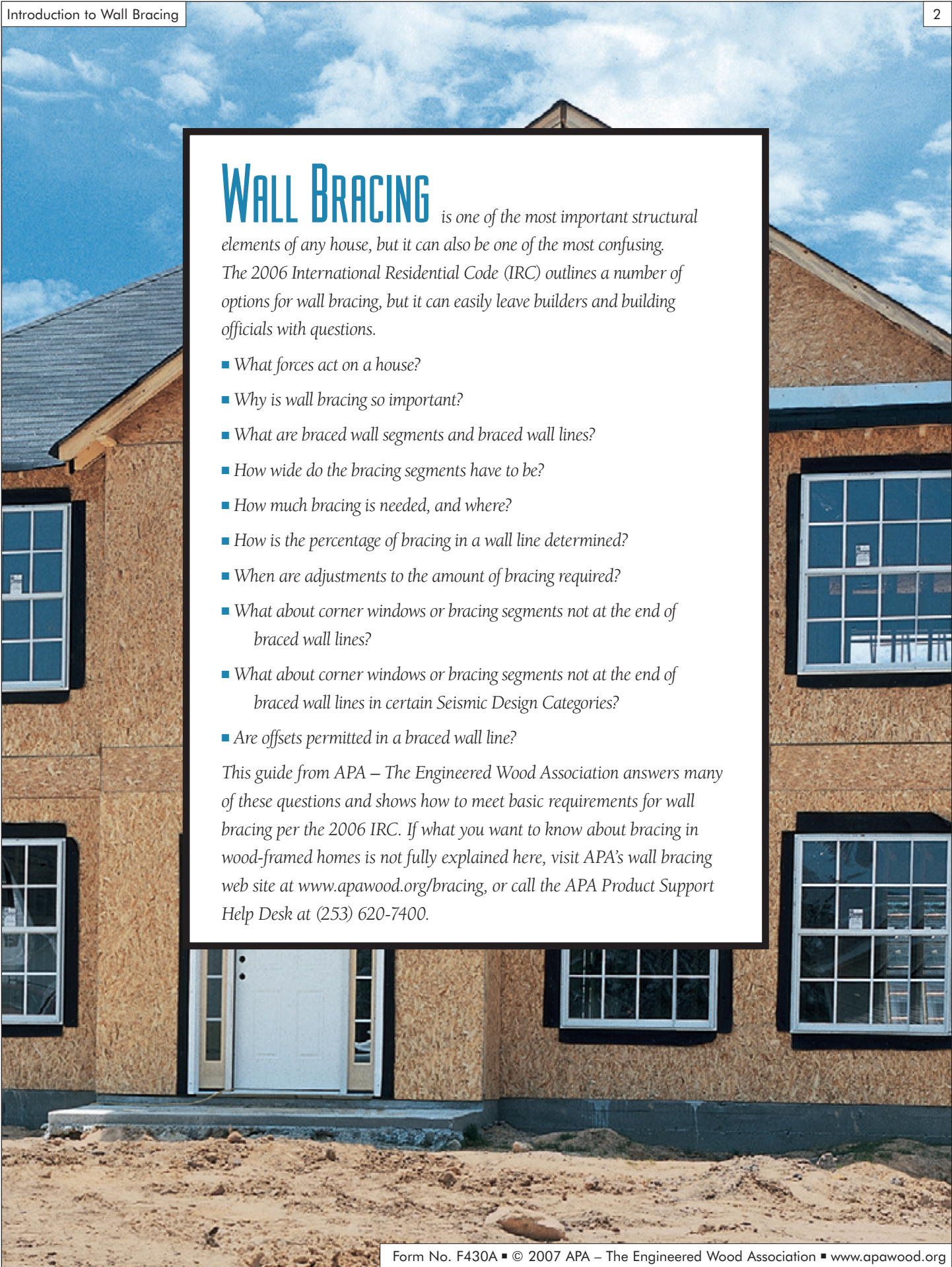


INTRODUCTION TO WALL BRACING



The background of the page is a photograph of a house under construction. The walls are covered in brown oriented strand board (OSB) sheathing. There are several windows with white frames and dark shutters. A white door is visible on the ground floor. The sky is blue with some white clouds. The house is set on a dirt lot.

WALL BRACING

is one of the most important structural elements of any house, but it can also be one of the most confusing. The 2006 International Residential Code (IRC) outlines a number of options for wall bracing, but it can easily leave builders and building officials with questions.

- What forces act on a house?
- Why is wall bracing so important?
- What are braced wall segments and braced wall lines?
- How wide do the bracing segments have to be?
- How much bracing is needed, and where?
- How is the percentage of bracing in a wall line determined?
- When are adjustments to the amount of bracing required?
- What about corner windows or bracing segments not at the end of braced wall lines?
- What about corner windows or bracing segments not at the end of braced wall lines in certain Seismic Design Categories?
- Are offsets permitted in a braced wall line?

This guide from APA – The Engineered Wood Association answers many of these questions and shows how to meet basic requirements for wall bracing per the 2006 IRC. If what you want to know about bracing in wood-framed homes is not fully explained here, visit APA's wall bracing web site at www.apawood.org/bracing, or call the APA Product Support Help Desk at (253) 620-7400.

