Chris Usher

Bracing Walls for Wind

The good news: You can frame a wall without hiring an engineer. The bad news: Plan review may give you brain cramps.

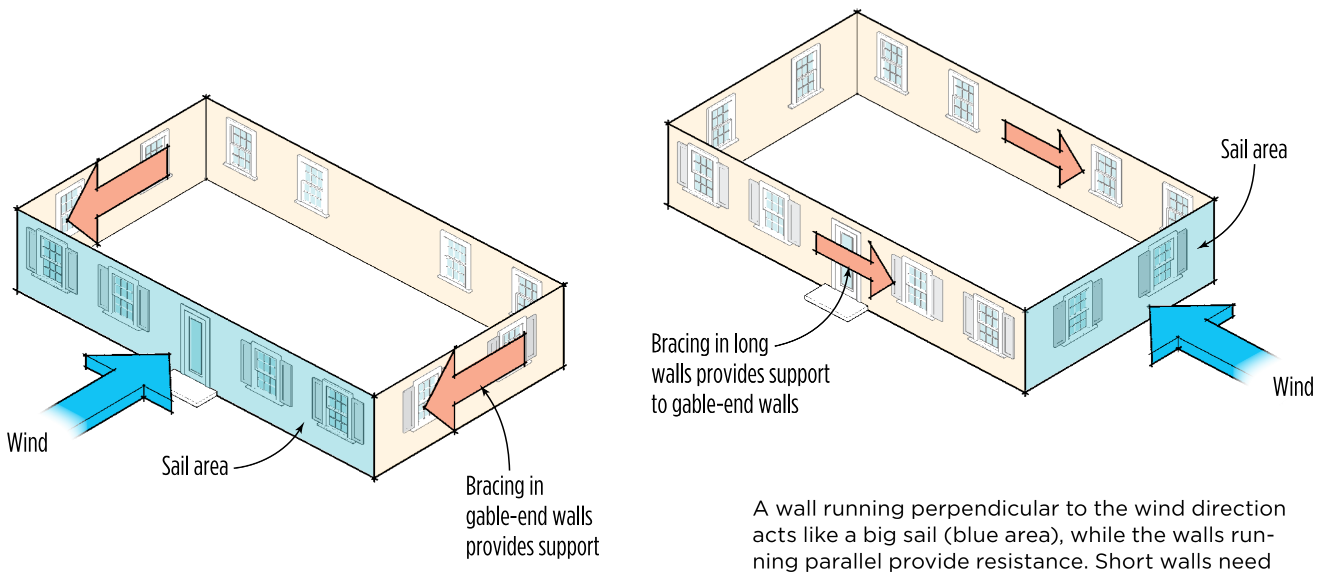
by Ted Cushman

The rules for bracing against wind pressures have gotten complicated. Way complicated. The 2006 IRC devoted a scant eight pages to wall bracing, and by 2009, that section of the code (R602.10) had ballooned to 30 pages. An effort to simplify the 2012 version still left Section R602.10 with 27 pages of wall bracing rules.

Those rules are limited in scope: The methods they prescribe are allowed only if the design wind speed is less than 110 mph and the building is three stories or less. For taller buildings or higher wind speeds, you'll need an engineer. But if you learn the ins and outs of the IRC wall bracing rules — complicated as they are — you should be able to build homes in most parts of the country without an engineer's help.

For this article, *JLC* spoke with Brian Foley, a building official with Fairfax County, Va. (population 1,118,602). Foley is a structural engineer who directs the engineering office at the Fairfax building department. He was also a member of the special International Code Council committee that updated and revised the wall bracing rules for the 2009 and 2012 editions of the IRC. (The publications available

Walls Act Like Sails in the Wind



A wall running perpendicular to the wind direction acts like a big sail (blue area), while the walls running parallel provide resistance. Short walls need enough bracing to resist the forces against the large "sail" area created by the longer wall (left), and vice versa.

from Fairfax County on wind bracing are as good as any you'll find on the topic: www.fairfaxcounty.gov/dpwes/publications/wind_bracing.) Virginia is far ahead of many states in adopting the new codes, and its experience in both coastal and inland terrain is giving builders in states that have yet to adopt the new code an early chance to learn hard-won lessons.

Wind vs. Seismic

Why did the IRC change the wall bracing rules after 2006? Simple, says Foley: If you're building in wind country and not in earthquake country, the old rules were wrong. The bracing rules in the 2003 IRC were brought in from the old Council of American Building Officials (CABO) One and Two Family Dwelling Code, and carried over into the 2006 IRC. "But all of the provisions in the 2003 and 2006 code were based on seismic loads only," says Foley. "And the way we analyze a structure for seismic is 180 degrees different from how you analyze a building for wind."

In earthquakes, Foley explains, the stress on a wall is caused by the mass of the wall reacting against the ground movement under the house — the earth moves, and the house, because of its inertia, wants to stay still. Because longer walls have more mass to react against the earth's motion, they experience greater forces in an earthquake, and need more bracing. Conversely, shorter walls have less mass, so they need less bracing — in an earthquake.

