

SECTION 21
WALL BRACING USING THE 2010 CALIFORNIA RESIDENTIAL CODE (CRC)

Projects that have been determined to be within the D₂ seismic design category (SDC) or that have been recategorized to SDC D₂ and have no features that would cause them to be considered “irregular” may use the prescriptive wall bracing methods of the CRC. All other projects must use the California Building Code (CBC). See page 21-15 for further information on seismic design categories.

A building or portion of a building shall be considered irregular when the following conditions exist:

1. Floors that are not stacked directly above each other creating a cantilever or setback condition, unless meeting all of the following conditions:
 - a. Floor joists are nominal 2" X10" or larger and spaced no more than 16" o.c. (9.5" I-joists meet this condition)
 - b. Cantilever or setback shall not exceed 4 x the nominal depth of joists
 - c. The ratio of the back span to cantilever is at least 2 to 1
 - d. Floor joists at the ends of braced wall panels are doubled
 - e. A continuous rim joist is connected to the ends of all cantilevered joists
 - f. Gravity loads at the end of cantilevered joists are limited to uniform wall and roof loads and the reactions from headers with a span of 8' or less

Note: Buildings located in SDC E using this code shall have no cantilevers

2. Roofs or floors that are not supported on all four sides by braced wall lines, except that roof overhangs and/or balconies may extend up to 6' beyond a braced wall line.
3. When the end of a braced wall panel extends more than one foot over an opening below unless supported by a header per Table 21-1. In no case may the entire braced wall panel be over an opening.
4. When an opening in a floor or roof exceeds the lesser of 12' or 50% of the least floor or roof dimension.
5. When portions of a floor level are vertically offset from each other, unless all floor framing members are supported by continuous perimeter foundations, or when floor framing is lapped and tied together.
6. When braced wall lines do not occur in two perpendicular directions.
7. When braced wall lines include concrete or masonry construction.

Table 21-1

Header size for openings below braced wall panels

Width of opening below braced wall panel	Required header size
4'	(1) 2x12 or (2) 2x10
6'	(2) 2x12 or (3) 2x10
8'	(3) 2x12 or (4) 2x10

The four major factors to consider when designing for braced wall lines are:

1. Type of Bracing – gypsum board, wood structural panel, others
2. Placement of braced wall panels with respect to corners
3. Maximum spacing allowed between braced wall lines and between braced panels within a braced wall line
4. Required length of wall bracing per braced wall line and minimum required dimensions

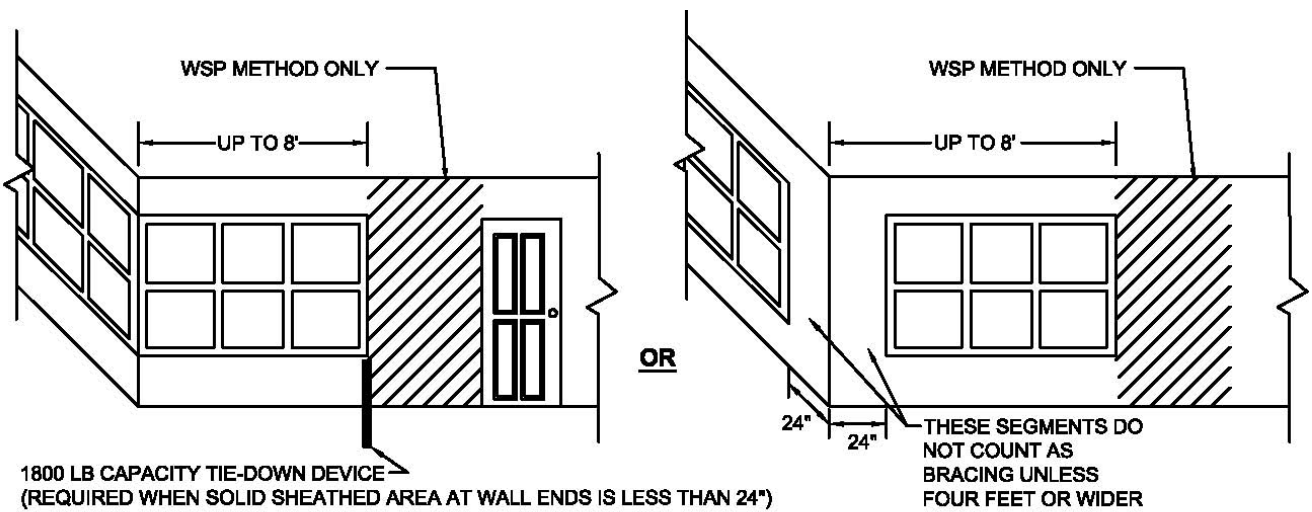
Type of Bracing - The CRC allows a number of types of wall siding, including wood structural panel (**WSP**), double-sided gypsum wallboard (**GB**), structural fiberboard sheathing (SFB), Portland cement plaster (PCP), and others to be used as wall bracing material. This manual addresses the more commonly used methods of bracing: WSP and GB as well as Alternate Braced Walls (**ABW**) and Garage Portal Frames (**PFH**) only. These aforementioned methods are all considered types of intermittent bracing. The code allows for the use of a continuous bracing method, however that method is outside of the scope of this chapter. Any of the methods listed in the CRC for use in SDC D₂ are permissible even if not addressed in this manual.

WSP, which is typically plywood or oriented strand board (OSB), shall be a minimum $\frac{3}{8}$ " thickness and shall be nailed with 6d common for $\frac{3}{8}$ " board and 8d common for $\frac{7}{16}$ " thickness. In each case nail spacing shall be 6" at the edges and 12" in the field.