WHAT FORCES ACT ON A HOUSE?

A house must be built to safely resist the loads anticipated during its lifetime. Lateral loads – those acting on the side of a house – result from winds or earthquakes as shown in Figures 1 and 2.

Figure 1

Walls must be strong enough to resist the wind forces that push against the home.

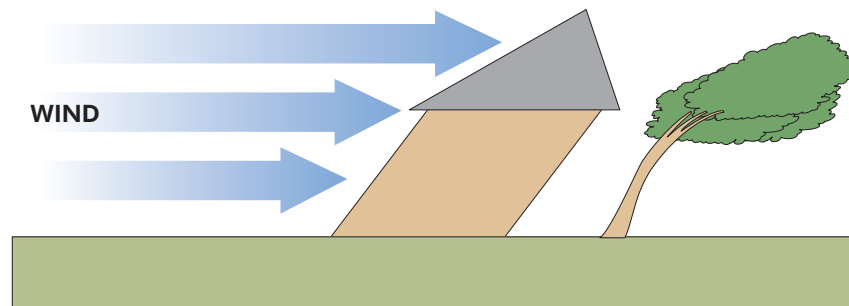
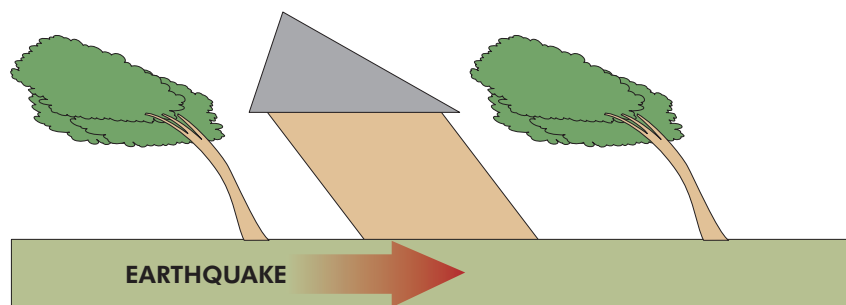


Figure 2

In an earthquake, the seismic ground motion acts on the foundation, while inertia attempts to keep the roof from moving with the foundation, causing forces on the walls.



Because high-wind events or earthquakes are infrequent, it can be difficult to grasp their possible damaging effects on a structure. Ensuring that homes can withstand lateral loads is critical to the safety of the building and its occupants in the event of high wind or an earthquake.

WHY IS WALL BRACING SO IMPORTANT?

During a high wind event or an earthquake, a house must be able to resist lateral loads. Wall studs alone, as shown in Figure 3, cannot resist the racking forces, but braced walls, such as those in Figure 4, have much more strength to resist the loads.

Figure 3

Without sufficient bracing, the walls of a house can rack, causing cosmetic damage, performance problems, and even structural failure.

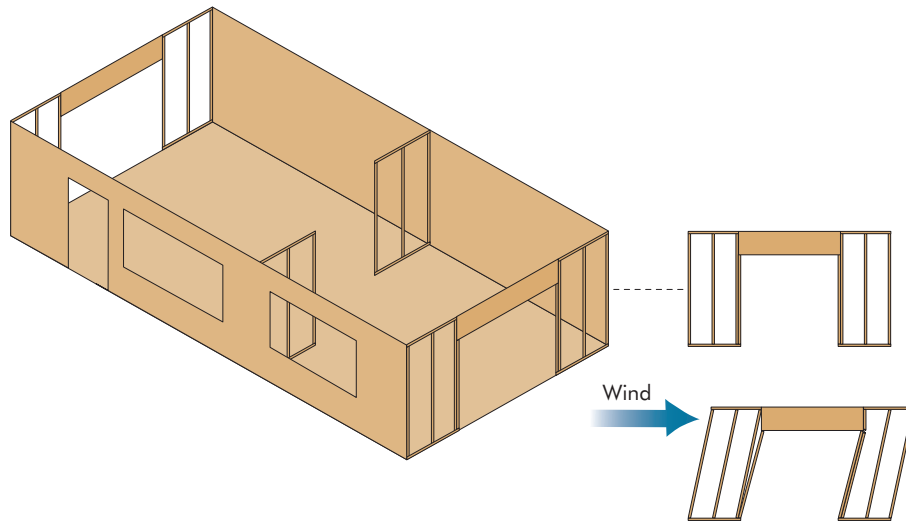
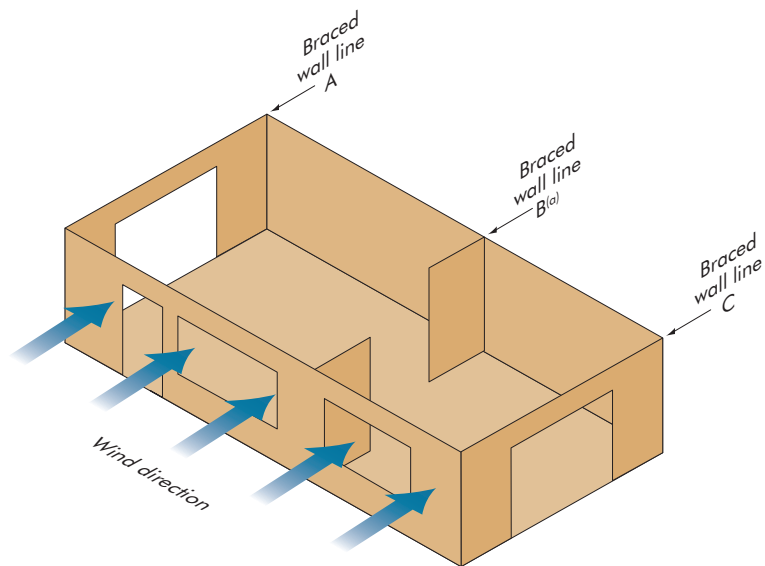


