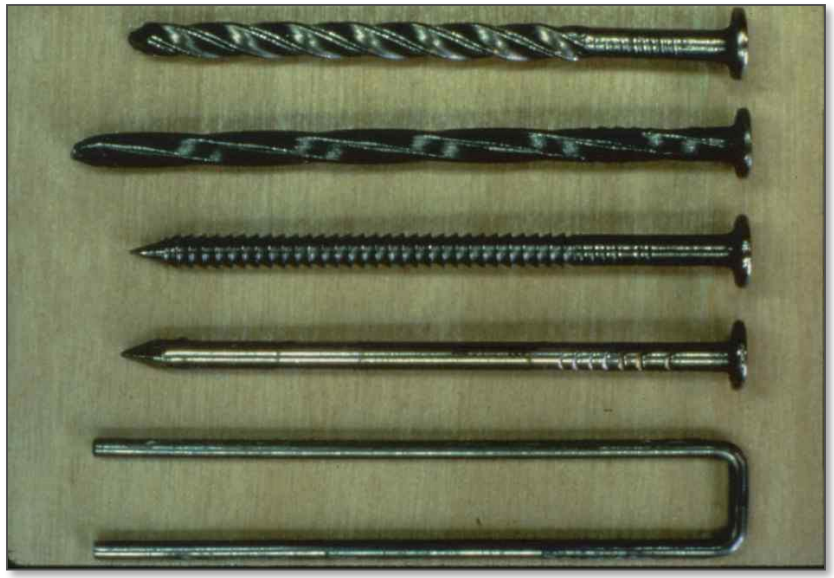
- **Fasteners requirements specific to materials**
  - **Some directly cited**
  - **Some references elsewhere**
- **Common causes of failures**
  - **Wrong connector**
  - **Too few**
  - **Not into framing member**
  - **Overdriven**
  - **Not staggered**
  - **Please review ICC-ESR 1539 for minimum equivalency!**



Bracing Methods: Table R602.10.4

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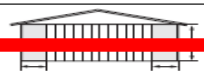
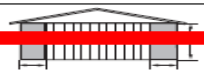
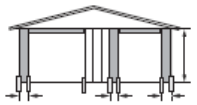
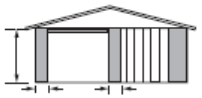
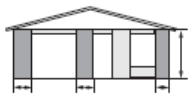
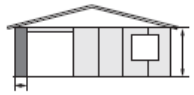
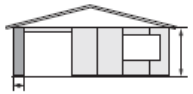
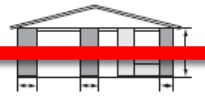
TABLE R602.10.4
BRACING METHODS

METHODS, MATERIAL		MINIMUM THICKNESS	FIGURE	CONNECTION CRITERIA[a]	
				Fasteners	Spacing
Intermittent Bracing Methods	**LIB** [illegible]	1 × 4 wood or approved metal straps at 45° to 60° angles for [illegible] stud spacing		Wood: 2-8d common nails or 3-8d ($2^1/_2$″ long x 0.113″ dia.) nails	Wood: per stud and top and bottom plates
				Metal strap: per manufacturer	Metal: per manufacturer
	DWB [illegible] wood boards	$^3/_4$″ (1″ nominal) for stud spacing		2-8d ($2^1/_2$″ long × 0.113″ dia.) nails or 2 - $1^3/_4$″ long staples	Per stud
	WSP Wood structural panel (See Section R604)	$^3/_8$″		Exterior sheathing per Table R602.3(3)	6″ edges 12″ field
				Interior sheathing per Table R602.3(1) or R602.3(2)	Varies by fastener
	BV-WSP[e] Wood structural panels with stone or masonry veneer (See Section R602.10.6.5)	[illegible]	[illegible]	8d common ($2^1/_2$″ × 0.131″) nails	4″ at panel edges 12″ at intermediate supports 4″ at braced wall panel end posts
	SFB Structural [illegible] fiberboard sheathing	$^1/_2$″ or $^{25}/_{32}$″ for [illegible] stud spacing		$1^1/_2$″ long × 0.12″ dia. (for $^1/_2$″ thick sheathing) $1^3/_4$″ long × 0.12″ dia. (for $^{25}/_{32}$″ thick sheathing) galvanized roofing nails	3″ edges 6″ field
	GB Gypsum board	[illegible]		Nails or screws per Table R602.3(1) for exterior locations	For all braced wall panel locations: 7″ edges (including top and bottom plates) 7″ field
				Nails or screws per Table R702.3.5 for interior locations	
	PBS Particleboard sheathing (See Section R605)	$^3/_8$″ or $^1/_2$″ for maximum 16″ stud spacing		For $^3/_8$″, 6d common (2″ long × 0.113″ dia.) nails For $^1/_2$″, 8d common ($2^1/_2$″ long × 0.131″ dia.) nails	3″ edges 6″ field
	PCP [illegible] cement plaster	See Section R703.7 for [illegible] stud spacing		$1^1/_2$″ long, 11 gage, $^7/_{16}$″ dia. head nails or $^7/_8$″ long, 16 gage staples	6″ o.c. on all framing members
	HPS [illegible] panel siding	$^7/_{16}$″ for maximum 16″ stud spacing		0.092″ dia., 0.225″ dia. head nails with length to accommodate $1^1/_2$″ penetration into studs	4″ edges 8″ field
	ABW Alternate braced wall	$^3/_8$″		See Section R602.10.6.1	See Section R602.10.6.1

(continued)

TABLE R602.10.4—continued
BRACING METHODS

	METHODS, MATERIAL	MINIMUM THICKNESS	FIGURE	CONNECTION CRITERIA[a]	
				Fasteners	Spacing
Intermittent Bracing Methods	**PFH** Portal frame with hold-downs	$^3/_8$″		See Section R602.10.6.2	See Section R602.10.6.2
	PFG Portal frame at garage	$^7/_{16}$″		See Section R602.10.6.3	See Section R602.10.6.3
Continuous Sheathing Methods	**CS-WSP** Continuously sheathed wood structural panel	$^3/_8$″		Exterior sheathing per Table R602.3(3)	6″ edges 12″ field
				Interior sheathing per Table R602.3(1) or R602.3(2)	Varies by fastener
	CS-G[b,c] Continuously sheathed wood structural panel adjacent to garage openings	$^3/_8$″		See Method CS-WSP	See Method CS-WSP
	CS-PF Continuously sheathed portal frame	$^7/_{16}$″		See Section R602.10.6.4	See Section R602.10.6.4
	CS-SFB[d] Continuously sheathed structural fiberboard	$^1/_2$″ or $^{25}/_{32}$″ for maximum 16″ stud spacing		$1^1/_2$″ long × 0.12″ dia. (for $^1/_2$″ thick sheathing) $1^3/_4$″ long × 0.12″ dia. (for $^{25}/_{32}$″ thick sheathing) galvanized roofing nails	3″ edges 6″ field

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad, 1 pound per square foot = 47.8 N/m^2, 1 mile per hour = 0.447 m/s.

a. Adhesive attachment of wall sheathing, including Method GB, shall not be permitted in Seismic Design Categories C, D_0, D_1 and D_2.

b. Applies to panels next to garage door opening where supporting gable end wall or roof load only. Shall only be used on one wall of the garage. In Seismic Design Categories D_0, D_1 and D_2, roof covering dead load shall not exceed 3 psf.

c. Garage openings adjacent to a Method CS-G panel shall be provided with a header in accordance with Table R602.7(1). A full-height clear opening shall not be permitted adjacent to a Method CS-G panel.

d. Method CS-SFB does not apply in Seismic Design Categories D_0, D_1 and D_2.

e. Method applies to detached one- and two-family dwellings in Seismic Design Categories D_0 through D_2 only.

Bracing Methods: Minimum length Required - Table R602.10.3(1)-2018 IRC

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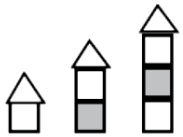
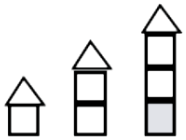
For wind – similar table for seismic

TABLE R602.10.1.2(1)[a, b, c, d, e]
BRACING REQUIREMENTS BASED ON WIND SPEED
(as a function of braced wall line spacing)

EXPOSURE CATEGORY B, 30 FT MEAN ROOF HEIGHT, 10 FT EAVE TO RIDGE HEIGHT, 10 FT WALL HEIGHT, 2 BRACED WALL LINES			MINIMUM TOTAL LENGTH (feet) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE			
Basic Wind Speed (mph)	Story Location	Braced Wall Line Spacing (feet)	Method LIB[f, h]	Method GB (double sided)[g]	Methods DWB, WSP, SFB, PCP, HPS[f, i]	Continuous Sheathing
≤ 85 (mph)		10	3.5	3.5	2.0	1.5
		20	6.0	6.0	3.5	3.0
		30	8.5	8.5	5.0	4.5
		40	11.5	11.5	6.5	5.5
		50	14.0	14.0	8.0	7.0
		60	16.5	16.5	9.5	8.0
		10	6.5	6.5	3.5	3.0
		20	11.5	11.5	6.5	5.5
		30	16.5	16.5	9.5	8.0
		40	21.5	21.5	12.5	10.5
		50	26.5	26.5	15.0	13.0
		60	31.5	31.5	18.0	15.5
		10	NP	9.0	5.5	4.5
		20	NP	17.0	10.0	8.5
		30				12.0
		40				15.5
		50	NP	39.0	22.5	19.0
		60	NP	46.5	26.5	22.5

Design Wind Speed

Adjustments made in footnotes

Bracing Methods: Minimum Required - Table R602.10.3(1)-2018 IRC

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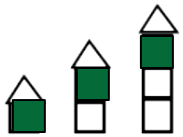
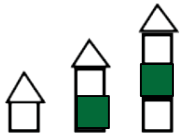
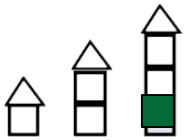
Story Location

TABLE R602.10.1.2(1)[a, b, c, d, e]
BRACING REQUIREMENTS BASED ON WIND SPEED
(as a function of braced wall line spacing)

EXPOSURE CATEGORY B, 30 FT MEAN ROOF HEIGHT, 10 FT EAVE TO RIDGE HEIGHT, 10 FT WALL HEIGHT, 2 BRACED WALL LINES			MINIMUM TOTAL LENGTH (feet) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE			
Basic Wind Speed (mph)	Story Location	Braced Wall Line Spacing (feet)	Method LIB[f, h]	Method GB (double sided)[g]	Methods DWB, WSP, SFB, PCP, HPS[f, i]	Continuous Sheathing
≤ 85 (mph)		10	3.5	3.5	2.0	1.5
		20	6.0	6.0	3.5	3.0
		30	8.5	8.5	5.0	4.5
		40	11.5	11.5	6.5	5.5
		50	14.0	14.0	8.0	7.0
		60	16.5	16.5	9.5	8.0
		10	6.5	6.5	3.5	3.0
		20	11.5	11.5	6.5	5.5
		30	16.5	16.5	9.5	8.0
		40	21.5	21.5	12.5	10.5
		50	26.5	26.5	15.0	13.0
		60	31.5	31.5	18.0	15.5
		10	NP	9.0	5.5	4.5
		20	NP	17.0	10.0	8.5
		30	NP	24.5	14.0	12.0
		40	NP	32.0	18.0	15.5
		50	NP	39.0	22.5	19.0
		60	NP	46.5	26.5	22.5

Bracing Methods: Minimum Required - Table R602.10.3(1)-2018 IRC

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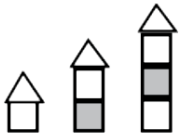
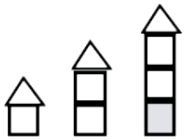
TABLE R602.10.1.2(1)[a, b, c, d, e]
BRACING REQUIREMENTS BASED ON WIND SPEED
(as a function of braced wall line spacing)

EXPOSURE CATEGORY B, 30 FT MEAN ROOF HEIGHT, 10 FT EAVE TO RIDGE HEIGHT, 10 FT WALL HEIGHT, 2 BRACED WALL LINES			MINIMUM TOTAL LENGTH (feet) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE			
Basic Wind Speed (mph)	Story Location	Braced Wall Line Spacing (feet)	Method LIB[f, h]	Method GB (double sided)[g]	Methods DWB, WSP, SFB, PCP, HPS[f, i]	Continuous Sheathing
≤ 85 (mph)		10	3.5	3.5	2.0	1.5
		20	6.0	6.0	3.5	3.0
		30	8.5	8.5	5.0	4.5
		40	11.5	11.5	6.5	5.5
		50	14.0	14.0	8.0	7.0
		60	16.5	16.5	9.5	8.0
		10	6.5	6.5	3.5	3.0
		20	11.5	11.5	6.5	5.5
		30	16.5	16.5	9.5	8.0
		40	21.5	21.5	12.5	10.5
		50	26.5	26.5	15.0	13.0
		60	31.5	31.5	18.0	15.5
		10	NP	9.0	5.5	4.5
		20	NP	17.0	10.0	8.5
		30	NP	24.5	14.0	12.0
		40	NP	32.0	18.0	15.5
		50	NP	39.0	22.5	19.0
		60	NP	46.5	26.5	22.5

Braced Wall Line Spacing

Bracing Methods: Minimum Required - Table R602.10.3(1)-2018 IRC

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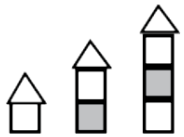
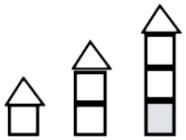
TABLE R602.10.1.2(1)[a, b, c, d, e]
BRACING REQUIREMENTS BASED ON WIND SPEED
(as a function of braced wall line spacing)