GB shall be a minimum of $\frac{1}{2}$ " thick and shall be attached with nails or screws at 7" spacing at panel edges, with nails spaced at 8" in the field and screws spaced at 12" or 16" in the field for framing members spaced at 24" and 16" respectively, for interior applications. For gypsum board applied to the exterior of walls all faster spacing shall be 7". Nails shall be $1\frac{1}{2}$ " galvanized for $\frac{1}{2}$ " gyp board and $1\frac{1}{4}$ " for $\frac{5}{8}$ " gyp board. Screws shall be type W or S, $1\frac{1}{4}$ " for $\frac{1}{2}$ " board and $1\frac{5}{8}$ " for $\frac{5}{8}$ " board.

Placement of Braced Wall Panels – Braced wall lines at exterior walls shall have a braced wall panel at each end of the braced wall line unless meeting the following conditions: For the WSP method braced panels may begin no more than 8' from ends as long as there are minimum 2' wide panels on each side of the corner in question (these will not be counted towards the required bracing lengths unless they are at least four feet in length). Or, the 2' sections may be omitted if a tie-down device with a minimum capacity of 1800 lbs is fastened to the stud at the end of the braced panel closest to the corner and attached to the foundation or framing below. See Figure 21-1.

FIGURE 21-1



BRACED WALL PANELS ADJACENT TO CORNERS

Maximum Spacing – Maximum spacing has two components: maximum spacing separating two braced wall lines and maximum spacing from one braced panel to the next within a given wall line.

Within a braced wall line there must be braced panels that do not exceed 25' separation when measured from the center line of each panel. For panels greater than four feet in length the measurement can be taken two feet into the panel such that the maximum spacing between the panels does not exceed 21'.

The maximum distance between two parallel braced wall lines is 25'. There are two exceptions that allow the spacing to be increased to 35':

- The first exception allows for one pair of braced wall lines to be increased to a maximum of 35' for one room in a dwelling not to exceed 900 square feet overall. No adjustments are required and all other braced wall pairs may not exceed 25' spacing.
- The second exception allows an increase up to 35' providing the length of bracing is increased in accordance with Table 21-2, the aspect ratio of the floor/roof above does not exceed 3:1, and the top plate is spliced with (12) 16d nails on each side of the splice. This option must be used if there will be more than one set of braced wall lines with greater than 25' separation.

Table 21-2

Adjustment for wall lines where spacing exceeds 25'

Braced Wall Line Spacing (feet)	Multiply Required Bracing Length by
25	1.0
30	1.2
35	1.4

- Values may be interpolated
- Where a braced wall line has a parallel braced wall line on both sides, the larger adjustment factor shall be applied.

Required Length of Wall Bracing – The minimum required length of wall bracing in a braced wall line shall be the greater of: the calculated minimum for wind, the calculated minimum for seismic, or the minimum required panel size.

The minimum wind requirement is calculated by taking the greater of the distances between a braced wall line and the next parallel braced wall line and looking up the base number in Table 21- 3, then multiplying that number by the wind adjustment factors one by one as they apply.

The minimum seismic requirement is calculated by taking the full length of each braced wall line, using that length to look up the base number in Table 21-4 and then multiplying by any seismic adjustments that apply.

The minimum length of wall line that can be counted towards meeting the braced wall requirement is 4' for WSP and 8' for GB. ABW & PFH have their own specific minimums and are each allowed to be substituted for 4' of required wall bracing despite the fact that they are both shorter in length.

Example 1: Calculating the required length of wall bracing for an individual wall line.

For line C Example Problem 21-1 (see Fig 21-2 p 21-7) the spacing between wall lines B & C is 25' and the length of wall line C is 20'.

In the wind table the basic value for wall line spacing 25', WSP, single story is 4.3. The adjustment factor for exposure C, single story is 1.2, for eave-to-ridge height rounding up from 8' to 10' gives a factor of 1.0, there are 3 braced lines in the direction of line C for a factor of 1.3. Multiplying the result is: $4.3 \times 1.2 \times 1.0 \times 1.3 = 6.7'$ for required bracing for wind.

For seismic the length of line C is 20' so the minimum wall bracing required without adjustments is 5.0'. In this example the wall height and wall and roof/ceiling loads are all standard and no adjustments need be applied.

The calculated wind minimum is 6.7'; the calculated seismic minimum is 5.0'. The 4' panels that are required at each end of the wall line exceed the calculated wind and seismic minimums therefore the (2) 4' panels govern and this wall will meet the wall bracing requirement with 8' of wall bracing.

Table 21-3**BRACING REQUIREMENTS FOR WIND**

85 mph wind speed, Exposure B, 10' eave-to-ridge height, 10' wall height, 2 braced wall lines. (Measurements in Feet) See below for adjustment factors.

Story Location	Braced Wall Line Spacing (between wall lines)	Gypsum Board (Double Sided)	Wood Structural Panel
One story or top of a two story	10	3.5	2.0
	15	4.8	2.8
	20	6.0	3.5
	25	7.3	4.3
	30	8.5	5.0
	35	10.0	5.8
Bottom story of a two story	10	6.5	3.5
	15	9.0	5.0
	20	11.5	6.5
	25	14.0	8.0
	30	16.5	9.5
	35	19.0	11.0

This table and the adjustment factors tables may be interpolated. For ease of use it may be simpler to round up. For instance if your eave-to-ridge height is 8' you may elect to use the value in the table for the eave-to-ridge height of 10', likewise for a wall spacing of 23' you may elect to use the value based on a 25' spacing.

NUMBER OF STORIES	EXPOSURE/HEIGHT FACTORS		
	Exposure B	Exposure C	Exposure D
1	1.0	1.2	1.5
2	1.0	1.3	1.6

SUPPORT CONDITION	ROOF EAVE-TO-RIDGE HEIGHT			
	5 ft or less	10 ft	15 ft	20 ft
Roof only	.7	1.0	1.3	1.6
Roof + floor	.85	1.0	1.15	1.3

NUMBER OF BRACED WALL LINES	ADJUSTMENT FACTOR
3	1.30
4	1.45
5 or more	1.60

For WSP & GB (& other) bracing methods the values are based on the application of gypsum board to the opposite face. If that is omitted a factor of 1.4 must also be applied (to the calculated minimum for wind). This does not apply to ABW & PFH systems.

