Mariposa County Building Department
Mike Kinslow, Building Director
5100 Bullion St., P.O. Box 1268, Mariposa, CA 95338
Phone (209)966-3934 Fax (209)742-5024

Brace Wall Design Requirements

Designers:

A Brace Wall design page is required for all substantial building plan submissions and new Single Family Residential construction as per the California Residential Code section R106.1.1. If your plans are stamped and signed by a California licensed Engineer or Architect you may disregard this memo. Your building plans submission will be returned to you without one of the above.

The following and attached information is a guideline for your Brace Wall Design submission. It is subject to change and is not intended to be all inclusive. It is highly recommended that you become very familiar with the provisions of the current California Residential Code chapter 6 – wall construction. It is also highly recommended that you purchase and study "A guide to the 2015 IRC Wood Wall Bracing Provisions". This book is available from the International Code Counsel's online book store. The Brace Wall work form on the last page of the attachment (or something similar on the plans) will be required for plan review. Parts of the following may reference the International Residential Code for examples and additional explanations. The current edition of the California Residential Code is what is required for design and is used in plan review.

1. It is the Designer's responsibility to establish the Seismic and Wind parameters (Building plan check just verifies the presented information) for the Brace Wall calculations. This includes the wind exposure category per the California Residential Code, section R301.2.1.4.
2. It is the Designer's responsibility to provide the Geo Tech soils report and design the footing to that report. A soils report waiver may be granted under a "one case at a time" special circumstances as determined by the Building Official. If a Geo Tech report is waivered it is still the designer's responsibility to accurately indicate the class of soil material and its load-bearing pressure designation and to address any soil problems (expansive clays, layers of organic material, other soil problems, etc.) that may be associated with the building site. This information shall be indicated on the foundation plan.
3. Follow the guidelines in the attached handout. Provide Brace Wall lines on your plans similar to page #212 of the 2013 California Residential Code and page #78 of the guide to the 2015 IRC Wood Wall Bracing Provisions workbook. Submit the attached and completed worksheet (or something similar) with your completed plans and application.
4. Due to the structural complexity of multiple story houses and large single story Single Family Residential structures, these projects will be sent out for independent plan review if they are not stamped and signed by a California licensed Engineer or Architect.

Thank you for your cooperation in this required State of California building code plan review process.

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When plans are submitted using the 2013 California **Residential** Code (CRC), and no engineering is provided, the following minimum requirements must appear on the submitted construction documents:
From **CRC Section R106.1.1** Information on construction documents: all braced wall lines shall be identified on the construction documents and all pertinent information including, but not limited to, bracing methods, location and length of braced wall panels, foundation requirements of braced wall panels at top and bottom shall be provided. Parts of the following may reference the International Residential Code for examples and additional explanations. The current edition of the California Residential Code is what is required for design and is used in plan review.

Wall bracing provisions should meet the requirements of the California Residential Code (CRC), primarily Section R602.10. If the wall bracing provisions cannot be satisfied, then an engineered design shall be provided. Portions of the building that do not meet the items below must be designed by a California licensed architect or civil or structural engineer using accepted engineering practice. Wall bracing provisions may be applied to a new structure, remodel, or addition. For the ease of application, the following flowchart guides designers through the process of applying the wall bracing provisions:

1. Establish Design Criteria/Assumptions – The following are assumed for the design. If your project doesn't meet the following items, see the referenced code sections for more information.
    a. Seismic Design Category (SDC) – D2 (Table R602.10.3(3))
    b. Wind Speed – 85 mph, Exposure B (Table R602.10.3(1), R301.2.1.4.3)
        i. Tree protected rural homes typically qualify as Exposure B. Homes in Mariposa County built on mountain tops, canyon sides and other hi wind areas need to be classified in accordance with section R301.2.1.4 and Table R602.10.3(2).
    c. Braced Wall Panel (BWP) Material (Table R602.10.4)
        i. Wood Structural Panels (WSP) – 3/8" thick plywood or Oriented Strand Board (OSB) attached to framing with 8d common nails at 6" o.c. at the edges and 12" o.c. field nailing.
        ii. Continuous CS-WSP – Continuous Sheathed Wood Structural Panels requires the entire story be sheathed with WSPs, full height walls as well as above and below openings. Thickness and attachment same as WSP.
        iii. Gypsum Board (GB) – ½" gyp board nailed or screwed to framing at 7" on center. Fastener size per Table R702.3.5.
        iv. Portland Cement Plaster (PCP) – Stucco, framing spaced <= 16" o.c. and PCP is attached to all framing members at 6" o.c.
    d. Irregularities (R301.2.2.2.5) – If the home doesn't meet the following irregularities, see the code section for design guidance
        i. Vertical irregularity – Limited to 4 times the nominal depth of the floor joists provided the following conditions are met
            1. Floor joists are nominal 2x10 or larger