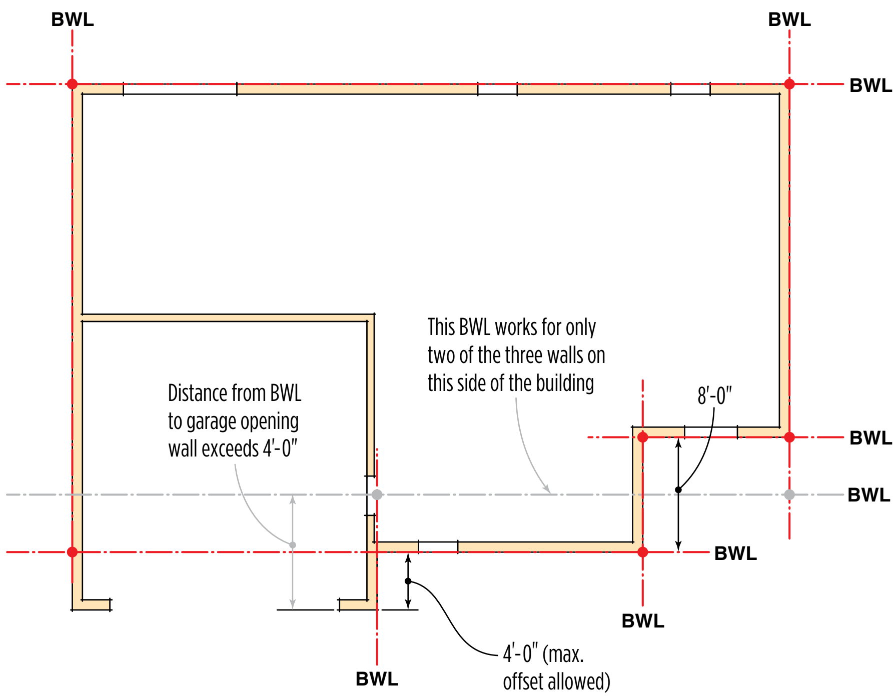
But a windstorm affects walls the opposite way, explains Foley. Walls that are facing the wind feel the wind pressure, but it's the walls parallel to the wind direction that do the work of resisting the force.

For example, take a typical colonial that's just a simple 25-by-50-foot box (see "Walls Act Like Sails in the Wind," above). When the wind blows against the 50-foot wall, it's the two short gable-end walls that have to handle the load; when the wind blows against the 25-foot wall, the bracing in the 50-foot walls comes into play. "With wind, the shorter wall has to resist more loads than the longer wall," says Foley. "And so shorter walls need more bracing than long walls in a wind situation — just the opposite of what they need for an earthquake." This means that builders who want to have a lot of glass on the short gable-end wall of a shoe-box-shaped building just might come up short in the bracing department.

So the new code has different bracing rules for seismic conditions and for wind conditions. But Foley says there's another reason the wall bracing rules needed updating: They just weren't keeping up with the times. The old code was based on historic behavior of traditional buildings — the traditional two-story colonial or one-story ranch, for example, with walls between each room. "But if today's plans don't include walls between the living room and the dining room, and there is no more foyer, and it's all a big open concept," Foley says, "then a lot of that rigidity that was the basis of the historical experience is gone."

A prime example is that the old code required a 4-foot braced panel at every corner and one every 25 feet on-center, and if you wanted a window at the corner, you had to hire an engineer. In the 2009 and later code versions, however, the requirement for a 4-foot solid wall section

Locating Braced Wall Lines



A braced wall line (BWL) does not have to align with a wall on the building. The code allows a BWL within 4 feet on either side of a wall. In the floor plan shown here, the gray BWL would not work for the entire side of the building, because it would be too far from the garage-opening wall. But together, the two red BWLs would work.

at every corner is gone. Now, the nearest bracing panel can fall as far as 10 feet away from the corner (see "Locating Braced Wall Panels," page 36).

The Downside: Complexity

Builders were at the table when the rules were revised, and they influenced the result. In some ways, the latest code offers builders more flexibility than ever for creative modern designs — but at a price. While the old code was restrictive but simple, the new code is, Foley admits, "exceedingly complex."

In Foley's experience, engineers are no more likely than builders to get the answers right. He notes that the Fairfax County building department routinely rejects engineer-stamped plans as well as builder-submitted plans. That's one reason Foley teaches an eight-hour class on wall bracing and the IRC; his students include not just builders and architects, but also engineers and code officials. "A lot of engineers just sit in one of my classes and then they use the prescriptive requirements," he says. "It makes me wonder why on earth a builder would hire them to do that." Foley believes that there are a lot of smart builders who, once they sit through the training, are able to manipulate their design to accommodate some of the flexibility built into the code.

One reason the new IRC Section R602.10 is so long is that, in an effort to be inclusive, it covers a lot of wall bracing methods that most builders don't use. Specifically, it covers traditional let-in bracing, stucco walls, diagonal wood boards, hardboard panel siding, and structural fiberboard, along with two different approaches to using wood structural panels (plywood or OSB), plus a slew of special narrow-wall options developed by the structural panel industry. So if you're a builder who uses insulating foam sheathing with just a few pieces of OSB or some metal straps in each wall for bracing, you can use one or another approach in Section R602.10 to accomplish that. In fact, the code will let you combine different methods in one house or even in one wall — teaming up let-in bracing on one end of a braced wall line with OSB panels on the other end, for example.

But if you're a builder who believes that simpler is better, your best bet is to stick with OSB or plywood, especially if you need high capacity. Compared with the other traditional methods, wood structural panels can supply more bracing in fewer linear feet of wall. They're most effective when used as continuous sheathing across the whole wall (if you don't cover the entire wall with sheathing, you need wider braced-wall panels at the points where you do sheathe it).

As an introduction to the topic, we'll look at a case study to examine how the required bracing is calculated in varying wind conditions and with different building options (see "Calculating the Required Length of Bracing," pages 32–34). But first, to understand this case study, it's necessary to be clear on a few key concepts.