Table 21-4
BRACING REQUIREMENTS FOR SEISMIC
(AS A FUNCTION OF BRACED WALL LINE LENGTH)
 Seismic Design Category D₂, 10' Wall Height,

10 PSF Floor dead load, 15 PSF roof/ceiling dead load		Minimum total length (feet) of braced wall panels required along each wall line	
Story Location	Braced wall line length	Gypsum Board (Double Sided)	Wood Structural Panel
One story or top of a two story	10	4.0	2.5
	20	8.0	5.0
	30	12.0	7.5
	40	16.0	10.0
	50	20.0	12.5
Bottom story of a two story	10	7.5	5.5
	20	15.0	11.0
	30	22.5	16.5
	40	30.0	22.0
	50	37.5	27.5

Adjustment factors to the length of required seismic wall bracing

Adjustment based on:		Adjustment Factor	
Story Height	≤ 10'	1.0	
	> 10' ≤ 12'	1.2	
Wall Dead Load	> 8 ≤ 15 psf	1.0	
	≤ 8psf	0.85	
Roof/ceiling dead load for wall supporting	Roof only & roof and 1 story	≤ 15psf	1.0
	Roof only	< 15 psf ≤ 25 psf	1.1
	Roof plus 1 story	< 15 psf ≤ 25 psf	1.2

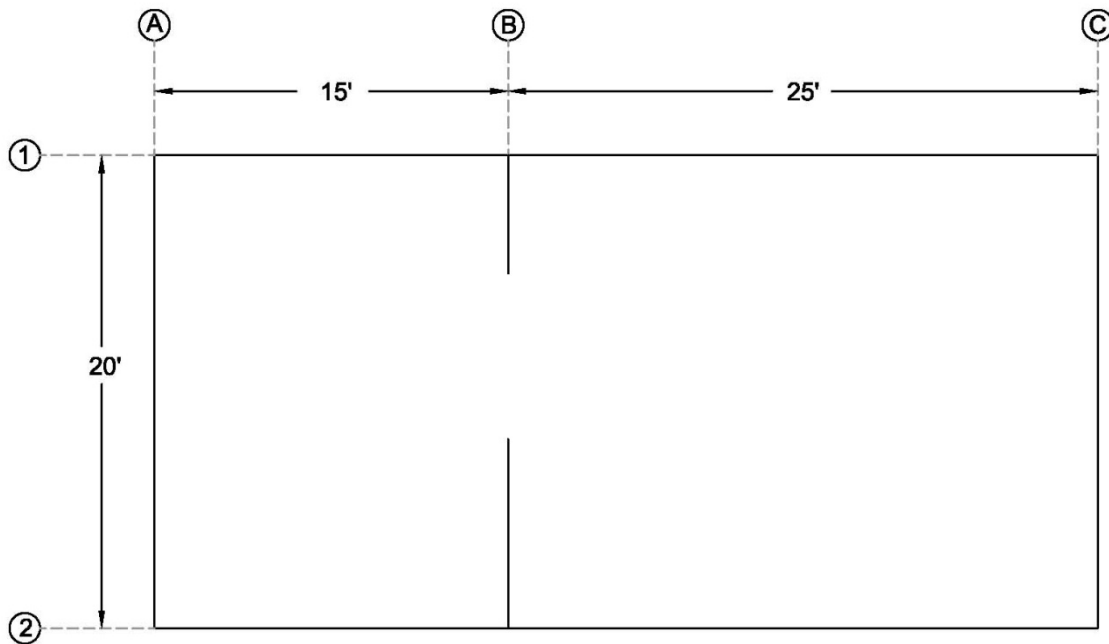
For WSP & GB (& other) bracing methods the values are based on the application of gypsum board to the opposite face. If that is omitted a factor of 1.5 must also be applied (to the calculated minimum for seismic). This does not apply to ABW & PFH systems.

Material Weights – Dead Loads

There are assumptions made in the seismic bracing table regarding material weights. A standard wood framed wall has a dead load of approximately 11 to 12 pounds per square foot (psf). The seismic table assumes a wall material weight of 8–15 psf. Similarly a standard wood framed roof/ceiling with comp or wood shingles has a weight that varies from 10 to 15 psf. If 15 psf is exceeded an adjustment factor must be applied.

In general, walls that exceed 15 psf and roof/ceilings that exceed 25 psf must have an engineering design and may not use standard wall bracing methods, although there are provisions for adding veneer to a first story that are outside the scope of this document.

Figure 21-2
(Example Problem 21-1)



ONE STORY, EXPOSURE C, 8' EAVE TO RIDGE HEIGHT, 9' WALL HEIGHT,
COMPOSITION ROOF, WOOD SIDING, WSP METHOD

Alternate Braced Walls (ABW) and Portal Frames with hold-downs (PFH).

