



2021 IRC Part 4 - Shearwalls

Wisdom and Associates, Inc.

Introduction

This class is designed to provide an introduction to the wall bracing or shearwall requirements of the International Residential Code. This class is a shortened version of our two full day classes covering wind and seismic shearwall design. This introduction is based on using wood structural panel sheathing and gypsum board to resist seismic and wind loads.

Since this is an introductory class, alternative methods of meeting shear wall requirements such as the Wood Frame Construction Manual are not covered. This class also will not cover all possible bracing methods permitted by the International Residential Code, and instead focus on the two most common methods in use, continuous sheathing with wood structural panels and gypsum board.

This class is an overview of the most commonly encountered codes for wind and seismic shear wall or braced wall panel construction and is oriented as a big picture overview. There are more details and exceptions than are covered here, so further study is recommended if you are going to do your own plan reviews. When it comes to shear wall and braced wall line design, no one is an expert in one day. Consistent practice and review of the codes will help deepen your understanding of the topic.

The main topics that will be covered in this class are why wall bracing is necessary and what its purpose is, the scope of the International Residential Code, what it covers and what the limitations are, Important definitions that will help us understand what is being asked by the code, the design criteria that apply to both wind and seismic bracing requirements, and a review of the general bracing requirements that apply to both wind and seismic design.

Purpose of Wall Bracing

The purpose of wall bracing or shear walls is to provide resistance to forces that would cause the building to rack or displace. The loads imposed that are being resisted are horizontal loads from wind and seismic forces. A properly braced wall line will prevent or mitigate building collapse, cracking, displacement, or turnover of the building off of its foundation.

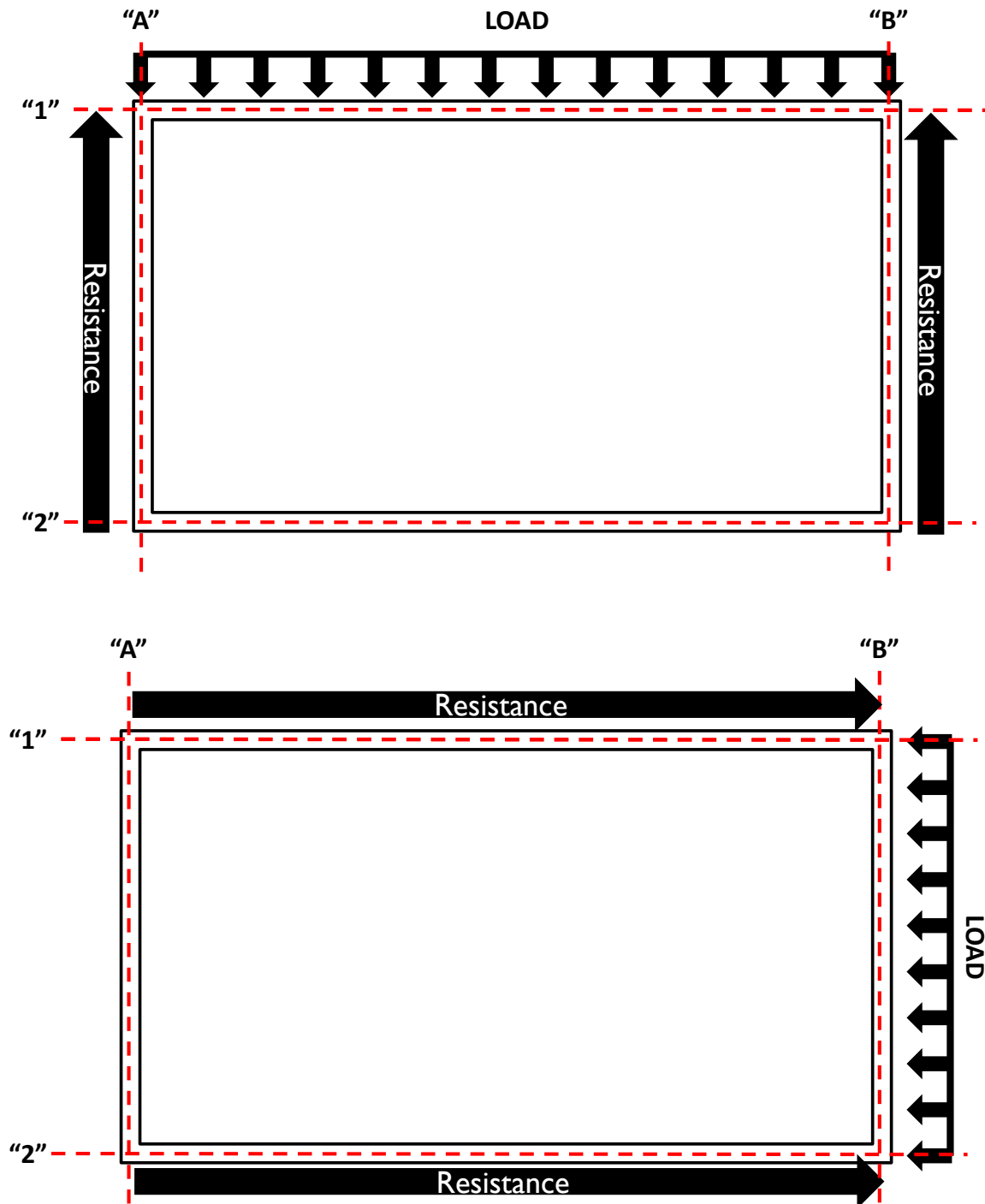
Wall bracing works by using braced wall panels or shearwall panels along a braced wall line to resist structural movement. When properly designed and constructed, the entire structure acts as a system to resist movement through connections at the walls, the floors, the ceilings and the roof. Each home or building consists of at least two sets of braced wall lines on which braced wall panels or shear walls are constructed. These two sets of parallel lines can be considered to form a basic box or rectangle with at least two lines facing north and south, and two lines facing east and west.

If inadequate or improper bracing is present in the structure, there are typically three kinds of failures that the building will experience. The first kind of failure is racking. Racking occurs when the bottom of the building stays in place attached to the foundation, but the upper part of the building slants in the direction of the load causing damage.

The second type of failure is overturning. Overturning occurs when the walls are adequately stiff to resist the forces, but the walls are not properly secured to the foundation. The building is then literally tipped up by the forces.

The third type of failure occurs when the building slides off of the foundation. In this case the walls themselves are adequately braced, but they are not adequately anchored to the foundation. This type of failure is similar to overturning, although the building is not actually picked up off of the foundation and tipped over.

Wall bracing is a system that uses braced wall panels along a braced wall line. These braced wall panels are full height segments of wall that are of a minimum length to qualify as bracing. How much bracing or the minimum total length of braced wall panels along a braced wall lines depends on the seismic zone, the number of stories present, and the method of bracing used. All three of these factors are used to determine the minimum adequate amount of bracing.



Scope & Manuals

IRC Wind Design Criteria - R301.2.1

- Limited to 140 mph
- Exceeds 140 mph - AWC Wood Frame Construction Manual

IRC Seismic Design Criteria - IRC R301.2.2

- Detached one and two family dwellings in Seismic Design Category D0, D1, and D2
- Townhouses in Seismic Design Category C, D0, D1, and D2
- Limited to 3 stores above grade (2 stories in SDC D2)

IRC Alternate determination of seismic design category - R301.2.2.1.1

- Use IBC
- Category E - reclassified as D2 if all exterior shear wall lines or braced wall panels in one plane vertically from foundation to uppermost story, no cantilevers, building is “regular”

IRC Alternate Provisions - R301.1.1

- AWC Wood Frame Construction Manual

Definitions - IRC

Braced Wall Line - A straight line through the building plan that represents the location of the lateral resistance provided by the wall bracing

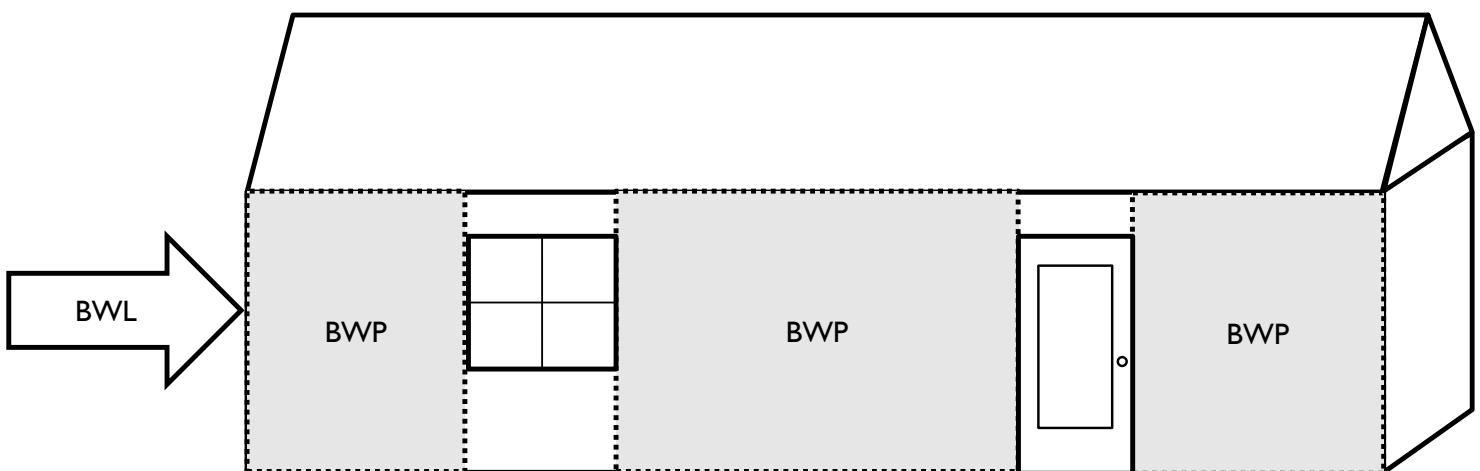
Braced Wall Line, Continuously Sheathed - A braced wall line with structural sheathing applied to all sheathable surfaces including the areas above and below openings.

Shear Wall - A general term for walls that are designed and constructed to resist racking from seismic and wind loads.

Braced Wall Panel - A full-height section of wall constructed to resist in-plane shear loads through interaction of framing members, sheathing material and anchors. The panel length meets the requirements of the bracing method, and contributes toward the total amount of bracing required along its braced wall line in accordance with Section R602.10.1

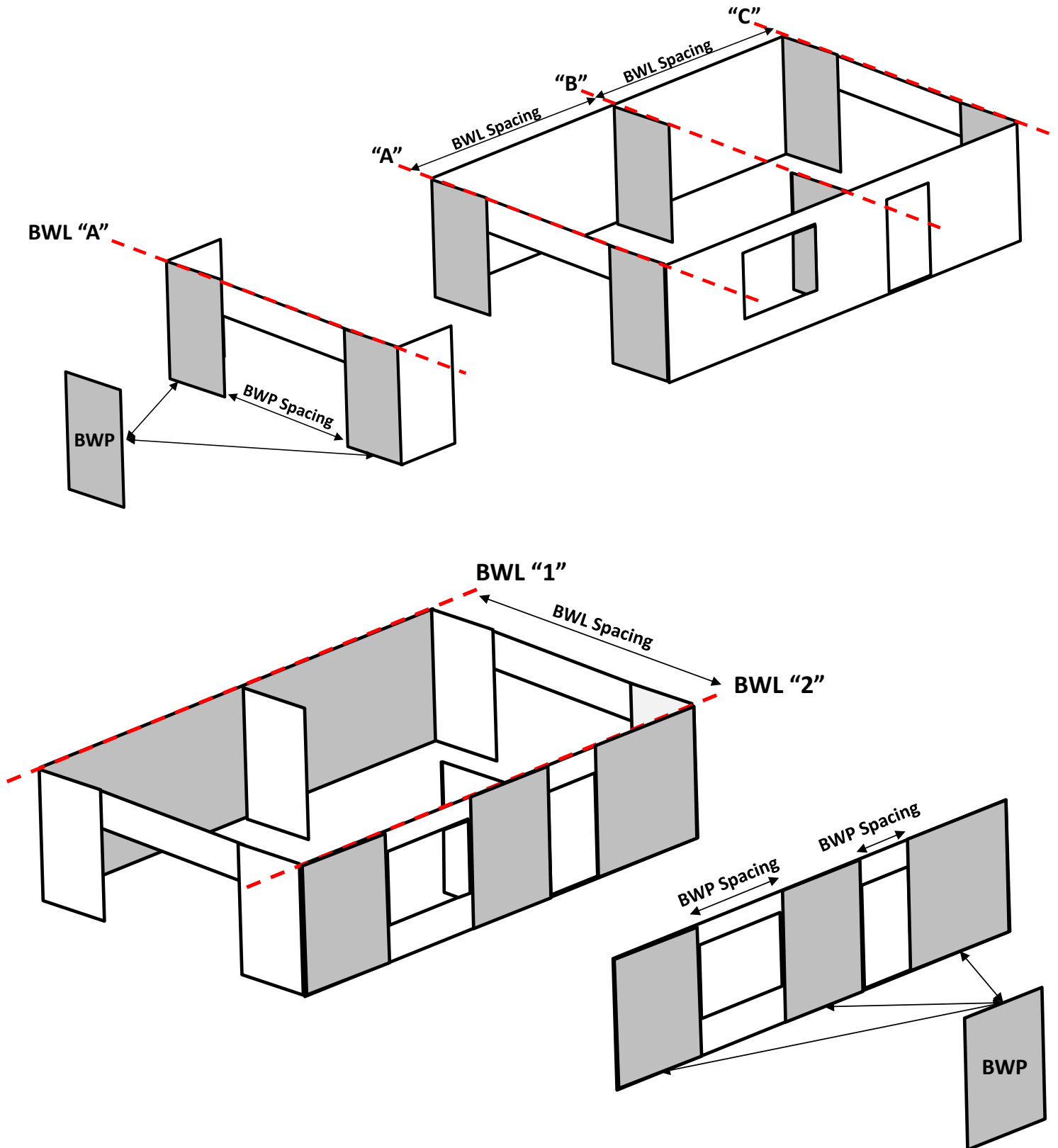
CS-WSP - Continuous Sheathing, Wood Structural Panel - Continuously sheathed wood structural panels applied to interior or exterior walls on one side, including above and below openings. Minimum 3/8" thickness.

GB - Gypsum Board - Minimum 1/2" gypsum board panels applied to both sides of a wall.



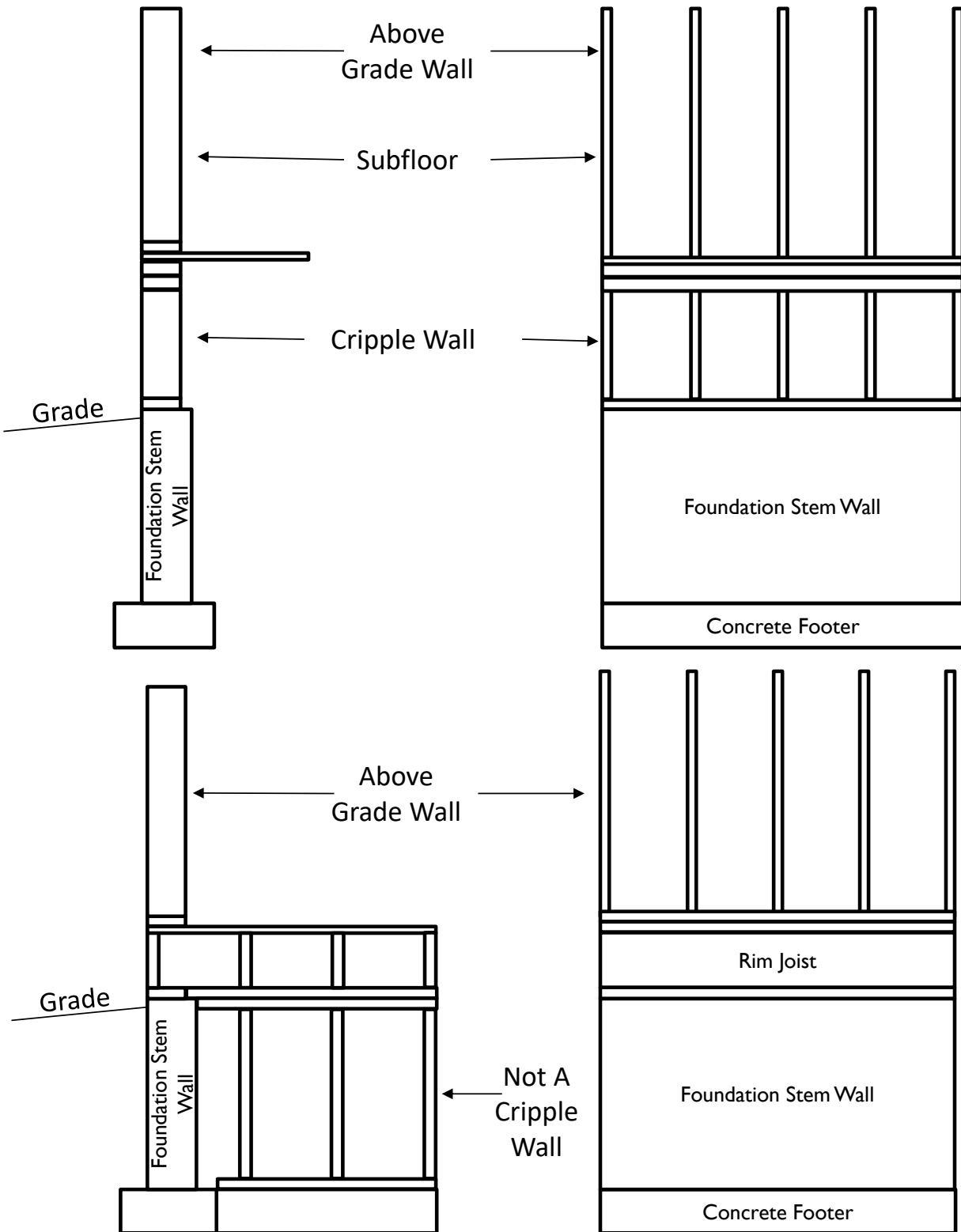
Definitions

Braced Wall Line Spacing - The distance between two or more parallel braced wall lines.



Definitions

Cripple Wall - A framed wall extending from the top of the foundation to the underside of the floor framing of a first story above grade plane.