EXPOSURE CATEGORY B, 30 FT MEAN ROOF HEIGHT, 10 FT EAVE TO RIDGE HEIGHT, 10 FT WALL HEIGHT, 2 BRACED WALL LINES			MINIMUM TOTAL LENGTH (feet) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE			
Basic Wind Speed (mph)	Story Location	Braced Wall Line Spacing (feet)	Method LIB[f, h]	Method GB (double sided)[g]	Methods DWB, WSP, SFB, PCP, HPS[f, i]	Continuous Sheathing
≤ 85 (mph)		10	3.5	3.5	2.0	1.5
		20	6.0	6.0	3.5	3.0
		30	8.5	8.5	5.0	4.5
		40	11.5	11.5	6.5	5.5
		50	14.0	14.0	8.0	7.0
		60	16.5	16.5	9.5	8.0
		10	6.5	6.5	3.5	3.0
		20	11.5	11.5	6.5	5.5
		30	16.5	16.5	9.5	8.0
		40	21.5	21.5	12.5	10.5
		50	26.5	26.5	15.0	13.0
		60	31.5	31.5	18.0	15.5
		10	NP	9.0	5.5	4.5
		20	NP	17.0	10.0	8.5
		30				12.0
		40				15.5
		50				19.0
		60	NP	46.5	26.5	22.5

Methods

Minimum Length of Bracing

Greater the spacing, the more bracing required

Wind Adjustment factors Table R602.10.3(2)

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TABLE R602.10.3(2) WIND ADJUSTMENT FACTORS TO THE REQUIRED LENGTH OF WALL BRACING

ADJUSTMENT BASED ON	STORY/ SUPPORTING	CONDITION	ADJUSTMENT FACTOR[a, b] [multiply length from Table R602.10.3(1) by this factor]	APPLICABLE METHODS
Exposure category	One-story structure	B	1.00	All methods
		C	1.20	
		D	1.50	
	Two-story structure	B	1.00	
		C	1.30	
		D	1.60	
	Three-story structure	B	1.00	
		C	1.40	
		D	1.70	
Roof eave-to-ridge height	Roof only	≤ 5 feet	0.70	
		10 feet	1.00	
		15 feet	1.30	
		20 feet	1.60	
	Roof + 1 floor	≤ 5 feet	0.85	
		10 feet	1.00	
		15 feet	1.15	
		20 feet	1.30	
	Roof + 2 floors	≤ 5 feet	0.90	
		10 feet	1.00	
		15 feet	1.10	
		20 feet	Not permitted	
Wall height adjustment	Any story	8 feet	0.90	
		9 feet	0.95	
		10 feet	1.00	
		11 feet	1.05	
		12 feet	1.10	
Number of braced wall lines (per plan direction)[c]	Any story	2	1.00	
		3	1.30	
		4	1.45	
		≥ 5	1.60	
		Fastened to the		

Wind Adjustment factors Table R602.10.3(2)

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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
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
Gypsum board fastening	Any story	4 inches o.c. at panel edges, including top and bottom plates, and all horizontal joints blocked	0.7	GB

Seismic Adjustment factors Table R602.10.3(4)

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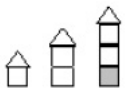
TABLE R602.10.3(4) SEISMIC ADJUSTMENT FACTORS TO THE REQUIRED LENGTH OF WALL BRACING

ADJUSTMENT BASED ON:	STORY/SUPPORTING	CONDITION	ADJUSTMENT FACTOR[a, b] [Multiply length from Table R602.10.3(3) by this factor]	APPLICABLE METHODS
Story height (Section 301.3)	Any story	≤ 10 feet	1.0	All methods
		> 10 feet and ≤ 12 feet	1.2	
Braced wall line spacing, townhouses in SDC C	Any story	≤ 35 feet	1.0	
		> 35 feet and ≤ 50 feet	1.43	
Braced wall line spacing, in SDC D_0, D_1, D_2[c]	Any story	> 25 feet and ≤ 30 feet	1.2	
		> 30 feet and ≤ 35 feet	1.4	
Wall dead load	Any story	> 8 psf and < 15 psf	1.0	
		< 8 psf	0.85	
Roof/ceiling dead load for wall supporting	Roof only or roof plus one or two stories	≤ 15 psf	1.0	
	Roof plus one or two stories	> 15 psf and ≤ 25 psf	1.1	
	Roof only	> 15 psf and ≤ 25 psf	1.2	
Walls with stone or masonry veneer, townhouses in SDC[d, e]		1.0		All intermittent and continuous methods
		1.5		
		1.5		

Braced Wall Panel Location (Intermittent Bracing)

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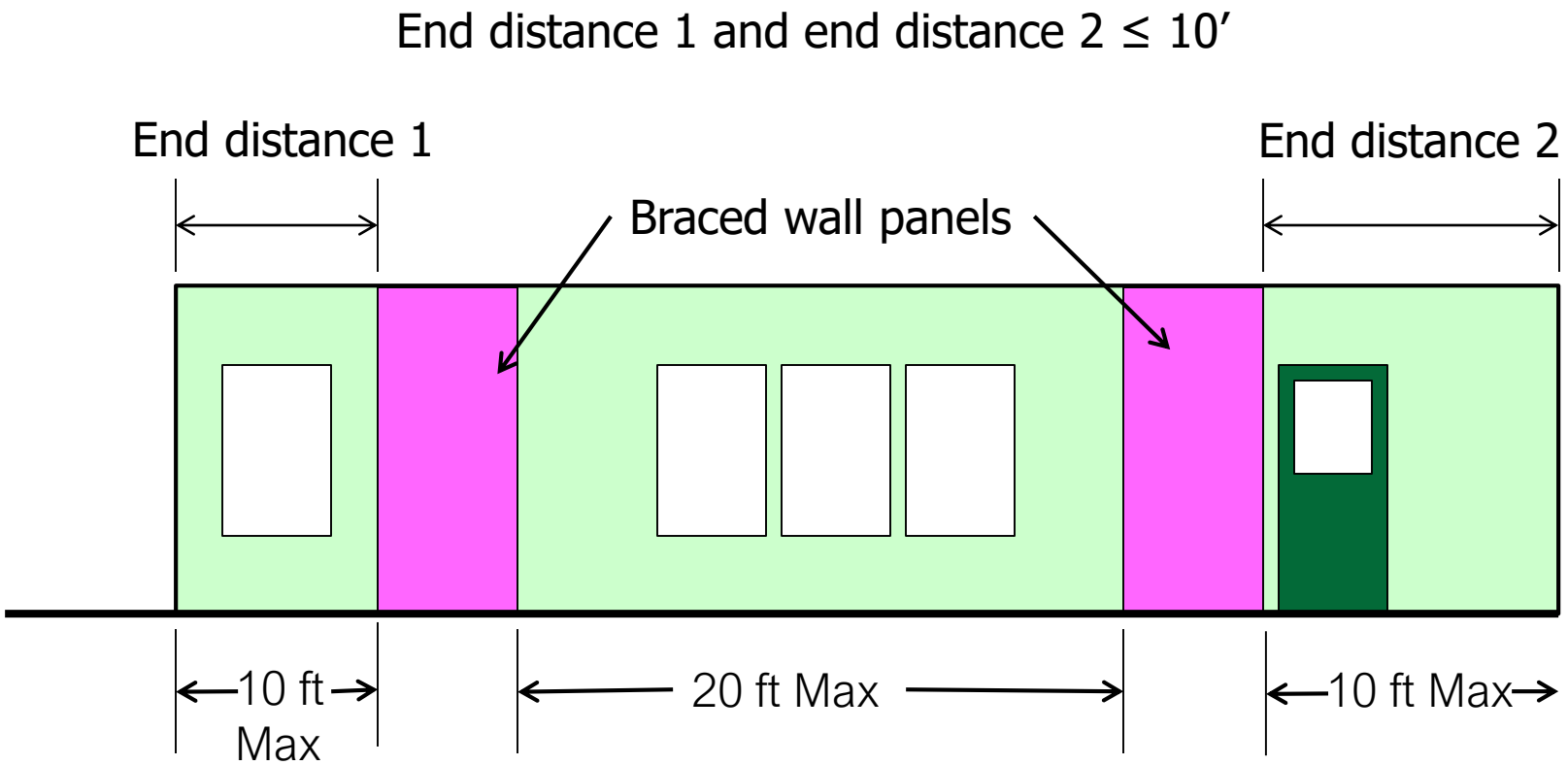
From R602.10.2.2 and related figures



Braced Wall Panel: General

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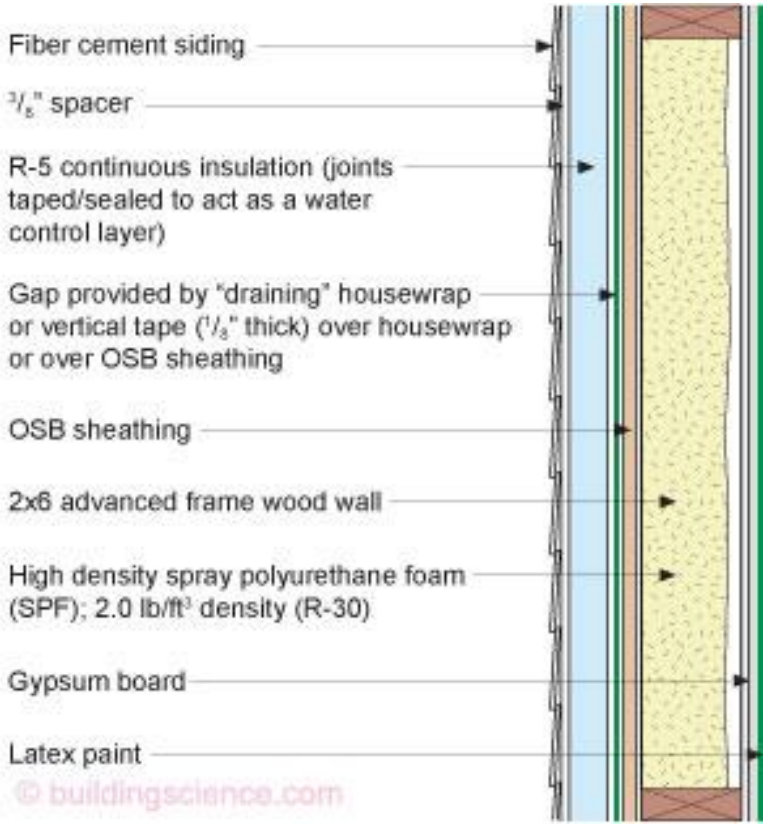
- **Gypsum wall board on side of the wall opposite bracing material – R602.10.4.3**
  - **Exceptions for some materials**



Braced Wall Panel: General

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- **Minimum length of panel specified, dependent on material – Table R602.10.5**

Braced Wall Panel: General

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- **Minimum length of panel specified, dependent on material – Table R602.10.5**

TABLE R602.10.5
MINIMUM LENGTH OF BRACED WALL PANELS

METHOD (See Table R602.10.4)		MINIMUM LENGTH[a] (Inches)					CONTRIBUTING LENGTH (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	Actual[b]
GB		48	48	48	53	58	Double sided = Actual Single sided = 0.5 × Actual
LIB		55	62	69	NP	NP	Actual[b]
ABW	SDC A, B and C, ultimate design wind speed < 140 mph	28	32	34	38	42	48
	SDC D_0, D_1 and D_2, ultimate design wind speed < 140 mph	32	32	34	NP	NP	
PFH	Supporting roof only	16	16	16	18[c]	20[c]	48
	Supporting one story and roof	24	24	24	27[c]	29[c]	48
PFG		24	27	30	33[d]	36[d]	1.5 × Actual[b]
CS-G		24	27	30	33	36	Actual[b]

Alternate Braced Wall Panel (Method ABW)

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- **Intended for narrow wall segments – Refer to Figure R602.10.6.1**
- **Hold-down devices required**
- **Requirements for foundation**
- **Specific nailing required**
- **Min. width per**
- **Table 602.10.5**
- **See anything in the pic?**

Alternate Braced Wall Panel (Method ABW)-for when you don't have enough wall!