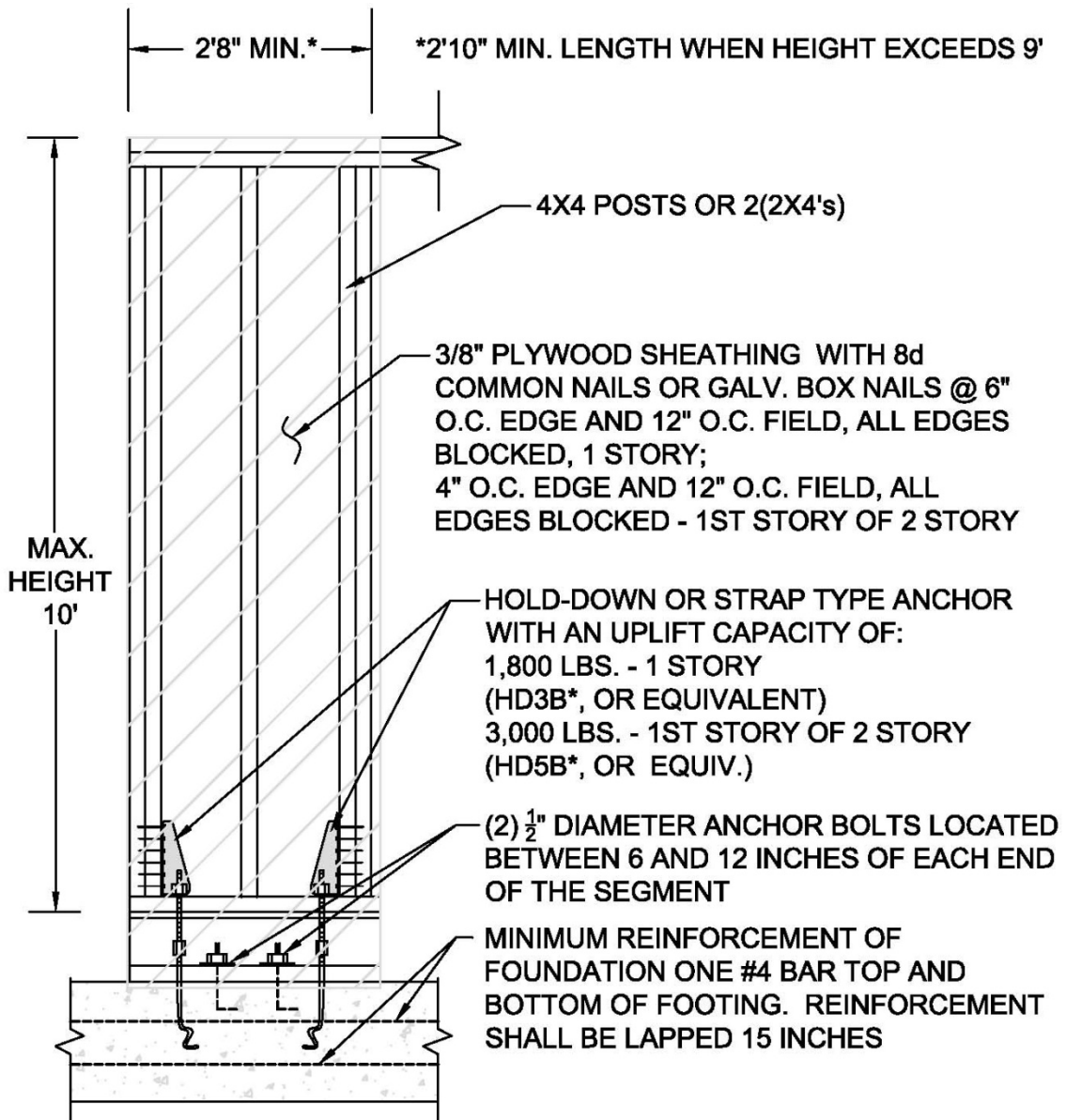
Two alternatives to standard wall bracing are ABW and PFH. Both of these alternatives allow for a section of wall that is less than 4' in width to be substituted for a 4' width. The PFH is designed to be used next to a large opening, typically a garage door, and the ABW is a more general application.

ABWs and PFHs may be used in a one story or on the first story of a two story only. ABWs must be supported directly on a foundation or on floor framing supported directly on a foundation which is continuous the entire length of the braced wall line. PFHs shall be supported directly on a continuous foundation. PFHs may not be used in a raised application.

ABWs shall be sheathed on one side with minimum $\frac{3}{8}$ " thick sheathing attached with 8d nails at 6" o.c. at edges and 12" o.c. in the field for single story construction. Edge nailing shall be reduced to 4" o.c. for ABWs on the first floor of two story construction. See Figure 21-2 for complete attachment information.

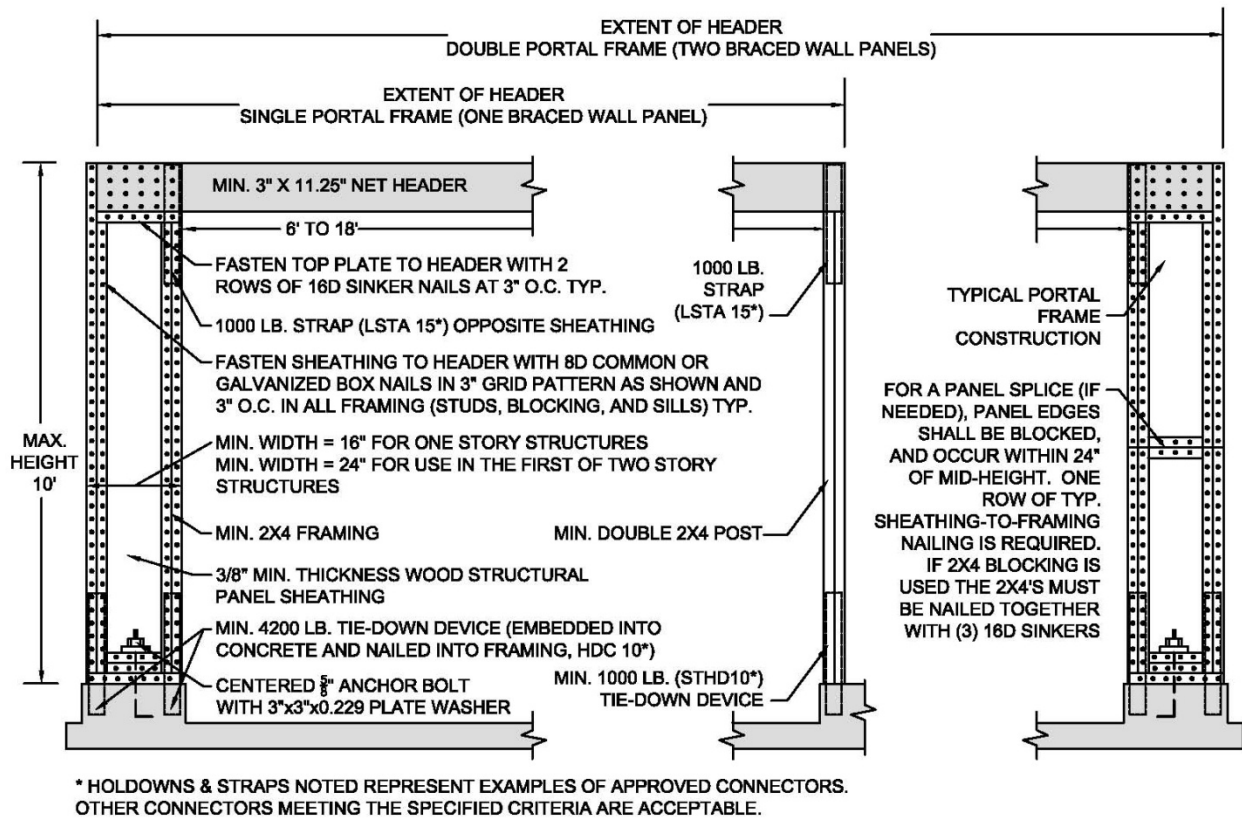
Portal frames with hold-downs shall be sheathed on one side with a minimum of $\frac{3}{8}$ " thick sheathing with 8d nails at 3" o.c. at all framing members and in a 3" grid at the header. See Figure 21-3 for complete attachment information.