2. The ratio of the backspan to cantilever is >= 2:1
3. Floor joists at the ends of BWPs are doubled
4. A continuous rim joist is connected to the ends of cantilevered joists.
5. Gravity loads are limited to uniform wall and roof loads and any headers in the wall must have a span <= 8'.

ii. Floor or roof overhang – Limited to 6'

iii. BWPs occurring over an opening in the wall below – Limited to 1' without special detailing, may overlap an opening more than 1' provided the following are met:
1. The opening length is <= 8'
2. The opening has a header of the following sizes:
   a. If the opening <= 4', the header is one 2x12 or two 2x10s
   b. If the opening <= 6', the header is two 2x12s or three 2x10s
   c. If the opening <= 8', the header is three 2x12s or four 2x10s
3. The entire length of the BWP does not occur over the opening

iv. Roof or floor opening – limited to the lesser of 12' or 50% of the least floor or roof dimension

v. Floor vertical offset – Ok provided the framing is supported by continuous foundations at the perimeter of the building or the floor framing is lapped or tied together per Section R502.6.1

vi. When BWLs do not occur in 2 perpendicular directions engineering is required

vii. When masonry or concrete construction is used engineering is required. Exceptions: fireplaces, chimneys, and masonry veneer

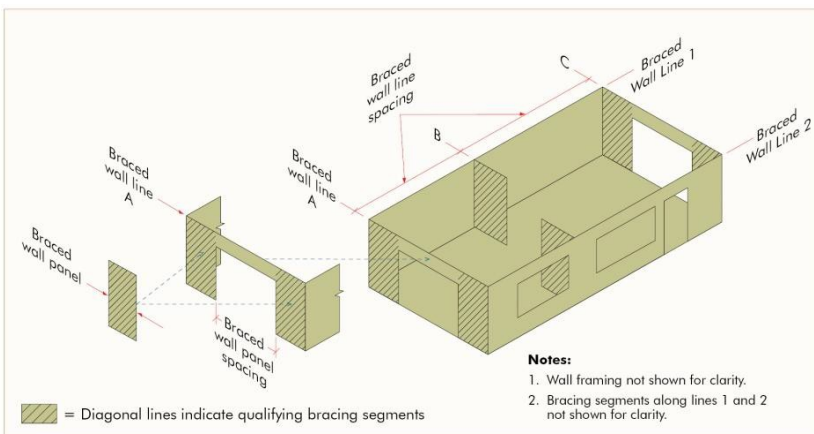


Figure 1 (Courtesy of APA)

2. Define Braced Wall Lines (BWLs) (R602.10.1)
   a. BWLs are straight lines in each direction of the building that contain Braced Wall Panels (BWPs). BWLs are commonly all exterior walls and interior walls where required.
   b. Designer should identify BWLs on plan with grid lines
   c. For SDC D2, BWLs are required every 25' (R602.10.1.3), exception: 35' with increased amount of BWPs or 1 room exception, see aforementioned code section for more information
   d. BWPs may be offset 4' in either direction from BWL (R602.10.1.2)
3. Define Braced Wall Panels (BWPs) (R602.10.2.2, R602.10.2.3)
   a. Must occur at corner for methods GB or PCP
   b. Must occur within 10' of corners for WSP or CS-WSP provided:
      i. 1800 pound hold down is installed on end of BWP closest to the corner for WSP
      ii. 800 pound hold down is installed on end of BWP closest to the corner for CS-WSP
      iii. Or 24" WSP provided at corner in both directions for either WSP or CS-WSP

c. Spaced <= 20’edge to edge
d. Meet BWP min. lengths based on: wall height, special detailing
   i. WSP & PCP = 4’ for 8-10’ tall wall
   ii. GB = 4’ for 8-10’ tall walls, Double Sided GB’s contributing length = actual length (for example, 4’ double sided GB = 4’ bracing), Single Sided GB’s contributing length = ½ actual length (for example, 4’ single sided GB = 2’ bracing)
   iii. CS-WSP min length based on wall height and opening ht (Table R602.10.5) = 24-48” for 8-10’ tall wall
   iv. WSPs with hold downs qualify for shorter lengths, see code for details