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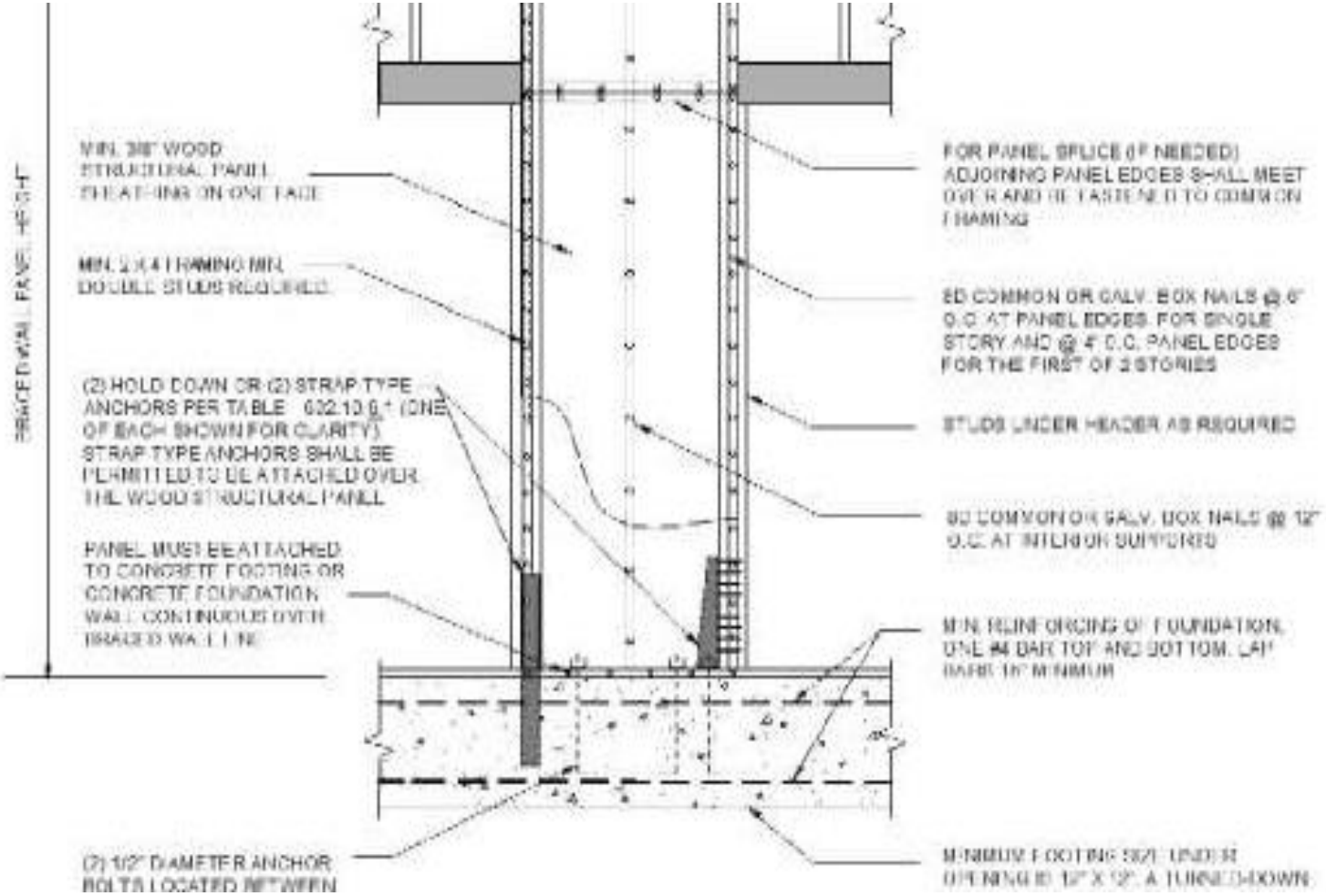
Figure R602.10.6.1



Alternate Braced Wall Panel (Method ABW)

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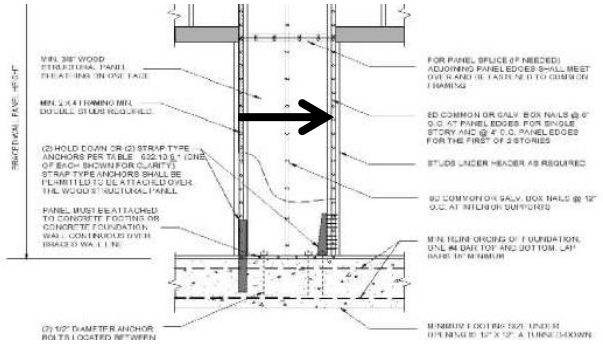
Table 602.10.5



METHOD (See Table R602.10.4)		MINIMUM LENGTH[a] (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[b]
GB		48	48	48	53	58	Double sided = Actual Single sided = 0.5 × Actual
LIB		55	62	69	NP	NP	Actual[b]
ABW	SDC A, B and C, wind speed < 110 mph	28	32	34	38	42	48
	SDC D_o, D_1 and D_2, wind speed < 110 mph	32	32	34	NP	NP	

Alternate Braced Wall Panel (Method ABW)

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Table R602.10.6.1

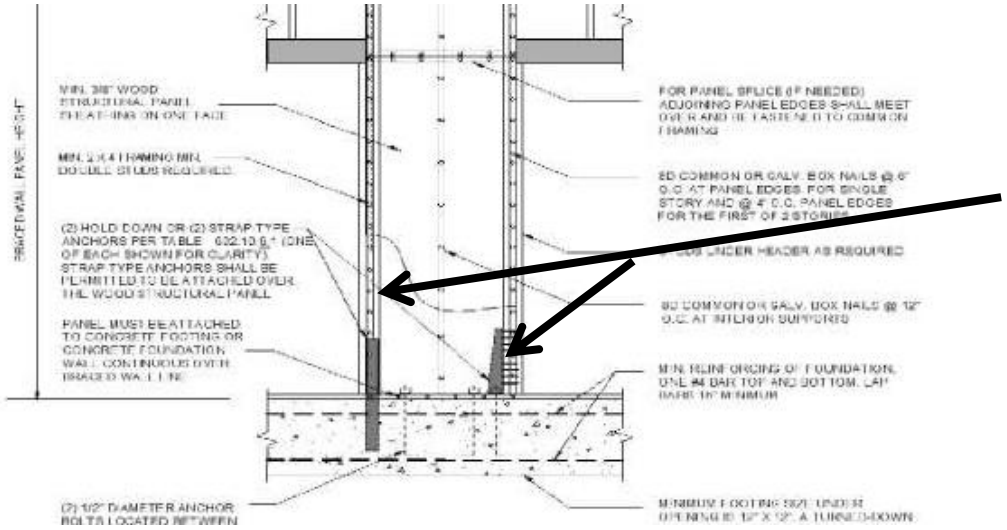

TABLE R602.10.6.1 MINIMUM HOLD-DOWN FORCES FOR METHOD ABW BRACED WALL PANELS

SEISMIC DESIGN CATEGORY AND WIND SPEED	SUPPORTING/STORY	HOLD DOWN FORCEÂ (pounds) Height of Braced Wall Panel				
		8 feet	9 feet	10 feet	11 feet	12 feet
SDC A, B and C Wind speed < 110 mph	One story	1,800	1,800	1,800	2,000	2,200
	First of two stories	3,000	3,000	3,000	3,300	3,600
SDC D_0, D_1 and D_2 Wind speed < 110 mph	One story	1,800	1,800	1,800	NP	NP
	First of two stories	3,000	3,000	3,000	NP	NP

Portal Frame Braced Wall Panel (Method PFG) - Figure R602.10.6.2

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- **Intended for narrow wall segments**
- **For use adjacent to garage door openings**
- **Limited to supporting roof or one story & roof**
- **Hold-down devices required**
- **Detailed construction requirements**
- **Requirements for foundation**

Portal Frame w/hold downs - Braced Wall Panel (Method PFH) – Figure R602.10.6.2

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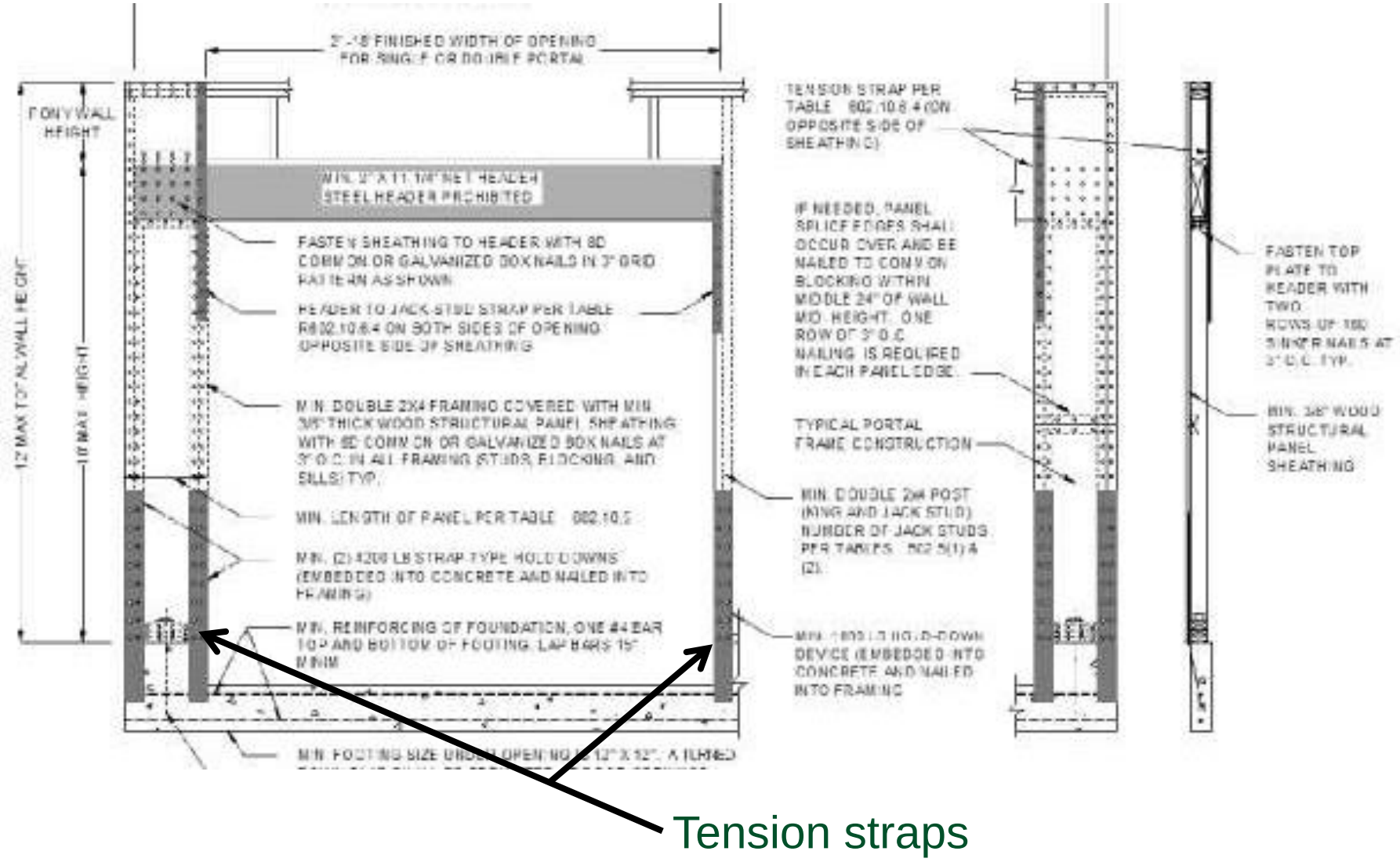

Portal Frame w/hold downs - Braced Wall Panel (Method PFH) – Table R602.10.6.4

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- **Determine tension straps -**

TABLE R602.10.6.4 TENSION STRAP CAPACITY REQUIRED FOR RESISTING WIND PRESSURES PERPENDICULAR TO METHOD PFH, PFG AND CS-PF BRACED WALL PANELS

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	0	10	18	1,000	1,000	1,000	1,000	1,000	1,000
	1	10	9	1,000	1,000	1,000	1,000	1,000	1,275
			16	1,000	1,000	1,750	1,800	2,325	3,500
			18	1,000	1,200	2,100	2,175	2,725	DR
	2	10	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	1,875	2,400	3,575	3,700	DR	DR
	2	12	9	1,000	1,200	2,075	2,125	2,750	4,000
			16	2,600	3,200	DR	DR	DR	DR
			18	3,175	3,850	DR	DR	DR	DR
	4	12	9	1,775	2,350	3,500	3,550	DR	DR
			16	4,175	DR	DR	DR	DR	DR
2 × 6 Stud Grade	2	12	9	1,000	1,000	1,325	1,375	1,750	2,550
			16	1,650	2,050	2,925	3,000	3,550	DR
			18	2,025	2,450	3,425	3,500	4,100	DR
	4	12	9	1,125	1,500	2,225	2,275	2,775	3,800
			16	2,650	3,150	DR	DR	DR	DR
			18	3,125	3,675	DR	DR	DR	DR

Portal Frame w/hold downs - Braced Wall Panel (Method PFH) – Table R602.10.5

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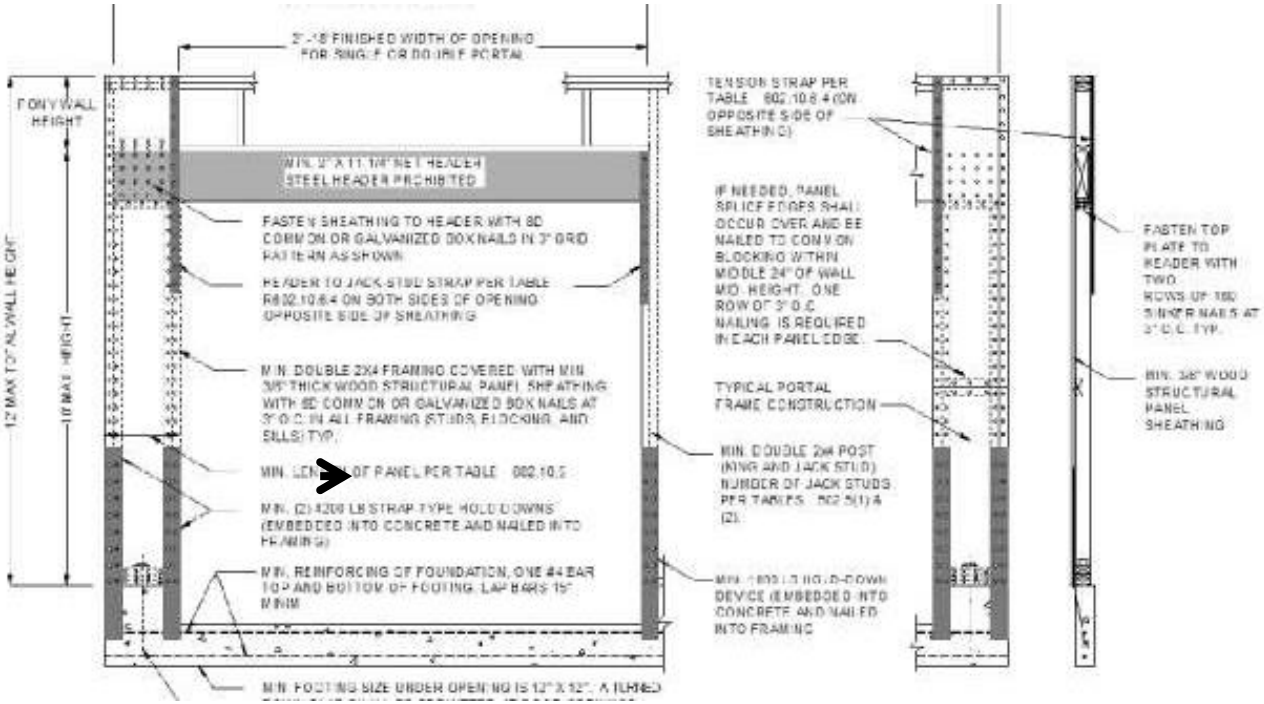