Braced Wall Lines

To specify the bracing in a wall of a house, you first have to establish what the code calls a "braced wall line" (BWL). The code definition is: "A straight line through the building plan that represents the location

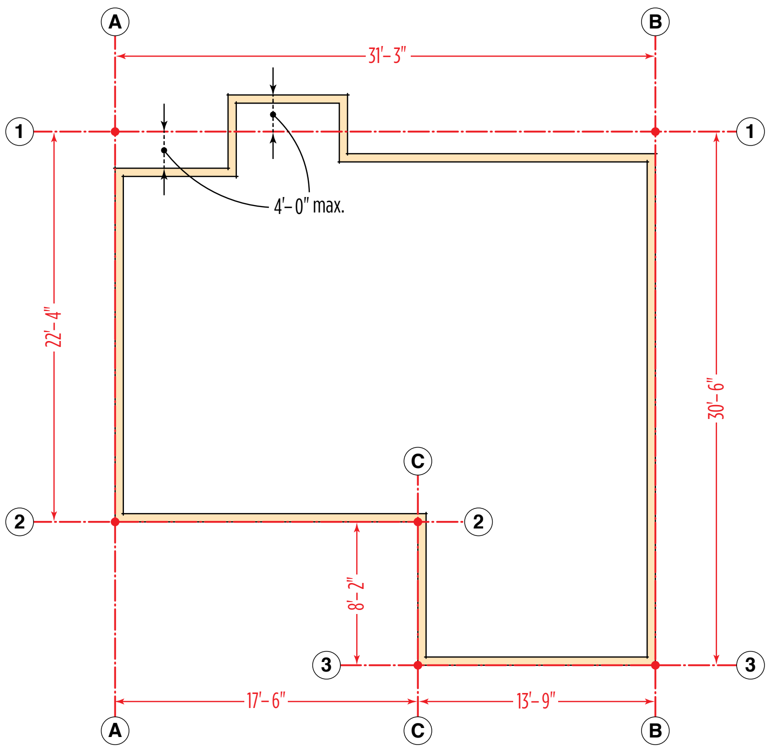
Calculating Average Spacing

When you're figuring the required bracing length, the spacing between braced wall lines is crucial to reading Table R602.10.3(1). But currently, the IRC 2012 does not tell us how to do this; it is up to your local building official, who may say it is the minimum length, the maximum length, or an average of the distances.

Consider the floor plan shown below. How far would you say braced wall line (BWL) A is from the next BWL running in the same direction? On one side (along BWL 1), it is 31′-3″ from B, but on the other end (along BWL 2), it is 17′-6″ from C.

The Virginia building code has adopted the averaging method of calculating the spacing so it is clear-cut for everyone. This is the method we applied in the examples on pages 32–34, and here are the results the method gives for the problem posed above:

- For 1, the distance to the "next" BWL is the average of 22′-4″ and 30′-6″ = 26′-5″
- For 2, it's an average of three distances: 22′-4″ (on the left end) and 8′-2″ and 22′-4″ (on the right end) = (22.3′ + 8.17′ + 22.3′)/3 = 17′-7″ (Note: Dimensions vary because of rounding and conversion from decimal feet to inches.)



BWL	Average Spacing (feet)
1	(22.3 + 30.5) / 2 = 26.4
2	(22.3 + 22.3 + 8.17) / 3 = 17.6
3	(8.17 + 30.5) / 2 = 19.4
A	(31.25 + 17.5) / 2 = 24.4
B	(31.25 + 13.75) / 2 = 22.5
C	(13.75 + 17.5 + 13.75) / 3 = 15

Note: Virginia code allows the spacing (distance from one braced wall line to the next) to be calculated as an average. This method may be allowed in the 2015 version of the IRC.

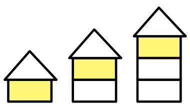
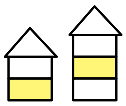
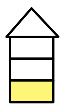
of the lateral resistance provided by the wall bracing." In other words, BWLs aren't the same as the actual walls; they are part of the plans, not part of the building. Actual walls do have to be close to the braced wall line, however. And in complicated plans, the locations you choose for the BWLs can affect whether your plan meets code or not, as you make choices about how to split the difference between pieces of wall that don't quite line up with each other. That's because a "braced wall *panel*" (or BWP, which is the physical bracing, as explained below) can be up to 4 feet away from the braced wall line it belongs to, but no more than that; otherwise, you can't include it as part of the required bracing (see "Locating Braced Wall Lines," previous page).

Spacing. Braced wall lines are allowed to be as far apart as 60 feet, but the spacing between parallel braced wall lines affects how much bracing they need (see "Calculating Average Spacing," above). Braced wall lines that are farther apart experience more racking load, so they require more bracing — which leaves less room in the wall for window and door openings. In practice, if a home's exterior walls are farther apart than 60 feet, you're going to need to rely on some bracing from interior partitions. On the other hand, when the outside house walls are closer together than 60 feet, you still may want to count the contribution of some interior walls in order to leave unbraced lengths of exterior wall available as openings for doors and windows.