IRC Wind Zones - Figure R301.2(5)

- Use figure R301.2(5)
- More detailed map at <https://hazards.atcouncil.org/>

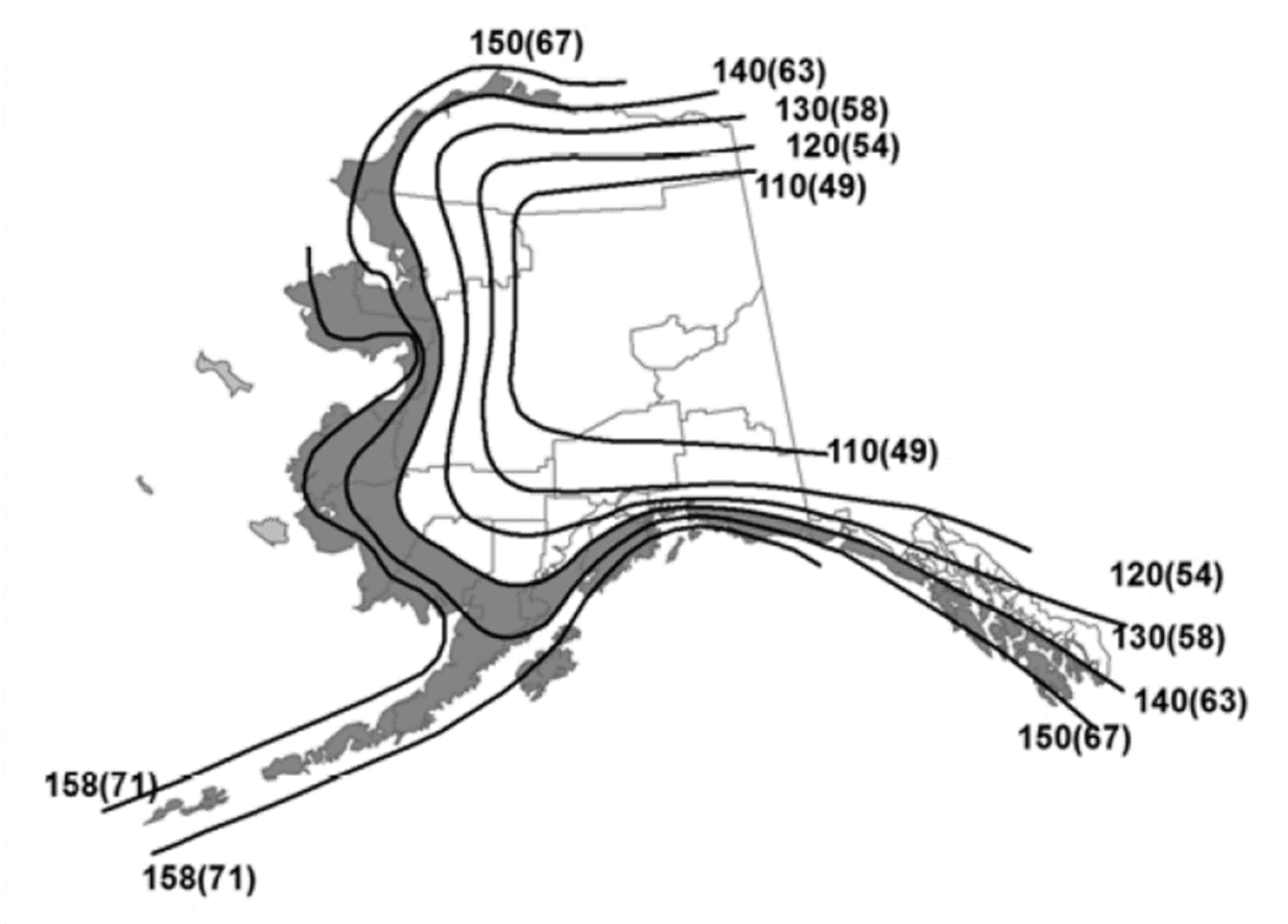
IRC Alternate Methods - R301.2.1.1

- AF&PA Wood Frame Construction Manual (WFCM).
- ICC Standard for Residential Construction in High-Wind Regions (ICC 600).
- ASCE Minimum Design Loads for Buildings and Other Structures (ASCE 7).
- AISI Standard for Cold-Formed Steel Framing— Prescriptive Method For One- and Two-Family Dwellings (AISI S230).
- International Building Code

Wind Speed Conversion - R301.2.1.3

- Code based on “ultimate” wind speed
- Many reference documents use “nominal” wind speed

Wind Speed Conversions											
Vult	110	115	120	130	140	150	160	170	180	190	200
Vasd	85	89	93	101	108	116	124	132	139	147	155



Wind Exposure Category - R301.2.1.4

- Wind exposure category of exposure affects design
- Each wind direction considered
- Locations between two categories must use the higher exposure
-
- **Category B**
- Urban, suburban, wooded
- Multiple home neighborhood
- Default exposure
-
- **Category C**
- Open terrain, scattered obstructions less than 30' high
- Flat open country, grasslands
-
- **Category D**
- Flat, unobstructed areas
- Wind over open water or flats 5000 feet or more

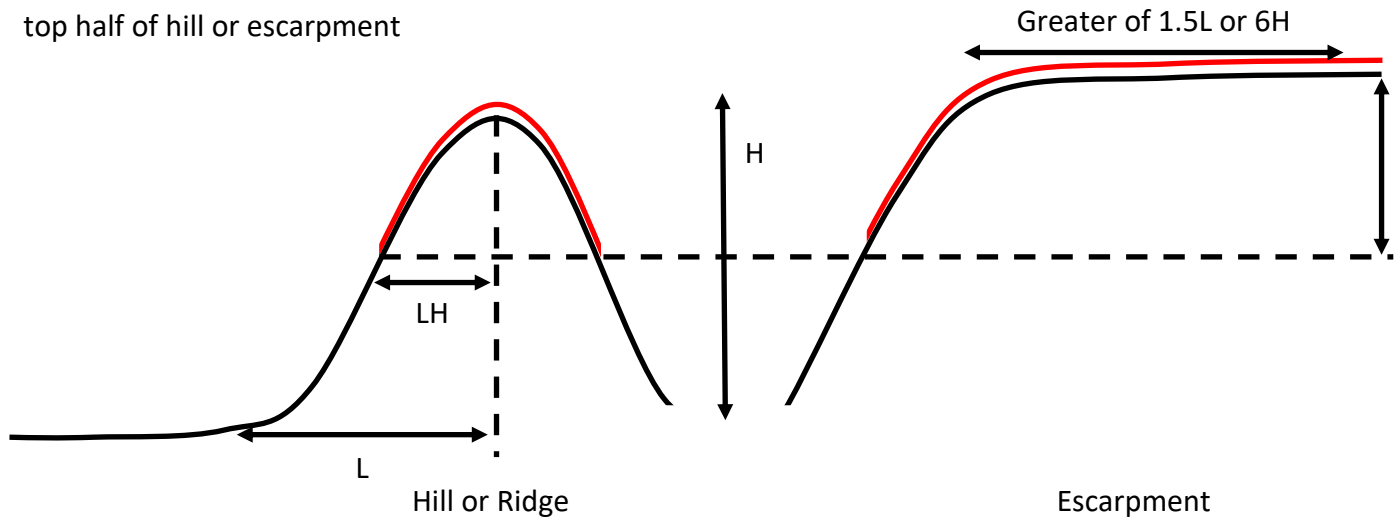
Topographic Wind Effect - R301.2.1.5

- Buildings on the top half of a hill, ridge or escarpment can experience wind speed-up
- Take into account for wind design
- Required conditions:
 1. Average slope 10% or greater
 2. The hill, ridge or escarpment is 60 feet or greater in height for Exposure B, 30 feet or greater in height for Exposure C, and 15 feet greater in height for Exposure D.
 3. Isolated from other hills by at least 2 miles, or
 4. At least twice as tall as other hills within 2 miles

Topographic Wind Example

- In a 120mph wind zone with a building located on the top half of a hill or escarpment with a 12.5% slope, what is the required ultimate design wind speed?
- 149 mph

Apply increased wind speed to
top half of hill or escarpment

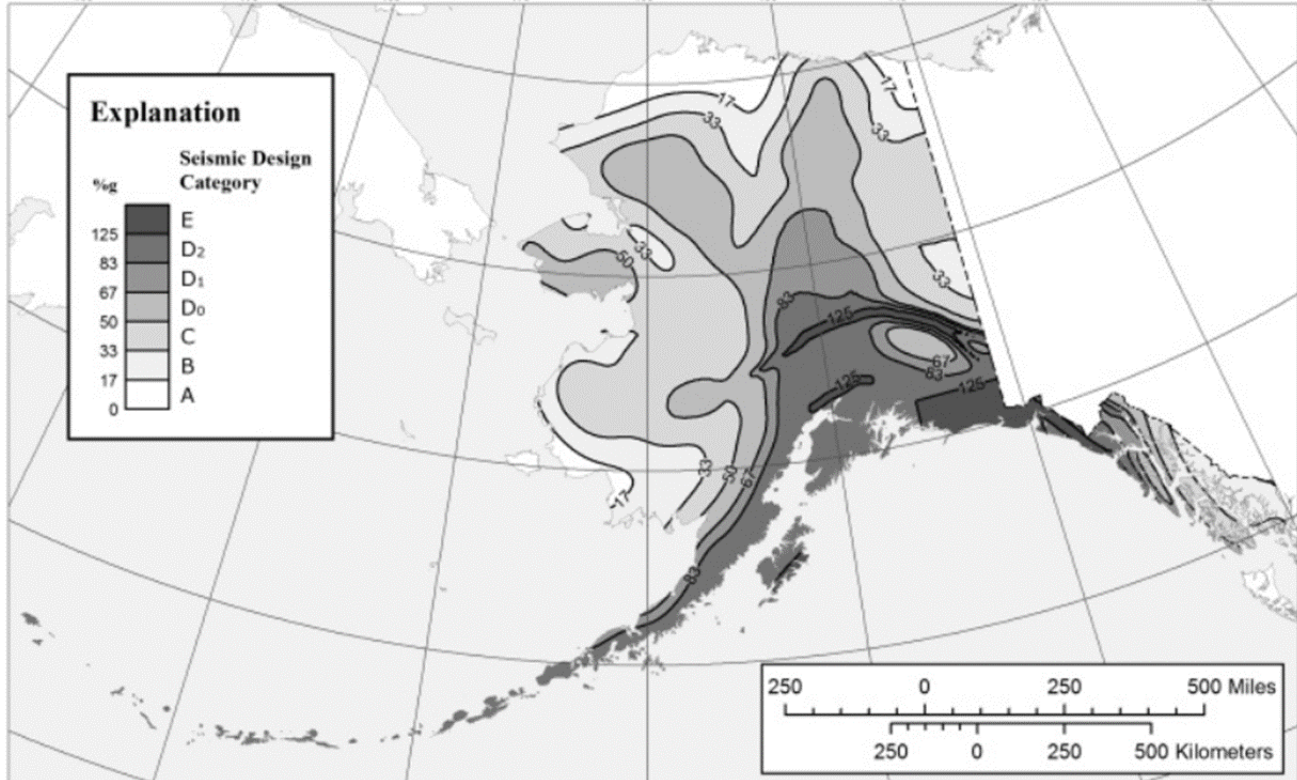


Ultimate Design Wind Speed Modification for Topographic Effect							
Ultimate Design Wind Speed	Average Slope Of The Top Half Of Hill, Ridge, Or Escarpment (percent)						
	0.10	0.125	0.15	0.175	0.20	0.23	0.25
	Required Ultimate Design Wind Speed-Up, Modified For Topographic Wind Speed Up (mph)						
110	132	137	142	147	152	158	162
115	138	143	148	154	159	165	169
120	144	149	155	160	166	172	176
130	156	162	168	174	179	NA	NA
140	168	174	181	NA	NA	NA	NA
150	180	NA	NA	NA	NA	NA	NA

Design Criteria

IRC Seismic Design Categories - Figure R301.2(2)

- Use figure R301.2(2) unless alternate map is allowed by building official
- More detailed map at <https://hazards.atcouncil.org/>

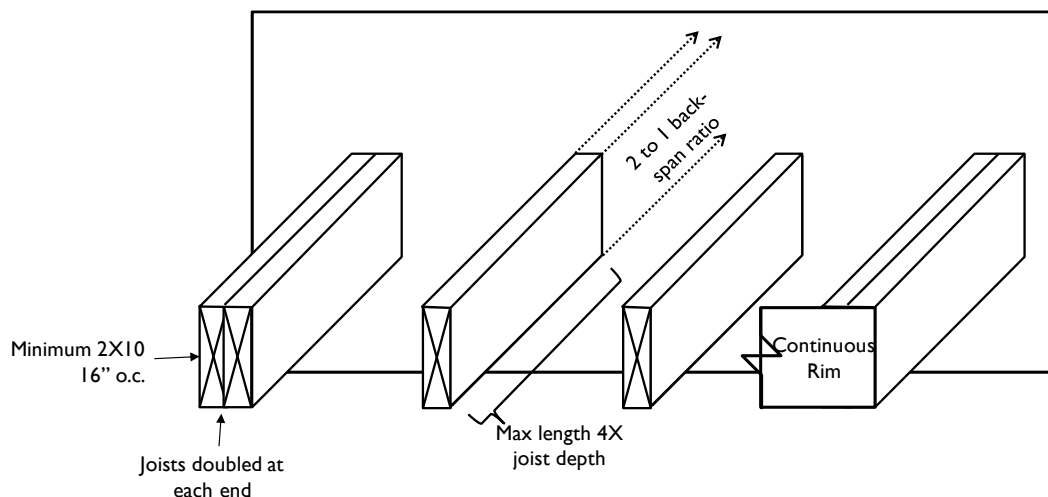


Chapter 3 - Building Planning

Irregular Buildings (R301.2.2.6) - There are 8 irregular building conditions that must be considered in Seismic categories C through D2. Irregular portions of buildings must be designed or follow listed exceptions.

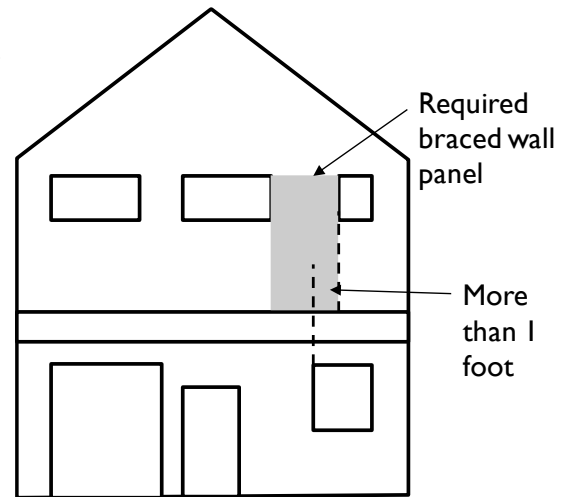
Shear walls not in one plane vertically from foundation to uppermost story (cantilever or setback), there is an exception for light frame construction:

- Minimum 2X10 floor joists, max 16" o.c.
- Cantilever does not exceed 4X joist depth
- 2 to 1 back span
- Continuous rim on cantilever
- Floor joists at each end doubled



Irregular Buildings (R301.2.2.6) Cont.

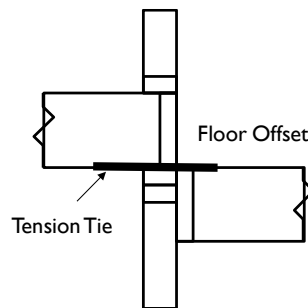
2. Where a section of floor or roof is not laterally supported by shear walls or braced wall lines on all edges
3. End of braced wall panel occurs over an opening in a wall below



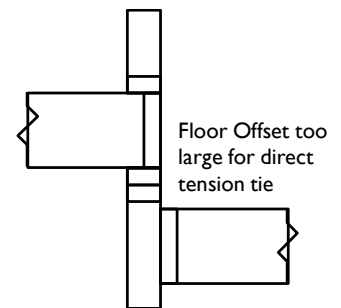
4. Opening in floor or roof does not exceed lesser of 12 feet or 50% of least floor or roof dimension (large stair openings, 2 story foyers)

5. Where portions of a floor level are vertically offset. Exceptions:

- Framing supported directly by continuous foundations at perimeter of building
- Floor framing tied per R502.6.1



"Regular"



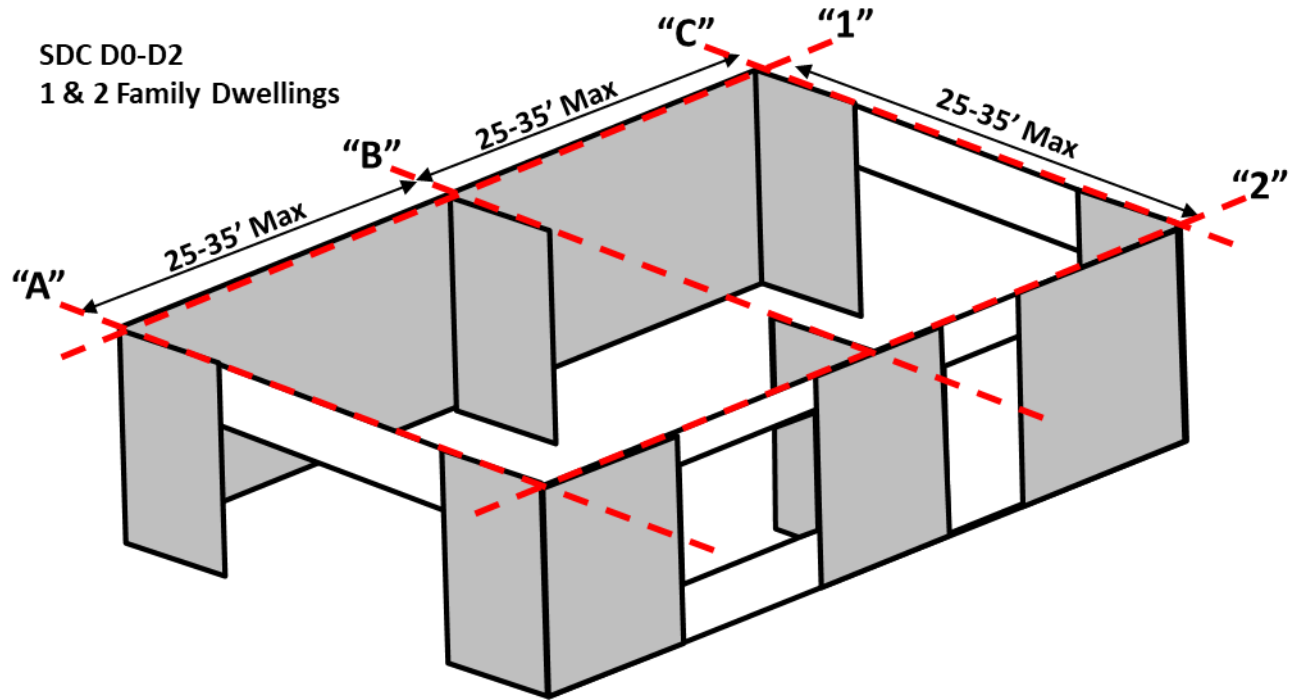
"Irregular"

6. Where shear walls and braced wall lines do not occur in two perpendicular directions
7. Masonry or concrete construction mixed with light frame walls above grade. Exception: fireplaces, chimneys, veneer
8. Hillside Light Frame Construction where the grade slope exceeds 1 in 5 on any side, the tallest cripple wall exceeds 7 feet, and less than 50% of interior walls finished. Exception: full height foundation on all but downhill side

IRC Wall Bracing Requirements - General

Braced Wall Line Spacing - Table R602.10.1.3

- 60' max between braced wall lines up to 140 mph
- 60' max between braced wall lines seismic category A - C single family
- 60' max between braced wall lines seismic category A - B townhouses
- 35' to 50' maximum between braced wall lines SDC C townhouses
- 25' to 35' max between braced wall lines SDC D0 - D2 single family & townhouses
- Up to 35' between BWLs to allow a single 900 SF room - no adjustment
- Up to 35' between multiple BWLs, use adjustment factor

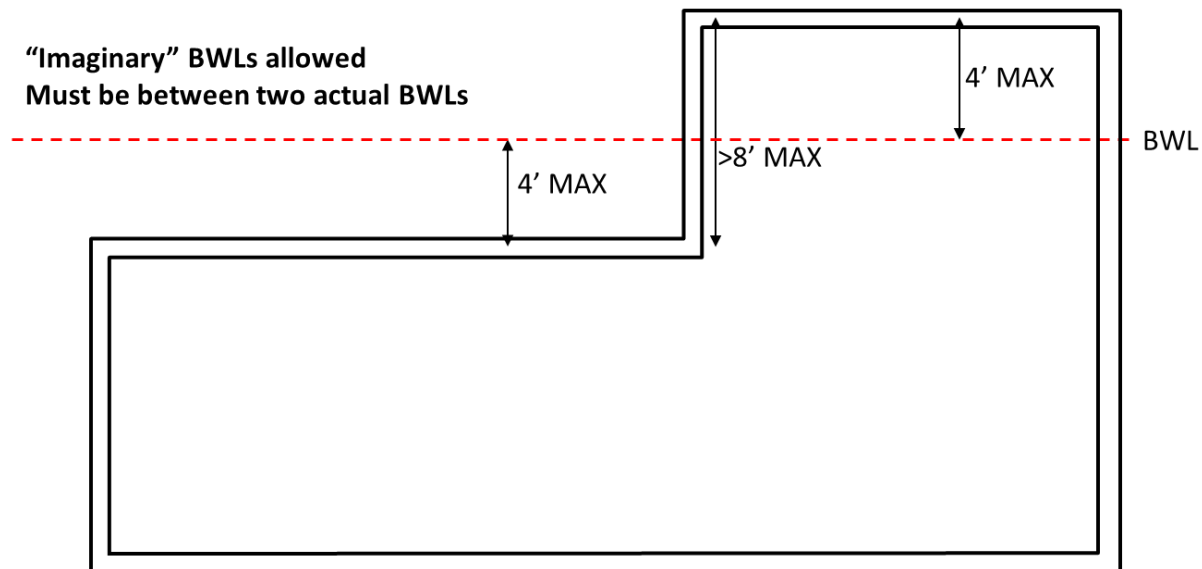


Length of Braced Wall line - R602.10.1.1

- Braced wall lines must end perpendicular to another braced wall line or exterior wall