Minimum length of braced wall panels

METHOD (See Table R602.10.4)		Portal header height					
		8 feet	9 feet	10 feet	11 feet	12 feet	
PFH	Supporting roof only	16	16	16	Note c	Note c	48
	Supporting one story and roof	24	24	24	Note c	Note c	
PFG		24	27	30	Note d	Note d	1.5 × Actual[b]
CS-PF	SDC A, B and C	16	18	20	Note e	Note e	1.5 × Actual[b]
	SDC D_0, D_1 and D_2	16	18	20	Note e	Note e	Actual[b]

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.
NP = Not Permitted.
a. Linear interpolation shall be permitted.
b. Use the actual length where it is greater than or equal to the minimum length.
c. Maximum header height for PFH is 10 feet in accordance with Figure R602.10.6.2, but wall height shall be permitted to be increased to 12 feet with pony wall.
d. Maximum header height for PFG is 10 feet in accordance with Figure R602.10.6.3, but wall height shall be permitted to be increased to 12 feet with pony wall.
e. Maximum header height for CS-PF is 10 feet in accordance with Figure R602.10.6.4, but wall height shall be permitted to be increased to 12 feet with pony wall.

Continuously Sheathed Braced Walls

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- **Provisions greatly revised over the last two code cycles.**

Continuously Sheathed Braced Walls

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- **Definition: Braced wall line, continuously sheathed – Braced wall line with structural sheathing applied to all sheathable surfaces including areas above and below openings.**
- **R602.10.4.2: All lines along exterior walls on same story shall be continuously sheathed.**
- **Must comply with the requirements of Section R602.10.7**
  - **Refers to Figure R602.10.7 which details end of braced walls conditions. One of these conditions are required.**

Continuously Sheathed Braced Walls

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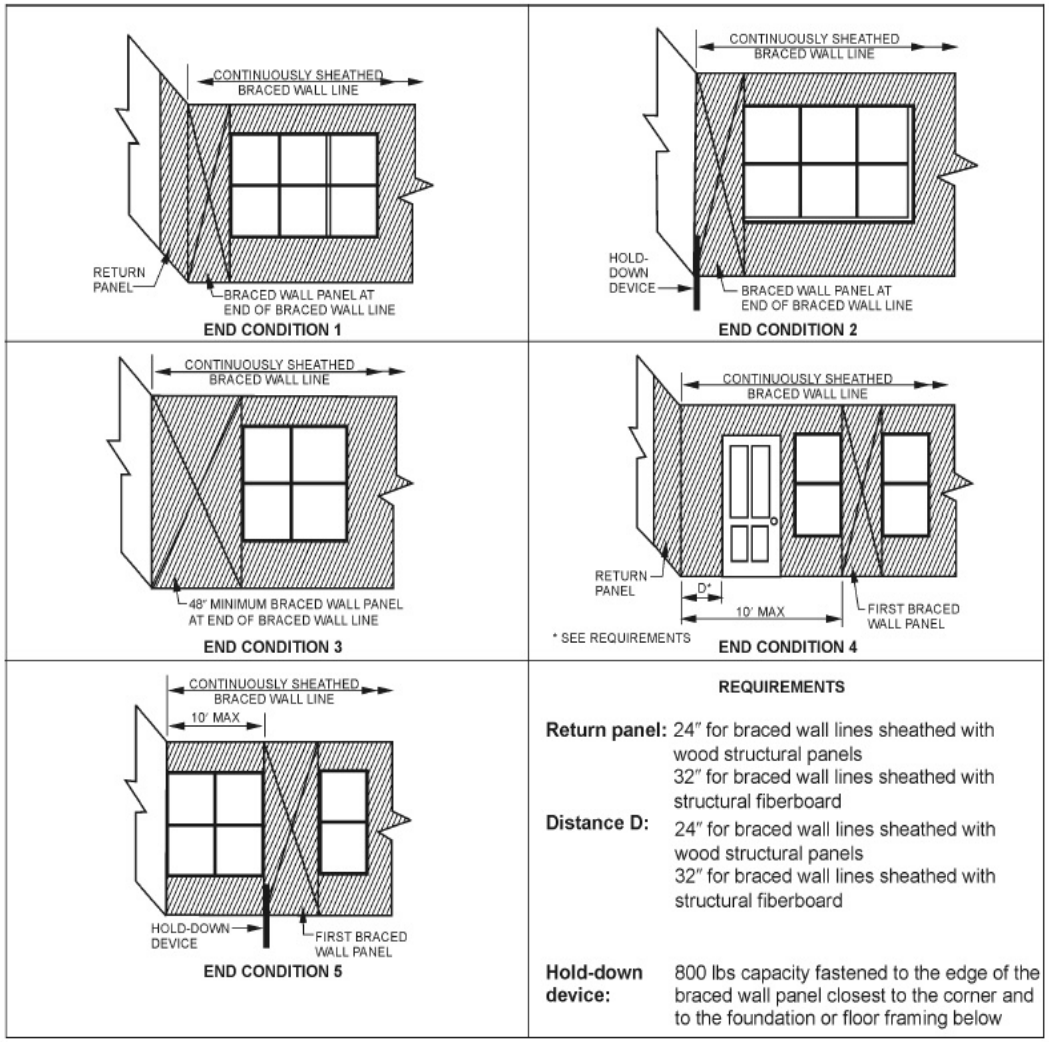
- **Figure R602.10.7**
- **Full sheathing reinforces all sides of the structure, even if the walls weren't designed as braced wall lines or shear walls.**



Continuously Sheathed Braced Walls

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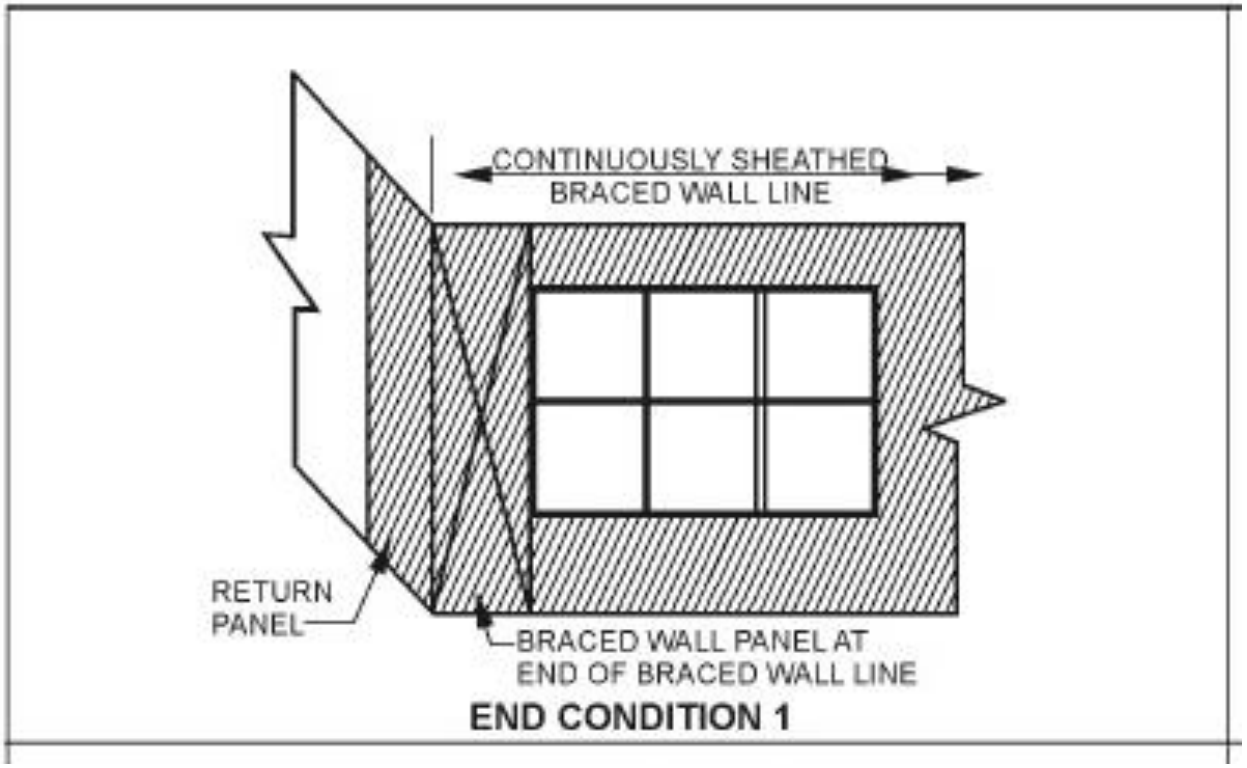
- **Return panel 24 inch wall.**
- **32 inch for structural fiberboard**



Continuously Sheathed Braced Walls

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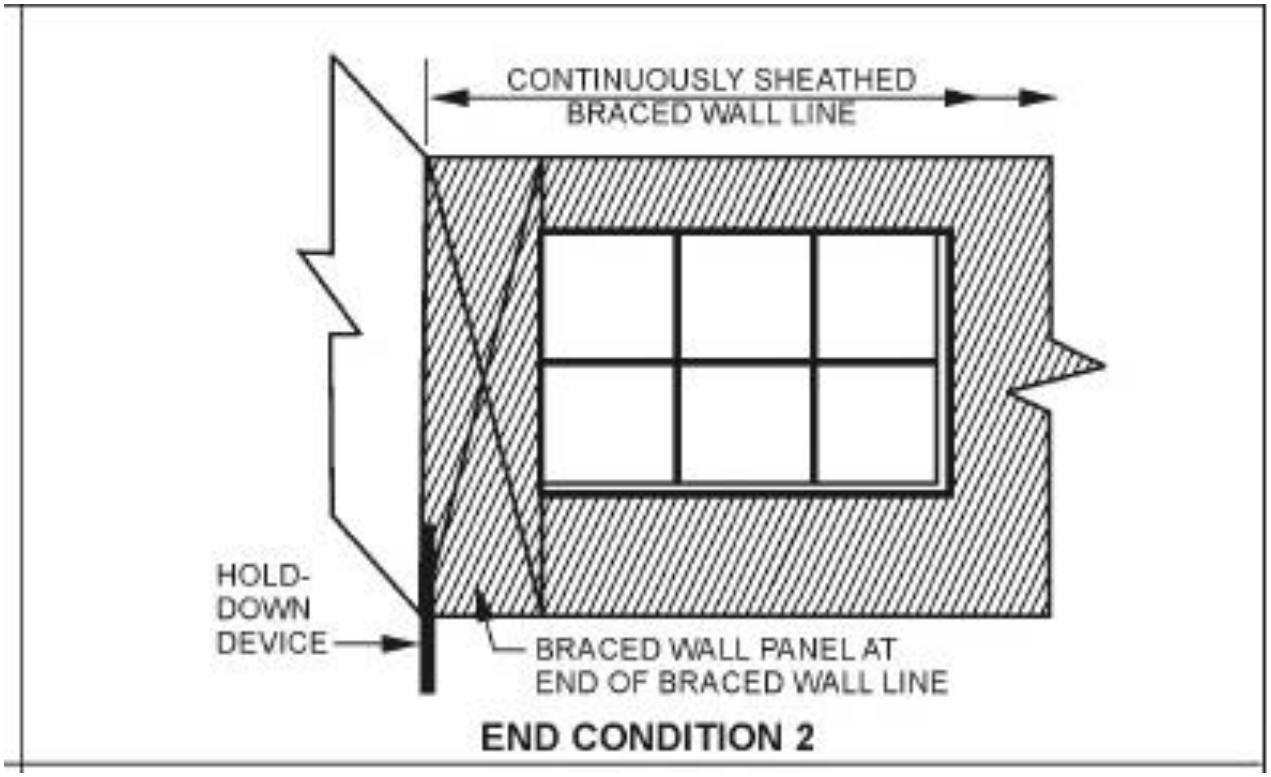
- **800 pound capacity fastened to the edge of the braced wall panel closest to the corner.**