Figure 21-3



ALTERNATE BRACED WALL (ABW)
1-STORY AND 1ST STORY OF 2-STORY STRUCTURE

FIGURE 21-4



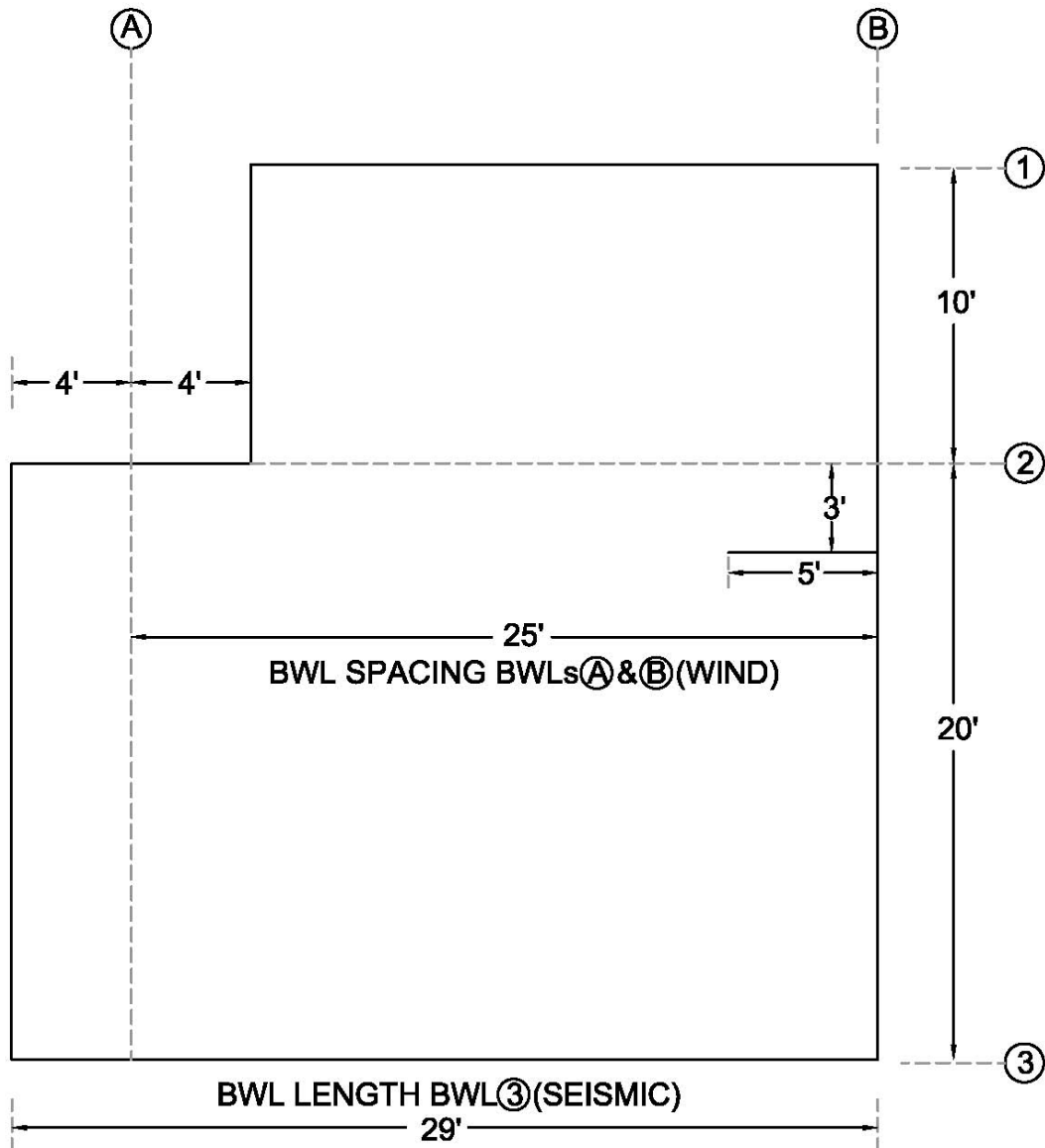
PORTAL FRAME WITH HOLD-DOWNS (PFH)

Assumed (imaginary) braced wall lines

A new addition to bracing design is the concept of an assumed braced wall line. When there are minor offsets along the length of a braced wall line, or in the case of a cutout corner it is possible to use an imaginary or assumed braced wall line. In order to use assumed braced wall lines the offset from an actual line to an assumed line may not exceed 4'. See Figure 21-4 for an example of an assumed wall line. Notice that braced wall line (BWL) A is chosen such that the lines in parallel with it are offset no more than 4' from the assumed line. In the other direction it is not possible to choose an assumed line between BWLs 1 and 2 that would not exceed the 4' offset for one or both lines. In this instance BWL 1 and 2 must correspond to the actual wall lines.