Figure 4

Walls with adequate bracing are unlikely to rack or collapse during high wind or an earthquake.



^(a) For information on offsets in a braced wall line, see page 13.
Note: Wall framing not shown for clarity.

WHAT ARE BRACED WALL SEGMENTS AND BRACED WALL LINES?

The building codes (IBC and IRC) use the terms **braced wall panel** and **braced wall line** throughout. To help avoid confusion between the terms “wall panel” and “braced wall panel,” this publication uses the term **“braced wall segment.”** (Braced wall panel = braced wall segment.)

A “braced wall segment,” shown in Figure 5, is a segment or portion of a braced wall line. It consists of the wall panel (e.g., plywood or OSB Rated Sheathing), the framing, and the fasteners. Multiple braced wall segments form braced wall lines, as shown in Figure 6.

Braced wall lines are what resist lateral loads in a house, as shown in Figure 7. Braced wall lines can be no more than 25 feet apart in high seismic regions (Seismic Design Category D or higher) and 35 feet elsewhere (SDC A-C), but IRC Sections R602.10.1.1 and R602.10.11.1 provide exceptions for using greater spacing.

Figure 5

The code provisions (IRC R602.10) dictate proper size and construction of braced wall segments, including materials, fastener spacing, and minimum width of the panel.

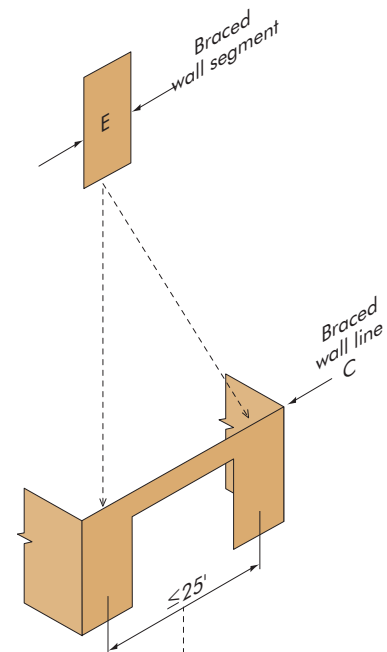


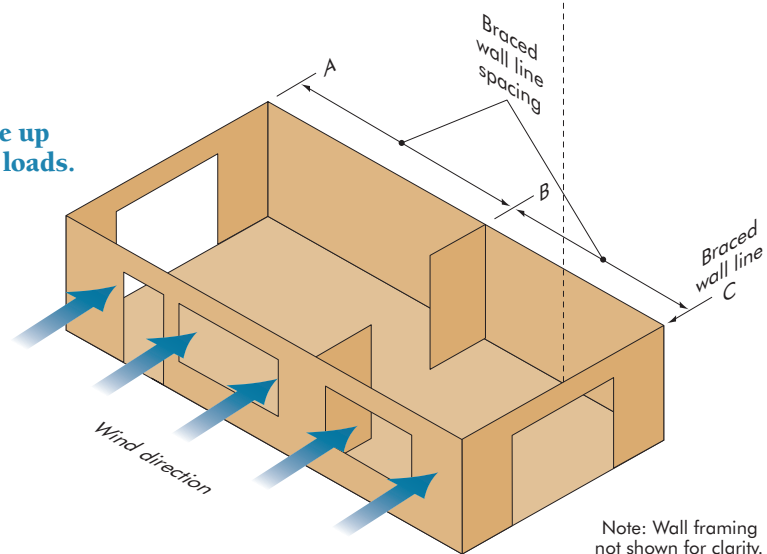
Figure 6

The code (IRC Table R602.10.1) requires:

1. Braced wall segments at ends of braced wall lines,
2. Braced wall segments at least every 25 feet on center in a braced wall line, and
3. A minimum amount (percentage) of braced wall segments in each braced wall line. See page 9 to determine percentage of bracing.

Figure 7

Properly spaced braced wall lines, made up of braced wall segments, resist racking loads.



HOW WIDE DO BRACING SEGMENTS HAVE TO BE?

Table 1 summarizes the minimum braced wall segment width requirements in the IRC. The minimum width depends on the bracing method and the type of construction material specified. The narrowest wall bracing segments the IRC allows are 24 inches, for the continuous wood structural panel sheathing method (IRC R602.10.5).

TABLE 1

IRC BRACING METHODS AND MINIMUM BRACED SEGMENT WIDTH (See referenced sections for detailed requirements.)