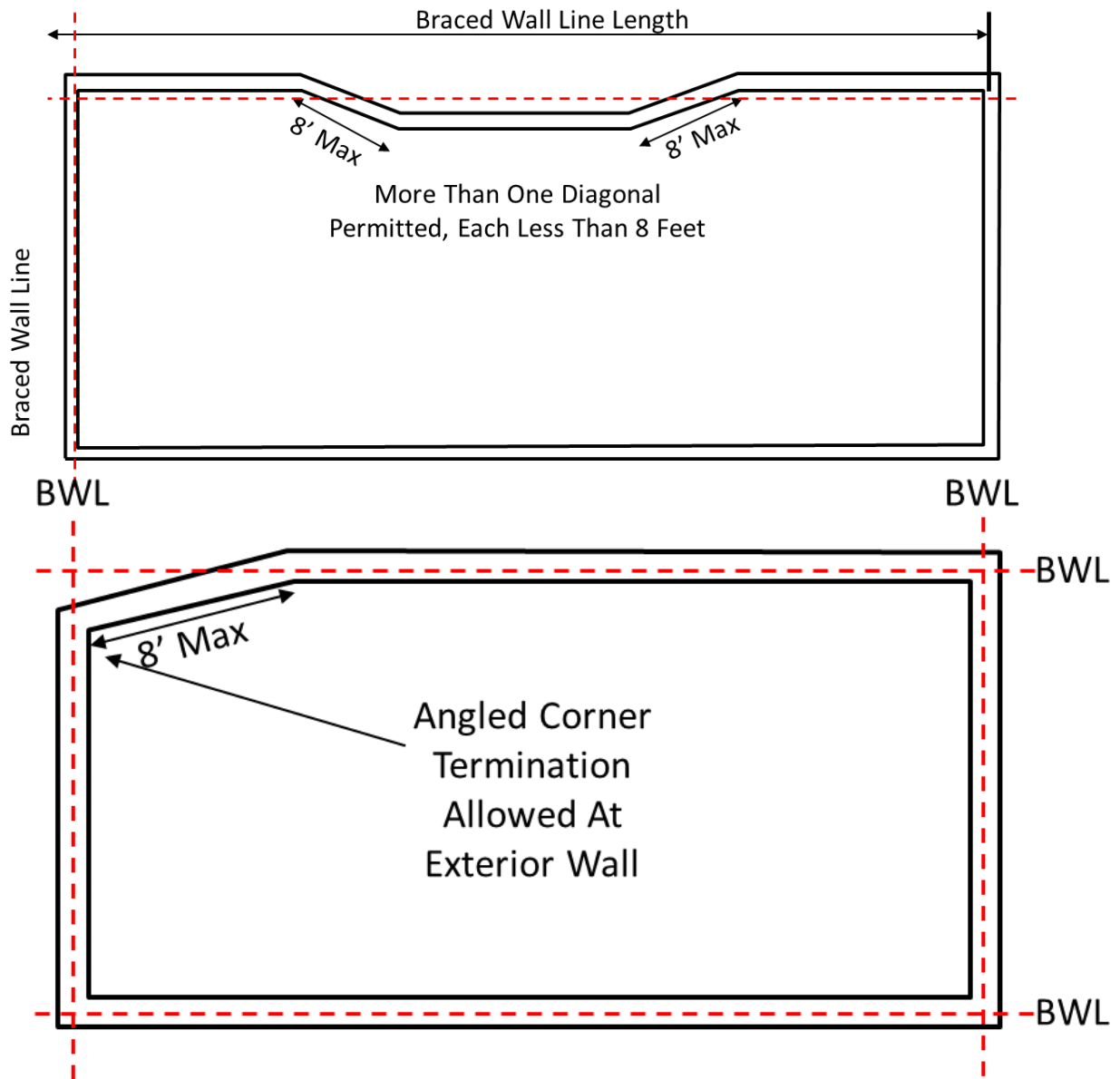
Braced Wall Line Offsets - R602.10.1.2

- Walls parallel to a braced wall line offset no more than 4 feet from the braced wall line



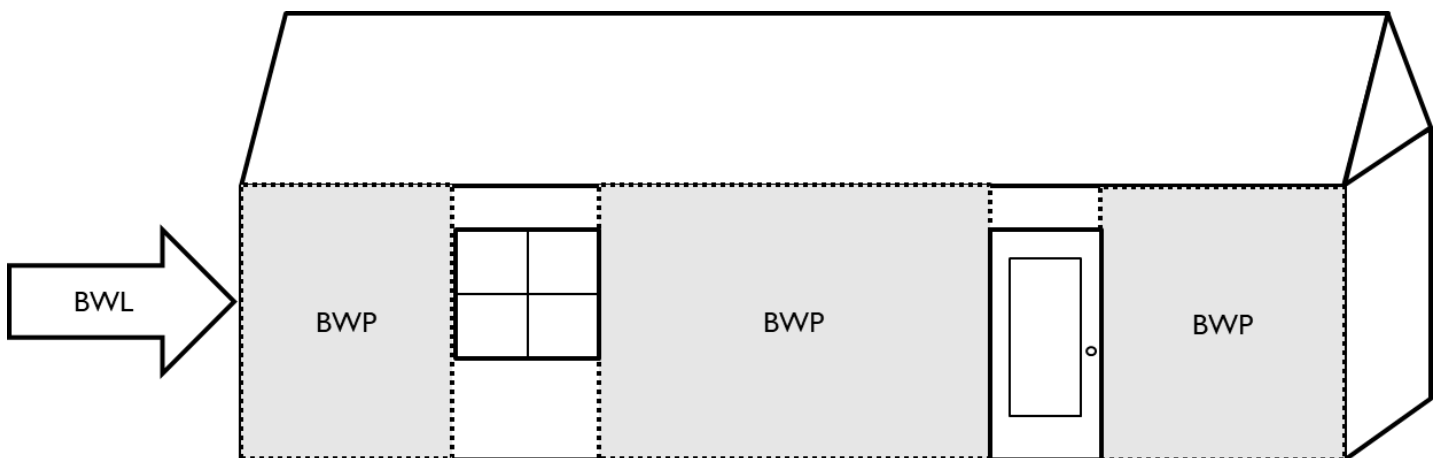
Angled Walls - R602.10.1.4

- Maximum diagonal length of 8 feet
- More than 8 feet it's a separate braced wall line



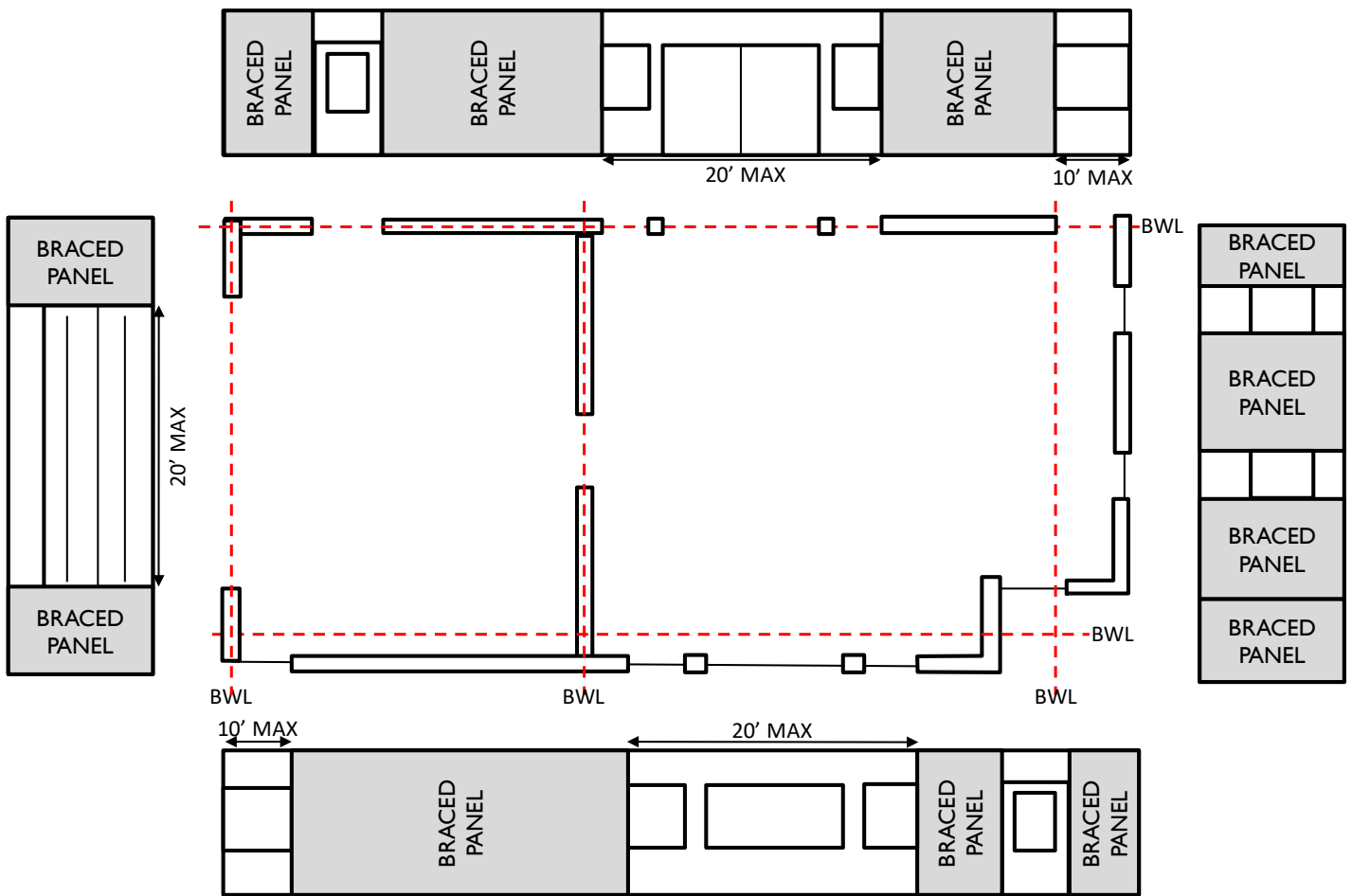
Braced Wall Panels - R602.10.2

- Braced wall panels are full height sections with no offsets



Location of Braced Wall Panels - 602.10.2.2

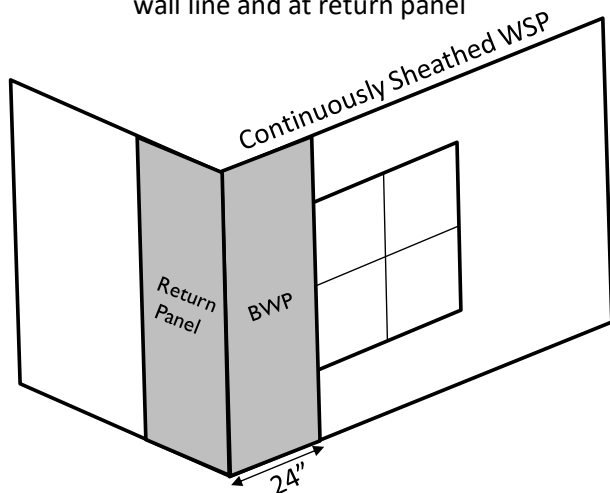
- Braced wall panel within 10' of each end of braced wall line
- Max 20' between braced wall panels



End Conditions For Braced Wall Panels With Continuous Sheathing - R602.10.7

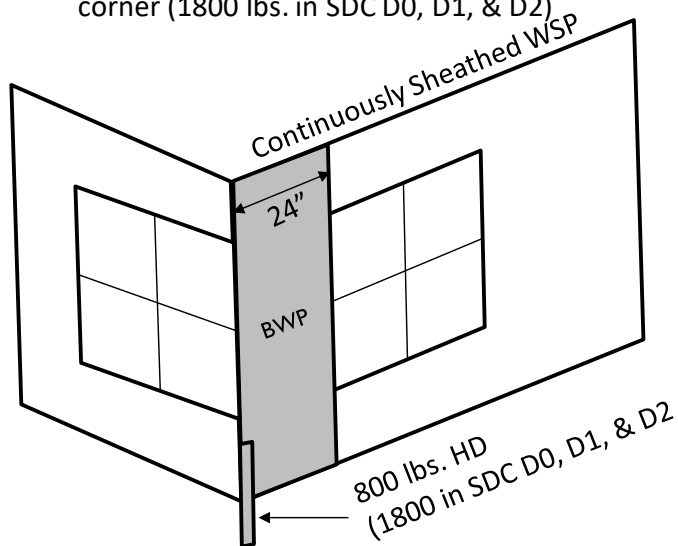
End Condition 1

Minimum 24" wide WSP at each end of braced wall line and at return panel



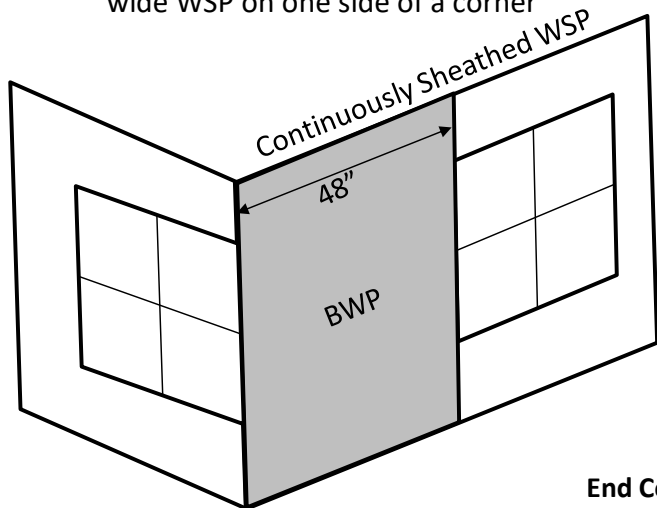
End Condition 2

No return panel present, install 800 lbs. HD in corner (1800 lbs. in SDC D0, D1, & D2)



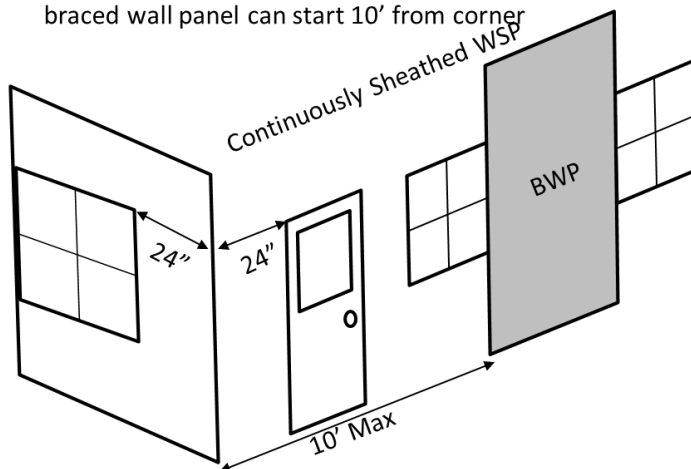
End Condition 3

No return panel or HD required if there is a 48" wide WSP on one side of a corner



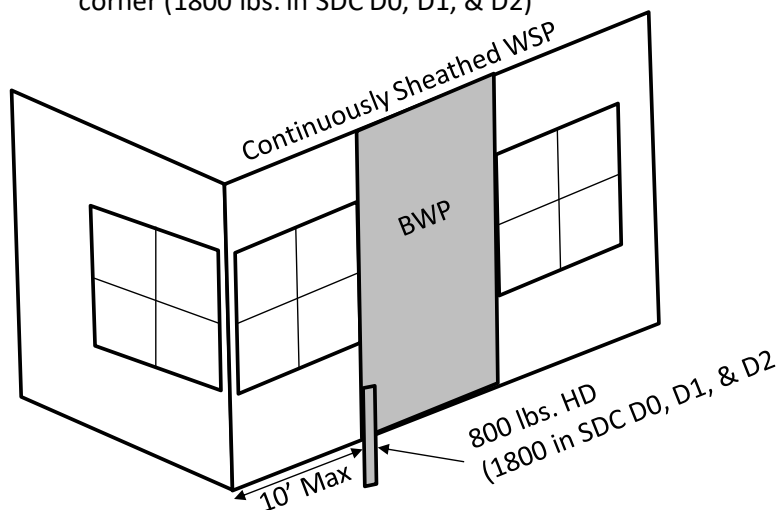
End Condition 4

24" wide WSP on each side of corner, first braced wall panel can start 10' from corner



End Condition 5

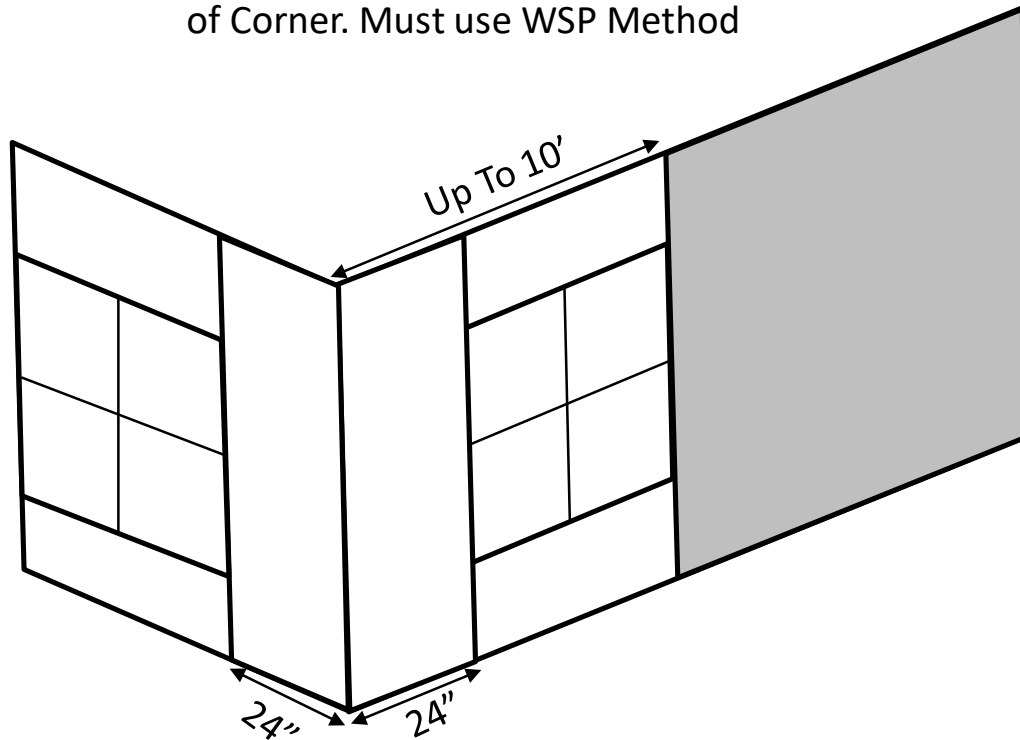
No return panel present install 800 lbs. HD at edge of first braced wall panel within 10' or corner (1800 lbs. in SDC D0, D1, & D2)



