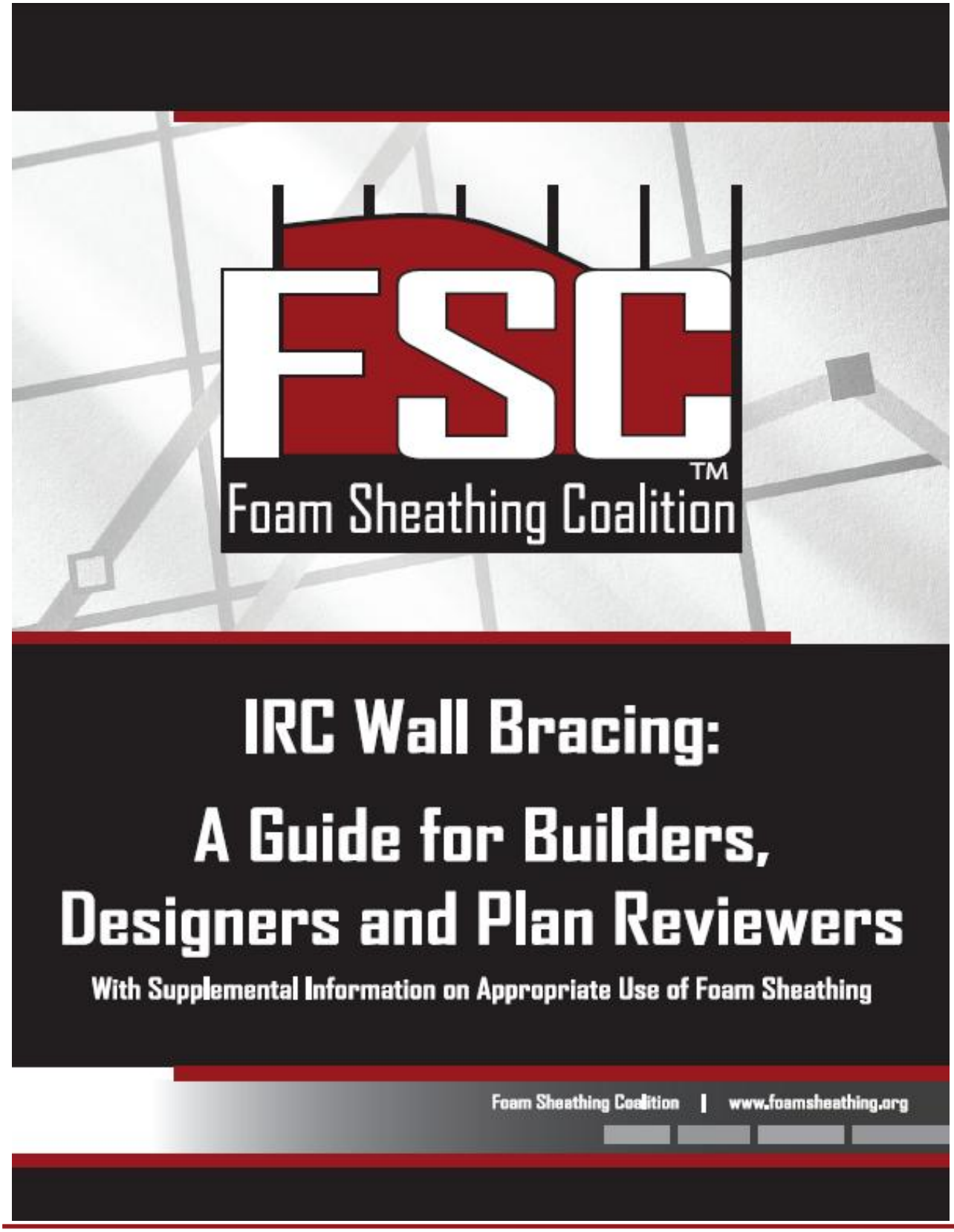


Table of Contents

Also under separate cover:
Supplement to 2009 IRC Wall Bracing Guide: Design Examples

Acknowledgments
The FSC expresses its appreciation to Gary Ehrlich, P.E. (NAHB) for significant technical contributions to and updating of the design example supplement to this Guide.