It is not permissible to choose assumed lines 4' inside of all the actual lines in an effort to reduce the overall bracing requirements.

FIGURE 21-5



In Figure 21-5 notice that the separation distance between BWLs A and B is the distance between an assumed line and an actual line. However when calculating seismic requirements the entire length of line C must be used, corner to corner.

The 5' segment that is offset from line 2 may be used towards the required bracing amount for line 2 because the offset is less than 4'. Also, because the segment is less than 8' it must be WSP method rather than GB which would require a minimum 8' length.

Cripple Walls

Cripple walls shall be sheathed with the same type of sheathing as the wall above (typically WSP). The minimum length of bracing shall be the length of bracing required for the wall above multiplied by 1.15.

The maximum distance between braced panels within a wall line in a cripple wall is 18' measured center to center, such that the maximum permitted length of unbraced wall line in a cripple wall is 14'.

Additionally, in the case where an interior braced wall line occurs without a continuous foundation below, the length of cripple wall bracing in the walls parallel to the interior braced wall line shall be the required length of bracing of the wall above multiplied by 1.5. Where that number results in an amount that cannot be achieved the capacity of the cripple wall bracing may be increased by decreasing the edge nailing to 4' o.c in lieu of the 1.5 multiplier.

Cripple walls that exceed 4' shall be framed of studs as if for an additional story.

Story height , story height limits, and maximum stud height

Story height is measured from the top of the floor framing to the top of the ceiling joists or floor framing of floor above. The story height limit is the sum of the allowable maximum stud height plus up to 16" of floor/ceiling framing. Adding in 1" for floor sheathing results in a maximum story height limit of 11' 7" for 10' wall studs.

Stud height may be increased up to 12' by applying additional factors to the required wall bracing lengths. For studs greater than 10' in height apply a factor of 1.1 to the required wall bracing for wind and a factor of 1.2 to the required wall bracing for seismic. Adding in the floor framing and sheathing allowance increases the maximum story height to 13' 7" for 12' studs.

Table 21-5

Maximum Stud Height	Bracing Increase Factor	Maximum Story Height
10'	N/A	11' 7"
12'	1.1 for wind; 1.2 for seismic	13' 7"

While the story height is limited per Table 21-5 it is possible to have taller studs to provide balloon framing at gable end walls and entry foyers. Wall sections with studs that exceed the maximum story height must be placed between braced wall panels and will not be counted towards the minimum required length of wall bracing.

Maximum stud height for non braced wall sections in gable end walls and entry foyers shall be per Table 21-6.

Table 21-6

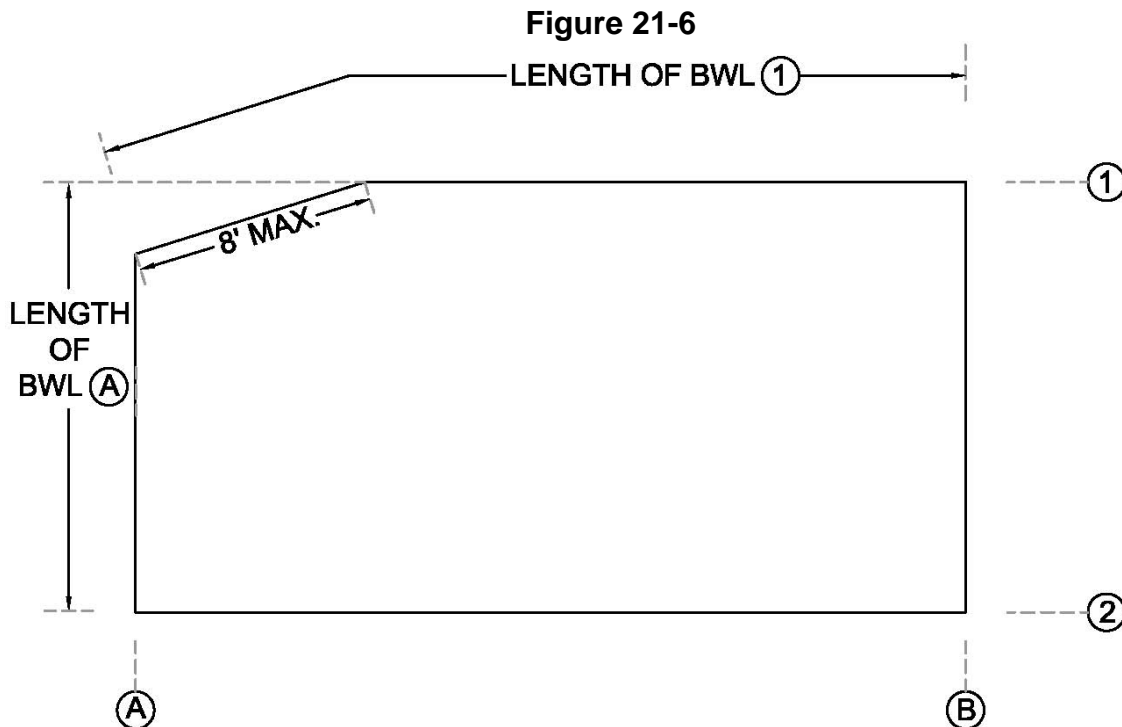
Height (feet)	24" stud spacing	16" stud spacing	24" stud spacing	16" stud spacing
	Supporting roof only		Supporting one floor & roof	
10	2 x 4	2 x 4	2 x 6	2 x 4
12	2 x 6	2 x 4	2 x 6	2 x 6
14	2 x 6	2 x 6	2 x 6	2 x 6
16	2 x 6	2 x 6	NA	2 x 6
18	NA	2 x 6	NA	2 x 6

Utility, standard, stud and No. 3 grade lumber is not permitted.
This table assumes eaves not over 2'.