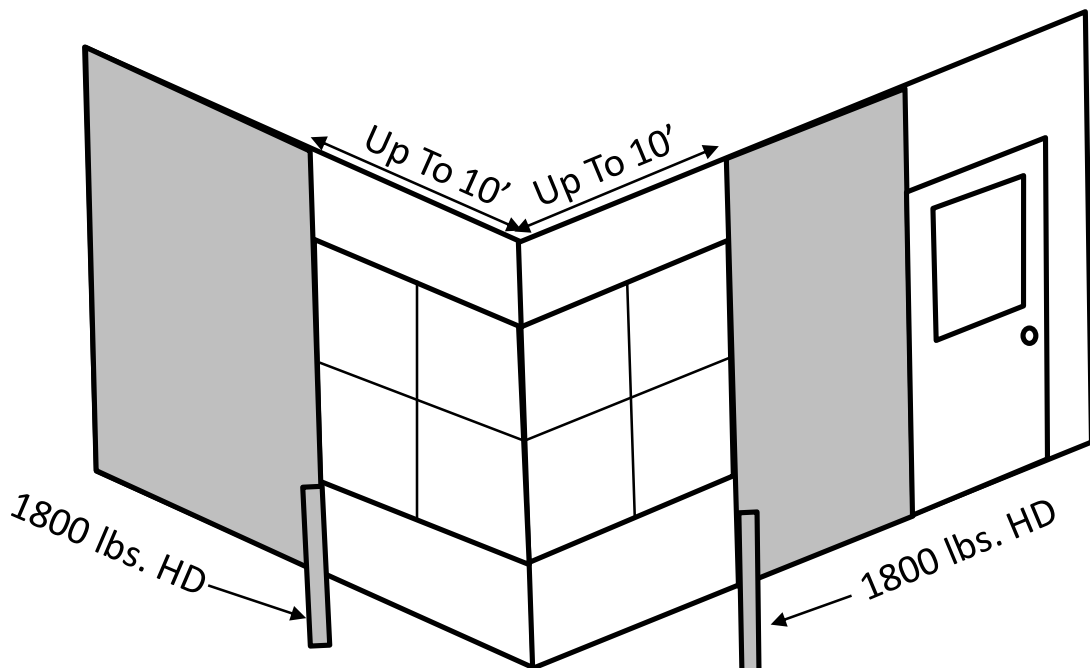
Location of Braced Wall Panels in SDC D0, D1, and D2 - R602.10.2.2.1

- Braced wall panel at each end of braced wall line
- Method WSP Exception:
 1. 24" wide panel at each building corner, or
 2. 1800 lb hold-down at edge of panel closest to the building corner

24" Panel On Each Side Of Corner, BWP Within 10 Feet of Corner. Must use WSP Method

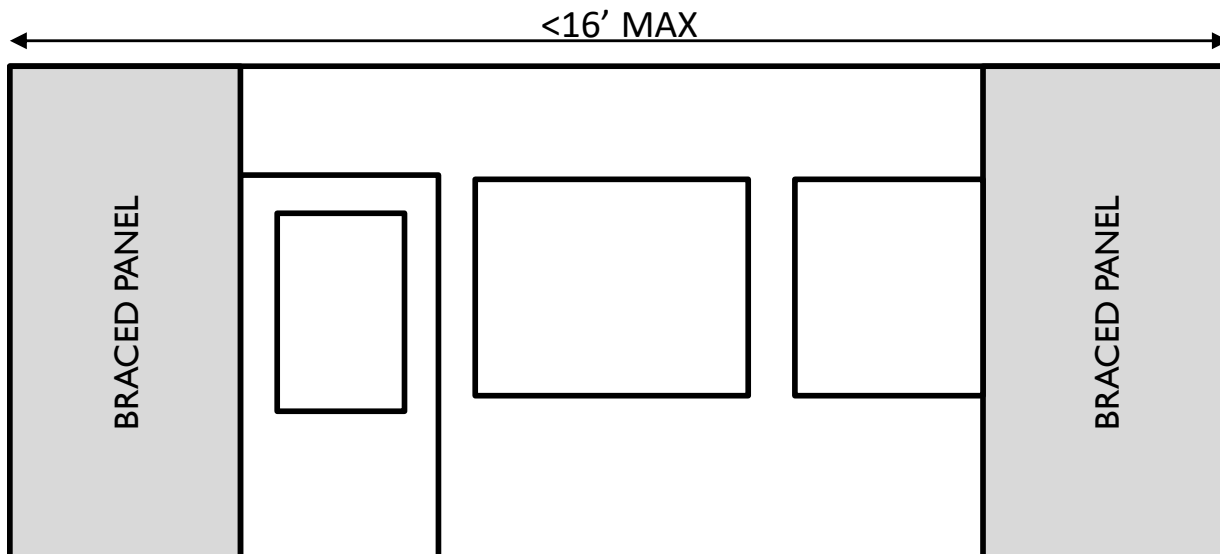


No Panel In Corner, BWP Within 10 Feet of Corner.
1800 lbs. HD At Corner Side Edge Of Each BWP

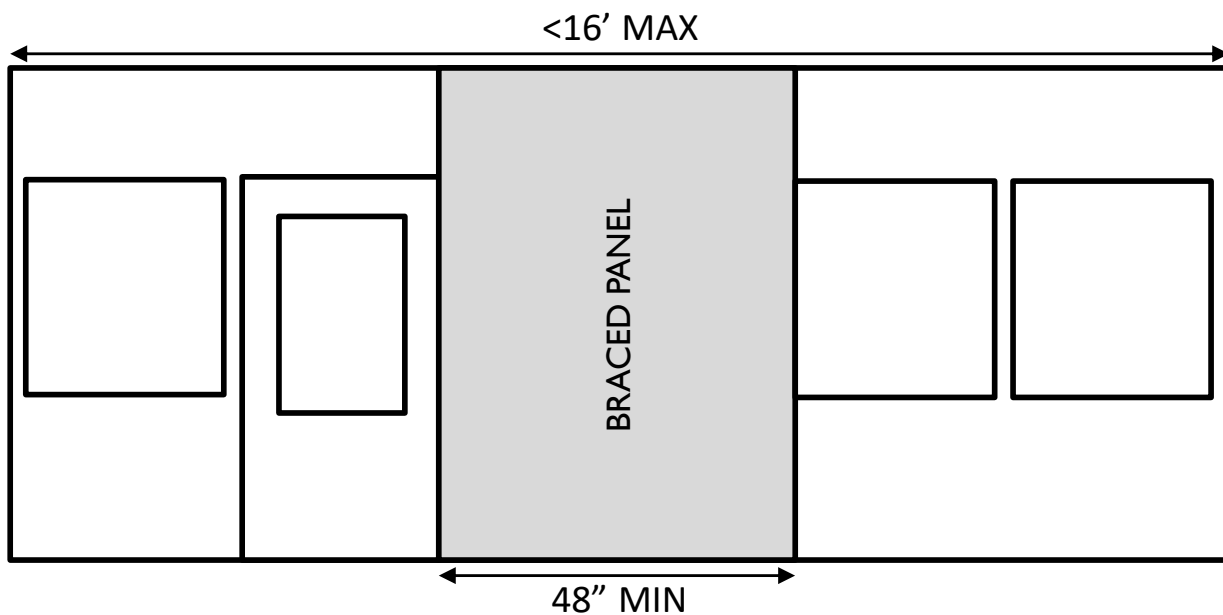


Minimum Number of Braced Wall Panels - R602.10.2.3

- Braced wall lines less than 16' in length, minimum 2 panels or 1 - 48" panel
- Braced wall lines more than 16' in length, minimum 2 panels



Braced Wall Lines Less Than 16' in Length, 2 Braced Panels Required
OR
1 Panel Minimum 48" Wide



Braced Wall Panel Interior Finish Materials - R602.10.4.3 & Table R602.10.3(4) #9

- Minimum 1/2" gypsum board interior finish material, or 50% increase in seismic bracing

Panel Joints - R602.10.4.4 & Table R602.10.3(4) #10

- Omitting blocking for WSP & CS-WSP bracing methods, 100% increase in seismic bracing

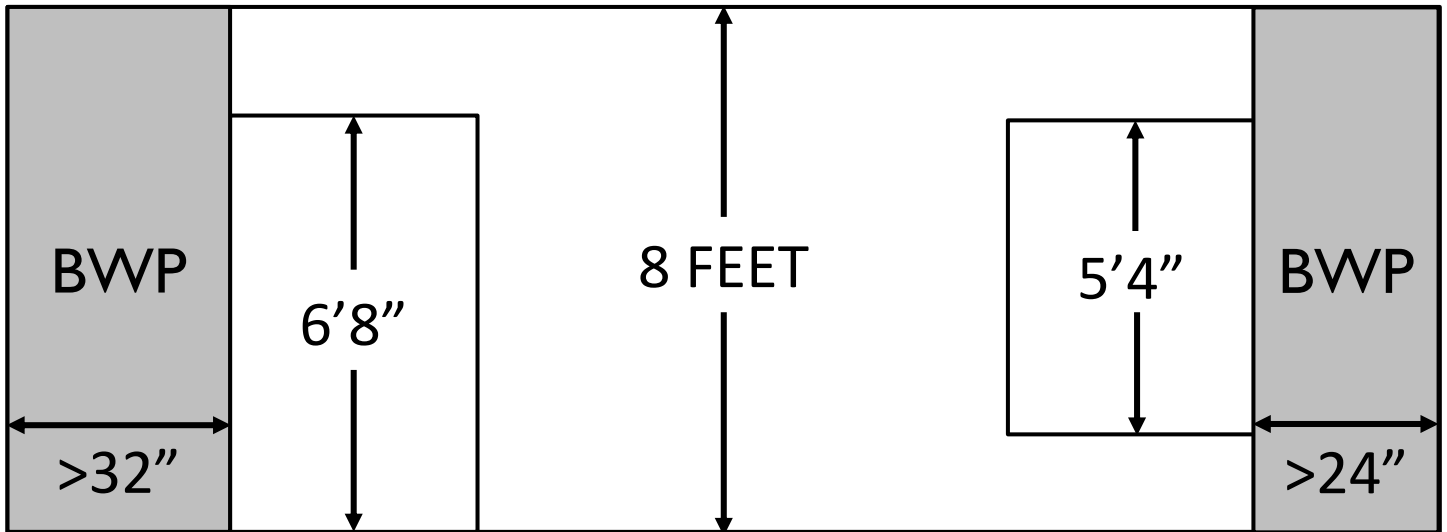
Mixing Methods - R602.10.4 (5)

- Mixing CS-WSP & GB only permitted in SDC A-C

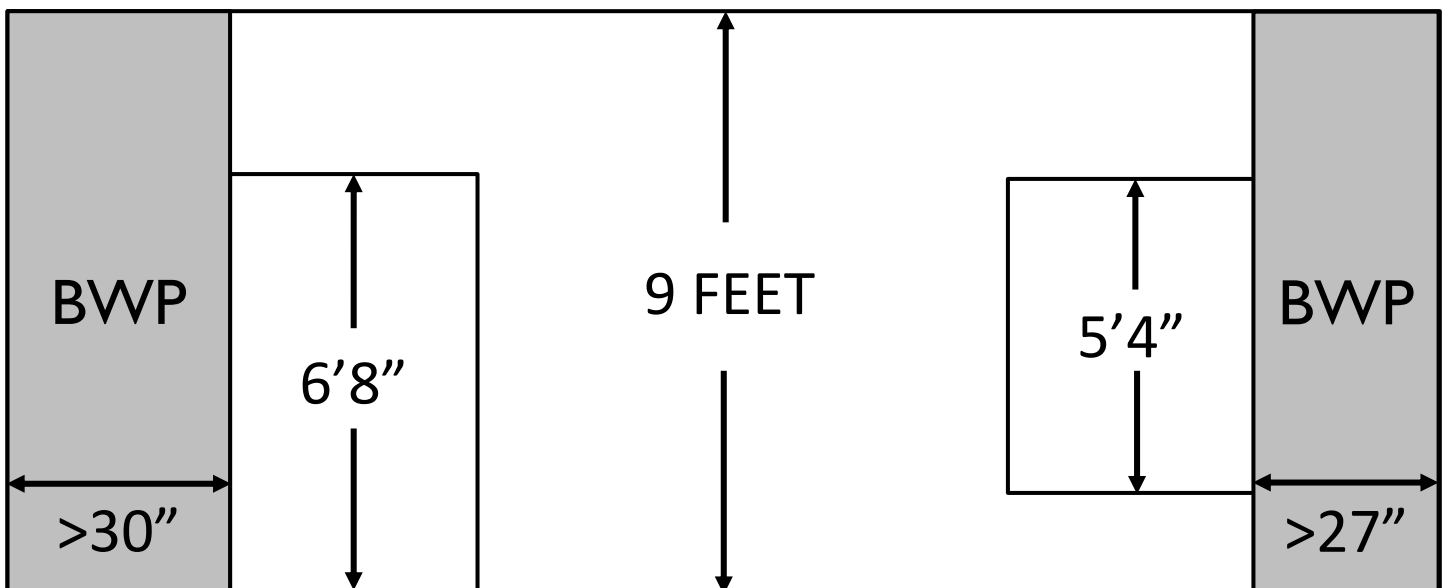
Minimum Length of Braced Wall Panels - Table R602.10.5

- Depending on size of opening, there is a minimum length of braced wall panel in the corner

Simplified Minimum Length of Braced Wall Panels								
Partial Table R602.10.5								
	Adjacent Clear Opening Height		Wall Height					Contributing Length
	Inches	Feet	8 Feet	9 Feet	10 Feet	11 Feet	12 Feet	
			Full Height Panel Width - Inches					
CS-WSP	<64	5-4	24	27	30	33	36	Actual
	68	5-8	26	27	30	33	36	
	72	6-0	27	27	30	33	36	
	76	6-4	30	29	30	33	36	
	80	6-8	32	30	30	33	36	
	84	7-0	35	32	32	33	36	
	88	7-4	38	35	33	33	36	
	92	7-8	43	37	35	35	36	
	96	8-0	48	41	38	36	36	
	100	8-4	-	44	40	38	38	
	104	8-8	-	49	43	40	39	
	108	9-0	-	54	46	43	41	
	112	9-4	-	-	50	45	43	
	116	9-8	-	-	55	48	45	
	120	10-0	-	-	60	52	48	
	124	10-4	-	-	-	56	51	
	128	10-8	-	-	-	61	54	
	132	11-0	-	-	-	66	58	
	136	11-4	-	-	-	-	62	
	140	11-8	-	-	-	-	66	
	144	12-0	-	-	-	-	72	
GB	N/A	N/A	48	48	48	53	58	Double Sided = Actual Single Sided = 0.5 X Actual



This illustration shows how the adjacent opening height affects the minimum required braced wall panel length. For an 8 foot tall wall, the minimum braced wall panel length required is at least 32 inches adjacent to openings that are 6 feet 8 inches. In all cases the minimum braced wall panel length is 24 inches, and an opening height of up to 5 feet four inches is permitted.

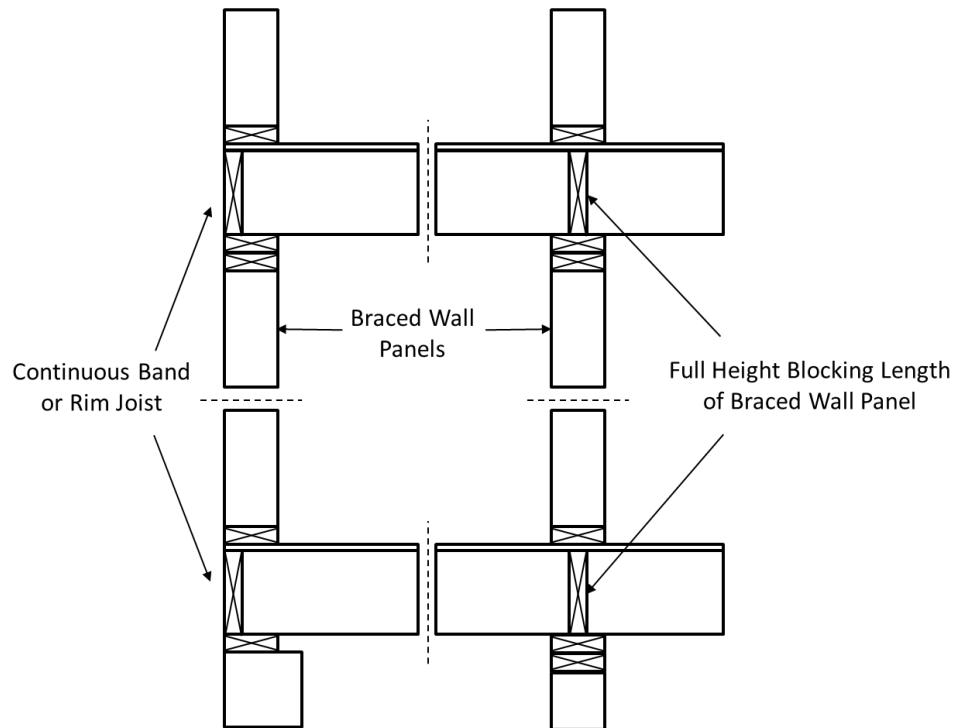


As the braced wall line gets taller, the minimum required length of the panel increases, and at the same time the minimum required length decreases relative to the height of the opening. This illustration shows a 9 foot wall with the same size openings. The minimum length of the braced wall panel decreases from 32 inches to 30 inches next to a 6 foot 8 inch door opening, however, the minimum required panel length to be counted as a braced wall panel increases from 24 inches to 27 inches.

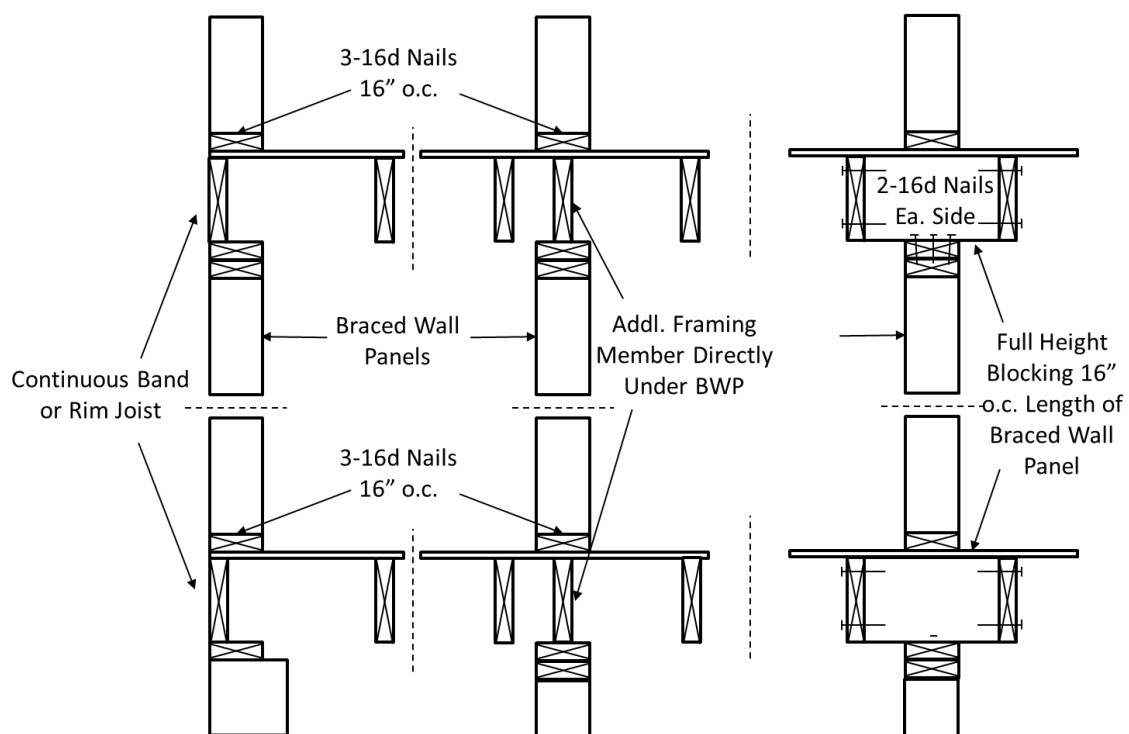
Braced Wall Panel Connections - R602.10.8

- Braced wall panels must have a rim joist, band joist, parallel framing member, or full height blocking 16" o.c. above and below

Framing Connections - Perpendicular



Framing Connections - Parallel



Connections to Roof Framing - R602.10.8.2

- SDC A-C, truss blocking required above all braced wall panels exceeding 9-1/4" heel height
- SDC D0 - D2, truss blocking required above all braced wall panels
- 2" gap above blocking permitted for ventilation

Braced Wall Panel Support - R602.10.9

- Braced wall panels over posts or piers must be engineered
- Masonry stem walls less than 48" in length must be specially reinforced (threaded rod & cut washers)
- ABW & PFH cannot attached to masonry stem walls

Cripple Walls - R602.10.10 (refers to framed walls on top of the foundation raising the floor level)