Introduction

The requirement for bracing conventional wood frame dwellings is not new. For years, homes have been successfully braced using a variety of techniques, even before the first building codes in the United States required it. Conventional wood frame dwellings must be adequately braced to resist lateral (racking) forces due to wind and earthquakes. To achieve this structural safety objective, several wall bracing options and requirements are offered prescriptively in the 2009 International Residential Code (IRC) Section R602.10 Wall Bracing. While the growing number of bracing options and requirements has created some confusion, understanding the many options and using them efficiently provides many advantages. Also, the 2009 IRC has improved the presentation of wall bracing requirements by use of many illustrations and a re-formatting of the provisions.

The main objective of this guide is to provide designers, code officials and builders with a basic understanding of how to apply the IRC bracing provisions for code-compliant dwellings. A second objective is to demonstrate how the IRC bracing provisions can be used to create maximum value in a diverse housing market.

Version 2.0 of this guide was released in late 2009. The purpose of version 2.0 is to update the content provided in earlier versions to include the many changes to wall bracing provisions that occurred with the release of the 2009 IRC. Due to the extensive nature of the revisions, no attempt was made to maintain the provisions of the 2003 and 2006 IRC. For guidelines relating to these versions, see Version 1.0. Many of the “beyond code” solutions and code corrections included in Version 1.0 have now been addressed in the 2009 IRC.

The guide is divided into six sections intended to supplement and enhance the 2009 IRC wall bracing provisions:

Section 1: Basic Concepts for Code-Compliant Wall Bracing
Section 2: Wall Bracing Methods
Section 3: Applying the Code
Section 4: ‘Beyond Code’ Bracing Solutions
Section 5: Wall Bracing Options for Foam-Sheathed Wall Systems
Section 6: Resources and References

In addition, Appendix A to this Guide provides a useful wall bracing design and plan check worksheet. Use of this worksheet is demonstrated in a separate design example supplement to this Guide. Also, Appendix B demonstrates a simple and efficient engineering-based approach to application of the IRC bracing provisions by design professionals. Finally, Appendix C provides supplemental technical information on appropriate sizing of foam sheathing and siding connections to resist wind load and support siding weight.

List of Figures/Tables

Section 1: Basic Concepts for Code-Compliant Wall Bracing

1.1 Why is Wall Bracing Needed?

Wall bracing provides racking resistance against horizontal (lateral) racking loads from wind and earthquakes and prevents the wall studs from distorting in the plane of the wall (racking) in "domino fashion" and, thus, prevents building collapse. As shown in Figure 1, racking loads on a building are considered to act separately in two perpendicular plan directions (i.e., N-S and E-W or front-rear and left-right). At least two wall lines parallel to each plan direction (and on opposite sides of the building) must be designed to resist potential racking loads.