Continuously Sheathed Braced Walls

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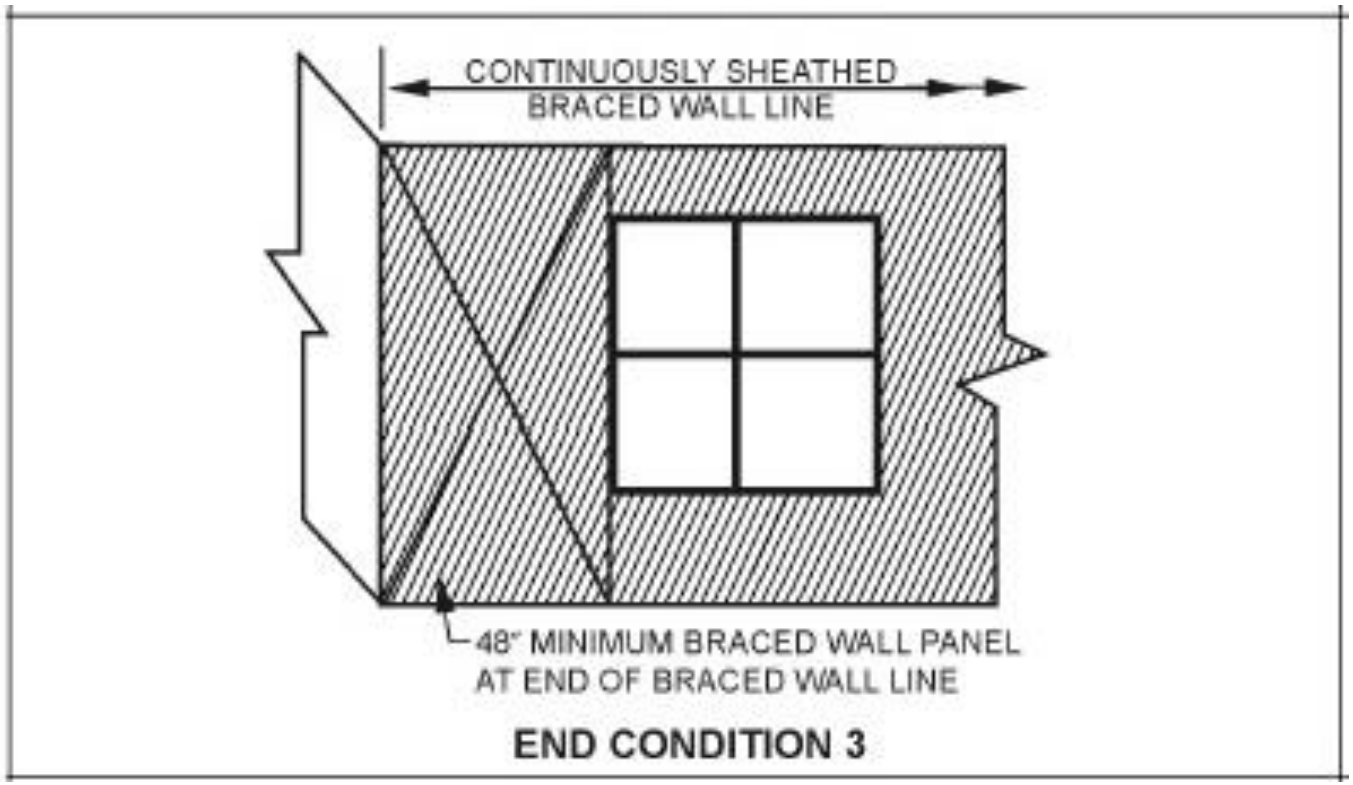
- **48 inch braced wall panel at end of braced wall line.**



Continuously Sheathed Braced Walls

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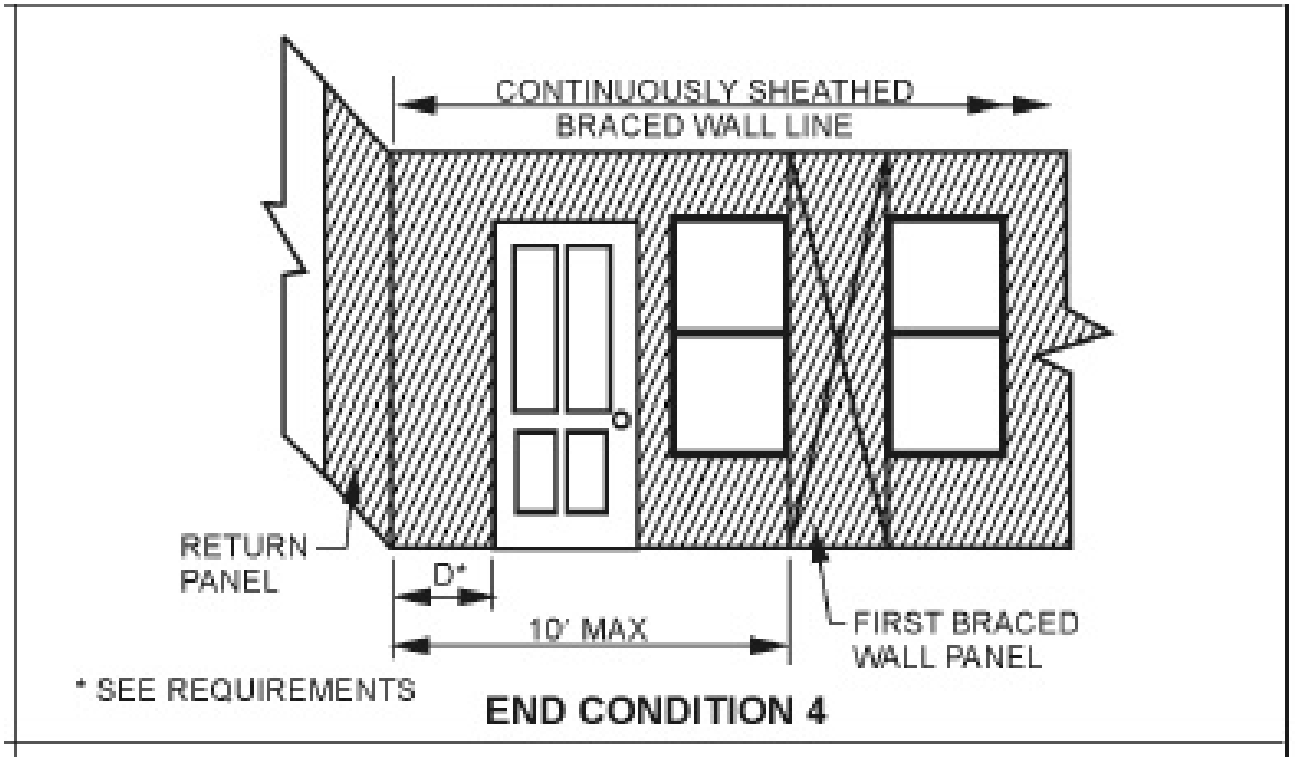
- **"D" distance is 24" for WSP and 32 " for structural fiberboard.**



Continuously Sheathed Braced Walls

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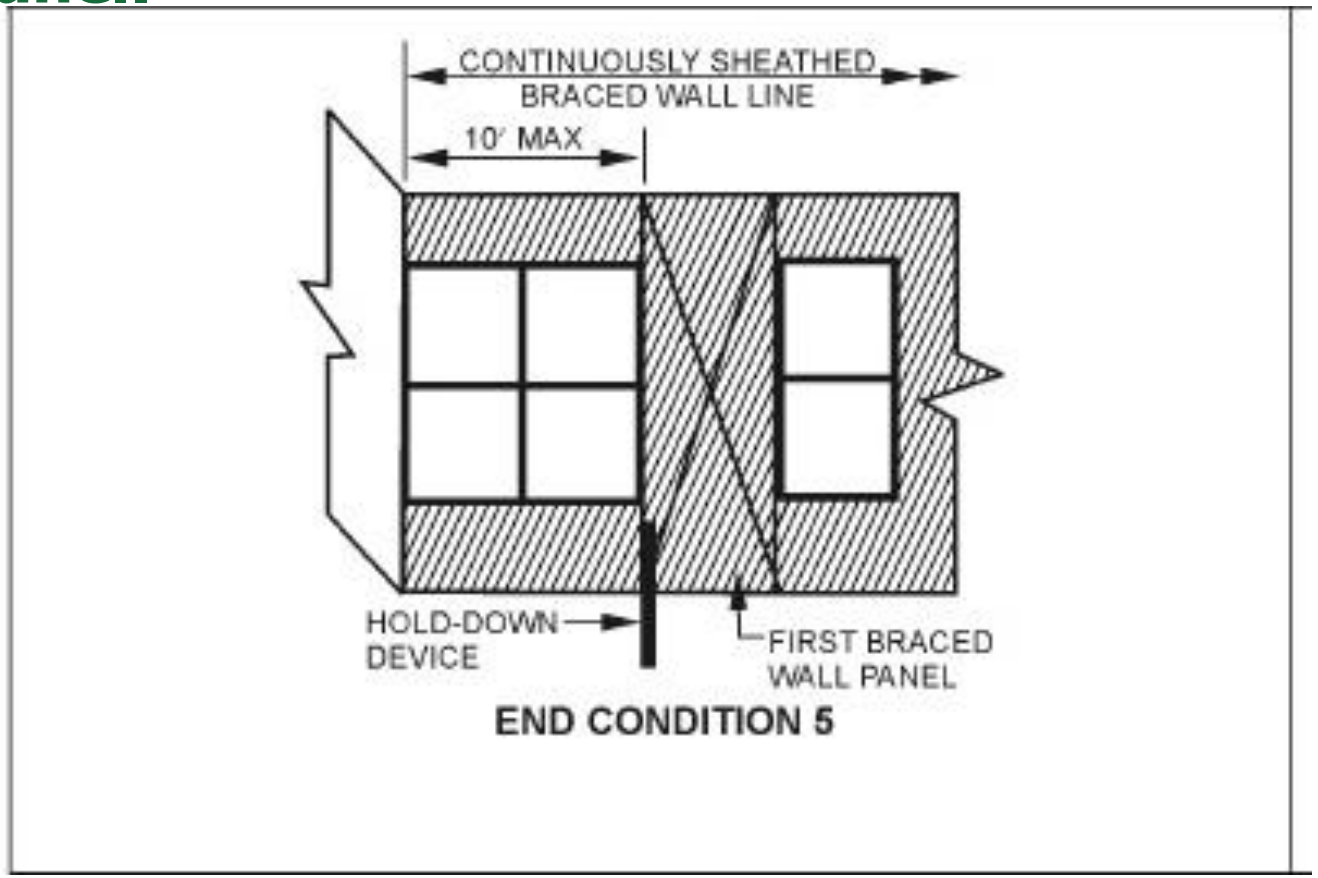
- **800 pound hold down device at first edge of braced wall panel.**



Connections to Other Elements

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- **Lots of details and figures**
- **Braced wall panel connection when perpendicular to floor/ ceiling Figure R602.10.8(1)**
- **Braced wall panel connection when parallel to floor/ceiling framing Figure R602.10.8(2)**
  - **Typical Framing Details for both directions**
- **Braced wall panel connections for roofing framing Figures R602.10.8.2(1) and (2)**
  - **Details both perpendicular connections for rafters & trusses**

Masonry stem walls – reinforce in accordance with Figure R602.10.9.

- **Detailed pictures with rebar placement shown.**

Suggested approach

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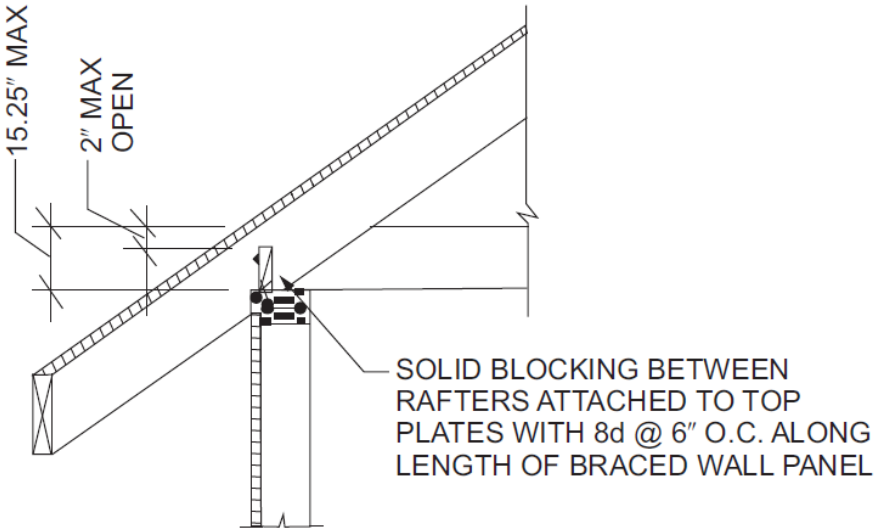
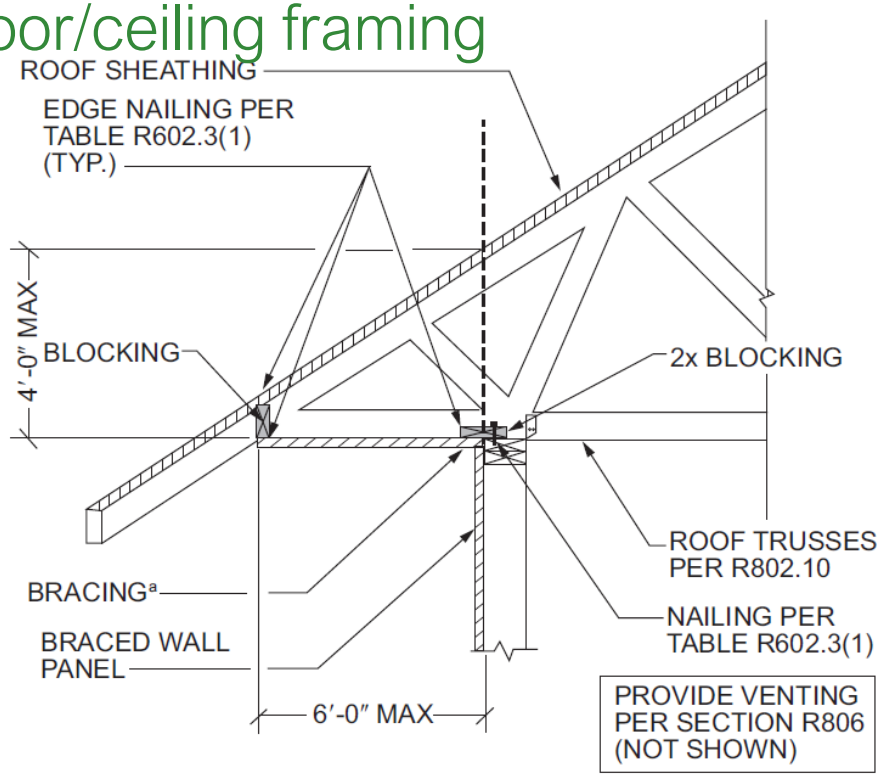
Lots of details and figures
Braced wall panels connected to floor/ceiling framing (R602.10.8(1)-10.82(2)



For SI: 1 inch = 25.4 mm.