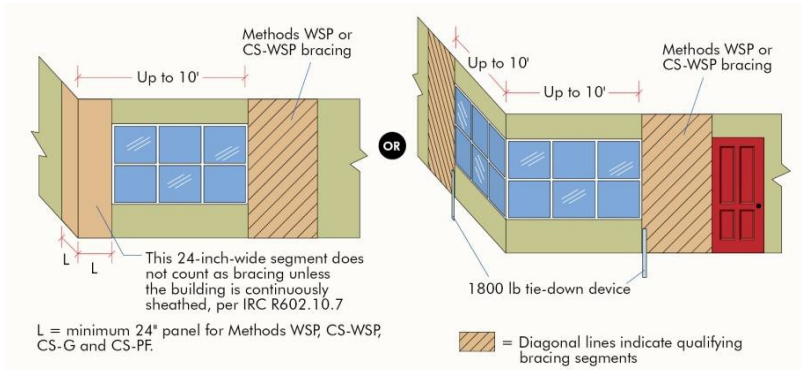
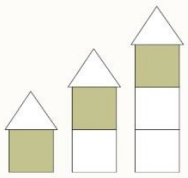
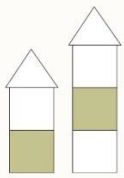


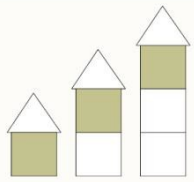
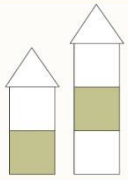
Figure 2 (Courtesy APA)

e. Identify locations, lengths, types on plan view (create key if using different materials)

4. Define the required length of bracing per BWL in Wind and Seismic tables
   a. Check wind and seismic table, greater length controls
   b. Wind table excerpt for Wind Speed 85 mph

Basic Wind Speed (mph)	Story Location	Braced Wall Line Spacing (feet)	Minimum Total Length (feet) of Braced Wall Panels Required Along Each Braced Wall Line		
			Method GB	Methods WSP, or PCP	Method CS-WSP
≤ 85		10	3.5	2.0	1.5
		20	6.0	3.5	3.0
		30	8.5	5.0	4.5
		40	11.5	6.5	5.5
		50	14.0	8.0	7.0
		60	16.5	9.5	8.0
		10	6.5	3.5	3.0
		20	11.5	6.5	5.5
		30	16.5	9.5	8.0
		40	21.5	12.5	10.5
		50	26.5	15.0	13.0
		60	31.5	18.0	15.5

c. Seismic table excerpt for SDC D2

Seismic Design Category (SDC)	Story Location	Braced Wall Line Length (feet)	Minimum Total Length (feet) of Braced Wall Panels Required Along Each Braced Wall Line			
			Method GB (Double Sided)	Method PCP	Method WSP	Method CS-WSP
SDC D_2		10	4.0	4.0	2.5	2.1
		20	8.0	8.0	5.0	4.3
		30	12.0	12.0	7.5	6.4
		40	16.0	16.0	10.0	8.5
		50	20.0	20.0	12.5	10.6
		10	7.5	7.5	5.5	4.7
		20	15.0	15.0	11.0	9.4
		30	22.5	22.5	16.5	14.0
		40	30.0	30.0	22.0	18.7
		50	37.5	37.5	27.5	23.4

5. Add up BWPs per BWL in step 3 and compare to Step 4
   a. If Step 3 > Step 4, done
   b. If Step 3 < Step 4, add additional BWPs
6. Example 4.3 Reprinted from the "Guide to the 2012 IRC Wood Wall Bracing Provisions" with permission from ICC and APA.