Table R602.10.3(1)
Bracing Requirements Based On Wind Speed*

Exposure Category B
30-Foot Mean Roof Height
10-Foot Eaves-To-Ridge Height
10-Foot Wall Height
2 Braced Wall Lines

Minimum Total Length (Feet) of Braced Wall Panels Required Along Each Braced Wall Line

Basic Wind Speed (mph)	Story Location	Braced Wall Line Spacing (feet)	Method LIB	Method GB	Methods DWB, WSP, SFB, PBS, PCP, HPS, CS-SFB	Methods CS-WSP, CS-G, CS-PF
≤90		10′	3.5′	3.5′	2.0′	2.0′
		20	7.0	7.0	4.0	3.5
		30	9.5	9.5	5.5	5.0
		40	12.5	12.5	7.5	6.0
		50	15.5	15.5	9.0	7.5
		60	18.5	18.5	10.5	9.0
		10	7.0	7.0	4.0	3.5
		20	13.0	13.0	7.5	6.5
		30	18.5	18.5	10.5	9.0
		40	24.0	24.0	14.0	12.0
		50	29.5	29.5	17.0	14.5
		60	35.0	35.0	20.0	17.0
		10	NP	10.5	6.0	5.0
		20	NP	19.0	11.0	9.5
		30	NP	27.5	15.5	13.5
		40	NP	35.5	20.5	17.5
		50	NP	44.0	25.0	21.5
		60	NP	52.0	30.0	25.5

*Excerpt for 90-mph windspeed only

This excerpt from IRC Table R602.10.3(1) enables us to find required wall bracing lengths. For a given wind speed and building story, locate spacing of each BWL in the third column, then follow across to the column for the bracing method you are using. In the examples on pages 32–34, we are using the middle set of values (highlighted above), which apply to the first floor of a two-story house or the second floor of a three-story house, and pulling our bracing lengths from the last column, which covers continuous sheathing-wood structural panels (CS-WSP).

Adjustment factor. Defining additional braced wall lines carries with it an adjustment factor — you could call it a penalty. (This is one of four adjustments discussed on page 35.) If you split your braced wall panels across more lines, the total amount of bracing you need goes up. It's a hard concept to wrap your head around, but the upshot is this: Simpler houses are easier to brace than complicated houses, and simpler bracing solutions are more efficient than complicated ones. If you can accomplish all your bracing with just two walls in each direction, there's an advantage in doing it that way.

Even though a braced wall line is an idea and not part of the physical building, it *does* have to be part of the plans. The 2009 IRC says you have to show the braced wall lines on your drawings, and you also have to draw in the locations of each braced wall panel. You're going to want to think this stuff through early on in the design process. You don't want to thrash out a whole design idea with your clients, have them fall in love with the final version, and then find out you can't build that patio door or bay window into your west wall because it won't leave enough room for the bracing, or find out that the wall between your kitchen and laundry room just isn't where it structurally needs to be. It can take multiple passes through the design process, running one after another scenario, moving windows and relocating partitions, before you get a solution that gives you the floor plan, views, traffic, egress, and elevations you want, and that also satisfies the code's requirements for wall bracing.

Braced Wall Panels

While braced wall lines are theoretical lines on the plans, "braced wall *panels*" are the actual physical bracing within a built wall. The code defines a braced wall panel as "a full-height section of wall constructed to resist in-plane shear loads through interaction of framing members, sheathing material, and anchors." In physical reality, we're talking about a short section of framed wall with plates, studs, and some kind of bracing material for stiffness. Braced wall panels have to run the full height of the wall, from bottom plate to top plate, with no interruptions for windows or doors. They also have to be a minimum length along the wall, which varies depending on the method used. Weaker materials, such as gypsum board, or weaker methods, such as let-in bracing, require more linear feet of panel to achieve the required bracing.

A braced wall panel using OSB or plywood typically has to be at least 32 inches long if the wall is continuously sheathed and the headers of openings adjacent to the panel are not higher than 80 inches off the floor. If the sheathing is not continuous but employs intermittent OSB or plywood panels, each panel typically has to be at least 4 feet long to be counted. However, there's an exception even to that

continued on page 36

Calculating the Required Length of Bracing

The amount of bracing required is a function of the wind speed, the exposure, the story of the house, the spacing of the braced wall lines, and the bracing method used. In his training course, Foley teaches a method for calculating the required bracing length that he calls "Choose it, Adjust it, Compare it."