FIGURE R602.10.8.2(1)
BRACED WALL PANEL CONNECTION TO PERPENDICULAR RAFTERS



For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. Methods of bracing shall be as described in Section R602.10.4.

FIGURE R602.10.8.2(2)
BRACED WALL PANEL CONNECTION OPTION TO PERPENDICULAR RAFTERS OR ROOF TRUSSES

Connections to Other Elements

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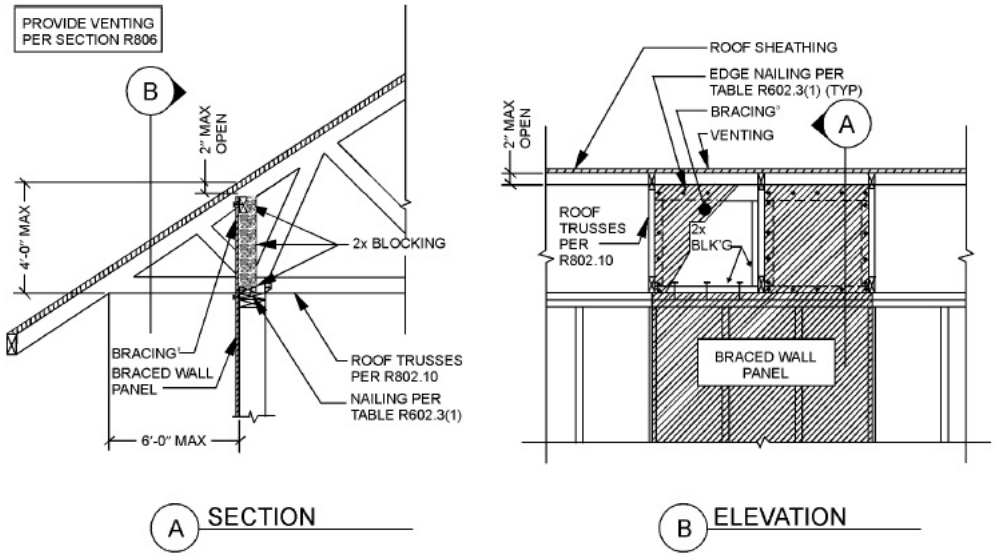
- **Lots of details and figures**
- **Braced wall panel connection option to perpendicular rafters or roof trusses Figure R602.10.8.2(3)**



For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. Methods of bracing shall be as described in Section R602.10.4.

FIGURE R602.10.8.2(3) BRACED WALL PANEL CONNECTION OPTION TO PERPENDICULAR RAFTERS OR ROOF TRUSSES

Connections to Other Elements

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- **Lots of details and figures**
- **Braced wall panel supported (R602.10.9)**
  - **Cantilevered joist – complying with Section R502.3.3 can support braced walls panel.**

TABLE R502.3.3(1) CANTILEVER SPANS FOR FLOOR JOISTS SUPPORTING LIGHT-FRAME EXTERIOR BEARING WALL AND ROOF ONLY[a, b, c, f, g, h] (Floor Live Load ≤ 40 psf, Roof Live Load ≤ 20 psf)

Member & Spacing	Maximum Cantilever Span (Uplift Force at Backspan Support in Lbs.)[d, e]											
	Ground Snow Load											
	≤ 20 psf			30 psf			50 psf			70 psf		
	Roof Width			Roof Width			Roof Width			Roof Width		
	24 ft	32 ft	40 ft	24 ft	32 ft	40 ft	24 ft	32 ft	40 ft	24 ft	32 ft	40 ft
2 × 8 @ 12″	20″ (177)	15″ (227)	–	18″ (209)	–	–	–	–	–	–	–	–
2 × 10 @ 16″	29″ (228)	21″ (297)	16″ (364)	26″ (271)	18″ (354)	–	20″ (375)	–	–	–	–	–
2 × 10 @ 12″	36″ (166)	26″ (219)	20″ (270)	34″ (198)	22″ (263)	16″ (324)	26″ (277)	–	–	19″ (356)	–	–
2 × 12 @ 16″	–	32″ (287)	25″ (356)	36″ (263)	29″ (345)	21″ (428)	29″ (367)	20″ (484)	–	23″ (471)	–	–
2 × 12 @ 12″	–	42″ (209)	31″ (263)	–	37″ (253)	27″ (317)	36″ (271)	27″ (358)	17″ (447)	31″ (348)	19″ (462)	–
2 × 12 @ 8″	–	48″ (136)	45″ (169)	–	48″ (164)	38″ (206)	–	40″ (233)	26″ (294)	36″ (230)	29″ (304)	18″ (379)

Connections to Other Elements

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- **Lots of details and figures**
- **Braced wall panel supported (R602.10.9)**
  - **Raised floor system post or pier foundations shall be designed in accordance with good engineering practice.**
  - **Masonry stem walls – reinforce in accordance with Figure R602.10.9.**
  - **Concrete stem walls – reinforced in accordance with Figure R602.10.9.**

Connections to Other Elements

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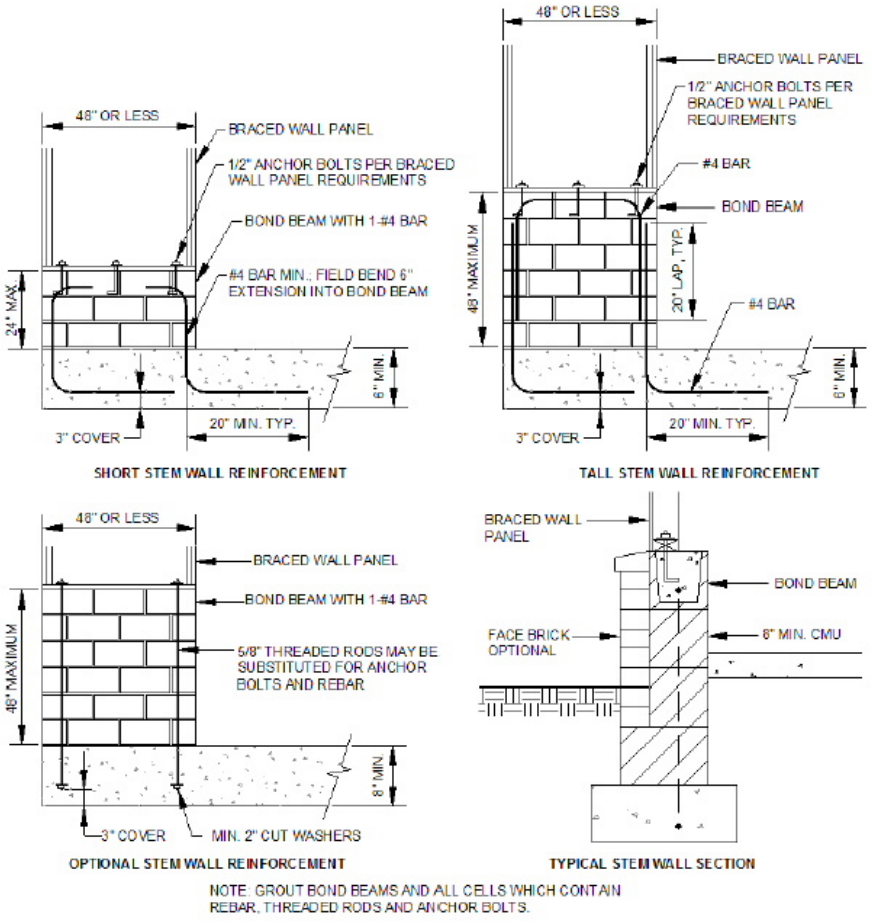
- **Alternate braced wall (ABW) and Portal frame with hold downs (PFH) cannot attach to masonry stem walls. – R602.10.9 exception #3.**



Connections to Other Elements

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Connections consistently refers back to Table R602.3(1)

	Roof		
1	Blocking between ceiling joists or rafters to top plate	4-8d box (2½" × 0.113"); or 3-8d common (2½" × 0.131"); or 3-10d box (3" × 0.128"); or 3-3" × 0.131" nails	Toe nail
2	Ceiling joists to top plate	4-8d box (2½" × 0.113"); or 3-8d common (2½" × 0.131"); or 3-10d box (3" × 0.128"); or 3-3" × 0.131" nails	Per joist, toe nail
3	Ceiling joist not attached to parallel rafter, laps over partitions [see Sections R802.3.1, R802.3.2 and Table R802.5.1(9)]	4-10d box (3" × 0.128"); or 3-16d common (3½" × 0.162"); or 4-3" × 0.131" nails	Face nail
4	Ceiling joist attached to parallel rafter (heel joint) [see Sections R802.3.1 and R802.3.2 and Table R802.5.1(9)]	Table R802.5.1(9)	Face nail
5	Collar tie to rafter, face nail or 1¼" × 20 ga. ridge strap to rafter	4-10d box (3" × 0.128"); or 3-10d common (3" × 0.148"); or 4-3" × 0.131" nails	Face nail each rafter
6	Rafter or roof truss to plate	3-16d box nails (3½" × 0.135"); or 3-10d common nails (3" × 0.148"); or 4-10d box (3" × 0.128"); or 4-3" × 0.131" nails	2 toe nails on one side and 1 toe nail on opposite side of each rafter or truss[i]
7	Roof rafters to ridge, valley or hip rafters or roof rafter	4-16d (3½" × 0.135"); or 3-10d common (3½" × 0.148"); or 4-10d box (3" × 0.128"); or 4-3" × 0.131" nails	Toe nail