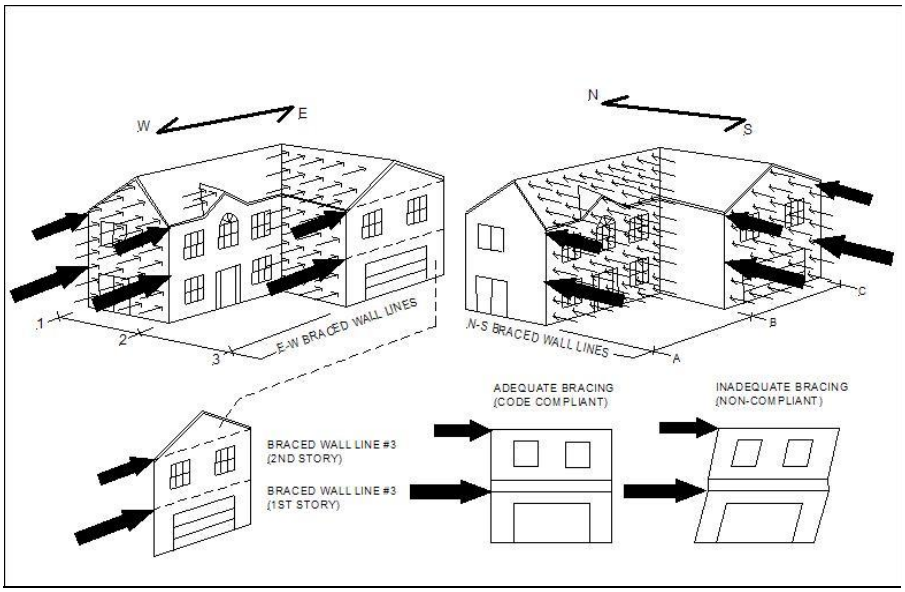


Figure 1*: Wall Bracing and Racking Forces*

1.2 How does Wall Bracing Work?

When bracing a wall, code-compliant bracing elements or "braced wall panels[1]" are located in required amounts on wall lines that are required to resist racking loads, known as "braced wall lines1". For simplicity, building codes have developed prescriptive bracing strategies that look only at designated "braced wall lines" and individual "braced wall panels" on those braced wall lines; in reality, walls act as a system in resisting racking forces, where nearly every component and wall segment provides some racking resistance.

The entire building - wall, floor and roof assemblies - interact to resist and distribute racking loads (Crandell & Kochkin, 2003). The minimum bracing requirements of the 2009 IRC modestly incorporate some of this whole-building system effect (Crandell, 2007; Crandell and Martin, 2009). While standard interior partition walls also contribute to racking resistance, the IRC does not account for their contribution. In addition, roof and floor diaphragms help distribute racking loads from walls with less bracing to those with more bracing. By considering only designated braced wall lines without considering the complete building system as a whole, the IRC bracing

[1] See **Section 1.5 Definitions** and **Section 1.6 Key Concepts & Rules** for details.

provisions generally result in conservative solutions. For example, if an individual braced wall line (e.g., garage opening wall) is deemed 'non-compliant' when strictly applying the IRC, it may actually be acceptable from the standpoint of the entire building system. To make practical use of these building system performance realities requires solutions that go beyond the simple assumptions that a prescriptive code or engineering code is based upon. Refer to **Section 4: 'Beyond Code' Bracing Solutions** and **Section 6: Resources and References** for additional support and resources.

Each braced wall line requires different amounts of bracing depending on the individual share of the racking load acting on the building as a whole (***Figure 1***). The amount of bracing required for a given wall line depends on:

Design Factor	Comment
The design wind or earthquake load (magnitude of hazard).	Buildings in higher hazard areas with large design wind speeds or earthquake ground motions, experience greater potential racking load.
The size of the building and how many stories are supported by a braced wall line.	Walls supporting multiple stories have greater racking loads than those supporting only a roof. Lower story walls serve to resist an accumulation of lateral load from upper story levels that must be passed down to the foundation and then to earth, much the same way that gravity (vertical) loads have a load path.
The spacing between braced wall lines.	For buildings that have widely-spaced wall lines and large interior open areas, the racking load shared by each wall line is increased relative to a building that has many closely-spaced wall lines in each plan direction.
The type or method of wall bracing used (strength of brace).	The method of bracing will also determine how much bracing is needed. Some methods allow for less bracing and narrower braced wall panels in comparison to other methods that require more bracing and wider braced wall panels to achieve equivalent performance (i.e., racking resistance meeting or exceeding racking load). When used in accordance with code, all bracing methods and materials provide roughly equivalent performance.

1.3 When Should I Consider Wall Bracing?

The design factors (see above) impact the amount of space available on a given wall for placing windows, doors and other non-bracing sheathing products such as insulating foam sheathing used for energy-code compliance or enhanced energy-saving performance. Thus, wall bracing can affect other important architectural objectives or design requirements and should be considered as early as possible in the building design process. In addition, the 2009 IRC contains the following new requirements regarding information included on building plans submitted to obtain a building permit:

> **R106.1.1 Information on construction documents. ...**Where required by the *building official*, 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.