Example 4.3: Two-story house in SDC D2

The basic wind speed is 85 mph with Exposure Category B. The roof has an eave-to-ridge height of 8 feet. Intermittent Method WSP (wood structural panel) will be used as the bracing material on the exterior braced wall lines. Intermittent Method GB (gypsum board) will be used on the interior braced wall lines. All braced walls have a height of 10 feet.

Example 4.3 highlights:

• The amount of bracing required based on the greater amount required by the ≤ 85 mph wind speed category and SDC D2.
• For a single-family dwelling located in SDC D0, D1 and D2, braced wall panels on the second floor cannot be placed over an opening on the first floor except in certain cases (IRC Section R301.2.2.2.5, Item 3, Exceptions).
• In SDC D0, D1 and D2, braced wall panels are not permitted to be located away from the ends of braced wall lines except in certain cases and only with Method WSP (IRC Section R602.10.2.2.1, Exceptions).
• For structures in SDC D0, D1 and D2, braced wall line spacing is limited to 25 feet (IRC Section R602.10.1.3 and Table R602.10.1.3).

Figures 4.3a and *4.3b* show the house and braced wall segments for each story. *Tables 4.3a* and *4.3b* summarize the amount of bracing required and the amount of bracing provided for each braced wall line on each story, based on wind and seismic requirements respectively.

FIGURE 4.3a

First-story plan with intermittent Methods WSP (wood structural panel) and GB (gypsum board) braced wall panels

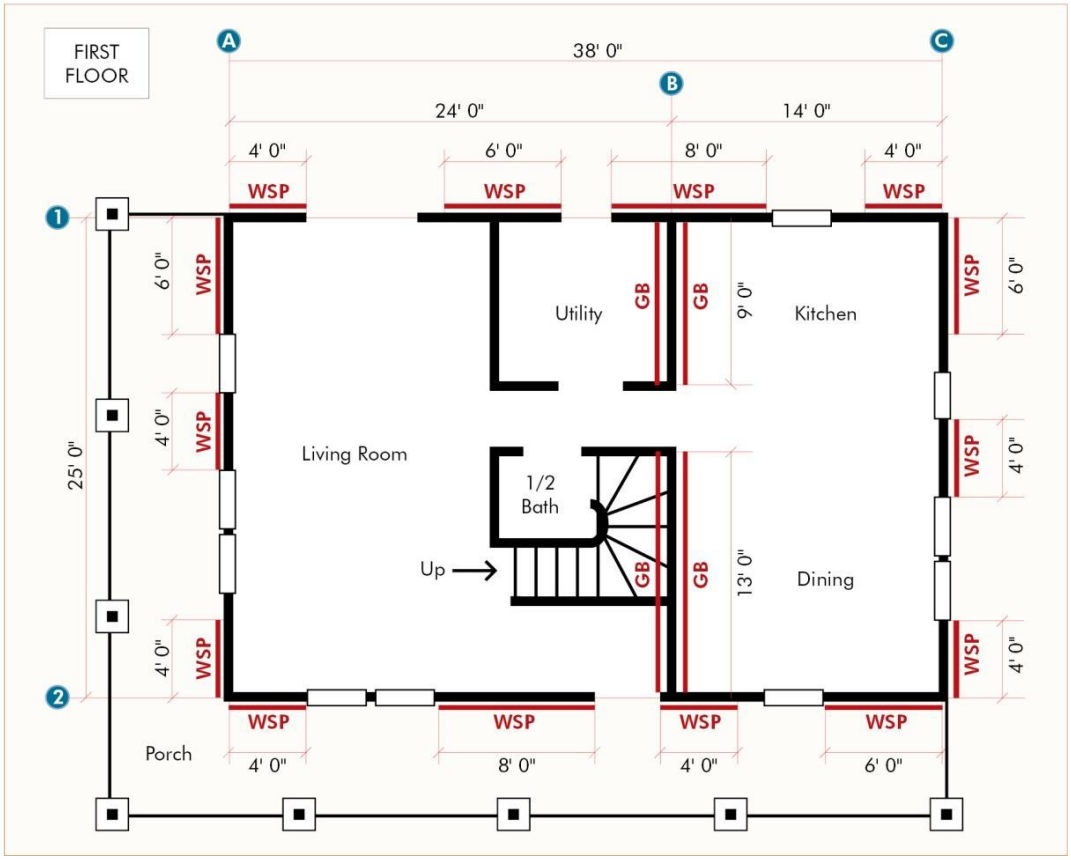


FIGURE 4.3b

Second-story plan with intermittent Methods WSP (wood structural panel) and GB (gypsum board) braced wall panels