IRC Section	Bracing Method	Construction Description	Minimum Width of Braced Wall Segment
R602.10.3	1	Nominal 1x4 let-in bracing	55"-96"
	2	Wood boards of 5/8" net thickness applied diagonally	48"
	3	Wood structural panel sheathing	48"
	4	Fiber board sheathing	48"
	5	Gypsum sheathing	96" ^(a)
	6	Particle board sheathing	48"
	7	Plaster	48"
	8	Hardboard panel siding	48"
R602.10.5	Continuous Sheathing	Wood structural panel sheathing	See Table 2
R602.10.6	Alternate	Wood structural panel sheathing	32"

^(a) 96" sheathed one side, 48" sheathed two sides.

The code allows a narrower width for the continuous wood structural panel sheathing method because of its superior structural performance. See Table 2. Wood structural panels form a strong, stiff shell when properly connected together. APA built on this concept in the development of the Narrow Wall Bracing Method, which enables the minimum width of a braced wall segment to be as narrow as 16 inches. For more information on the APA Narrow Wall Bracing Method, consult APA publication *Whole House Wall Bracing*, Form G440.

Table 2 details the minimum bracing segment widths using continuous wood structural panel sheathing, with both the methods listed in IRC R602.10.5 and the APA Narrow Wall Bracing Method.

TABLE 2

MINIMUM WIDTH OF BRACED WALL SEGMENTS USING CONTINUOUS WOOD STRUCTURAL PANEL SHEATHING

Bracing Method	Braced Wall Segment Height-to-Width Ratio	Length of Braced Wall Segment (in.) for Wall Height of:				Maximum Opening Height Next to Braced Wall Segment (% of Wall Height)
		8-foot	9-foot	10-foot	12-foot	
IRC R602.10.5	2:1	48	54	60	72	100%
	3:1	32	36	40	48	85%
	4:1	24	27	30	36	65%
APA Narrow Wall Bracing Method ^(a)	6:1	16	18	20	24	Up to top of header

^(a) See APA publication *Whole House Wall Bracing*, Form G440, for details and latest code recognition.

Figure 8

This figure demonstrates how the minimum bracing segment widths in Table 2 are determined (for 3:1 and 4:1 height-to-width ratios). The same principles apply to 2:1 or 6:1 height-to-width ratio panels.

Height to width ratio	Calculating minimum bracing panel widths using IRC R602.10.5	Example calculation
3:1		
4:1		

HOW MUCH BRACING IS NEEDED, AND WHERE?

The amount of wall bracing needed in each braced wall line, as specified by the building codes, depends on the Seismic Design Category (SDC) or wind speed, the stories above the braced wall line, and the method of bracing being used.

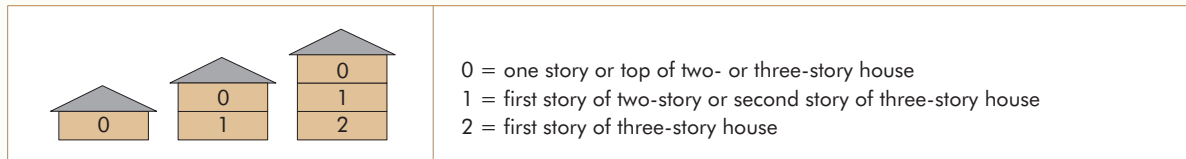
Braced segments must occur at each end of the braced wall line and at least every 25 feet on center. They must also make up a certain percentage of the braced wall line. Table 3 summarizes the bracing requirements.

TABLE 3

BRACING REQUIREMENTS (For complete details see Table R602.10.1 of the IRC)

Seismic Design Category (SDC) or Wind Speed	Stories Above Braced Wall Line ^(a)	Method of Bracing Permitted ^{(b),(c)}	Amount of Bracing Per Wall Line		Maximum Spacing Between Braced Wall Lines (ft)
			Braced segments shall occur at each end and at least every 25 ft o.c. but not less than the following percentages:		
			For Method 3 Bracing	For Other Methods Permitted	
SDC A and B or winds 100 mph and less	0	Methods 1-8	16%	16%	35 ^(d)
	1	Methods 1-8	16%	25%	
	2	Methods 2-8	25%	35%	
SDC C or winds less than 110 mph	0	Methods 1-8	16%	25%	35 ^(d)
	1	Methods 2-8	30%	45%	
	2	Methods 2-8	45%	60%	
SDC D ₁ or winds less than 110 mph	0	Methods 2-8	20%	30%	25 ^(e)
	1	Methods 2-8	45%	60%	
	2	Methods 2-8	60%	85%	
SDC D ₂ or winds less than 110 mph	0	Methods 2-8	25%	40%	25 ^(e)
	1	Methods 2-8	55%	75%	

^(a) Stories above braced wall line.



^(b) Continuous structural panel sheathing (IRC R602.10.5) is permitted everywhere.

^(c) Alternate braced wall segments (IRC R602.10.6) are permitted in one story and the first story of two story houses, and limited to continuous foundations.

^(d) See IRC Section R602.10.1.1 for exceptions.