- Continuous foundation required (R602.9)
- Braced with the length and method of the wall above plus 15%, or re-designated as the 1st story (602.10.10.3)
- Add 50% more bracing if gypsum board not applied to cripple wall

IRC Requirements - SDC D0, D1, & D2**Braced Wall Panel Support - R602.10.9.1 (refers to R403.1.2)**

- All exterior walls on continuous concrete footings
- Building plan dimension exceeds 50' all interior braced wall panels supported on continuous footings
- D2 - 2 story - All interior and exterior braced wall panels supported on continuous foundations

Interior Monoslab Bearing - R403.1.3.4

- Interior footing minimum 12" depth for bearing walls and braced wall lines

Cripple Wall Bracing SDC C for Townhouses and D0, D1 for Single Family Dwellings - R602.10.10.1

- Maximum 14' between braced wall panels
- Where interior braced wall lines are not supported on a continuous foundation below, parallel cripple walls must be sheathed using WSP or CS-WSP method plus 50%. This amount can be reduced 30% with 4" edge nailing

Cripple Wall Bracing SDC D2 - R602.10.10.2

- Must use seismic bracing tables 602.10.(3)

Re-Designation of Cripple Walls - R602.10.10.3

- Cripple walls less than 48" in height can be braced as if they are a first story
- Cripple walls more than 48" in height counted as an additional story

Wall Anchorage for SDC D0, D1, & D2 - R602.11.1

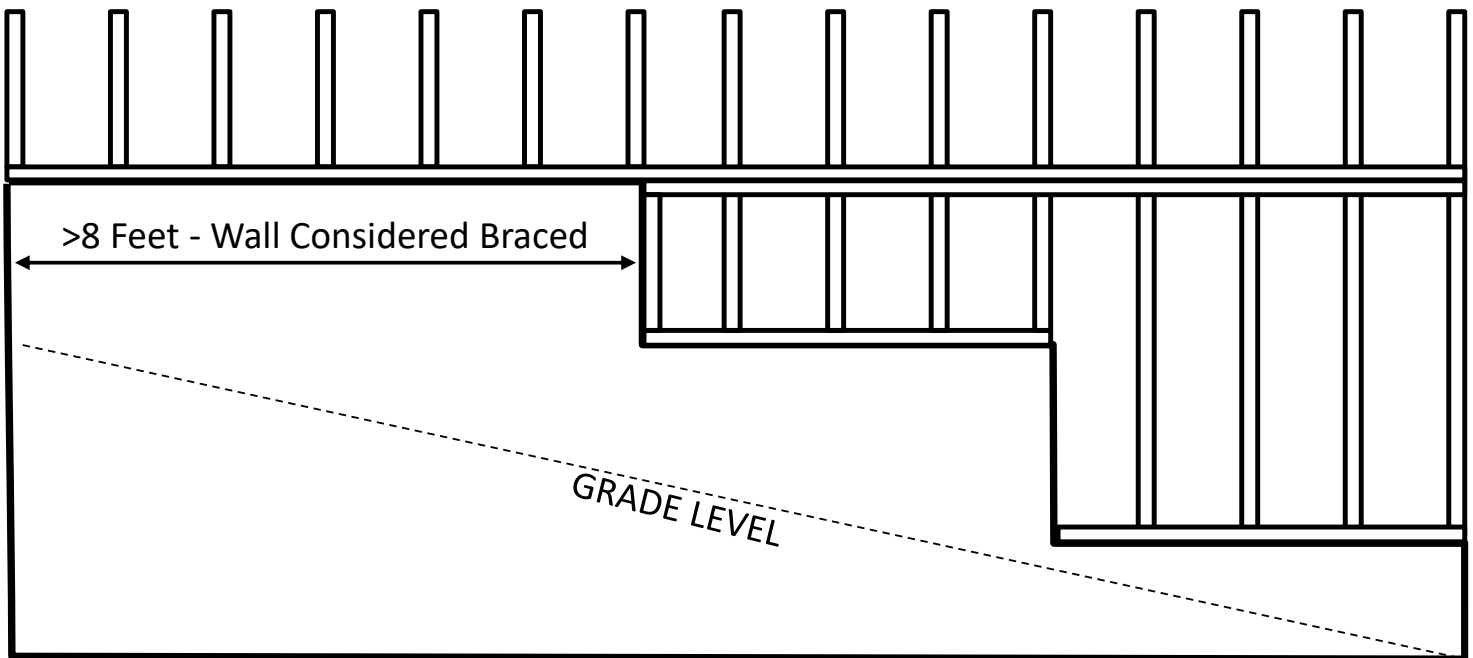
- Must use 3" X 3" plate washers on anchor bolts

Stepped Foundations in SDC D0-D2 - R602.11.2

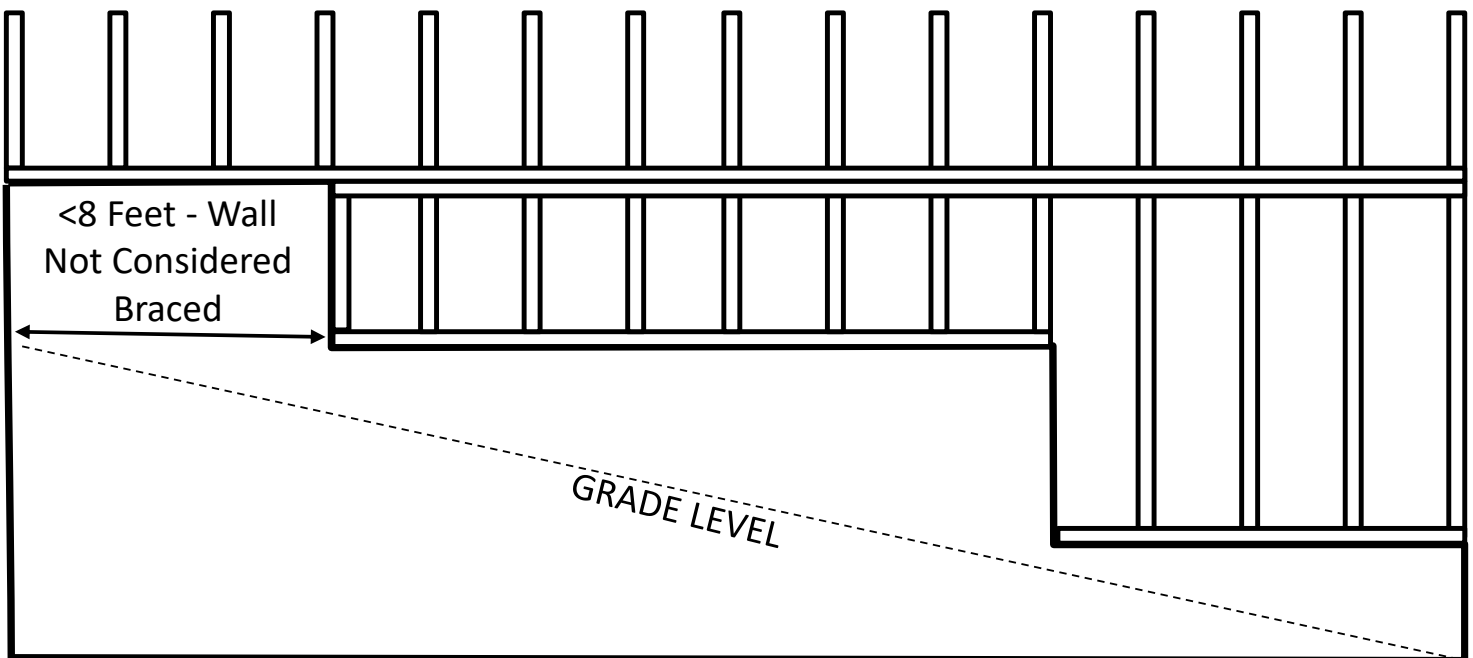
- At least 8 feet of braced wall directly on sill plate, wall line considered braced
- Less than 8 feet, must meet cripple wall requirements

Stepped Foundations in SDC D0-D2 - R602.11.2

- At least 8 feet of braced wall directly on sill plate, wall line considered braced
- Less than 8 feet, must meet cripple wall requirements



This illustration shows a situation where there is a cripple wall that is part of the braced wall line. However, since there is at least 8 feet of the braced wall line directly on the sill plate on top of the foundation, the wall line is considered braced and the cripple wall bracing adjustments do not apply.



This illustration is similar except there is not 8 feet of braced wall line directly on top of the foundation, so cripple wall bracing rules apply.

IRC Seismic Bracing Requirements - Bracing Methods

Bracing Methods - R602.10.4

- 12 intermittent bracing methods
- 4 continuous bracing methods
- Intermittent methods not designed to be continuously sheathed, a series of braced panels on a braced wall line
- Continuous methods fully sheathed around all openings

Method Continuous Sheathing, Wood Structural Panels - R602.10.4.2

- All available wall space must be sheathed; over, under, and around openings and gable ends
- Minimum 3/8" thick structural sheathing (R602.3(3))
- Nailed 6" edge / 12" field with 6d nails
- Orientation of sheets does not matter
- Must have 1/2" gypsum board or equivalent on one side, or adjustment factor (R602.10.4.3)
- Vertical panel joints over studs (R602.10.4.4)
- Horizontal panel joints over 2X blocking, or adjustment factor

Method Gypsum Board - Table R602.10.4

- 7" fastener spacing edge and field when used for bracing
- Horizontal blocking not required

Minimum Length - Table R602.10.5

Contributing Length - R602.10.5.1

- CS-WSP - Panels must meet minimum length to contribute to required wall bracing length
- GB - Double sided panels must meet minimum length to contribute to required wall bracing length
- Single sided panels contribute 50%

Required Bracing Amounts - IRC Table R602.10.3(3)

- Based on SDC C - D2 (A and B default to wind)
- Story Location
- Percentage of wall length requiring full height sheathing in minimum length segment(s)

Required Bracing Adjustments - IRC Table R602.10.3(4)

- Bracing amount adjusted based on certain conditions

Mixing Methods - IRC R602.10.4(5)

- Mixing CS-WSP & GB only permitted in SDC A-C

Simplified Bracing Requirements Based On - CS-WSP & GB (Partial Table R602.10.3(3))			
SDC	Story Location	*Required Percentage of Wall Bracing - CS-WSP	**Required Percentage of Wall Bracing - GB
Category C (Townhouses Only)	First Story	14%	25%
	First Story of Two, Middle of Three	26%	45%
	First Story of Three	38%	60%
Category D0	First Story	16%	28%
	First Story of Two, Middle of Three	32%	53%
	First Story of Three	45%	73%
Category D1	First Story	17%	30%
	First Story of Two, Middle of Three	38%	60%
	First Story of Three	51%	85%
Category D2	First Story	21%	40%
	First Story of Two, Middle of Three	47%	75%
	First Story of Three	NA	NA
Category D2 - Cripple Wall	N/A	64%	N/A
*CS-WSP Based on 3/8" thick sheathing & 6" edge/12" field nailing			
** Based on 1/2" gypsum board on both sides of interior wall, 7" fastener spacing			

The required amount of wall bracing for earthquake resistance is based on seismic design categories C through D2. Buildings located in seismic zones A and B have no seismic bracing requirement and default to the wind bracing requirements.

The required amount of bracing also depends on the story location. The bottom floor of a two story or three story buildings and the middle floor of three story buildings have greater bracing requirements due to supporting additional floor loads than do single story buildings.

The required amount of bracing is a percentage of the wall length that is full height segments of the minimum length.

Seismic Bracing Adjustments (Table R602.10.3(4))					
Item Number	Adjustment Based On	Story	Condition	Adjustment Factor ^{a,b}	Applicable Methods
1	Story Height	Any Story	≤ 10 feet	1.0	All Methods
			> 10 feet to ≤ 12 feet	1.2	
2	Braced wall line spacing, townhouses is SDC C	Any Story	≤ 35 feet	1.0	
			> 35 feet to ≤ 50 feet	1.43	
3	Braced wall line spacing in SDC D0, D1, & D2 ^c	Any Story	> 25 feet to ≤ 30 feet	1.2	
			> 30 feet to ≤ 35 feet	1.4	
4	Wall Dead Load	Any Story	> 8 psf and < 15 psf	1.0	
			< 8 psf	0.85	
5	Roof/ceiling dead load for wall supporting ^{d,e}	1, 2, or 3 story building	≤ 15 psf	1.0	
		2 or 3 story building	>15 psf and ≤25 psf	1.1	
		1-story building or top story	>15 psf and ≤25 psf	1.2	
6	Walls with stone or masonry veneer, townhouses is SDC C ^{d,e}	1 story, top of 2 or 3 story	1.0		
		Bottom of 2 story, middle of 3 story	1.5		
		Bottom of 3 story	1.5		
7	Walls with stone or masonry veneer, one & two family dwellings D0 - D2 ^{d,f}	Any Story	See Table R602.10.6.5		BV-WSP
8	Walls with stone or masonry veneer, one & two family dwellings D0 - D2 ^{d,f}	First and second story of two-story dwelling	See Table R602.10.6.5	1.2	WSP, CS-WSP
9	Interior gypsum board finish	Any Story	Omitted from inside face of braced wall panels	1.5	DWB, WSP, SFB, PBS, PCP, HPS, CS-WSP, CS-G, CS-SFB
10	Horizontal Blocking	Any Story	Horizontal blocking omitted	2.0	WSP, CS-WSP

a. Linear interpolation shall be permitted

b. The total length of bracing required for a given wall line is the product of all applicable adjustment factors.

c. The length to width ration for the floor/roof diaphragm shall not exceed 3:1

d. Applies to stone or masonry veneer exceeding the first story height.

e. The adjustment factor for stone or masonry veneer shall be applied to all exterior braced wall lines and all braced wall lines on the interior of the building, backing or perpendicular to and laterally supporting veneered

f. See Section R602.10.6.5 for requirements where stone or masonry veneer does not exceed the first story height

Item 1 is story height. Story heights less than 10 feet require no adjustment. Story heights from 10 feet to a maximum of 12 feet require a 20 percent increase in bracing.

Item 2 is braced wall line spacing in townhouses in Seismic Design Category C. For townhouses in seismic design category C, the spacing between braced wall lines affects the required amount of bracing. Spacing between braced wall lines from 35 feet to a maximum of 50 feet requires a 43% increase in bracing.

Item 3 is braced wall line spacing in seismic design categories D0 through D2. For any dwellings in seismic categories D0 through D2 there is an adjustment factor when the spacing between braced wall lines exceeds 25 feet. From 25 to 30 feet, the bracing is increased 20%. From 30 to 35 feet, the bracing is increased 40 percent. Spacing between parallel braced wall lines cannot exceed 35 feet in these seismic zones.

Item 4 deals with wall dead loads. Wall dead loads less than 8 pounds per square foot can reduce required bracing 15%. 15 pounds per square foot is the maximum permitted wall dead load.

Item 5 requires a wall bracing increase for roof ceiling dead loads exceeding 15 pounds per square foot. This deals with dead load only and does not consider live loads such as snow.

Item 6 requires walls with stone or masonry veneer to increase bracing for townhouses in seismic design category C. Items one through six apply to all bracing methods, both intermittent and continuously sheathed.

Item 7 deals with stone or masonry veneer in seismic design categories D0 through D2. Stone and masonry is a separate section and separate bracing method within the wall bracing portion of the code, due to the additional dead load on the walls.

Item 8 also deals with stone or masonry veneer in seismic design categories D0 through D2, but this time as applied to the wood structural panel and wood structural panel with continuous sheathing methods. Table 602.10.6.5 is used along with a correction factor to increase the minimum required amount of wall bracing.

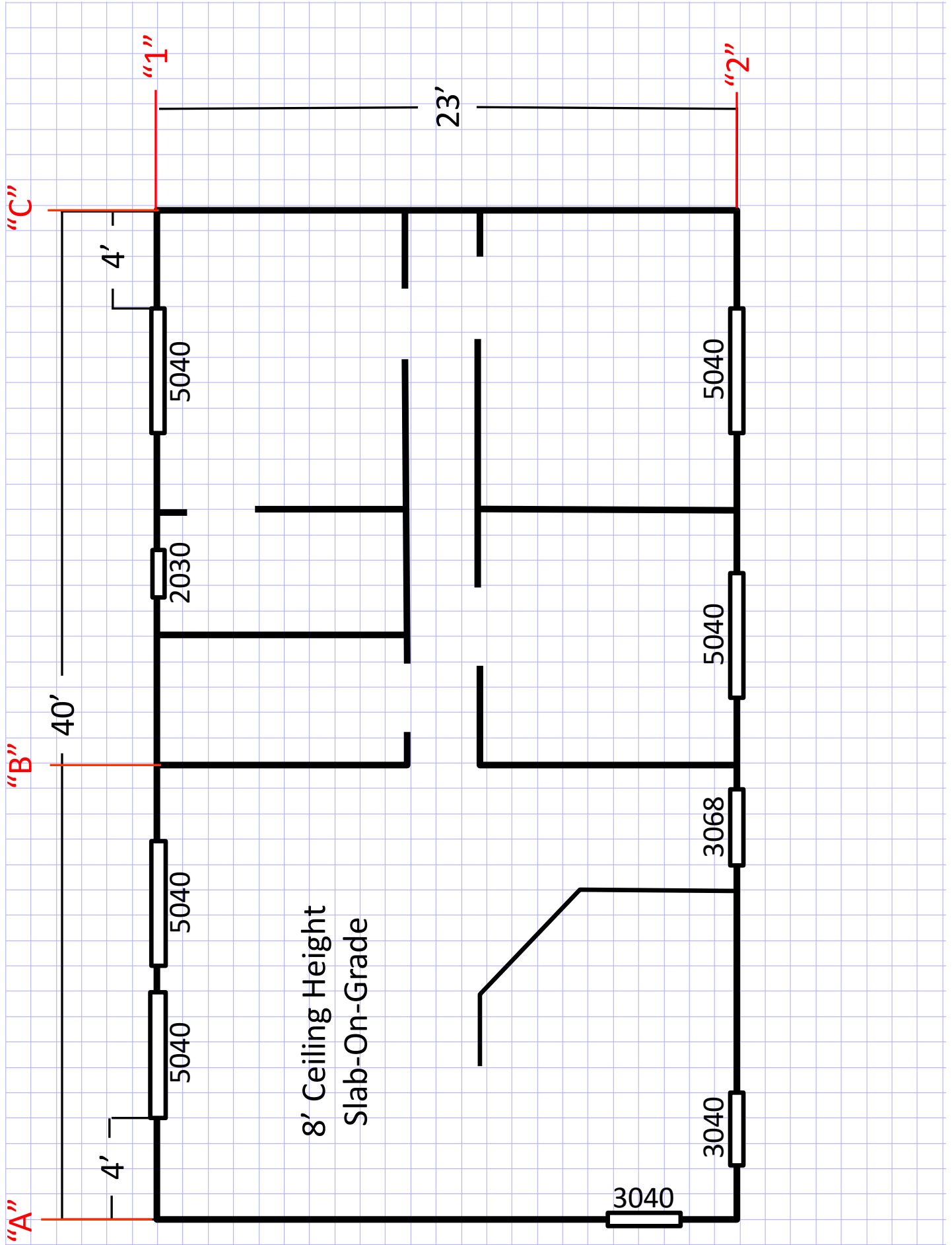
Item 9 is interior gypsum board finish. The seismic wall bracing table assumes that the interior side of a braced wall line using continuous sheathing wood structural panel method has gypsum board installed on the interior face of the wall. If gypsum board or an equivalent is not installed on the inside, a 50% increase in the amount of bracing is required.

Item 10 assumes that all horizontal joints in braced wall lines using wood structural panels are blocked with 2X materials. If the horizontal joints are not blocked then the amount of required wall bracing is doubled.

There are several important notes that need reviewed with this table. Linear interpolation is permitted. This means that if there is a bracing situation that fits between two of the given categories in the table, then the difference can be split. For example, if the wall story height is 11 feet, then the difference between the 10 foot wall factor of 1 and the 12 foot wall factor of 1.2 could be split, and a wall height factor of 1.1 could be used.

The total length of bracing required for a given wall line is the product of all applicable adjustment factors. Each factor from the table is multiplied together, and then the product is multiplied by the required bracing length from the tables.