1. Choose it. Select required amount from Table R602.10.3(1).

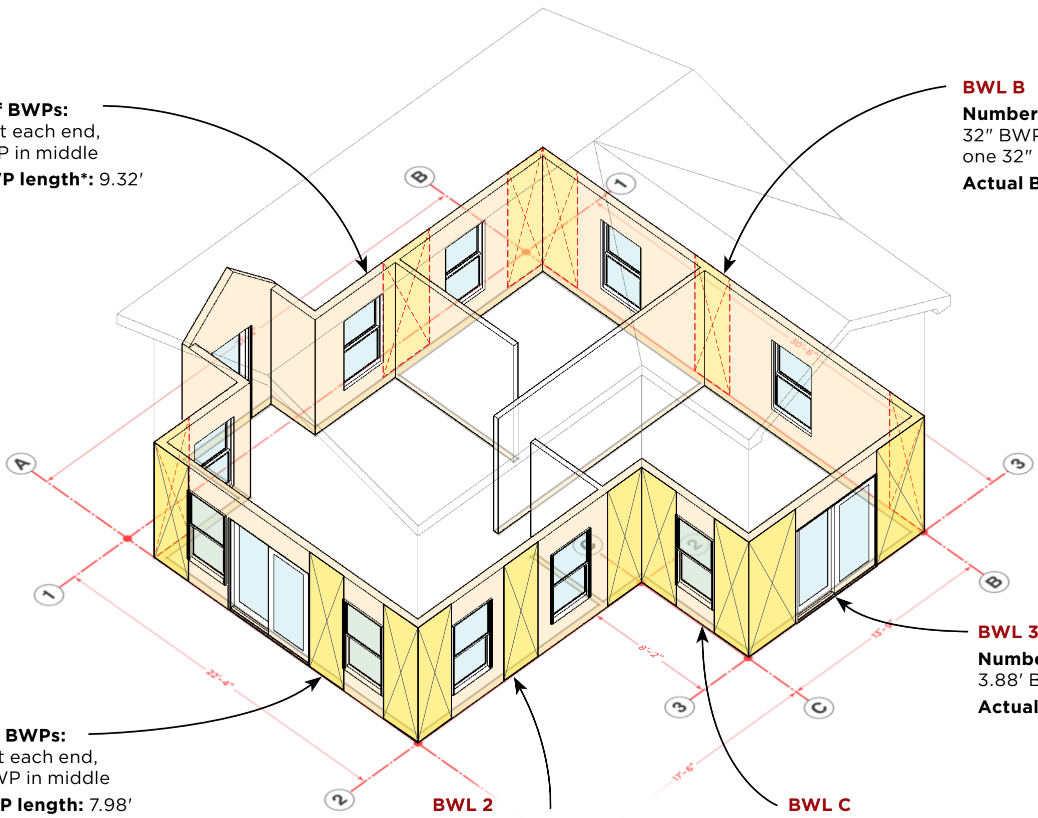
2. Adjust it. Multiply by adjustment factors.

3. Compare it. Actual BWP length must be greater than the required BWP length.

In the three examples below, we use Foley's method to find the required bracing for the first floor of the example house shown.

Step 1: Locate the braced wall lines (BWLs) on the plans. Remember, BWLs do not have to line up with actual walls. In this example, BWL 1 accommodates a few walls that are all within the 4′ maximum offset.

Step 2: Determine the spacing between the braced wall lines. The spacing is shown in column 1 of the results table. See "Calculating Average



* Actual BWP lengths are totals

Example 1

This base case assumes that the sample house is in Exposure B, with 8-foot walls and a shallow-pitched (3/12) intersecting roof. The adjusted BWP length is the result of multiplying the "Required bracing length" successively by each value in the four "Adjustment Factors" columns. For example, in the top line of the table at right, 8.1 x 1 x 0.85 x 0.9 x 1.3 = 8.06; the "Actual BWP length" takes on-center framing into account.

			Adjustment Factors					
BWL	Avg. Spacing	Req'd bracing length (tabular value)	Exposure B	Eaves-to-ridge ht. (3.2 ft.)	Wall ht. (8 ft.)	No. BWL in same direction	Req'd BWP length (adjusted)	Actual BWP length
1	26.4′	8.1′	1	0.85	0.9	1.3	8.06′	9.32′
2	17.6	5.78	1	0.85	0.9	1.3	5.75	7.98
3	19.4	6.32	1	0.85	0.9	1.3	6.29	7.76
A	24.4	7.6	1	0.85	0.9	1.3	7.56	7.98
B	22.5	7.12	1	0.85	0.9	1.3	7.09	7.98
C	15.0	5.0	1	0.85	0.9	1.3	4.97	5.32

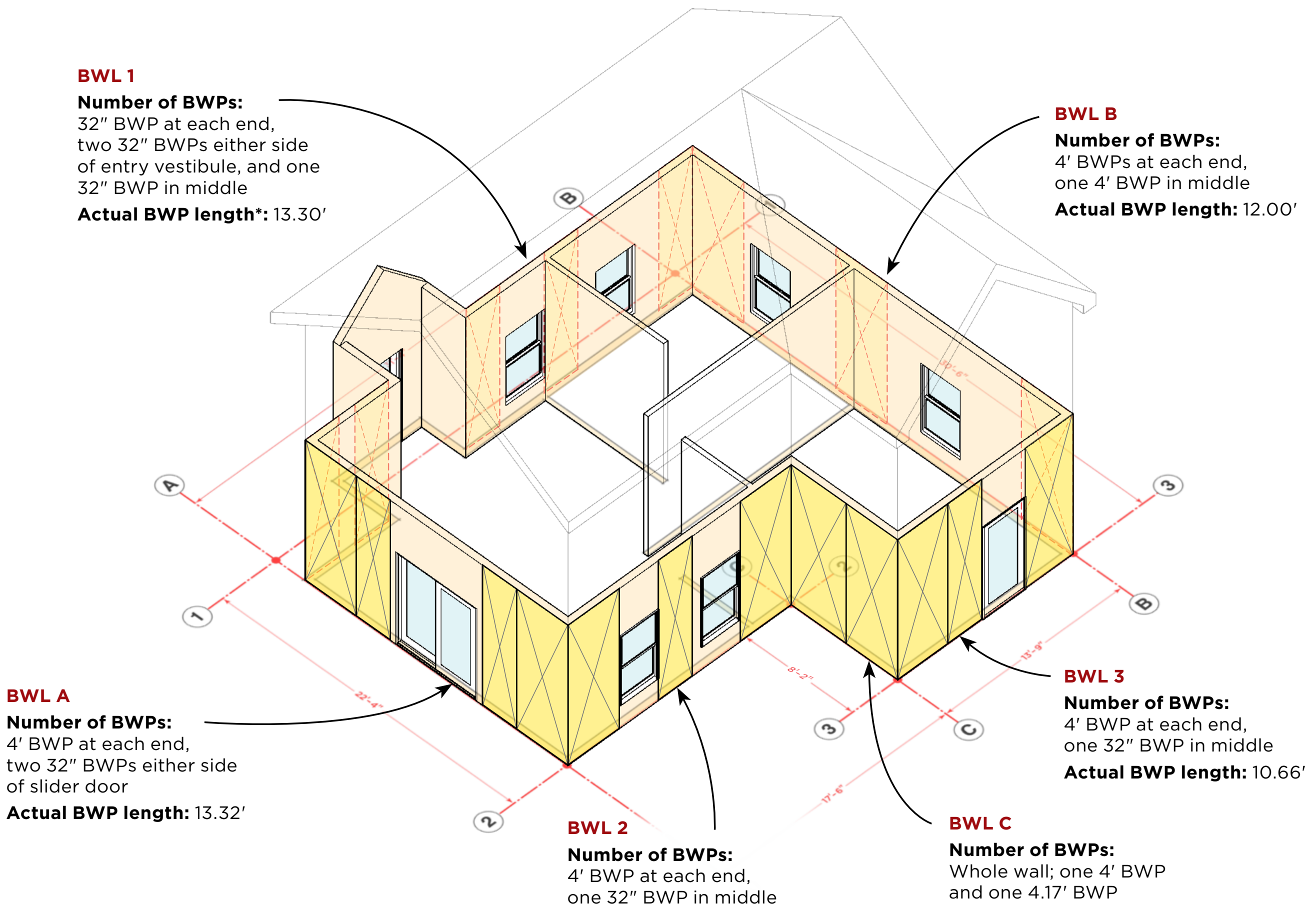
Bracing method: CS-WSP (except where noted); Wind speed: 90 mph; Number of stories: 2