^(e) See IRC Section R602.10.11.1 for exceptions.

HOW IS THE PERCENTAGE OF BRACING IN A WALL LINE DETERMINED?

The bracing percent in a given wall line is simply the sum of the length of the qualifying braced wall segments in the braced wall line divided by the total length of the braced wall line. For example, the percentage of bracing in Figure 9 is the sum of the two bracing segments E and F, divided by the length L and multiplied by 100%. Figure 10 illustrates the percentage of wall bracing in a line with the continuous wood structural panel sheathing bracing described in IRC R602.10.5.

Figure 9

To calculate the percentage of bracing in a wall line in this figure, consider the following:

$$\% \text{ Bracing in wall line C} = \frac{(E+F)}{L} \times 100\%$$

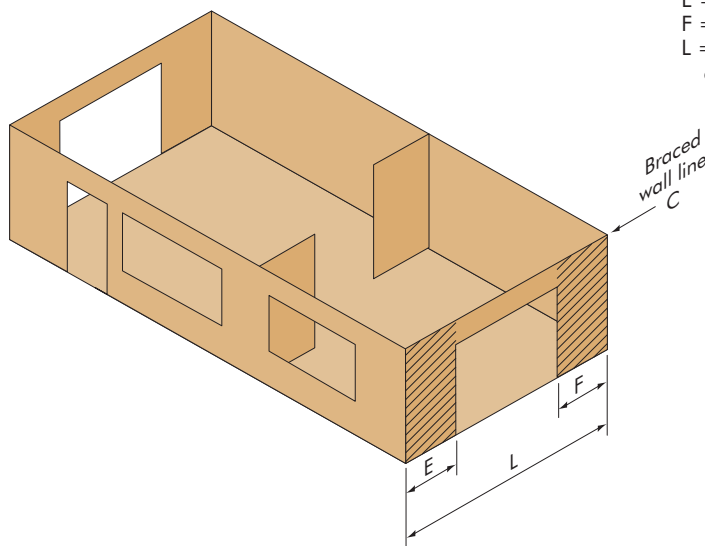
for example:

$$E = 4'$$

$$F = 4'$$

$$L = 20'$$

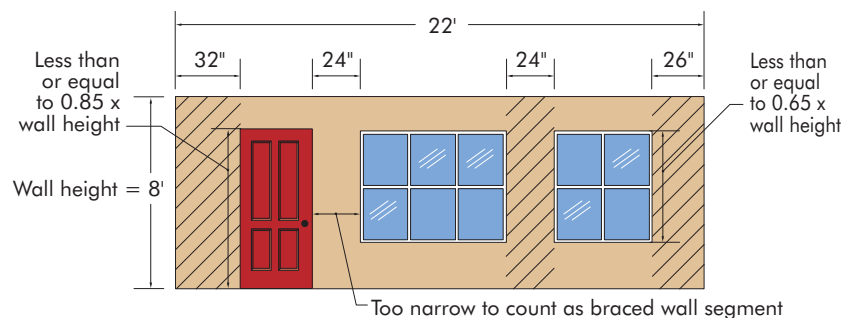
$$\% \text{ Bracing} = \frac{(4'+4')}{20'} \times 100\% = 40\%$$



Note: Wall framing not shown for clarity.

Figure 10

In this example using the continuous wood structural panel sheathing bracing (IRC R602.10.5), the percentage of bracing calculates to 31%. Minimum bracing widths are in accordance with Table 2. The 24-inch-wide segment next to the door is too narrow to count as a bracing segment because, as shown in Table 2, a braced wall segment next to the door must be 32 inches wide for the 8-foot wall.



$$\text{The amount of bracing} = (32''+0''+24''+26'')/12'' = 6.83'$$

The percent of wall braced = $6.83'/22' \times 100\% = 31\%$ which, for example, exceeds the requirement of 25% given in Table 3 for SDC A-B/100 mph with two stories above the braced wall line.

WHEN ARE ADJUSTMENTS TO THE AMOUNT OF BRACING REQUIRED?

The code allows for reductions in the percentage of bracing required in a wall line when using continuous wood structural panel sheathing (IRC R602.10.5). When using tall walls however, the code requires increases in the percentage of bracing (IRC R301.3).

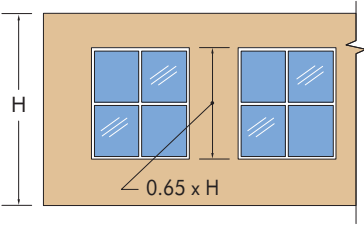
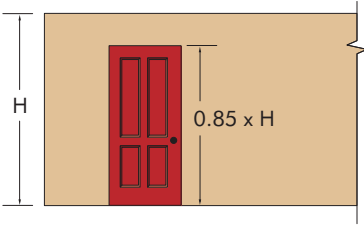
Reductions

When using continuous wood structural panel sheathing bracing (IRC R602.10.5), the amounts of bracing required as shown in Table 3 may be decreased by a factor of:

- 0.9 for walls with openings 0.85 x the wall height and less, or
- 0.8 for walls with openings of 0.65 x wall height and less.

Figure 11

The amount of bracing required can be reduced for certain conditions.