The length to width ratio, or aspect ration, cannot exceed 3 to 1. If the length of the building is 60 feet for example, the minimum width could be no less than 20 feet, which would be a 3 to 1 ratio.



IRC Siesmic Calculations

Project Name: **Practice 1**

Date:

Seismic Category: **D2**

Seismic Adjustment Factors

Story Height ¹	1.0	(10' to 12' height, adjustment factor of 1.2)
Wall Dead Load ⁴	1.0	(Less than 8 psf, adjustment factor of 0.85)
Roof/Ceiling Dead Load ⁵	1.0	(15 to 25 psf, adjustment factor of 1.5)
Stone/Masonry in SDC C-D2 ^{6, 7, 8}	1.0	(Applies to walls that have, or are perpendicular to, masonry veneer)
Interior Gypsum Board ⁹	1.0	(Omitted from inside face of exterior walls, adjustment factor of 1.5)
Horizontal Blocking ¹⁰	1.0	(Omitted from WSP and CS-WSP methods, adjustment factor of 2.0)
Seismic Factor Total	1.0	

Braced Wall Line	Bracing Method	Braced Wall Line Length	Story	Required Bracing Length	Braced Wall Line Spacing Factor ^{2, 3}	Seismic Adj. Factor	Cripple Wall Bracing Factor	Total Required Bracing Length	Bracing Length Provided	Notes
1	CS-WSP	40'	1 of 1	8.4'	1.0	1.0	1.0	8.4'	22'	OK as drawn
2	CS-WSP									
A	CS-WSP									
B	GB	23'	1 of 1	9.2'	1.0	1.0	1.0	9.2'	20'	OK as drawn
C	CS-WSP									

Required Bracing Amounts - Wind

- Based on wind speed
- Story Location
- Spacing between braced wall lines
- Seismic may overrule

Simplified Wind Bracing Requirements - CS-WSP & GB				
Ultimate Wind Speed	Story	Spacing Between BWLs	*Minimum Total Length of Braced Wall Panels per Braced Wall Line - GB	**Minimum Total Length of Braced Wall Panels per Braced Wall Line - CS-WSP
≤120	1 of 1	10	4.0	2.0
		20	7.0	3.5
		30	10.5	5.0
		40	13.5	6.5
		50	16.5	8.0
		60	19.5	9.5
	1 of 2, Middle of 3	10	7.5	3.5
		20	14.0	7.0
		30	20.0	9.5
		40	25.5	12.5
		50	31.5	15.5
		60	37.5	18.5
	Bottom of 3	10	11.0	5.5
		20	20.5	10.0
		30	29.0	14.5
		40	38.0	18.5
		50	47.0	23.0
		60	55.5	27.0
≤130	1 of 1	10	4.5	2.5
		20	8.5	4.0
		30	12.0	6.0
		40	15.5	7.5
		50	19.5	9.5
		60	23.0	11.0
	1 of 2, Middle of 3	10	8.5	4.5
		20	16.0	8.0
		30	23.0	11.5
		40	30.0	15.0
		50	37.0	18.0
		60	44.0	21.5
	Bottom of 3	10	13.0	6.5
		20	24.0	11.5
		30	34.5	17.0
		40	44.5	22.0
		50	55.0	26.5
		60	65.0	31.5

Simplified Wind Bracing Requirements - CS-WSP & GB				
Ultimate Wind Speed	Story	Spacing Between BWLs	*Minimum Total Length of Braced Wall Panels per Braced Wall Line - GB	**Minimum Total Length of Braced Wall Panels per Braced Wall Line - CS-WSP
≤140	1 of 1	10	5.5	2.5
		20	10.0	5.0
		30	14.0	7.0
		40	18.0	9.0
		50	22.5	11.0
		60	26.5	13.0
	1 of 2, Middle of 3	10	10.0	5.0
		20	18.5	9.0
		30	27.0	13.0
		40	35.0	17.0
		50	43.0	21.0
		60	51.0	25.0
	Bottom of 3	10	15.0	7.5
		20	27.5	13.5
		30	39.5	19.5
		40	51.5	25.0
		50	63.5	31.0
		60	75.5	36.5
** Based on 1/2" gypsum board on both sides of interior wall, 7" fastener spacing				
*CS-WSP Based on 3/8" thick sheathing & 6" edge/12" field nailing				
Where three or more parallel braced wall lines are present and the distances between adjacent braced wall lines are different, the average dimension shall be permitted to be used for braced wall line spacing.				

IRC Wind Bracing Adjustments - (Table R602.10.3(2))					
Item Number	Adjustment Based On	Story	Condition	Adjustment Factor ^{a,b}	Applicable Methods
1	Exposure category ^d	One Story	B	1.00	All Methods
			C	1.20	
			D	1.50	
		Two Story	B	1.00	
			C	1.30	
			D	1.60	
		Three Story	B	1.00	
			C	1.40	
			D	1.70	
2	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	NP	
3	Story height	Any Story	8 Feet	0.90	
			9 Feet	0.95	
			10 Feet	1.00	
			11 Feet	1.05	
			12 Feet	1.10	
4	Number of braced wall lines (per plan direction) ^c	Any Story	2	1.00	
			3	1.30	
			4	1.45	
			> 5	1.60	
5	Additional 800 lb. Hold-Down Device	Top Story Only	Fastened to Each End of Each BWP to Foundation or Framing Below	0.80	DWB, WSP, SFB, PBS, PCP, HPS
6	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
7	Gypsum board fasteneing	Any Story	4 inches o.c. at panel edges incl. top and bottom plates, all horizontal joints blocked	0.70	GB
8	Horizontal Blocking	Any Story	Horizontal blocking omitted	2.00	WSP, CS-WSP

a. Linear interpolation shall be permitted

b. The total adjustment factor is the product of all adjustment factors.

c. The adjustment factor is permitted to be 1.0 when determining bracing amounts for intermediate braced wall lines provided the bracing amounts on adjacent braced wall lines are based on a spacing and number that neglects the intermediate braced wall line.

d. The same adjustment factor shall be applied to all braced wall lines on all floors of the structure, based on the worst-case exposure category.

Item 1 applies to wind bracing is the exposure category. Exposure category is based on the number of stories of the building, and the surrounding terrain.

Item 2 refers to the roof eave to edge height. This category is divided into roof only for a one story building, roof plus one floor for a two story building, and roof plus two floors for a two story building. Then, based on the height of the roof from the eave to the peak, an adjustment factor is applied.

Item 3 refers to the story height. The taller the story, or distance from floor to floor vertically, the greater the adjustment factor.

Item 4 applies an adjustment factor based on the number of braced wall lines per plan direction. If there are three or more braced wall lines running parallel, then and increase adjustment factor is applied accordingly.

Item 5 permits the reduction in required bracing by 20% when an additional hold down device, which may be a strap or a hold down, is fastened to each end of each braced wall panel to the foundation or framing below. This essentially turns the braced wall line into a segmented shearwall line, and a reduction in the required amount of bracing can be reduced. This method only applies to certain types of wall bracing.

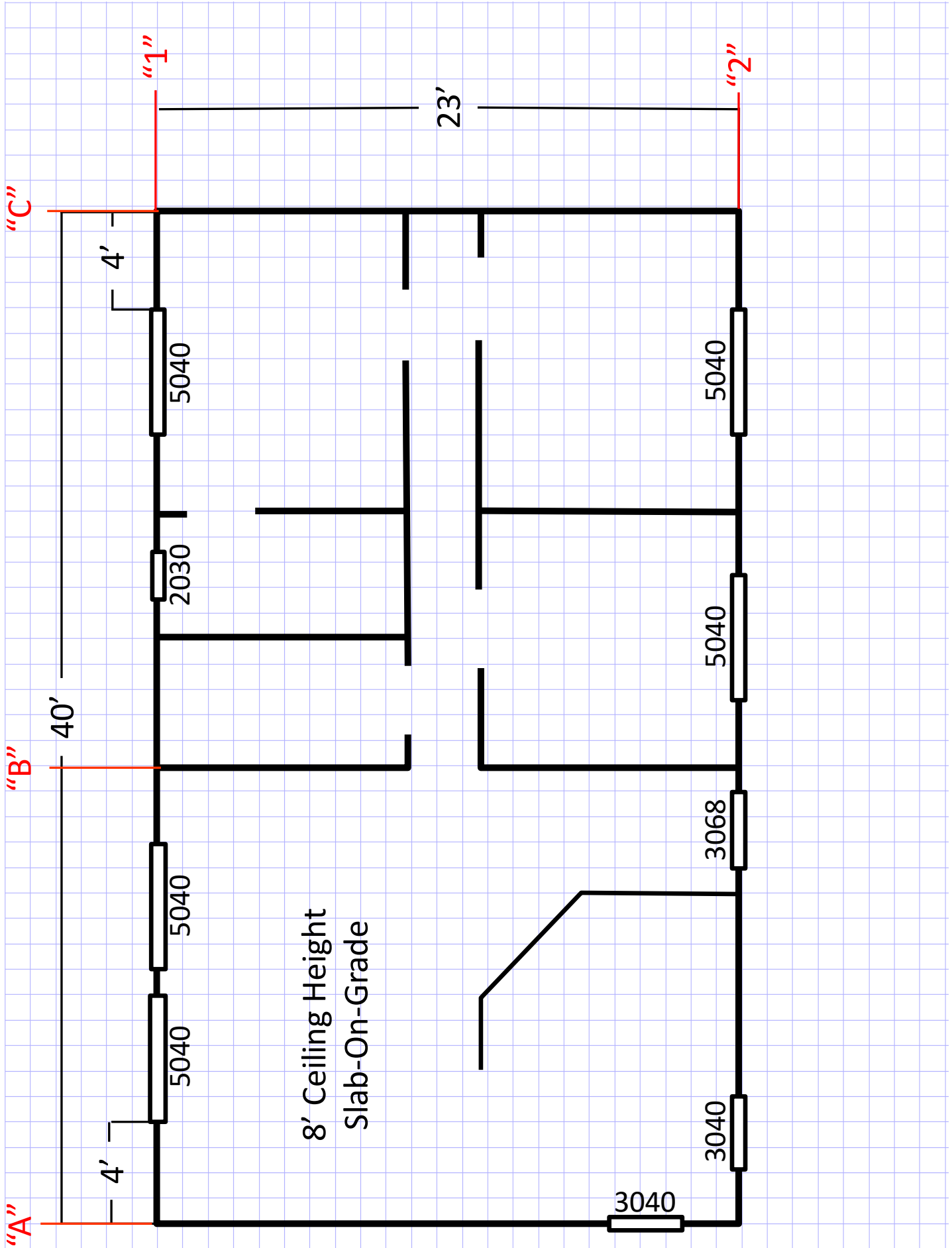
Item 6 requires a 40% increase in the amount of bracing if gypsum board or an equivalent interior finish is omitted from the inside face of the braced wall panels. The tables assume that gypsum board or an equivalent is being used on the interior face, and if not, more bracing is required.

Item 7 allows a 30% reduction in the required amount of bracing for the gypsum board bracing method if the gypsum board panel edge fastening is reduced to 4 inches on center, and the horizontal edges of the gypsum board are blocked.

Item 8 assumes that when using either wood structural panel bracing method, that the horizontal joints of the wood structural panels are blocked. If not, then the required amount of bracing must be doubled.

There are two particularly important notes for this table. The first is that the total adjustment factor for the required amount of bracing is the product of all adjustment factors. All adjustment factors are multiplied together with the required amount of bracing for the adjusted total which is the required amount.

The second is Note d which states that the same adjustment factor shall be applied to all braced wall lines on all floors of the structure, based on the worst-case exposure category.



IRC Wind Calculations

Project Name: Practice 1

Date:

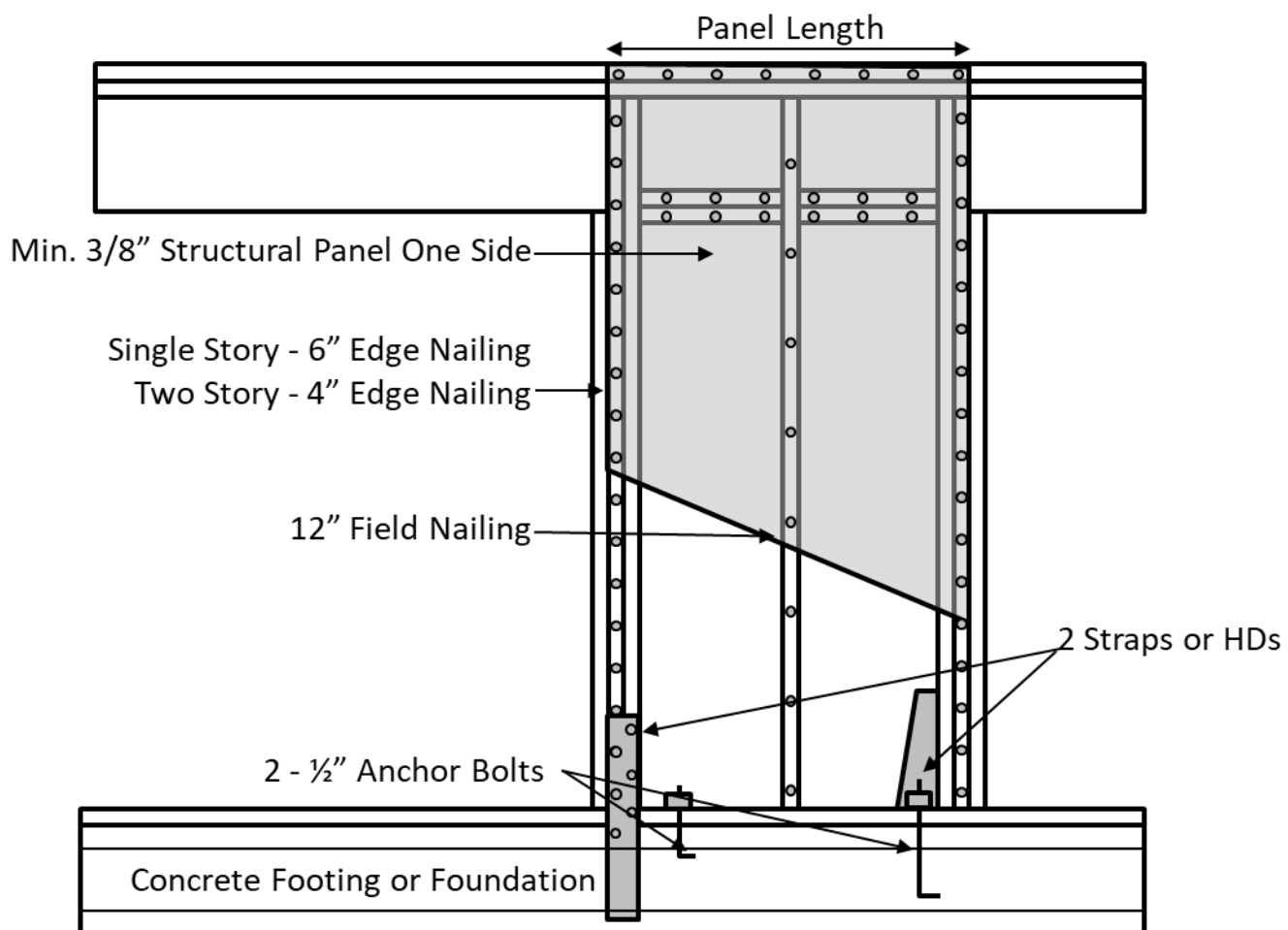
Wind Category: 140 mph

Wind Adjustment Factors

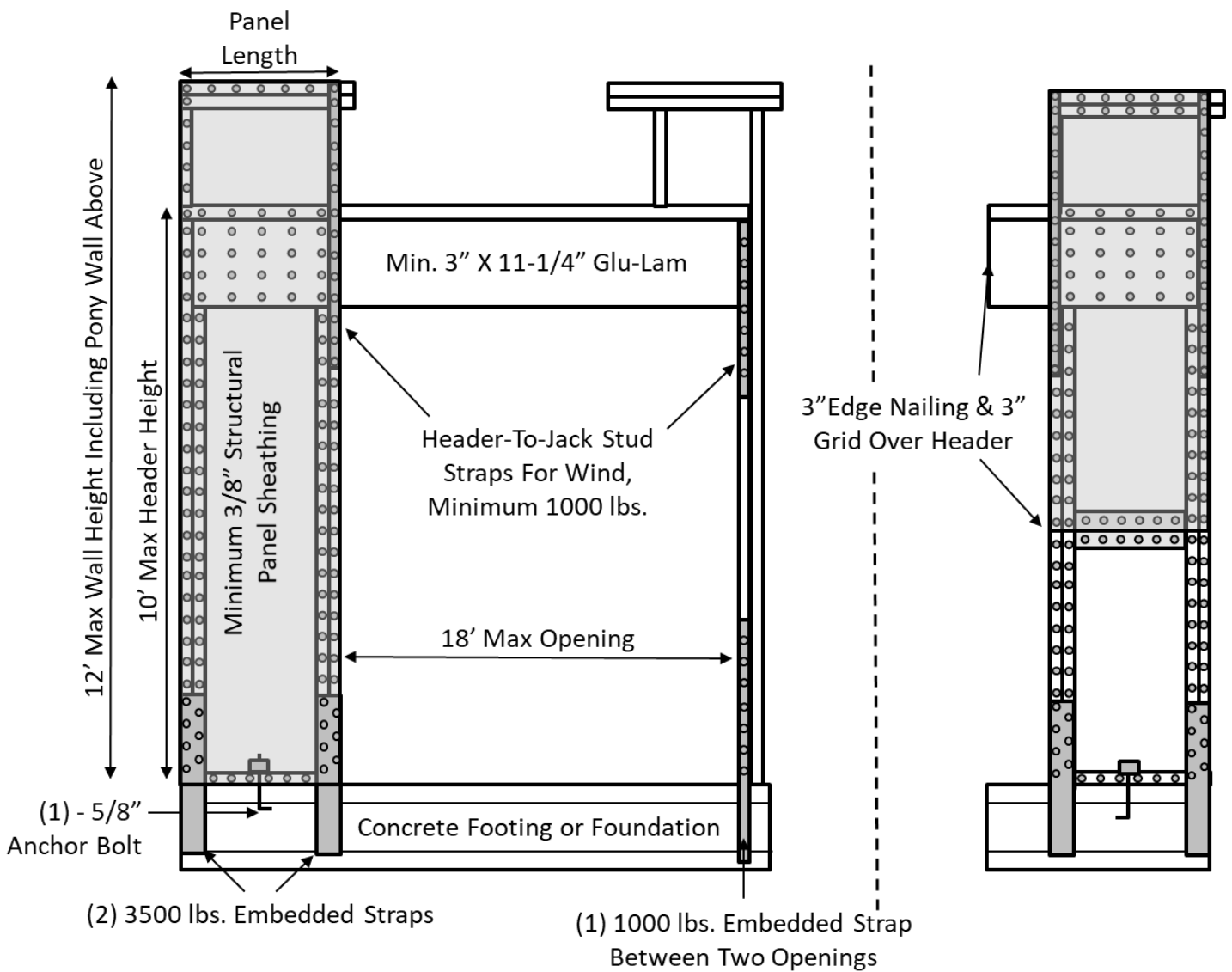
Exposure Category ¹	Numbered Wall Lines		Lettered Wall Lines	
	One Story, B	1.0	One Story, B	1.0
Roof Eave To Ridge Height ²	Roof Only, <5 Feet	0.7	Roof Only, <5 Feet	0.7
Story Height ³	8	0.90	8	0.90
Number Of Braced Wall Lines per Plan Direction ⁴	2	1.0	3	1.3
Interior Gypsum Board Finish ⁶	Yes	1.0	Yes	1.0
Horizontal Blocking ¹⁰	Yes	1.0	Yes	1.0
Wind Factor Total		0.63		0.82

Braced Wall Line	Bracing Method	Spacing Between BWLs	Required Bracing Length	Wind Factor Adjust.	Total Required Bracing Length	Bracing Length Provided	Notes
1	CS-WSP, First/Top Story	23	7	0.63	4.4	22.0	OK As Drawn
2	CS-WSP, First/Top Story						
A	CS-WSP, First/Top Story	20					
B	GB, First/Top Story	20	10	0.82	8.2	20.0	OK As Drawn
C	CS-WSP, First/Top Story	20					