Spacing," page 30, for a breakdown of how the BWL spacing was calculated.

Step 3: Look up the required bracing length in Table R602.10.3(1). (For help reading the table, see the excerpt on page 31.) Note that the results we list in column 2 of the chart in Example 1 are "interpolated" values: Because our actual spacing falls in between the spacing increments in Table R602.10.3(1), we calculated a number that lies proportionately between values in the Methods CS-WSP column.

Step 4: Adjust the required bracing using the appropriate adjustment factors. In Example 1, the house is located on an Exposure B site (no adjustment needed); the first-floor walls are 8 feet high (earning a slight credit of 0.9); and we have three BWLs running in the same direction both ways (requiring an adjustment of 1.3 to each BWL). The adjusted bracing length (last column) is reflected in the braced wall panels shown on the house.

[Note: To make these calculations using an interactive spreadsheet, search for "wind-bracing" at fairfax county.gov.]



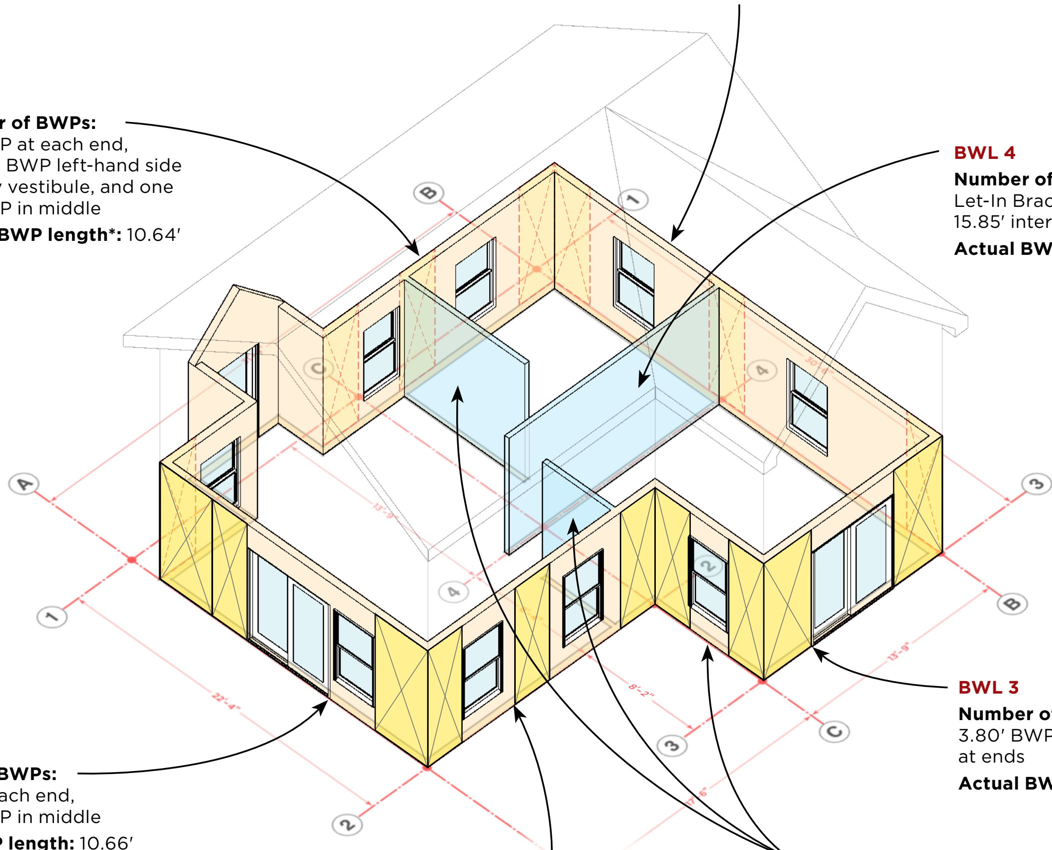
* Actual BWP lengths are totals

Example 2

In this example, we are exploring what happens to the same house if we relocate it on a more exposed site (Exposure C), raise the first-floor wall height to 11 feet, and make the intersecting gable roof steeper. The table lists the changes, and the illustration above graphically shows the reduction in the wall space available for windows and doors.