Maximum opening size in wall line		
Amount of bracing reduction factor for wall line	0.8	0.9
Example	If per Table 3 the wall line requires 25% and the wall is braced per IRC R602.10.5 with no opening in the wall line greater than 0.65 x H, then the 25% may be reduced to $25\% \times 0.8 = 20\%$	If per Table 3 the wall line requires 45% and the wall is braced per IRC R602.10.5 with no opening in the wall line greater than 0.85 x H, then the 45% may be reduced to $45\% \times 0.9 = 40.5\%$

Increases

For walls 12 feet tall, the amount of bracing required must be increased by 1.2. In accordance with IRC Section R301.3, a braced wall can be 12 feet tall if three conditions are met:

1. It is wood framed,
2. It is braced in accordance with IRC Table R602.10.1 (Table 3 in this guide), and
3. The amount of bracing required by IRC Table R602.10.1 is increased by 1.2.

Note that stud heights greater than 10 feet must be justified by analysis or in accordance with IRC Table R602.3.1 (IRC Section R602.3.1), as applicable.

For High Seismic (SDC D₁ and D₂)

For Seismic Design Category (SDC) D₁ and D₂, adjustments to bracing amounts for interior braced wall lines based on wall line spacing (IRC R602.10.11.1) and adjustments when using stone and masonry veneer (IRC R703.7), may be made.

For SDC D₁ and D₂, when the dead load of the roof/ceiling exceeds 15 psf, the bracing amounts must be multiplied by 1.1 for walls supporting a roof only and 1.2 for walls supporting a roof and one story (IRC Table R301.2.2.2.1).

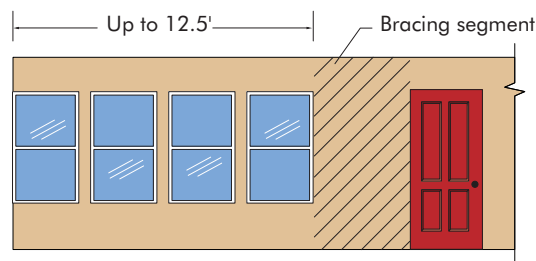
WHAT ABOUT CORNER WINDOWS OR BRACING SEGMENTS NOT AT THE END OF BRACED WALL LINES?

Bracing may occur away from the end of a braced wall line and still be code compliant. See Figures 12, 13a and 13b.

For all bracing methods except continuous sheathing (IRC R602.10.5) in Seismic Design Category A-C, bracing located less than 12.5 feet from the end of the wall line is considered to be at the end, as shown in Figure 12. If bracing is located more than 12.5 feet from the end, then an engineered collector is needed to help transfer lateral loads per code (IRC R602.10.1). See APA Technical Topic *Collector Design for Bracing in Conventional Construction*, Form TT-102, for more information on design of a collector.

Figure 12

Braced wall segments can occur up to 12.5 feet from the end of a wall in SDC A-C.



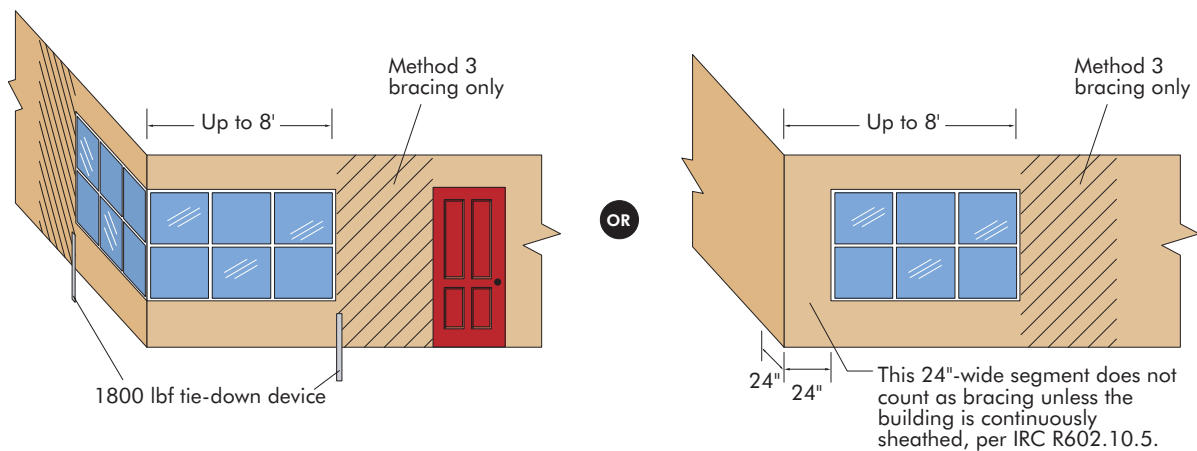
WHAT ABOUT CORNER WINDOWS OR BRACING SEGMENTS NOT AT THE END OF BRACED WALL LINES IN SEISMIC DESIGN CATEGORY D₁ AND D₂?