Is This Important …

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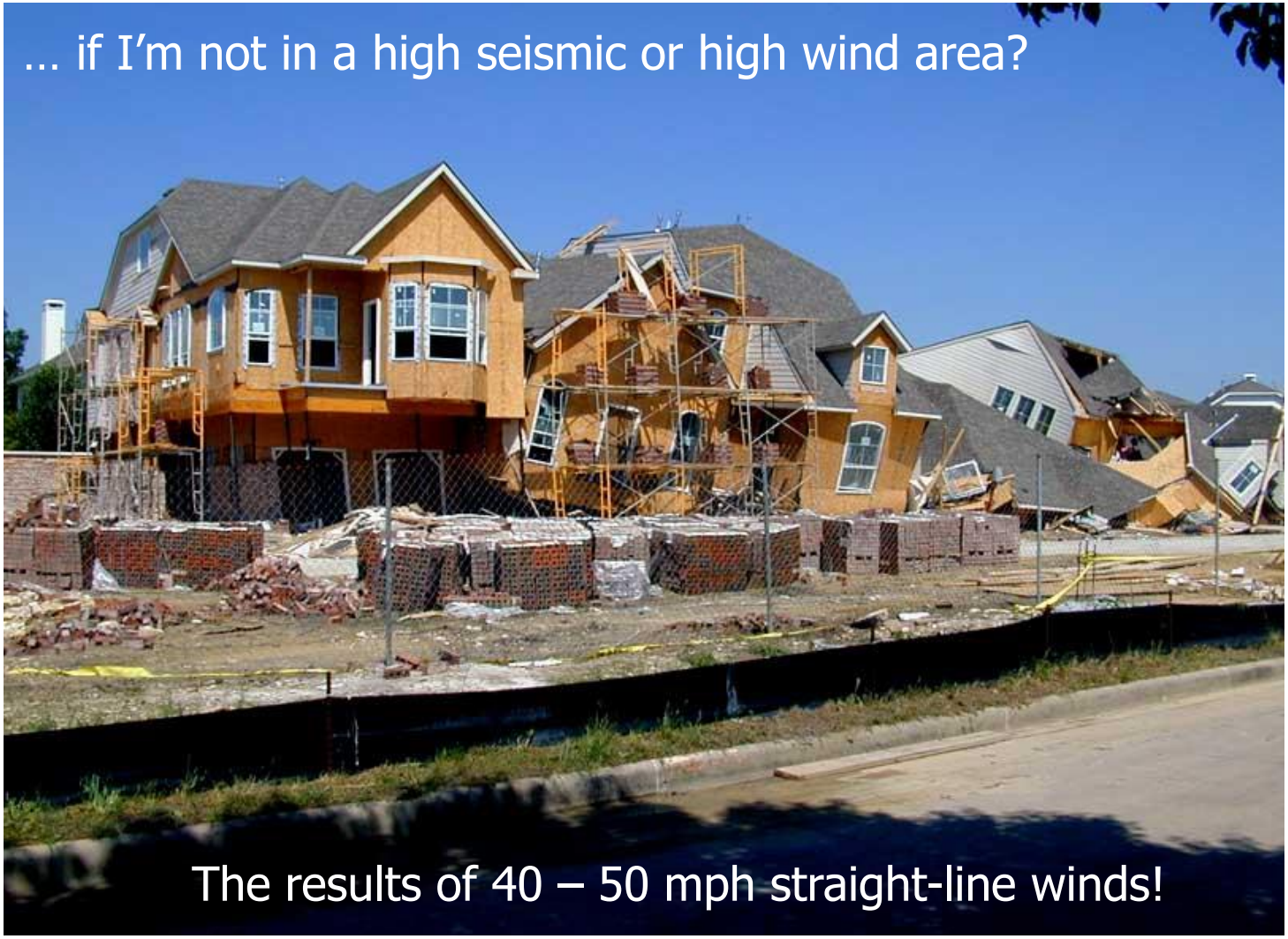
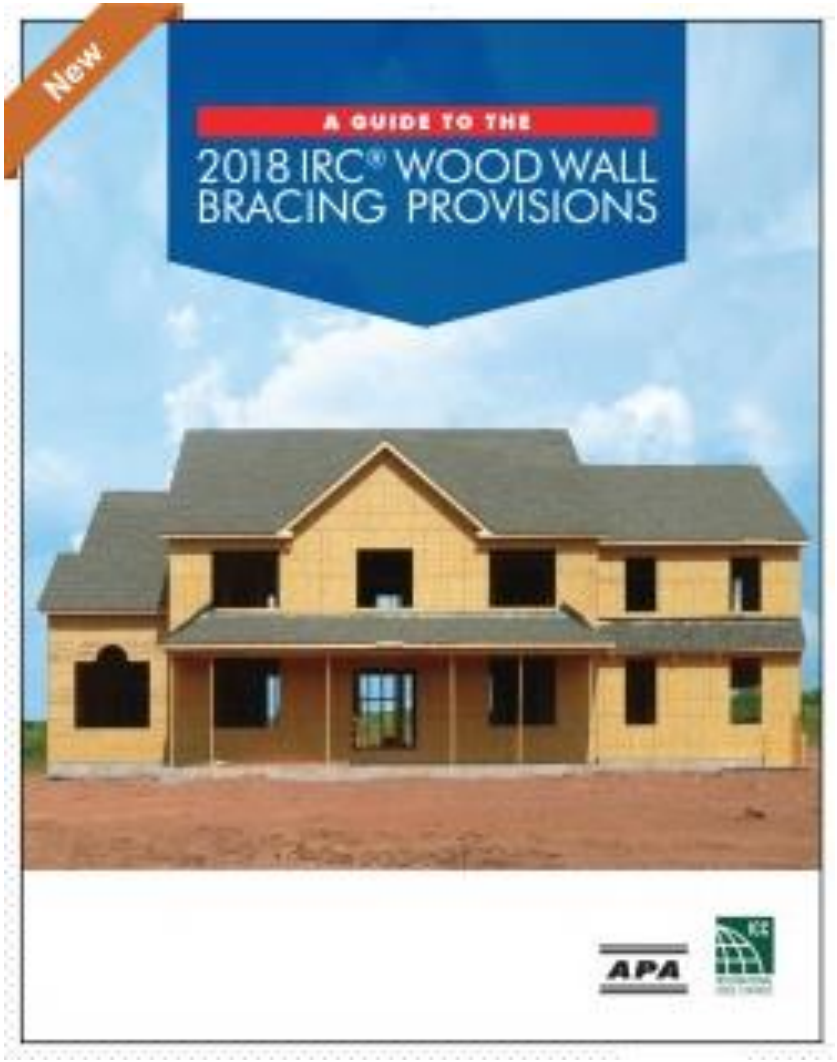
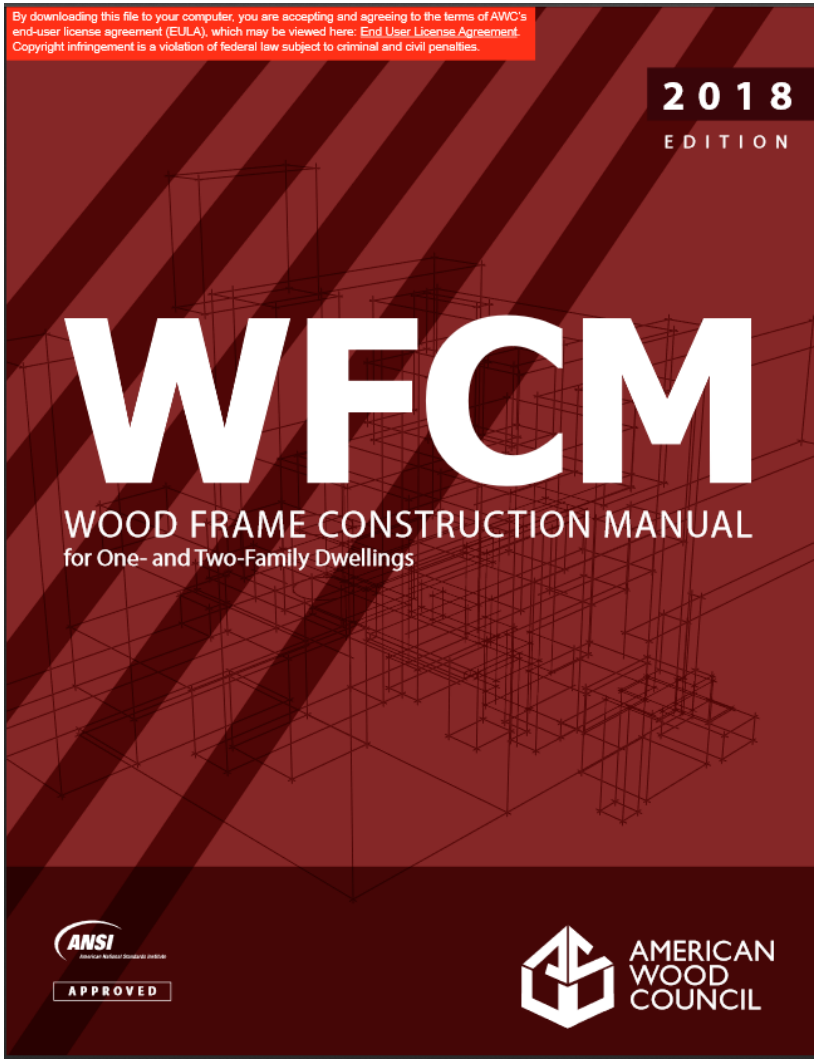


Additional Resources





2015 WFCM High Wind Guides

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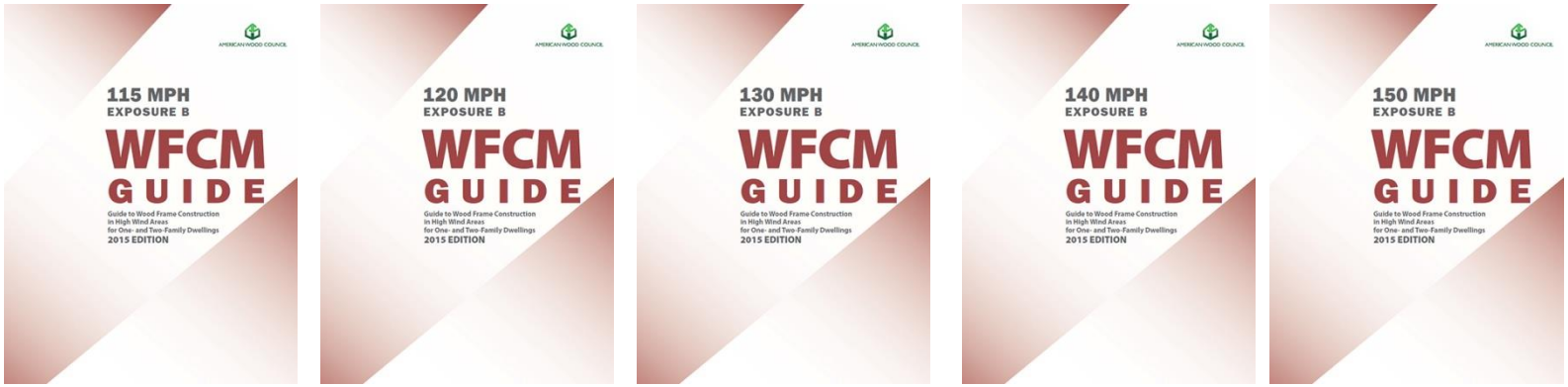
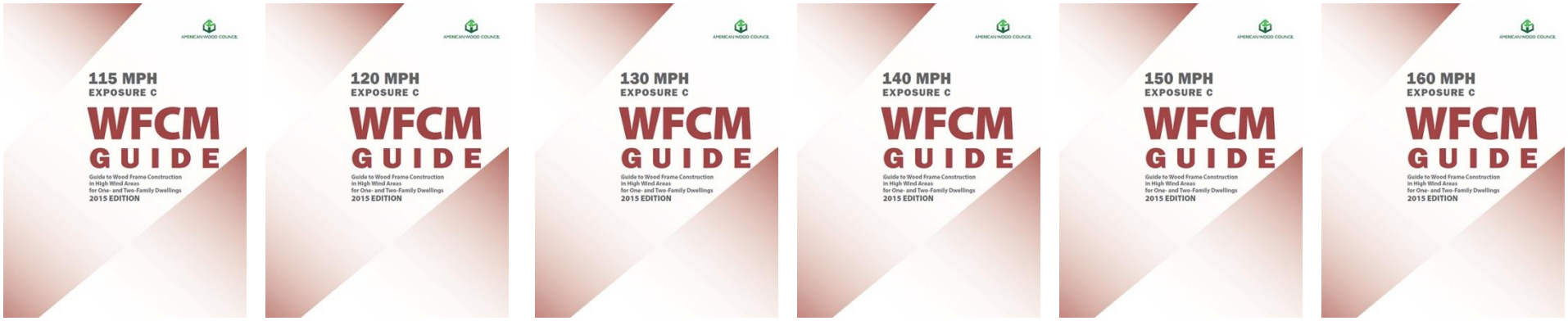
Exposure B: 115 – 150 MPH



Exposure C: 115 – 160 MPH



2015 High Wind Guide-Details

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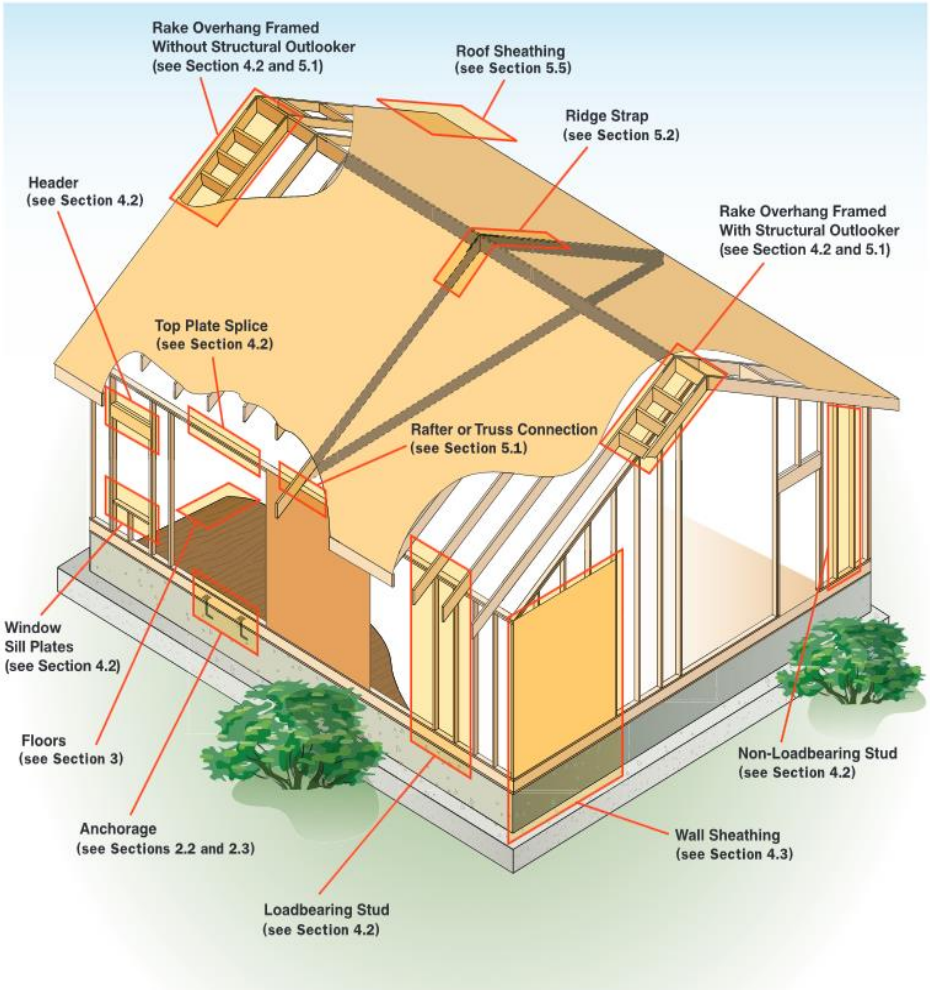