			Adjustment Factors					
BWL	Avg. Spacing	Req'd bracing length (tabular value)	Exposure C	Eaves-to-ridge ht. (7 ft.)	Wall ht. (11 ft.)	No. BWL in same direction	Req'd BWP length (adjusted)	Actual BWP length
1	26.4′	8.1′	1.3	0.91	1.05	1.3	13.08′	13.3′
2	17.6	5.78	1.3	0.91	1.05	1.3	9.33	10.66
3	19.4	6.32	1.3	0.91	1.05	1.3	10.21	10.66
A	24.4	7.6	1.3	0.91	1.05	1.3	12.27	13.32
B	22.5	7.12	1.3	0.91	1.05	1.3	11.51	12.0
C	15.0	5.0	1.3	0.91	1.05	1.3	8.07	8.25

Bracing method: CS-WSP (except where noted); Wind speed: 90 mph; Number of stories: 2



Example 3

To make room for more windows and doors, we can extend BWL C and add BWL 4, which adds bracing on three interior walls. But we must include let-in metal bracing ("Method LIB" in Table R602.10.3[1]) in these interior walls before hanging drywall, then fasten the drywall to the required "GB" schedule. The location and building features for Example 3 are the same as in Example 2, but the distances between BWLs are shorter, reducing the required bracing lengths. We pick up a slight penalty for adding BWL 4, but compared with Example 2, we reduce the amount of bracing required, allowing us to return to the Example 1 window and door layout, except for one less window along BWL A.

			Adjustment Factors					
BWL	Avg. Spacing	Req'd bracing length (tabular value)	Exposure C	Eaves-to-ridge ht. (7 ft.)	Wall ht. (11 ft.)	No. BWL in same direction	Req'd BWP length (adjusted)	Actual BWP length
1	18.0′	5.9′	1.3	0.91	1.05	1.45	10.63′	10.64′
2	13.0	4.40	1.3	0.91	1.05	1.45	7.92	7.98
3	12.4	4.22	1.3	0.91	1.05	1.45	7.6	7.76
4*	13.0	8.8	1.3	0.91	1.05	1.45	15.85	15.85
A	17.5	5.75	1.3	0.91	1.05	1.3	9.29	10.66
B	13.75	4.62	1.3	0.91	1.05	1.3	7.47	7.98
C*	15.0	10.0	1.3	0.91	1.05	1.3	16.15	19.82

Bracing method: CS-WSP (except where noted); Wind speed: 90 mph; Number of stories: 2
* Let-In Bracing (LIB) method applied

Adjustment Factors

After finding the required bracing length in Table R602.10.3(1), you need to multiply that number by four adjustment factors. Included here are the factors for one- and two-story structures. For three-story buildings, refer to Table R602.10.3(2) in the IRC.

Adjustment: Exposure

	Exposure Category	Adjustment Factor
One-story structure	B	1.00
	C	1.20
	D	1.50
Two-story structure	B	1.00
	C	1.30
	D	1.60

Adjust for Exposure. The more exposure, the more bracing required. In Exposure B, where terrain, trees, or other buildings provide shelter from wind, the adjustment multiplier is 1 — no change. But in Exposure C (open grasslands or flat plains with few trees) or Exposure D (next to unobstructed open land such as a salt flat or a lake that freezes in winter), for a two-story building the required bracing length must be multiplied by 1.30 or 1.60, respectively.

Adjustment: Eaves-to-Ridge Height

	Eaves-to-Ridge Height	Adjustment Factor
Roof only	≤5 feet	0.70
	10 feet	1.00
	15 feet	1.30
	20 feet	1.60
Roof + 1 floor	≤5 feet	.85
	10 feet	1.00
	15 feet	1.15
	20 feet	1.30

Adjust for Eaves-to-Ridge Height. The more building there is above the floor you are bracing, the more wind pressure you will need to brace against. This includes both the floor above and the height of the roof, which adds to the "sail" area. Steeper roofs increase this sail area and therefore require more bracing.

Adjustment: Wall Height

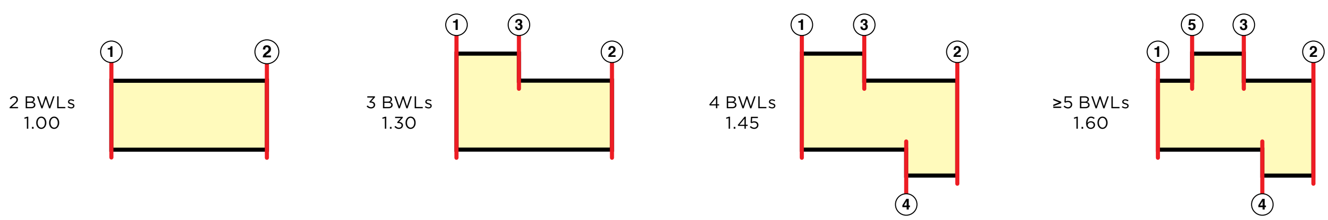
	Wall Height	Adjustment Factor
Any story	8 feet	0.90
	9 feet	0.95
	10 feet	1.00
	11 feet	1.05
	12 feet	1.10

Adjust for Wall Height. If you have 10-foot walls, your adjustment factor is 1 — no change. But for 11-foot walls, you have to multiply by 1.05, and for 12-foot walls, the multiplier is 1.10. The good news here is that you get to reduce the bracing if the walls are shorter than 10 feet: for 9-foot walls, you multiply by .95 (a reduction), and for 8-foot walls you multiply by .90.