Per IRC R602.10.11.2, a braced wall segment must occur at the end of a braced wall line for all bracing methods except Method 3 (wood structural panel bracing). Wood structural panel bracing may be placed up to 8 feet from the end, provided one of the following provisions is met, as shown in Figure 13a and 13b:

1. A minimum 1800 lbf tie-down device is on each braced wall segment closest to the corner, as shown in Figure 13a, or
2. A minimum 24-inch-wide segment is at the corners, as shown in Figure 13b.

Figures 13a and 13b

For SDC D₁ and D₂, two options exist for bracing away from corners (Method 3 bracing only).



ARE OFFSETS PERMITTED IN A BRACED WALL LINE?

Many home designs feature offsets along walls. IRC R602.10.1 permits offsets up to 4 feet, provided that the total out-to-out offset dimension is not greater than 8 feet, as shown in Figures 14, 15, and 16.

Figure 14

A braced wall line can have 4-foot offsets.

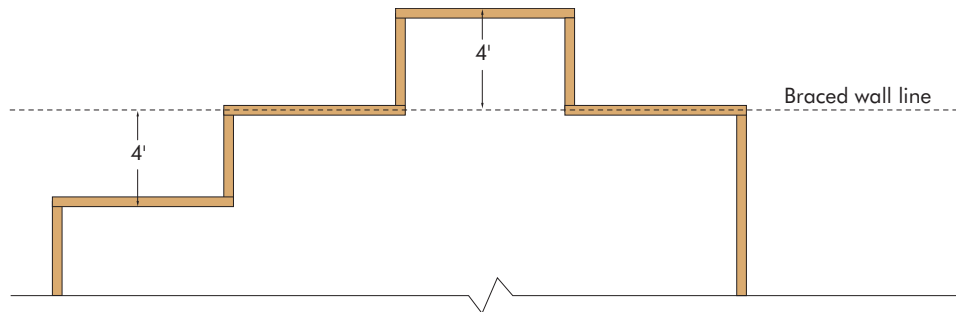


Figure 15

The code permits 8 feet total out-to-out offsets (4 feet each way) in a braced wall line.

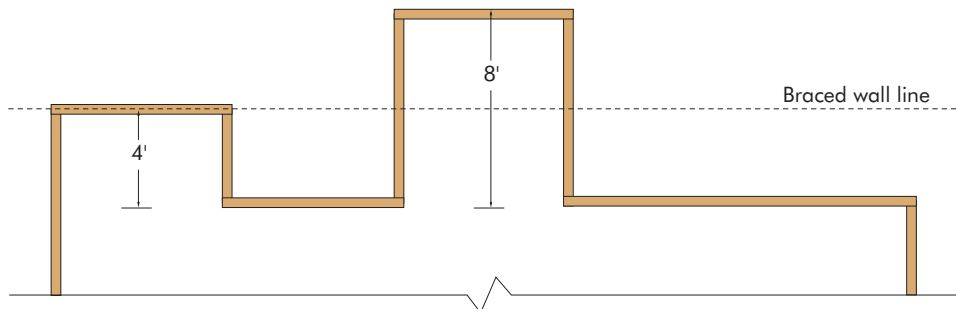
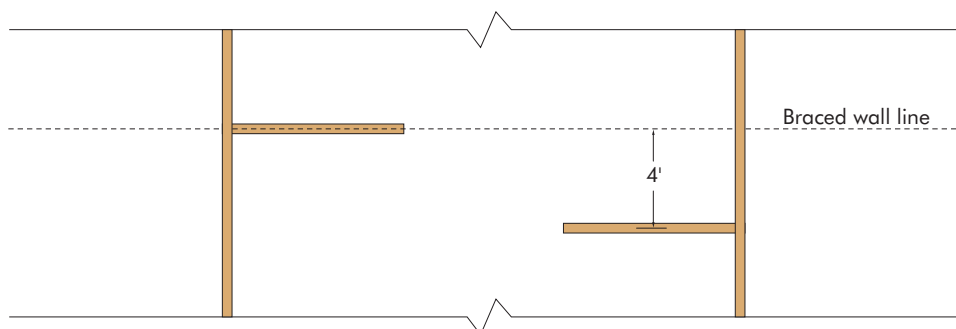


Figure 16

Offsets may also occur in discontinuous braced wall lines.