High Wind Guide-Design Example

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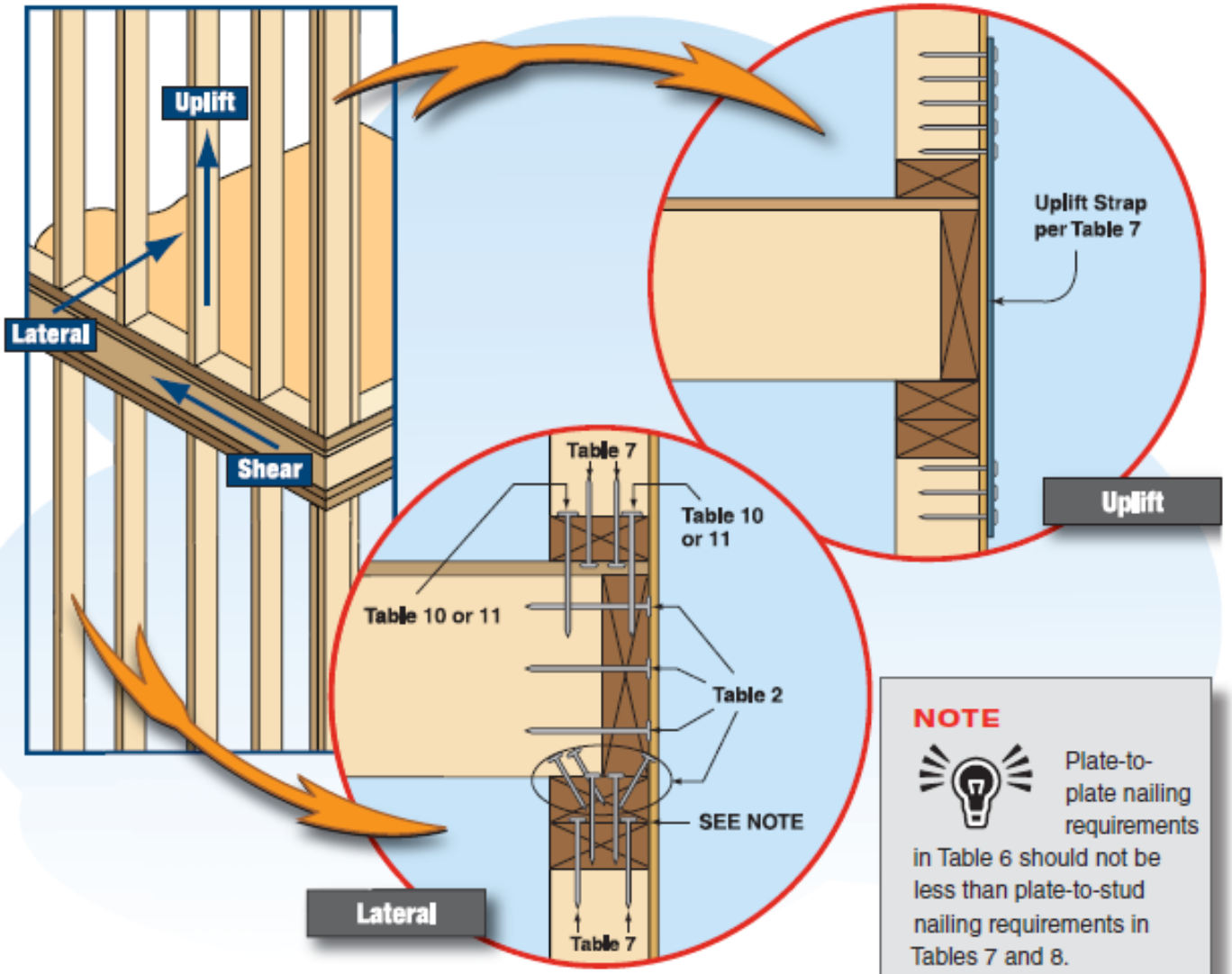

Figure 14. Story-to-Story Uplift and Lateral Connections

WFCM High Wind Guide Details

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Controlling Hold-Down – 1st floor

10,260 lb > 8,720 lb

10,260 lb can be used at all 4 corners on 1st floor

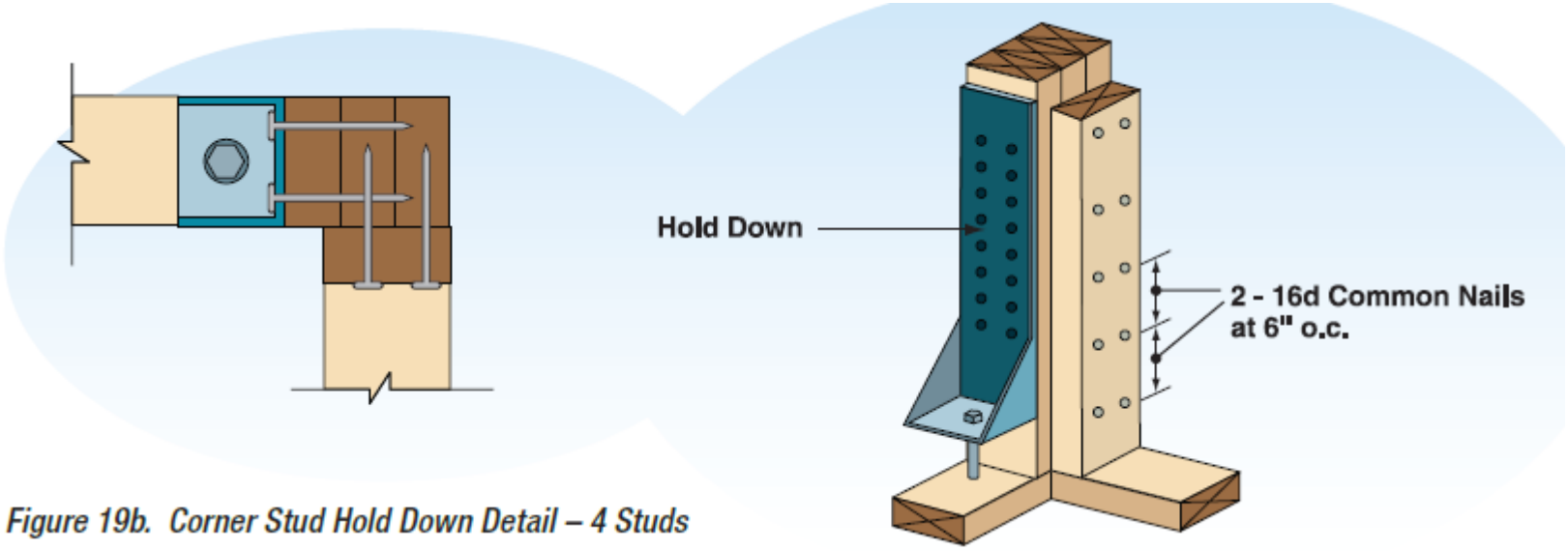

Figure 19b. Corner Stud Hold Down Detail – 4 Studs

2nd floor hold downs require 4,360 lb capacity

APA-Simplified Wall Bracing

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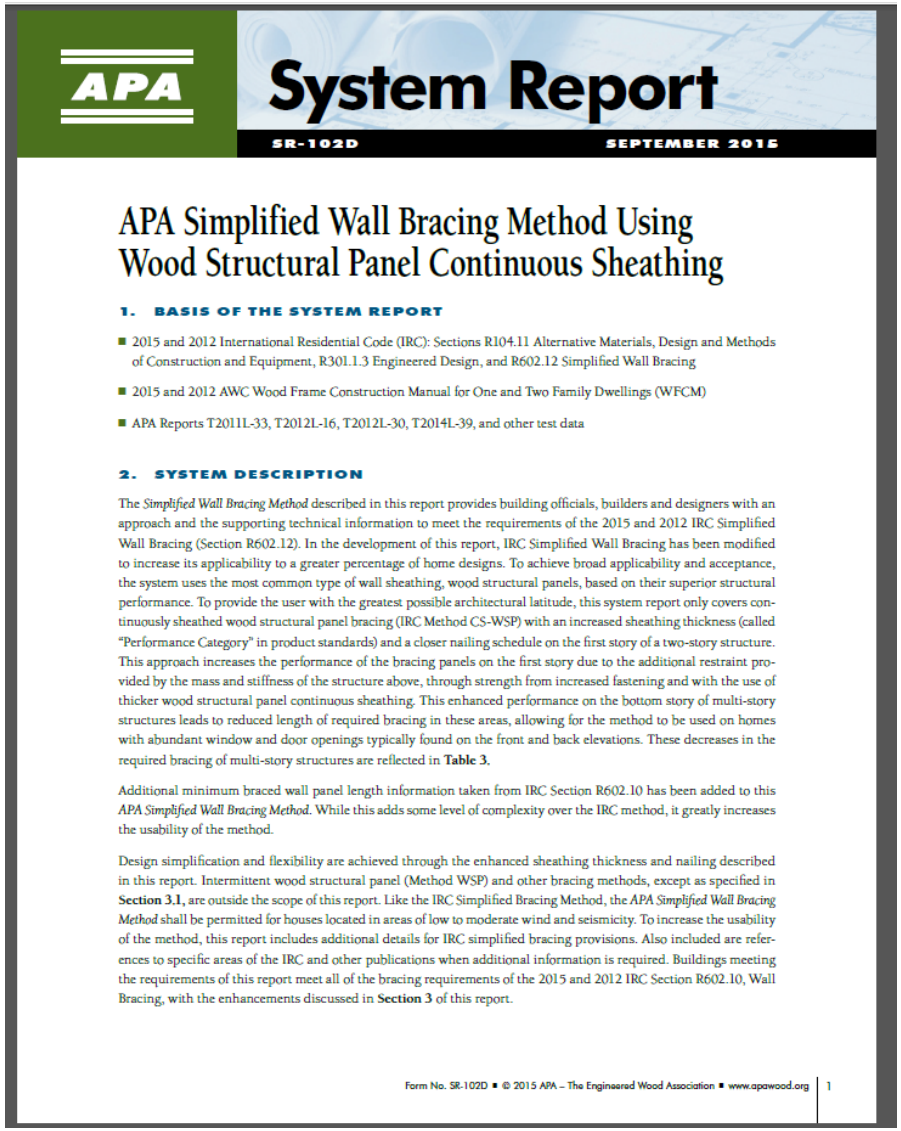

APA

System Report

SR-102D SEPTEMBER 2015

APA Simplified Wall Bracing Method Using Wood Structural Panel Continuous Sheathing

1. BASIS OF THE SYSTEM REPORT

- 2015 and 2012 International Residential Code (IRC): Sections R104.11 Alternative Materials, Design and Methods of Construction and Equipment, R301.1.3 Engineered Design, and R602.12 Simplified Wall Bracing
- 2015 and 2012 AWC Wood Frame Construction Manual for One and Two Family Dwellings (WFCM)
- APA Reports T2011L-33, T2012L-16, T2012L-30, T2014L-39, and other test data

2. SYSTEM DESCRIPTION

The *Simplified Wall Bracing Method* described in this report provides building officials, builders and designers with an approach and the supporting technical information to meet the requirements of the 2015 and 2012 IRC Simplified Wall Bracing (Section R602.12). In the development of this report, IRC Simplified Wall Bracing has been modified to increase its applicability to a greater percentage of home designs. To achieve broad applicability and acceptance, the system uses the most common type of wall sheathing, wood structural panels, based on their superior structural performance. To provide the user with the greatest possible architectural latitude, this system report only covers continuously sheathed wood structural panel bracing (IRC Method CS-WSP) with an increased sheathing thickness (called "Performance Category" in product standards) and a closer nailing schedule on the first story of a two-story structure. This approach increases the performance of the bracing panels on the first story due to the additional restraint provided by the mass and stiffness of the structure above, through strength from increased fastening and with the use of thicker wood structural panel continuous sheathing. This enhanced performance on the bottom story of multi-story structures leads to reduced length of required bracing in these areas, allowing for the method to be used on homes with abundant window and door openings typically found on the front and back elevations. These decreases in the required bracing of multi-story structures are reflected in **Table 3**.

Additional minimum braced wall panel length information taken from IRC Section R602.10 has been added to this *APA Simplified Wall Bracing Method*. While this adds some level of complexity over the IRC method, it greatly increases the usability of the method.

Design simplification and flexibility are achieved through the enhanced sheathing thickness and nailing described in this report. Intermittent wood structural panel (Method WSP) and other bracing methods, except as specified in **Section 3.1**, are outside the scope of this report. Like the IRC Simplified Bracing Method, the *APA Simplified Wall Bracing Method* shall be permitted for houses located in areas of low to moderate wind and seismicity. To increase the usability of the method, this report includes additional details for IRC simplified bracing provisions. Also included are references to specific areas of the IRC and other publications when additional information is required. Buildings meeting the requirements of this report meet all of the bracing requirements of the 2015 and 2012 IRC Section R602.10, Wall Bracing, with the enhancements discussed in **Section 3** of this report.

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- **Western Wood Products Association**
  - **ww2.wwpa.org**
- **Wood Truss Council of America**
  - **www. sbcindustry.com**

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Questions? Thank you!

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