Diagonal Wall Segments –Angled Corners

In order to be considered a 'regular' building and to use the CRC bracing provisions braced wall lines must occur in perpendicular directions. However, it is possible to have an angled line at the corner of the building and still be considered 'regular'. A wall segment of up to 8' in length and no more than 45 degrees is permissible. The wall segment would be counted as a continuation of the adjacent wall and its length would be added to the length of the adjacent wall when determining the amount of required wall bracing. If the wall segment is exactly at 45 degrees it may be counted with either but not both of the adjacent wall lines. See Figure 21-6

The wall segment is subject to the standard requirements for wall bracing. It may have wall bracing at the corner or if it contains the entryway for the house and there is not room for bracing than the 8' rule applies.



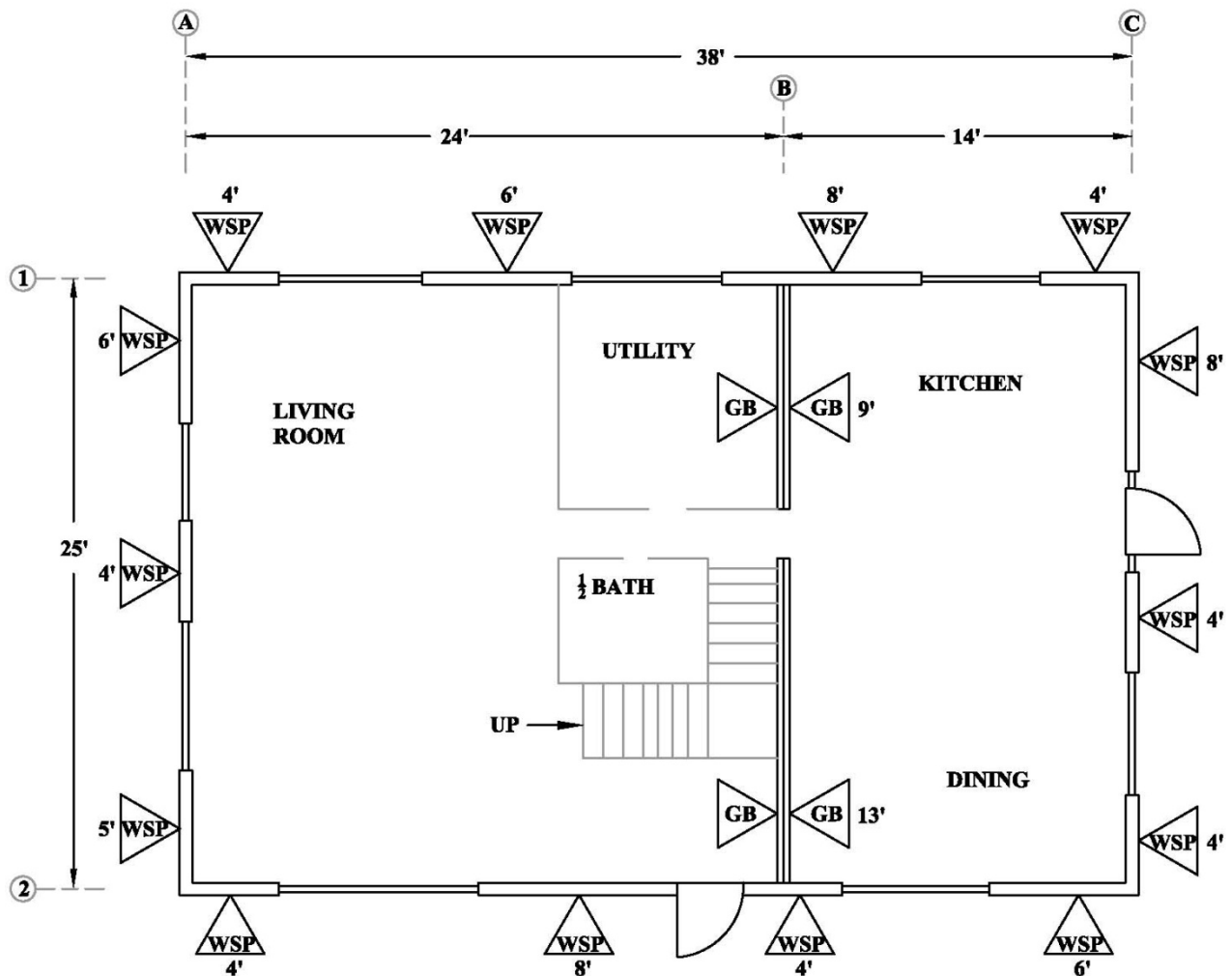
Mixing of Bracing Methods

Braced wall methods may be mixed between floors of a house and between wall lines but not within a wall line. For instance, exterior wall lines will typically be braced with WSP while interior wall lines may be braced with GB or WSP. They may not contain both bracing methods within an individual braced wall line. The alternate bracing methods ABW and PFH are substitutions and may be used within a wall line that is braced with WSP.

Example 2 – How to calculate and document a wall bracing plan

Example 2 is the lower floor of a 2 story residence. Exposure B, eave-to-ridge height 8', wall height 10', gypsum board on the interior walls, and foundation under the interior braced wall line.

Figure 21-7 (Example 2)



The wind value is obtained by looking up the value in the wind chart and applying all relevant adjustment factors. Notice that there are parallel lines on either side of line B, the larger distance of 24' is used in determining the spacing between braced wall lines.

Similarly the seismic value is obtained from the seismic table and any relevant adjustment factors are applied. Standard light framed wood construction with 8-10' ceilings will infrequently have seismic adjustment factors. Values are then displayed in a tabular form. The actual length of bracing provide for each line is compared to the required amounts for both wind and seismic.