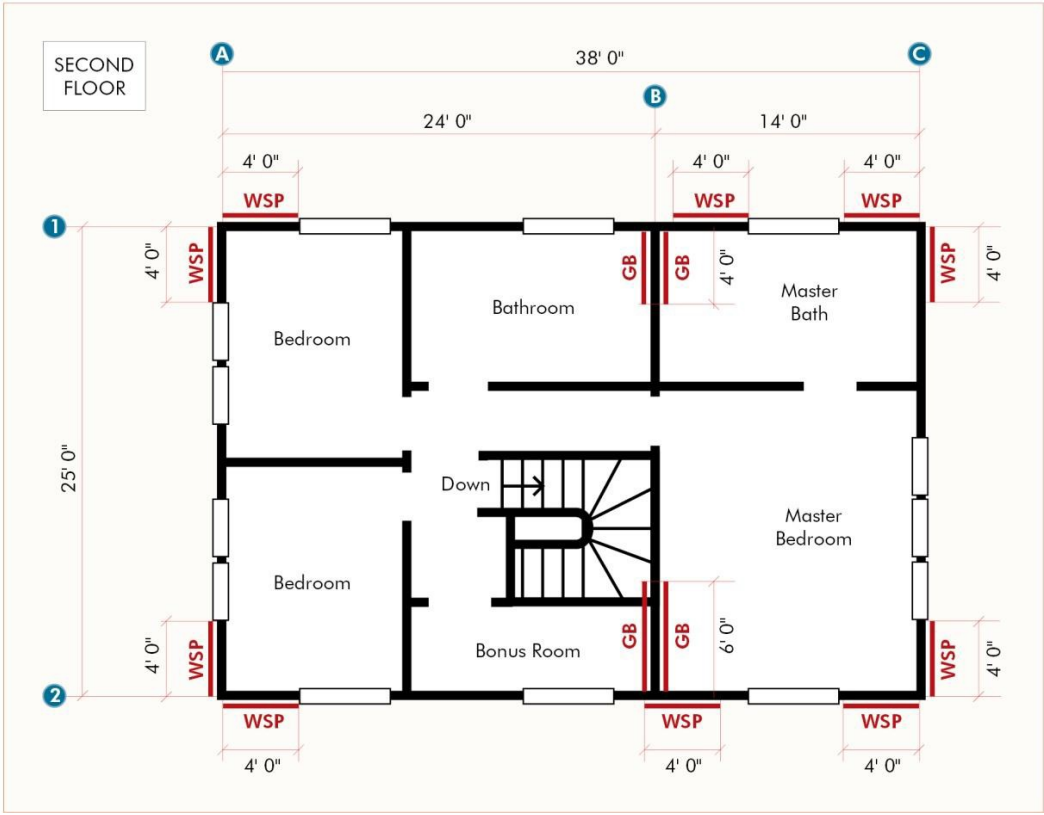


TABLE 4.3a

Calculations for the first of two stories to determine the required bracing length based on wind speed and Seismic Design Category

WIND CALCULATIONS

IRC Tobie R602.10.3(2)

Wind Adjustment Factors *(TABLE* 3.4)	Numbered Woll lines	lettered Woll lines
Exposure Category	1.00	1.00
Roof Eave-to-Ridge Height	0.94	0.94
Wall Height	1.00	1.00
Number of Braced Wall Lines	1.00	1.30
Wind Factor Total	0.94	1.22

Braced Woll line	Bracing Method	Braced Woll line Spacing (ft)	Required Bracing (ft)	Wind Factor Total	Total Required Bracing length (ft)	Bracing length Provided (ft)	Status
	WSP	25	8.0	0.94	7.52	22	Okay
2	WSP	25	8.0	0.94	7.52	22	Okay
A	WSP	24	7.7	1.22	9.39	14	Okay
B	GB	24	13.5	1.22	16.47	22	Okay
C	WSP	14	4.7	1.22	5.73	14	Okay