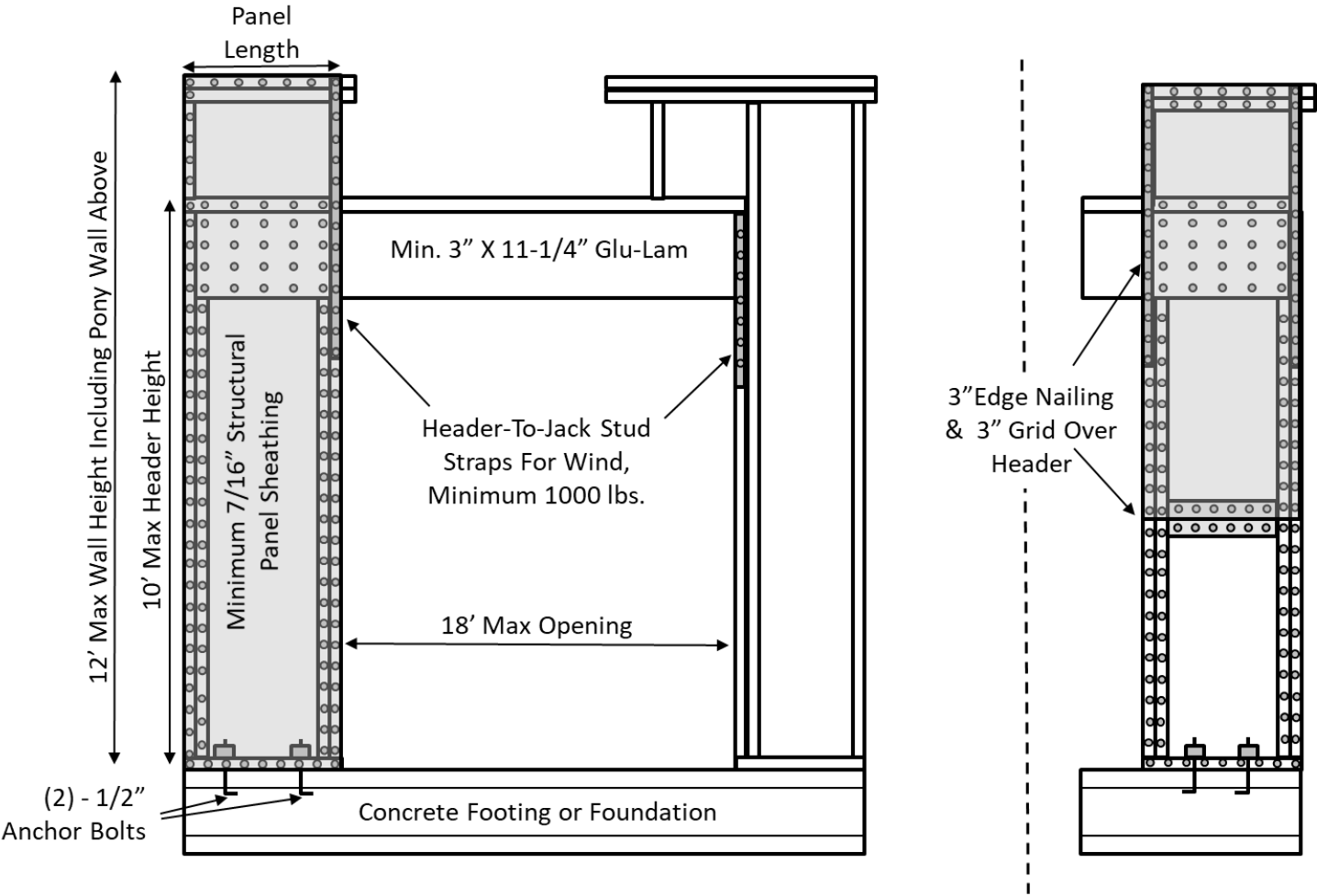
Hold Down Method - ABW								
R602.10.6.1								
Seismic Design Category			Wall Height					Contributing Length (inches)
			8 Feet	9 Feet	10 Feet	11 Feet	12 Feet	
ABW* SDC A, B, C	Minimum Panel Length (inches)		28	32	34	38	42	48
	Minimum HD Capacity	Roof Only	1800	1800	1800	2000	2200	
		First of Two Stories	3000	3000	3000	3300	3600	
ABW* SDC D0, D1, D2	Minimum Panel Length (inches)		32	32	34	NP	NP	48
	Minimum HD Capacity	Roof Only	1800	1800	1800	NP	NP	
		First of Two Stories	3000	3000	3000	NP	NP	
* 6" edge nailing on single story or top of two story, 4" edge nailing on bottom of two story. Panel edges blocked.								



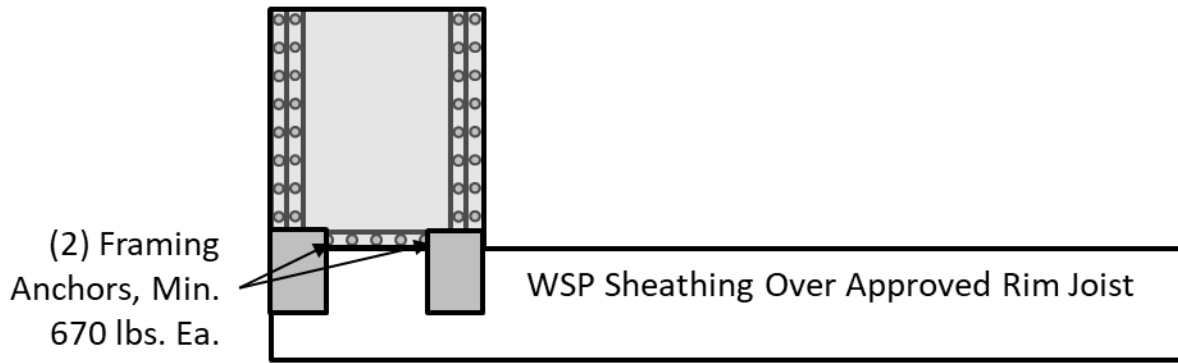
Hold Down Method - PFH							
R602.10.6.2							
Condition		Opening Header Height					Contributing Length (inches)
		8 Feet	9 Feet	10 Feet	11 Feet	12 Feet	
PFH - Roof Only*	Minimum Panel Length (inches)	16	16	16	**NP	**NP	48
PFH - One Story & Roof*	Minimum Panel Length (inches)	24	24	24	**NP	**NP	48
* (2) 3500 lbs embedded straps on each side of end panels, 1000 lbs. embedded HD at studs between double openings. 3" panel edge nailing. Panel edges blocked.							
**Pony wall above header up to next floor allowed, tension strap required from panel to top of pony wall for wind resistance							



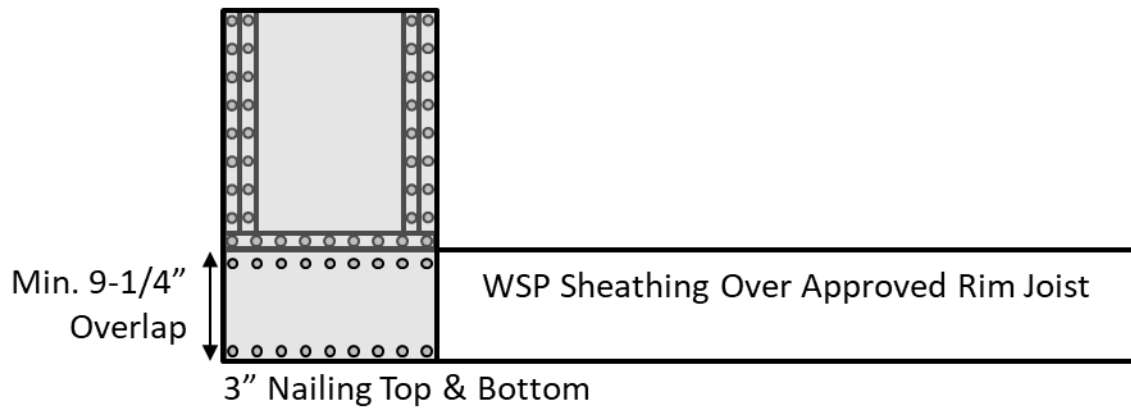
Hold Down Method - CS-PF R602.10.6.4							
Seismic Design Category		Wall Height					Contributing Length (inches)
		8 Feet	9 Feet	10 Feet	11 Feet	12 Feet	
CS-PF* SDC A, B, C	Minimum Panel Length (inches)	16	18	20	**NP	**NP	1.5 X Actual
CS-PF* SDC D0, D1, D2	Minimum Panel Length (inches)	16	18	20	**NP	**NP	Actual
*Minimum 2 anchor bolts per segment. 3" panel edge nailing. Panel edges blocked. Framing anchors required where panel do not lap rim joist on second story installation.							
**Pony wall above header up to next floor allowed, tension strap required from panel to top of pony wall for wind resistance							



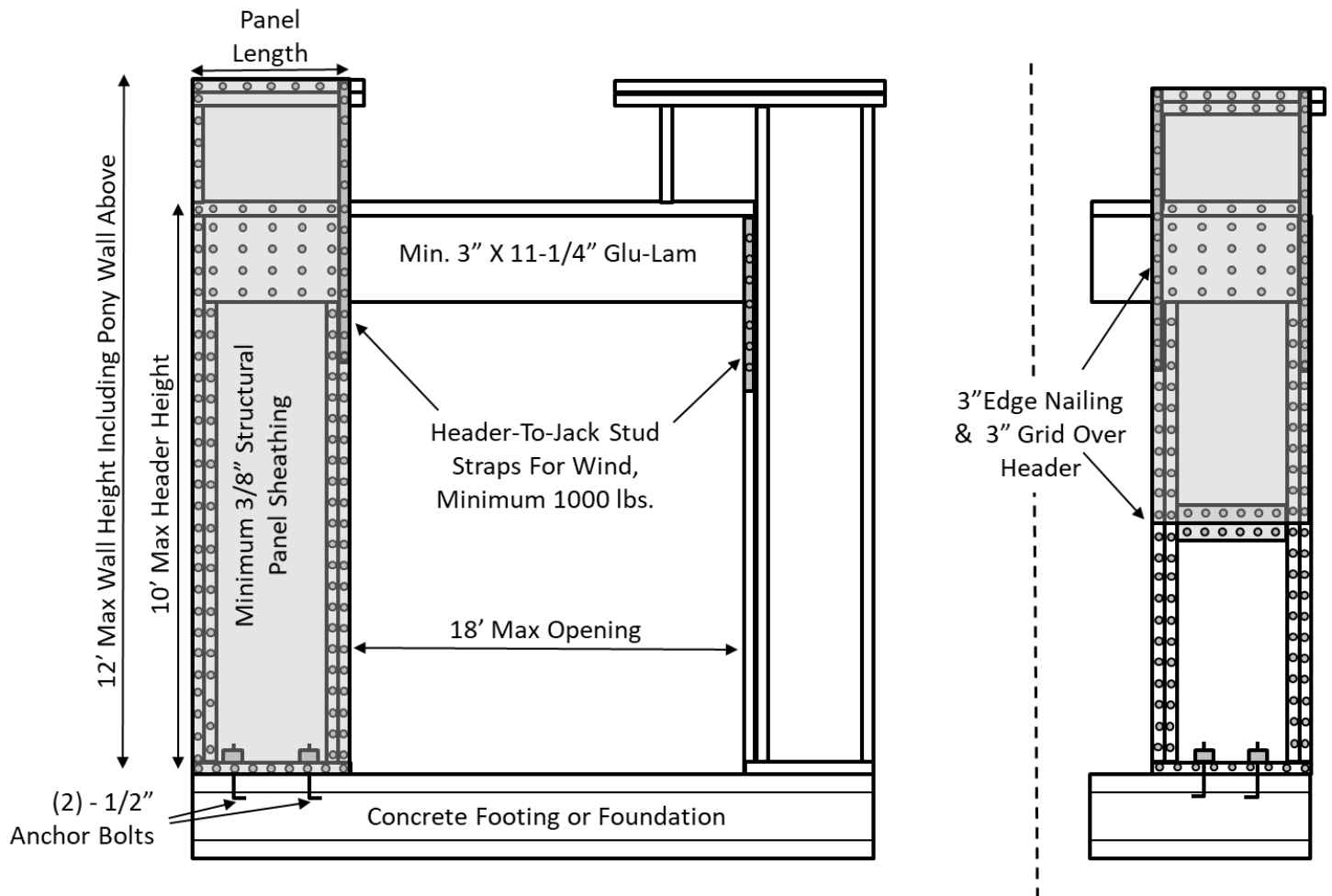
Over Raised Wood Floor
Sheathing Does Not Lap Over Band Or Rim Joist

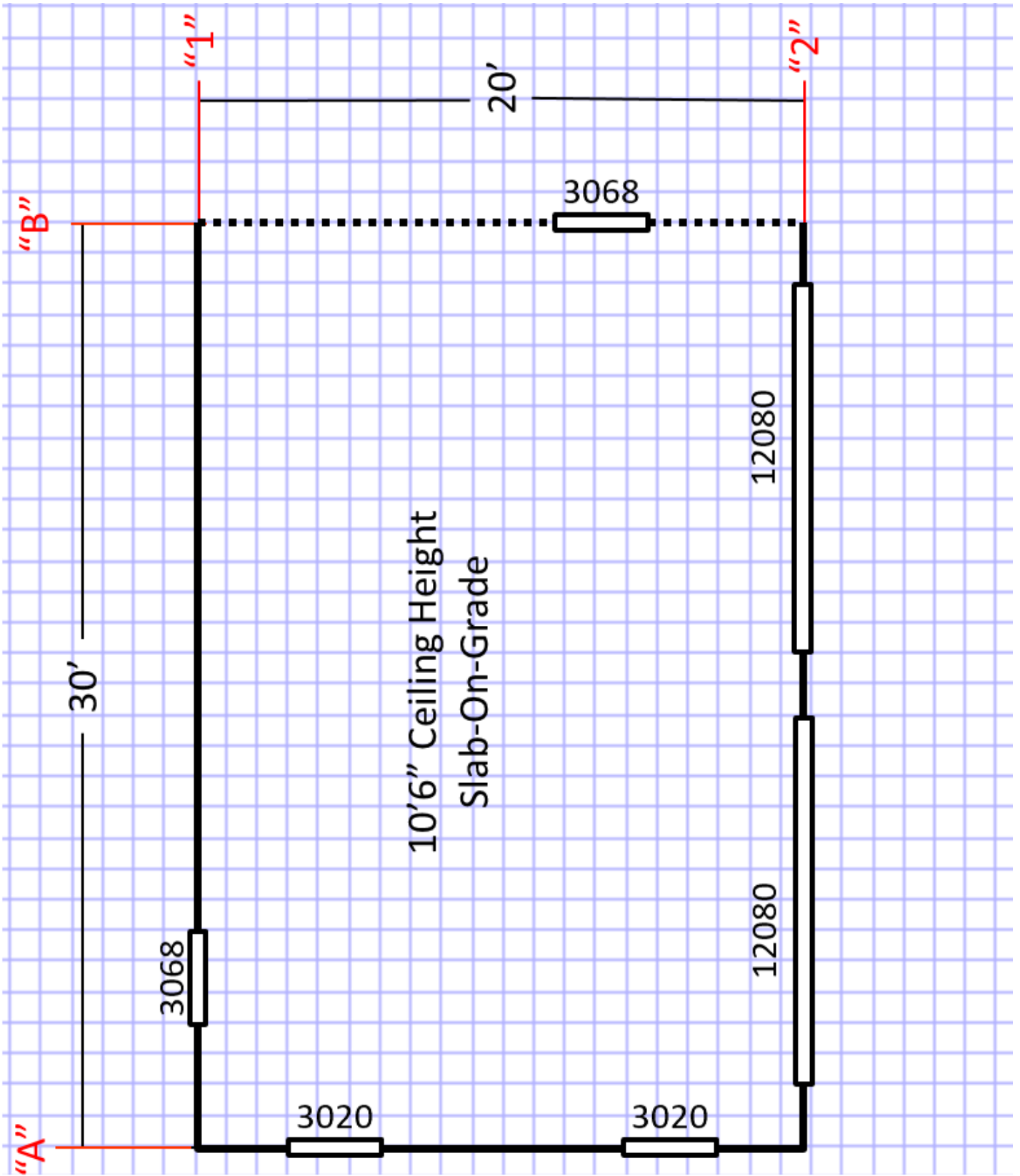


Over Raised Wood Floor
Sheathing Does Lap Over Band Or Rim Joist



Hold Down Method - PFG							
R602.10.6.2							
Condition		Opening Header Height					Contributing Length (inches)
		8 Feet	9 Feet	10 Feet	11 Feet	12 Feet	
PFG**	Minimum Panel Length (inches)	24	27	30	*NP	*NP	48
*Pony wall above header up to next floor allowed, tension strap required from panel to top of pony wall for wind resistance							
** Limited to Sesimic Design Categories A, B, and C							





IRC Siesmic Calculations

Project Name: Practice 2

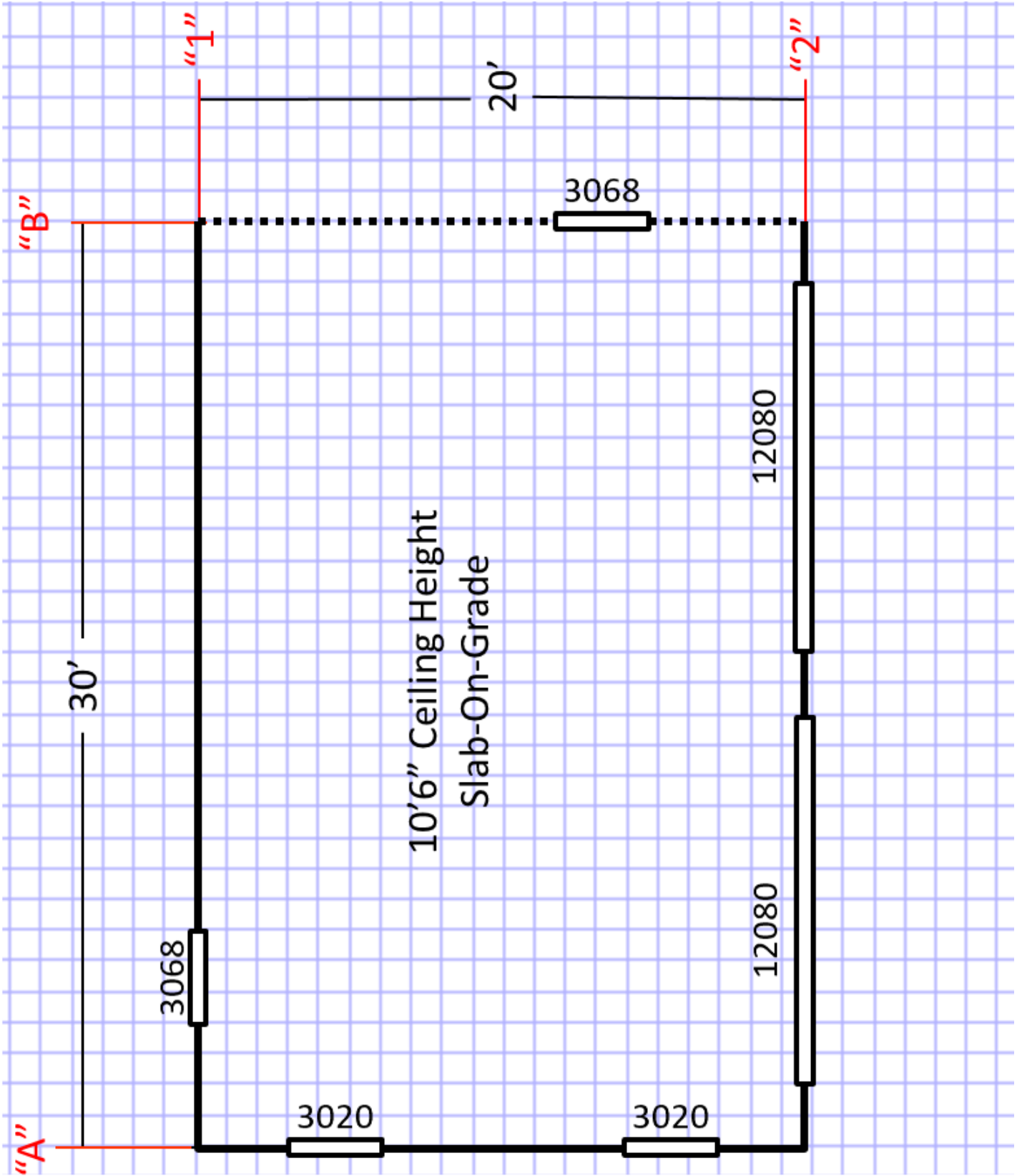
Date:

Seismic Category: D2

Seismic Adjustment Factors

Story Height ¹	1.2	(10' to 12' height, adjustment factor of 1.2)
Wall Dead Load ⁴	1.0	(Less than 8 psf, adjustment factor of 0.85)
Roof/Ceiling Dead Load ⁵	1.0	(15 to 25 psf, adjustment factor of 1.5)
Stone/Masonry in SDC C-D2 ^{6, 7, 8}	1.0	(Applies to walls that have, or are perpendicular to, masonry veneer)
Interior Gypsum Board ⁹	1.0	(Omitted from inside face of exterior walls, adjustment factor of 1.5)
Horizontal Blocking ¹⁰	1.0	(Omitted from WSP and CS-WSP methods, adjustment factor of 2.0)
Seismic Factor Total	1.2	

Braced Wall Line	Bracing Method	Braced Wall Line Length	Story	Required Bracing Length	Braced Wall Line Spacing Factor ^{2, 3}	Seismic Adj. Factor	Cripple Wall Bracing Factor	Total Required Bracing Length	Bracing Length Provided	Notes
1	CS-WSP	30'	1 of 1	6.3'	1	1.2	1	7.6'	27'	OK As Drawn
2	CS-WSP									
A	CS-WSP									
B	GB									



IRC Wind Calculations

Project Name: Practice 2

Date:

Wind Category: 130 mph

Wind Adjustment Factors		Numbered Wall Lines		Lettered Wall Lines	
Exposure Category ¹		One Story, D	1.5	One Story, D	1.5
Roof Eave To Ridge Height ²		Roof Only, 10 Feet	1.0	Roof Only, 10 Feet	1.0
Story Height ³		11	1.05	11	1.05
Number Of Braced Wall Lines per Plan Direction ⁴		2	1.0	2	1.0
Interior Gypsum Board Finish ⁶		Yes	1.0	Yes	1.0
Horizontal Blocking ¹⁰		Yes	1.0	Yes	1.0
Wind Factor Total			1.58		1.58

Braced Wall Line	Bracing Method	Spacing Between BWLs	Required Bracing Length	Wind Factor Adjust.	Total Required Bracing Length	Bracing Length Provided	Notes
1	CS-WSP, First/Top Story						
2	CS-WSP, First/Top Story						
A	CS-WSP, First/Top Story						
B	GB, First/Top Story						

ANSWER KEYS

IRC Siesmic Calculations

Project Name: Practice 1

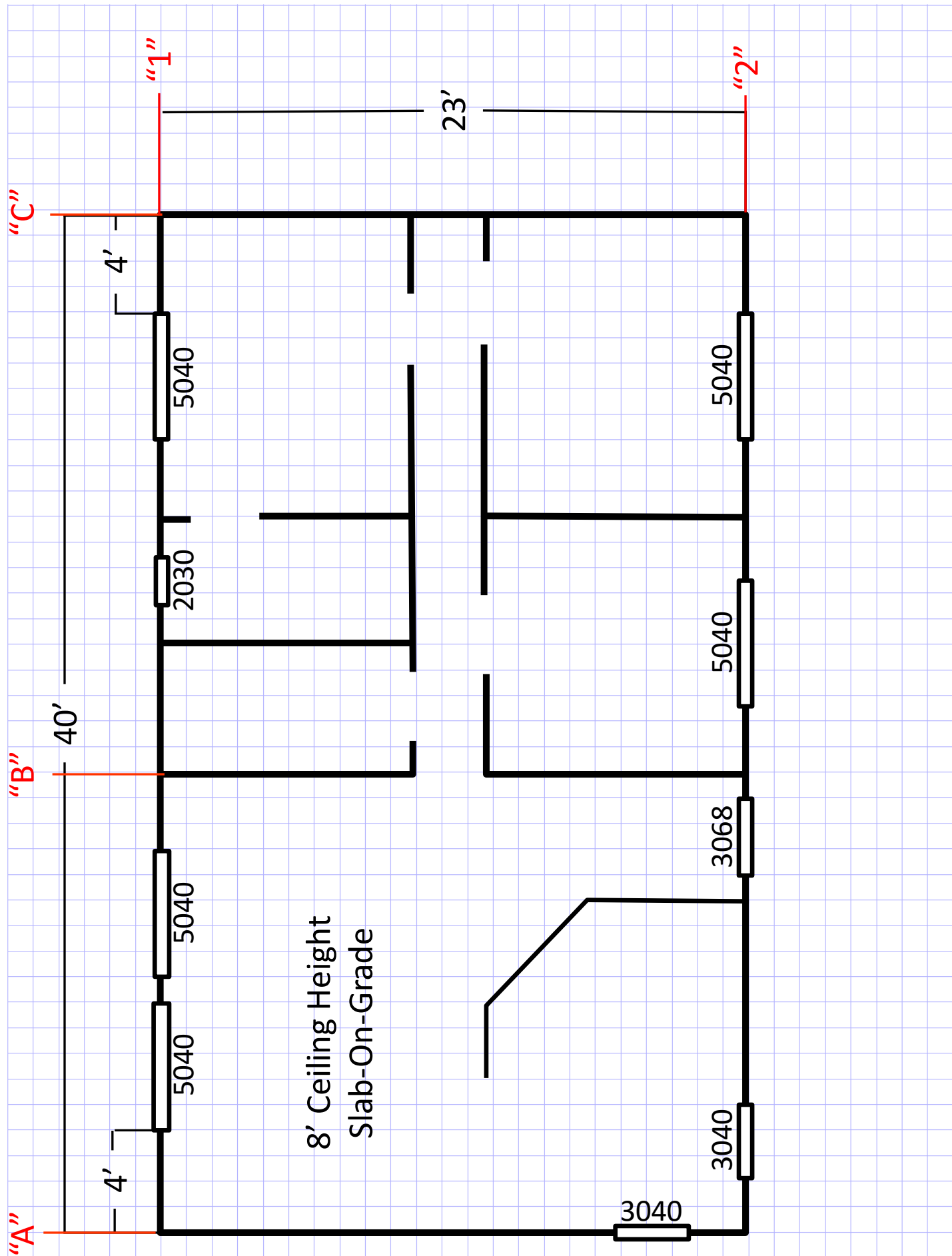
Date:

Seismic Category: D2

Seismic Adjustment Factors

Story Height ¹	1.0	(10' to 12' height, adjustment factor of 1.2)
Wall Dead Load ⁴	1.0	(Less than 8 psf, adjustment factor of 0.85)
Roof/Ceiling Dead Load ⁵	1.0	(15 to 25 psf, adjustment factor of 1.5)
Stone/Masonry in SDC C-D2 ^{6, 7, 8}	1.0	(Applies to walls that have, or are perpendicular to, masonry veneer)
Interior Gypsum Board ⁹	1.0	(Omitted from inside face of exterior walls, adjustment factor of 1.5)
Horizontal Blocking ¹⁰	1.0	(Omitted from WSP and CS-WSP methods, adjustment factor of 2.0)
Seismic Factor Total	1.0	

Braced Wall Line	Bracing Method	Braced Wall Line Length	Story	Required Bracing Length	Braced Wall Line Spacing Factor ^{2, 3}	Seismic Adj. Factor	Cripple Wall Bracing Factor	Total Required Bracing Length	Bracing Length Provided	Notes
1	CS-WSP	40'	1 of 1	8.4'	1.0	1.0	1.0	8.4'	22'	OK as drawn
2	CS-WSP	40'	1 of 1	8.4'	1.0	1.0	1.0	8.4'	24'	OK as drawn
A	CS-WSP	23'	1 of 1	4.8'	1.0	1.0	1.0	4.8'	20'	OK as drawn
B	GB	23'	1 of 1	9.2'	1.0	1.0	1.0	9.2'	20'	OK as drawn
C	CS-WSP	23'	1 of 1	4.8'	1.0	1.0	1.0	4.8'	23'	OK as drawn



IRC Wind Calculations

Project Name: Practice 1

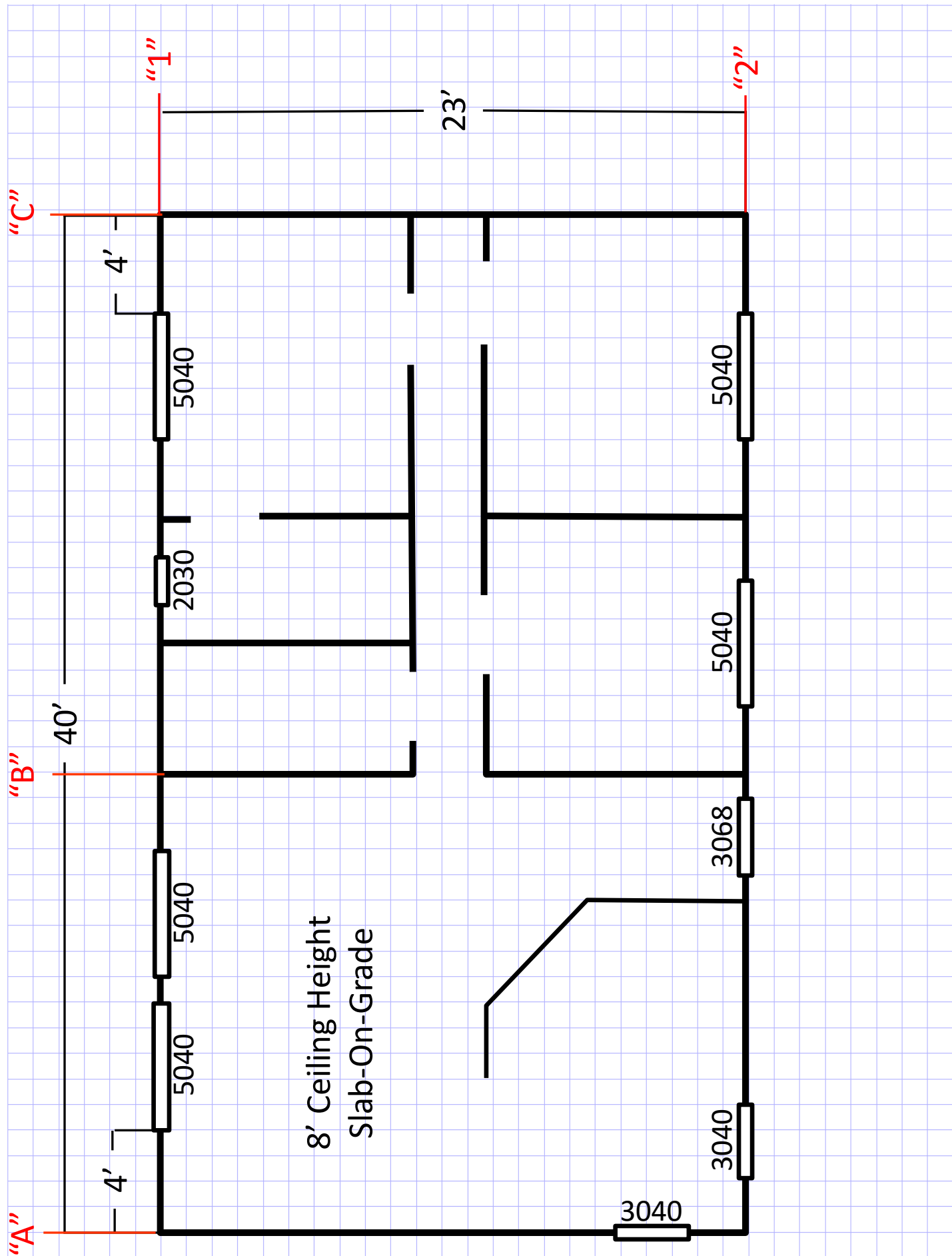
Date:

Wind Category: 140 mph

Wind Adjustment Factors

Exposure Category ¹	Numbered Wall Lines		Lettered Wall Lines	
Roof Eave To Ridge Height ²	One Story, B	1.0	One Story, B	1.0
Story Height ³	Roof Only, <5 Feet	0.7	Roof Only, <5 Feet	0.7
Number Of Braced Wall Lines per Plan Direction ⁴	8	0.90	8	0.90
Interior Gypsum Board Finish ⁶	2	1.0	3	1.3
Horizontal Blocking ¹⁰	Yes	1.0	Yes	1.0
	Yes	1.0	Yes	1.0
Wind Factor Total		0.63		0.82

Braced Wall Line	Bracing Method	Spacing Between BWLs	Required Bracing Length	Wind Factor Adjust.	Total Required Bracing Length	Bracing Length Provided	Notes
1	CS-WSP, First/Top Story	23	7	0.63	4.4	22.0	OK As Drawn
2	CS-WSP, First/Top Story	23	7	0.63	4.4	24.0	OK As Drawn
A	CS-WSP, First/Top Story	20	5	0.82	4.1	20.0	OK As Drawn
B	GB, First/Top Story	20	10	0.82	8.2	20.0	OK As Drawn
C	CS-WSP, First/Top Story	20	5	0.82	4.1	23.0	OK As Drawn



IRC Siesmic Calculations

Project Name: Practice 2

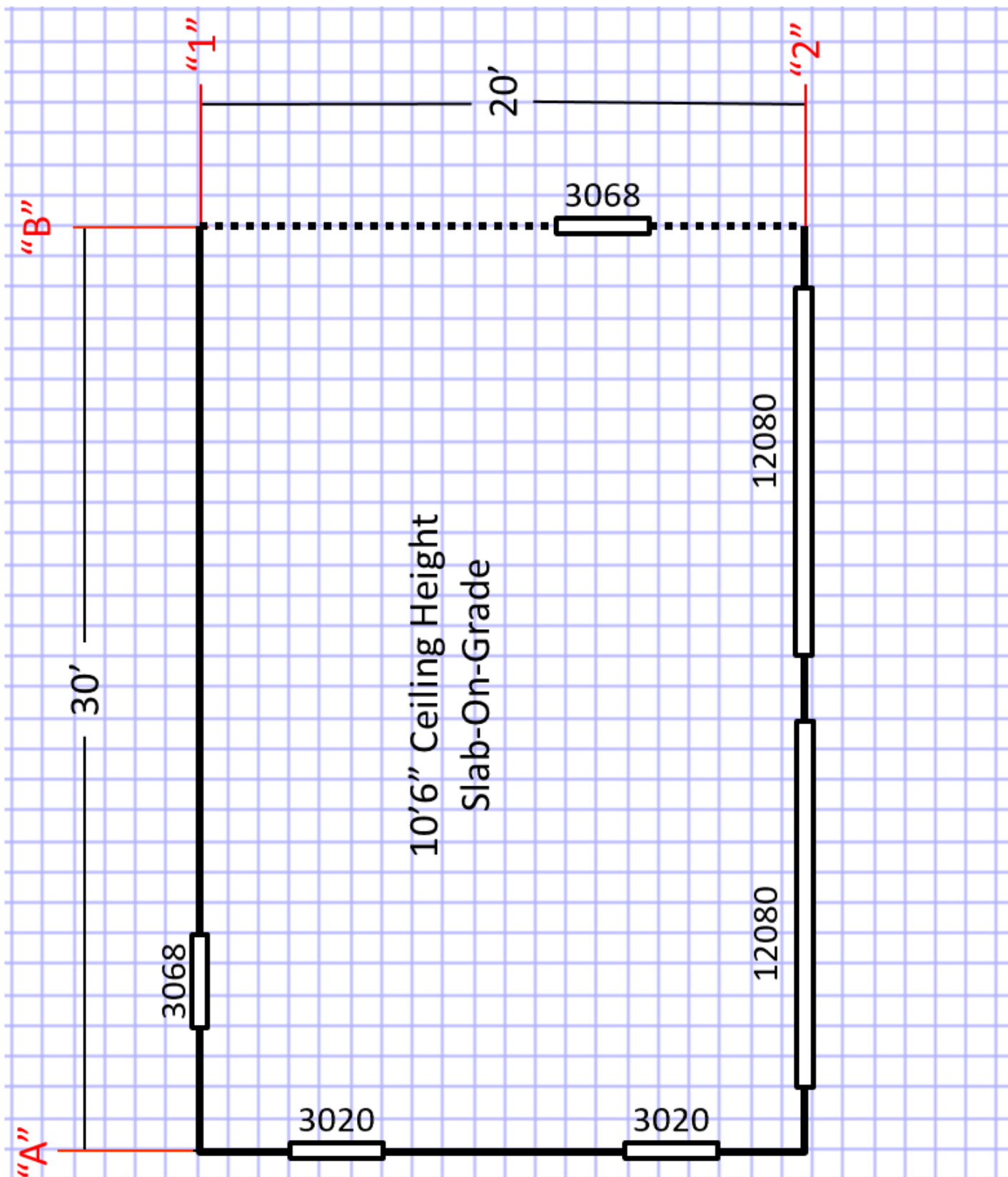
Date:

Seismic Category: D2

Seismic Adjustment Factors

Story Height ¹	1.2	(10' to 12' height, adjustment factor of 1.2)
Wall Dead Load ⁴	1.0	(Less than 8 psf, adjustment factor of 0.85)
Roof/Ceiling Dead Load ⁵	1.0	(15 to 25 psf, adjustment factor of 1.5)
Stone/Masonry in SDC C-D2 ^{6,7,8}	1.0	(Applies to walls that have, or are perpendicular to, masonry veneer)
Interior Gypsum Board ⁹	1.0	(Omitted from inside face of exterior walls, adjustment factor of 1.5)
Horizontal Blocking ¹⁰	1.0	(Omitted from WSP and CS-WSP methods, adjustment factor of 2.0)
Seismic Factor Total	1.2	

Braced Wall Line	Bracing Method	Braced Wall Line Length	Story	Required Bracing Length	Braced Wall Line Spacing Factor ^{2,3}	Seismic Adj. Factor	Cripple Wall Bracing Factor	Total Required Bracing Length	Bracing Length Provided	Notes
1	CS-WSP	30'	1 of 1	6.3'	1	1.2	1	7.6'	27'	OK As Drawn
2	CS-WSP	30'	1 of 1	6.3'	1	1.2	1	7.6'	12'	PFH @ each full height panel, 3 total.
A	CS-WSP	20'	1 of 1	4.2'	1.2	1.2	1	6.0'	14'	OK As Drawn
B	GB	20'	1 of 1	8'	1.2	1.2	1	11.6'	17'	OK As Drawn



IRC Wind Calculations

Project Name: Practice 2 Date: _____
 Wind Category: 130 mph

Wind Adjustment Factors

Exposure Category ¹	Numbered Wall Lines		Lettered Wall Lines	
Roof Eave To Ridge Height ²	One Story, D	1.5	One Story, D	1.5
Story Height ³	Roof Only, 10 Feet	1.0	Roof Only, 10 Feet	1.0
Number Of Braced Wall Lines per Plan Direction ⁴	11	1.05	11	1.05
Interior Gypsum Board Finish ⁶	2	1.0	2	1.0
Horizontal Blocking ¹⁰	Yes	1.0	Yes	1.0
Wind Factor Total	Yes	1.0	Yes	1.0
		1.58		1.58

Braced Wall Line	Bracing Method	Spacing Between BWLs	Required Bracing Length	Wind Factor Adjust.	Total Required Bracing Length	Bracing Length Provided	Notes
1	CS-WSP, First/Top Story	20	4	1.58	6.3	27.0	OK As Drawn
2	CS-WSP, First/Top Story	20	4	1.58	6.3	0.0	PFH at each full height panel, 3 total.
A	CS-WSP, First/Top Story	30	6	1.58	9.5	14.0	OK As Drawn
B	GB, First/Top Story	30	12	1.58	19.0	17.0	Sheet one side w/ min. 3/8" sheathing.