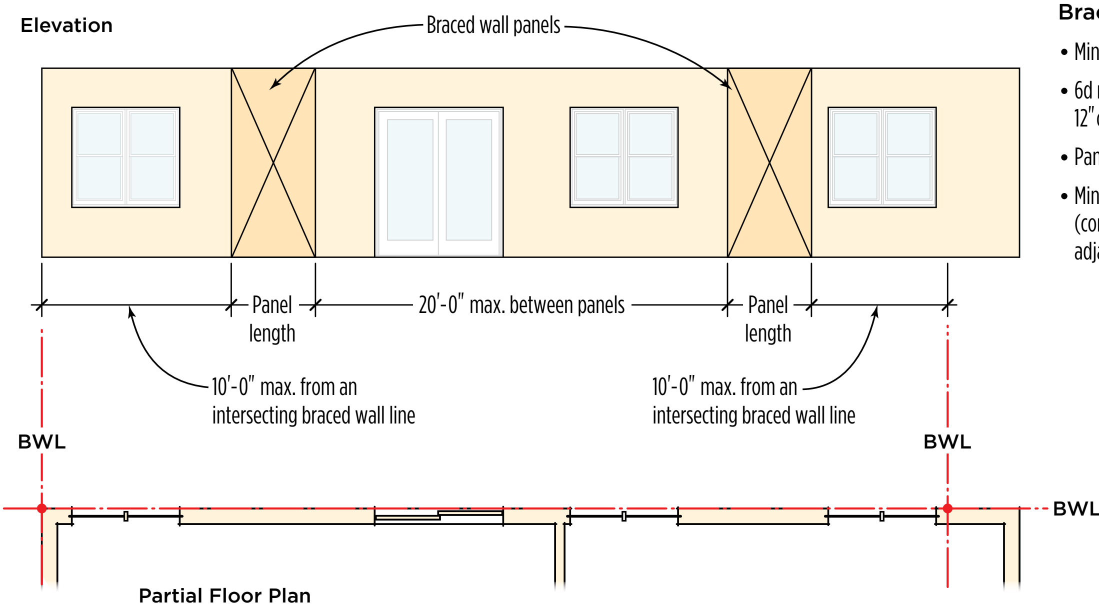
Adjustment: Number of Braced Wall Lines

	BWLs in Plan Direction	Adjustment Factor
Any story	2	1.00
	3	1.30
	4	1.45
	≥5	1.60

Adjust for Number of Braced Wall Lines. If you're resisting the wind force with just two outside walls, you stick to what came out of the table, plus the other adjustments already applied. But if you're using three, four, or five braced wall lines to pick up the load, you need to multiply by the appropriate number found in the table at left.



Locating Braced Wall Panels



Braced Wall Panel Specs:

- Minimum 3/8"-thick plywood or OSB
- 6d nails at 6" o.c. edges, 12" o.c. in field, typical
- Panel extends full height to wall plate
- Minimum 24" panel length (continuous sheathing only when adjacent openings ≤80")

To qualify as a braced wall panel (BWP), a section of sheathing cannot have any openings in it and must be fastened following the minimum specs shown above. BWPs must be spaced no more than 20 feet apart, and begin within 10 feet of each end of the intersecting braced wall lines (BWLs). In this example, the intersecting BWL on the left aligns with the corner, so the 10-foot maximum dimension coincides with the corner. On the right, however, the BWL is offset to the house interior, creating an allowable unbraced length of wall that is greater than 10 feet from the corner. If an intersecting BWL is offset toward the exterior of the house wall, the distance to the corner would be less than 10 feet.

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rule: Shorter intermittent panels can be included in the bracing total, but with a reduction factor applied. So while a 4-foot section of sheathed wall counts as 4 feet, you can also get "partial credit" for shorter sections: a 42-inch-long panel is worth 36 inches in your calculations, and a 36-inch panel is worth 27 inches. These reductions only apply, however, if the wall is no more than 8 feet tall; in taller walls, BWP lengths under 48 inches don't count at all.

Advanced Methods

If you do come up short on wall space in which to install braced panels, you still may not have to go to an engineer. The latest code editions have a few advanced methods built into them that might let you gain adequate bracing in a very short section of wall:

- The "alternate braced wall" (ABW) method uses short braced-wall elements that include hold-down straps or anchors placed at wall ends.
- Method PFH, "portal frame with hold-downs," is a way to build in bracing around wide window or door openings using very narrow wall sections with closely nailed sheathing.
- Method PFG ("portal frame at garage") accomplishes a similar feat with garage openings, where designs commonly don't allow enough length in the wall segments flanking the door opening to meet the minimum size for a braced wall panel.

All of these methods make up for the lack of wall length by using double studs, very close nailing, and strong anchorage at the base of the wall to create a strong, stiff structural element that resists racking.

As Brian Foley observes, there's no way anybody is going to master the ins and outs of this difficult code section by reading one article in a magazine. But that doesn't mean you can't ever learn it. Whether you take a class like Foley's all-day course or just do your own research and learn on the job, one house at a time, getting a good handle on the wall bracing rules is within reach for any capable builder. And once you do have it down, this part of the code offers you plenty of ways to build high-quality houses — and do it cost-effectively.

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