SEISMIC CALCULATIONS

IRC Tobie R602.10.3(4) Seismic Adjustment Factors *(TABLE* 3.6)	Adjustments
Story Height	1.00
Woll Dead Load	1.00
Roof/Ceiling Dead Load	1.00
Stone/Masonry in SOC C-0 $_2$	n/a
Cripple Wall	n/a
Seismic Factor Total	1.00

Braced Wall Line	Bracing Method	Braced Wall line length (ft)	Required Bracing (ft)	Braced Woll line Spacing Factor	Seismic Factor Total	Total Required Bracing length (ft)	Bracing length Provided (ft)	Status
1	WSP	38	20.90	1.0	1.0	20.90	22	Okay
2	WSP	38	20.90	1.0	1.0	20.90	22	Okay
A	WSP	25	13.75	1.0	1.0	13.75	14	Okay
B	GB	25	18.75	1.0	1.0	18.75	22	Okay
C	WSP	25	13.75	1.0	1.0	13.75	14	Okay

TABLE 4.3b

Calculations for the second of two stories to determine the required bracing length based on wind speed and Seismic Design Category

WIND CALCULATIONS

IRC Table R602.10.3(2) Wind Adjustment Factors *(TABLE* 3.4)	Numbered Wall Lines	Lettered Wall Lines
Exposure Category	1.00	1.00
Roof Eave-to-Ridge Height	0.88	0.88
Wall Height	1.00	1.00
Number of Braced Wall Lines	1.00	1.30
Wind Factor Total	0.88	1.14

Braced Wall Line	Bracing Method	Braced Wall Line Spacing (ft)	Required Bracing (ft)	Wind Factor Total	Total Required Bracing Length (ft)	Bracing Length Provided (ft)	Status
	WSP	25	4.25	0.88	3.74	12	Okay
2	WSP	25	4.25	0.88	3.74	12	Okay
A	WSP	24	4.10	1.14	4.67	8	Okay
B	GB	24	7.00	1.14	7.98	10	Okay
C	WSP	14	2.60	1.14	2.96	8	Okay

SEISMIC CALCULATIONS

IRC Table R602.10.3(4) Seismic Adjustment Factors *(TABLE* 3.6)	Adjustments
Story Height	1.00
Wall Dead Load	1.00
Roof/Ceiling Dead Load	1.00
Stone/Masonry in SOC C-0_2	n/a
Cripple Wall	n/a
Seismic Factor Total	1.00

Braced Wall Line	Bracing Method	Braced Wall Line Length (ft)	Required Bracing (ft)	Braced Wall Line Spacing Factor	Seismic Factor Total	Total Required Bracing Length (ft)	Bracing Length Provided (ft)	Status
1	WSP	38	9.50	1.0	1.0	9.50	12	Okay
2	WSP	38	9.50	1.0	1.0	9.50	12	Okay
A	WSP	25	6.25	1.0	1.0	6.25	8	Okay
B	GB	25	10.00	1.0	1.0	10.00	10	Okay
C	WSP	25	6.25	1.0	1.0	6.25	8	Okay

PRESCRIPTIVE WALL BRACING WORKSHEET

See Residential Wall Bracing Guide for step-by-step instructions on how to use this worksheet

WIND ADJUSTMENT FACTORS

Numbered Wall Lines			Lettered Wall Lines		
1st Story	2nd Story	3rd Story	1st Story	2nd Story	3rd Story

Table R602.10.1.2(1) assumes wind exposure category B, 30 ft mean roof height, 10 ft eave to ridge height, 10 ft wall height, and 2 braced wall lines sharing load in a given plan direction on a given story level. For any other conditions, apply the appropriate adjustment factors.