Plan Ahead! In the building planning stages, a simple plan adjustment often makes the difference between an efficient, code-compliant plan and one that is inefficient or non-compliant. In some cases, an engineered solution may be required where the IRC prescriptive solutions are insufficient for the architectural requirements. Planning ahead by using this Guide and the 2009 IRC bracing provisions will help turn bracing challenges into solutions that are efficient, practical, and code-compliant.

1.4 Scope Limitations

This guide is limited to the following use conditions:

- *International Residential Code*, 2009 Edition
- Conventional wood frame construction
- One- and two-family dwellings of no more than three-stories [2]
- Design wind speed of less 110 mph (3 second gust)
- Seismic Design Category (SDC) of A/B/C per IRC Section R301.2.22

This Guide is intended to be a helpful companion to the 2009 IRC for typical wall bracing applications in the lower wind and seismic hazard regions of the U.S. Within the above scope limitations, the user should use both documents side by side. Therefore, this document references relevant sections within the 2009 IRC. Also, this Guide is not an exhaustive treatment of the IRC wall bracing provisions. In no case should any information in this Guide be taken to supersede the intent or specific requirements of the 2009 IRC or the locally applicable building code including local amendments to the IRC, if any.

By limiting the scope to lower wind and seismic conditions, the IRC bracing provisions and this Guide are simplified. But, they still cover the majority of conditions in the United States. To identify your specific seismic and wind speed location, see (A) IRC Figure R301.2(2) Seismic Design Categories and (B) IRC Figure 301.2(4) Basic Wind Speeds for 50 year Mean Recurrence Interval. In addition, the building site's wind exposure category (B-suburban/wooded, C-open terrain, D-coastal, non-hurricane or mud-flats) must be identified per IRC Section R301.2.1.4 and the mapped design wind speed must adjusted for topographic wind speed-up effects as applicable per IRC Section R301.2.1.5.

[2] *Townhouses in SDC C are excluded from this guide because additional seismic design limitations in IRC Section R301.2.2 and Section R602.10 apply and are outside the scope of this guide. However, this requirement is not scientifically justified given that wind and seismic forces do not change based on building occupancy and the same structural and bracing requirements must be satisfied regardless of a dwelling's classification as single-family detached or single-family attached (townhouse) construction. In some cases, this limitation for townhouses in SDC C has been waived by local code amendment or by approved design. In fact, the limitations of IRC Section R301.2.2 for building irregularities (constraints on configuration) do not apply to conventional construction in IBC Section 2308 until the next higher seismic design category, SDC D.*

1.5 Definitions

The following definitions explain some important terms used throughout the IRC bracing requirements and this Guide. Refer also to 2009 IRC Chapter 2.

BRACED WALL LINE. A straight line through the building plan that represents the location of the lateral resistance provided by the wall bracing.

BRACED WALL LINE, CONTINUOUSLY SHEATHED. A *braced wall line* with structural sheathing applied to all sheathable surfaces including the areas above and below openings.

BRACED WALL LINE, INTERMITTENT BRACING. A *braced wall line* with discrete structural sheathing panels or braces provided only at specified locations and not requiring continuous structural sheathing on other portions of a wall.

BRACED WALL PANEL. A full-height section of wall constructed in compliance with an approved bracing method to resist in-plane shear loads through interaction of framing members, bracing materials, connections and anchors.

1.6 Key Concepts and Rules

This section presents a number of key concepts and rules that are fundamental to understanding and correctly applying the IRC bracing provisions.

Braced Wall Line (R602.10.1) – Walls that are braced to resist racking are identified as **braced wall lines (BWLs)** on building plans as shown in Figures 1 and 2. Generally, all exterior walls are considered to be part of a braced wall line (shown as dashed lines in Figure 2) and are required to be properly braced with **braced wall panels (BWPs)**. Although not always required, interior walls also may be used as braced wall lines to minimize the amount of bracing required on exterior walls or to comply with the maximum 60-ft braced wall line spacing addressed in the IRC provisions.