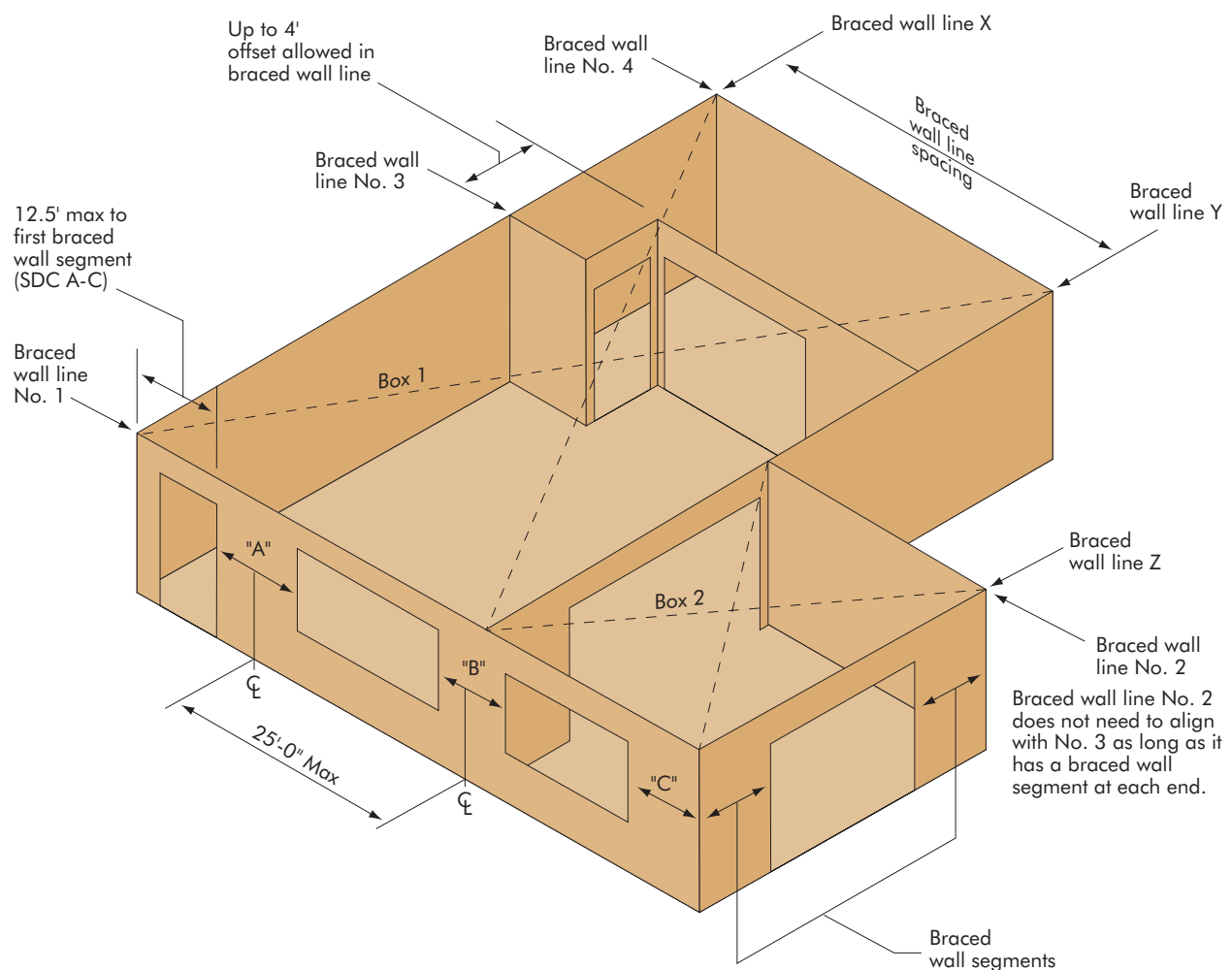
SUMMARY: PUTTING TOGETHER THE ELEMENTS OF A WELL-BRACED HOME

This guide is intended to illustrate the basic wall bracing requirements in the 2006 IRC and to explain the importance of wall bracing. Most of the concepts described in this guide are illustrated in Figure 17:

- The difference between braced wall lines and braced wall segments and how they may occur in an actual structure can be seen in Figure 17 below.
- For a wall segment to count as bracing, it must be a certain width, depending on the method of bracing used.
- Bracing segments must occur at ends (or a distance from the end) of each wall line, be spaced no more than 25 feet on center, and not be less than a certain percentage, depending on location in the house, design wind speed or Seismic Design Category, and bracing type. Table 3 of this guide gives the required percentage of bracing that a wall must have, and Figures 9 and 10 show how to calculate the percentage of bracing that a wall has.
- Four-foot offsets can occur in a braced wall line.

Figure 17

This diagram of a home shows wall bracing requirements from the 2006 IRC.



MORE INFORMATION ON WALL BRACING

Learn more about bracing in *A Guide to the 2006 Wood Wall Bracing Provisions*, a comprehensive guide published by APA and the International Code Council. To order the book, contact APA (see contact information on back cover) or the ICC, at 1-800-786-4452 Monday-Friday 8 a.m. to 7 p.m. Central Time or visit the ICC store at www.iccsafe.org/store.

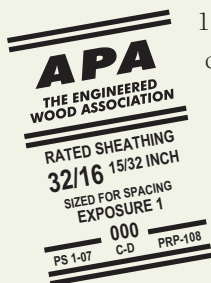
More information can also be found in the following APA publications:

- *Whole House Wall Bracing*, Form G440
- *Collector Design for Bracing in Conventional Construction*, Form TT-102
- *Explanation of IRC Continuous Structural Panel Sheathing Option to Meet Wall Bracing Requirements*, Form TT-079
- *Frequently Asked Questions About APA's Narrow Wall Bracing Method*, Form TT-080
- *A Portal Frame With Hold Downs for Wall Bracing or Engineered Applications*, Form TT-100
- *IRC Exemption from Wall Bracing Requirements in Seismic Design Category C*, Form TT-101

All of the publications can be found on APA's bracing web site, at www.apawood.org/bracing.

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INTRODUCTION TO WALL BRACING

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