EXPOSURE FACTOR - select adjustment factor based on exposure and story height:
(Exposure B is typical. Exposure C only occurs where exposed to open terrain such as shorelines)

Exposure B - 1 story = 1.0 -2 story = 1.0 - 3 story = 1.0
Exposure C - 1 story = 1.2 - 2 story =1.3 - 3 story = 1.4

EAVE HEIGHT FACTOR - select support condition & height to determine adjustment factor:

Support Condition	Roof Eave To Ridge Height			
	≤ 5 ft	≤ 10 ft	≤ 15 ft	≤ 20 ft
1 Story or Top Story of 2 or 3 Story	0.7	1.0	1.3	1.6
1st Story of 2 Story or 2nd Story of 3 Story	0.85	1.0	1.15	1.3
1st Story of 3 Story	0.9	1.0	1.1	NP

WALL HEIGHT FACTOR - select adjustment factor based on ceiling height:
- 8 Ft Ceiling = 0.90 - 9 Ft Ceiling = 0.95 - 10 Ft Ceiling = 1.0
- 11 Ft Ceiling = 1.05 - 12 Ft Ceiling = 1.10

NO. OF BRACED WALL LINES FACTOR
- select adjustment factor based on number of braced wall lines:
- 2 Wall Lines: 1.0 - 3 Wall Lines: 1.30 - 4 Wall Lines: 1.45 - 5 Wall Lines: 1.60

TOTAL GENERAL WIND ADJUSTMENT FACTORS
Multiply all of the above adjustment factors for each story:

SPECIFIC WIND ADJUSTMENT FACTORS - *Specific to certain types of bracing methods or building conditions:*

GYPSUM WALL BOARD FACTOR - Apply 1.4 adjustment factor if all the following conditions occur:
- Bracing method is either DWB, WSP, FSB, PBS, PCP or HPS and
- Gypsum board is not applied to inside face of braced wall panels.

_____ @ Braced Wall Lines _____
@ Story _____

GYPSUM WALL BOARD BRACING METHOD - Apply 0.7 adjustment factor if all of the following conditions are met:
- Bracing method is GB and
- Gypsum board is attached with 4" spacing at panel edges, including top and bottom plates and
- Blocking is provided at all horizontal joints.

_____ @ Braced Wall Lines _____
@ Story _____

ONE SIDED GYPSUM WALL BOARD FACTOR - Apply 2.0 adjustment factor if all of the following conditions are met:
- Bracing method is GB and
- Gypsum board is only attached to one side.

_____ @ Braced Wall Lines _____
@ Story _____

HOLD DOWN FACTOR - Apply 0.8 adjustment factor if all of the following conditions are met:
- Bracing method is DWB, WSP, SFB, PBS, PCP and HPS methods and
- Limited to 1 story buildings or top story of 2 or 3 story buildings and
- 800# hold down installed at each end of braced wall panels along the braced wall line.

_____ @ Braced Wall Lines _____
@ Story _____

CRIPPLE WALL BRACING - Apply 1.15 adjustment factor if cripple walls occur
Wall panel spacing shall be decreased to 18 ft. See additional requirements in Section 602.10.9.1

_____ @ Braced Wall Lines _____

SEISMIC ADJUSTMENT FACTORS

STORY HEIGHT FACTOR - Select the adjustment factor based on story height **All Wall Lines**

≤ 10 ft = 1.0 ≤ 11 ft = 1.1 ≤ 12 ft = 1.2 _____

BRACED WALL LINE SPACING FACTOR - Select the adjustment factor if braced wall line spacing is greater than 25 ft. The spacing can only exceed 25 ft to accommodate 1 single room not exceeding 900 SF. When a braced wall line has a parallel braced wall line on both sides, the larger adjustment factor shall be used. See additional requirements in Section 602.10.1.5

≤ 25 ft = 1.0 ≤ 30 ft = 1.2 ≤ 35 ft = 1.4

_____@ Braced Wall Lines _____
@ Story _____

_____@ Braced Wall Lines _____
@ Story _____

GYPSUM WALL BOARD FACTOR - Apply 1.5 adjustment factor if all the following conditions occur:
- Bracing method is either DWB, WSP, FSB, PBS, PCP or HPS and
- Gypsum board is not applied to inside face of braced wall panels.

_____ @ Braced Wall Lines _____
@ Story _____

WALL DEAD LOAD FACTOR - Apply 0.85 adjustment factor if wall dead load is less than or equal to 8 psf. (This applies only to interior walls with gypsum board on each side.)

_____@ Braced Wall Lines _____
@ Story _____

ROOF/CEILING DEAD LOAD FACTOR FOR WALL SUPPORTING - Select adjustment factor based on the roof/ceiling dead load and wall support condition. (Typical composition or metal roof covering will have a roof dead load ≤ 15psf if no ceiling finish is installed. The addition of a finished ceiling will increase the dead load to > 15 psf .