Wind Adjustments	Numbered Lines	Lettered Lines
Wind Exposure	1.0	1.0
Eave-to-Ridge Height *	0.94	0.94
Number of Braced Wall Lines	1.0	1.0
No Gyp on Interior	N/A	N/A
Cripple Wall Adj	N/A	N/A
Total Wind Adjustment	0.94	1.22

* For simplicity this adjustment factor may be taken as 1.0

Seismic Adjustments	All Wall Lines
Story Height	1.0
Wall Dead Load	1.0
Roof/Ceiling Dead Load	1.0
No Gyp on Interior	N/A
Cripple Wall Adj	N/A
Total Seismic Adjustment	1.0

The above adjustments are presented in a table format for ease of understanding. They may be presented as a list or any format that is easily readable. The following table or one similar should be provided for all braced wall plans with a wall bracing diagram similar to Figure 21-7. In the table below seismic adjustment factor has been omitted as it is 1.0 throughout. In the event that the seismic adjustment factor varies it shall be incorporated in the table.

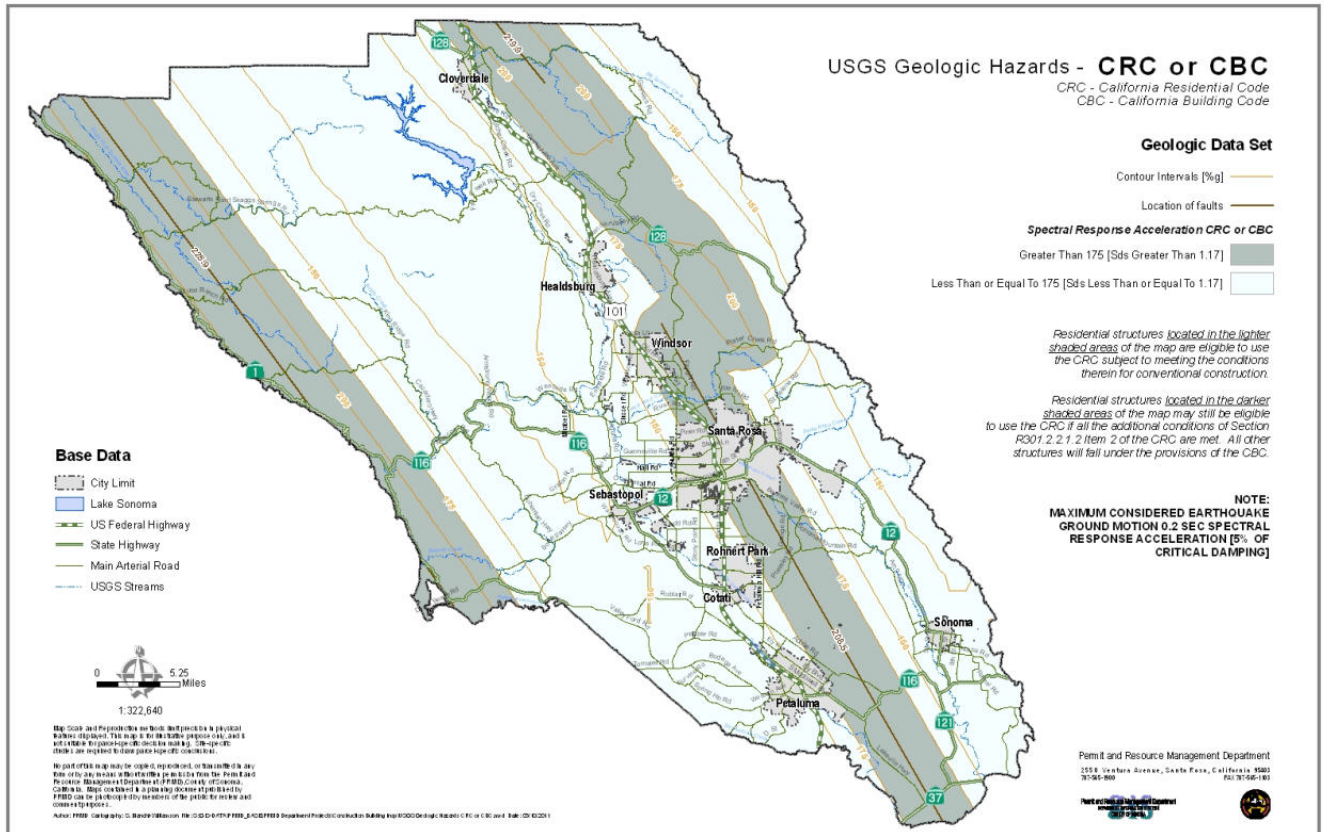
Braced Wall Line	Bracing Type	Wind Table Value	Wind Adjustment Factor	Wind Requirement	Seismic Table Value	Bracing Length Provided	Status
1	WSP	8.0	.94	7.52	20.9	22	✓
2	WSP	8.0	.94	7.52	20.9	22	✓
A	WSP	7.7	1.22	9.40	13.75	15	✓
B	GB	13.5	1.22	16.47	18.75	22	✓
C	WSP	4.7	1.22	5.73	13.75	16	✓

Bracing has been shown to be adequate for this floor. The same process is repeated for the upper floor and two tables should be presented for a two story project.

Seismic Design Categories

In the map of Figure 21-8 the lighter colored areas represent SDC D₂. The darker colored areas represent SDC E. For a project that is located in SDC E there are some conditions that may allow a project to use the CRC as if it was in D₂. Information about these conditions is available in the 2010 CRC and by contacting PRMD Building Plan Check Staff.

Figure 21-8



This map is available online at:

http://www.sonoma-county.org/prmd/gisdata/pdfs/usgs_crc_cbc.pdf

Additional Available Resources

2010 California Residential Code

2009 International Residential Code & Commentary

2009 IRC Wood Wall Bracing Provisions

SRJC Community Education Wall Bracing Class