Wall Supporting	Roof/Ceiling Dead Load	Adj. Factor
Roof Only	≤ 15 psf	1.0
Roof Only	>15 psf ≤ 25 psf	1.1
Roof plus Occupied Attic	> 15 psf ≤ 25 psf	1.2

_____@ Braced Wall Lines _____
@ Story _____

CRIPPLE WALL BRACING - Apply 1.15 adjustment factor if cripple walls occur.
Wall panel spacing shall be decreased to 18 ft. See additional requirements in Section 602.10.9.1

_____@ Braced Wall Lines _____
@ Story _____

WALLS WITH STONE OR MASONRY VENEER
See Section 602.12 and 703.7. Braced wall length shall not be less than required by Table 602.12(2)

TABLE EXAMPLE

WIND CALCULATIONS

IRC Table R602.10.3(2) Wind Adjustment Factors (*TABLE 3.4*)	Numbered Wall Lines	Lettered Wall Lines
Exposure Category	1.00	1.00
Roof Eave-to-Ridge Height	0.94	0.94
Wall Height	1.00	1.00
Number of Braced Wall Lines	1.00	1.30
Wind Factor Total	**0.94**	**1.22**

Braced Wall Line	Bracing Method	Braced Wall Line Spacing (ft)	Required Bracing (ft)	Wind Factor Total	Total Required Bracing Length (ft)	Bracing Length Provided (ft)	Status
1	WSP	25	8.0	0.94	7.52	22	Okay
2	WSP	25	8.0	0.94	7.52	22	Okay
A	WSP	24	7.7	1.22	9.39	14	Okay
B	GB	24	13.5	1.22	16.47	22	Okay
C	WSP	14	4.7	1.22	5.73	14	Okay

SEISMIC CALCULATIONS

IRC Table R602.10.3(4) Seismic Adjustment Factors (*TABLE 3.6*)	Adjustments
Story Height	1.00
Wall Dead Load	1.00
Roof/Ceiling Dead Load	1.00
Stone/Masonry in SDC C-D_2	n/a
Cripple Wall	n/a
Seismic Factor Total	**1.00**

Braced Wall Line	Bracing Method	Braced Wall Line Length (ft)	Required Bracing (ft)	Braced Wall Line Spacing Factor	Seismic Factor Total	Total Required Bracing Length (ft)	Bracing Length Provided (ft)	Status
1	WSP	38	20.90	1.0	1.0	20.90	22	Okay
2	WSP	38	20.90	1.0	1.0	20.90	22	Okay
A	WSP	25	13.75	1.0	1.0	13.75	14	Okay
B	GB	25	18.75	1.0	1.0	18.75	22	Okay
C	WSP	25	13.75	1.0	1.0	13.75	14	Okay

Please follow this example when you calculate the required length of bracing on your plans

CALCULATIONS FOR LENGTH OF BRACED WALL PANELS STORY _____

Multiply all adjustment factors and the required wall bracing lengths to determine the total adjusted wall bracing length for each wall line for wind and for seismic. The bracing length provided shall be equal to or greater than the higher of the two. Provide a separate calculation for each story.

WIND CALCULATION Refer to Table R602.10.1.2 (1)

Braced Wall Line	Bracing Method	Braced Wall Line Spacing	Required Bracing Length	General Wind Adjustment Factor	Specific Wind Adjustment Factor(s) *	Total Adjusted Bracing Length (Required Bracing Length X All Adjustment Factors)	Bracing Length Provided
1							
2							
3							
4							
5							
A							
B							
C							
D							
E							

***** *A braced wall line may have more than one specific wind adjustment factor.*

SEISMIC CALCULATION Refer to Table R602.10.1.2 (2)

Braced Wall Line	Bracing Method	Braced Wall Line Length	Required Bracing Length	Seismic Adjustment Factor(s) *	Total Adjusted Bracing Length (Required Bracing Length X All Adjustment Factors)	Bracing Length Provided
1						
2						
3						
4						
5						
A						
B						
C						
D						
E						

***** *A braced wall line may have more than one seismic adjustment factor. Show all adjustment factors.*