There are several rules and limitations for designating the layout of individual braced wall lines on each story level and each plan direction of a building. These rules are intended to accommodate building plans that are not perfectly rectangular with wall lines that contain offsets (i.e., are not in a single straight line). Two important rules are as follows:

BWL Offset Rule *(R602.10.1.4)* - Figure 2 illustrates limitations on the permissible off-set of braced wall panels in off-set portions of a designated braced wall line.

BWL End Rule *(R602.10.1)* – The end of a braced wall line can be determined in two ways as shown in Figure 2. The end may occur at the intersection of a perpendicular exterior wall (actual wall line) or projection thereof or with the intersection of a perpendicular braced wall line (dashed line representing the bracing effect of actual walls). The case resulting in the maximum BWL length must be used.

These above rules have important implications for flexible and efficient bracing designs. They also are important to consider when locating BWPs along or near the ends of a BWL as addressed later. While not addressed in the scope of this guide, the ends of a BWL must be known to be

able to determine its length which is used to determine the amount of seismic bracing required in high-hazard earthquake areas. Wind bracing amounts in the IRC are not dependent on BWL length and the BWL only needs to provide sufficient space for the length of wind bracing required.

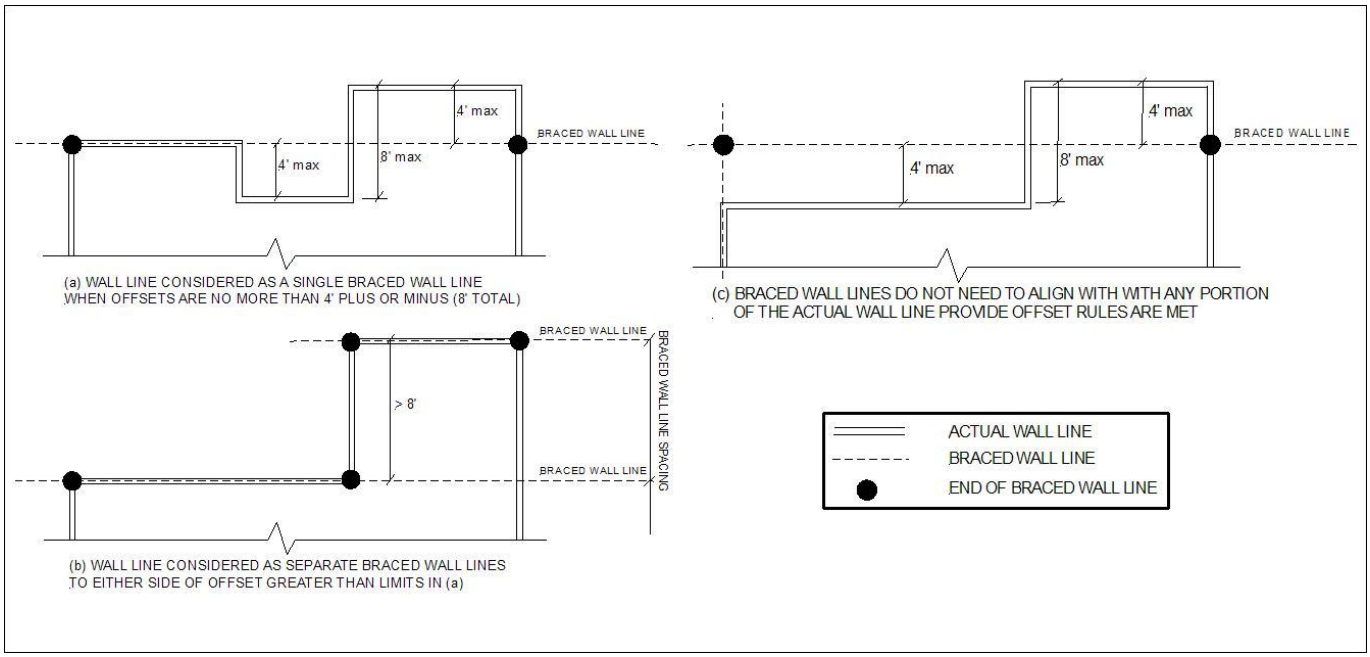
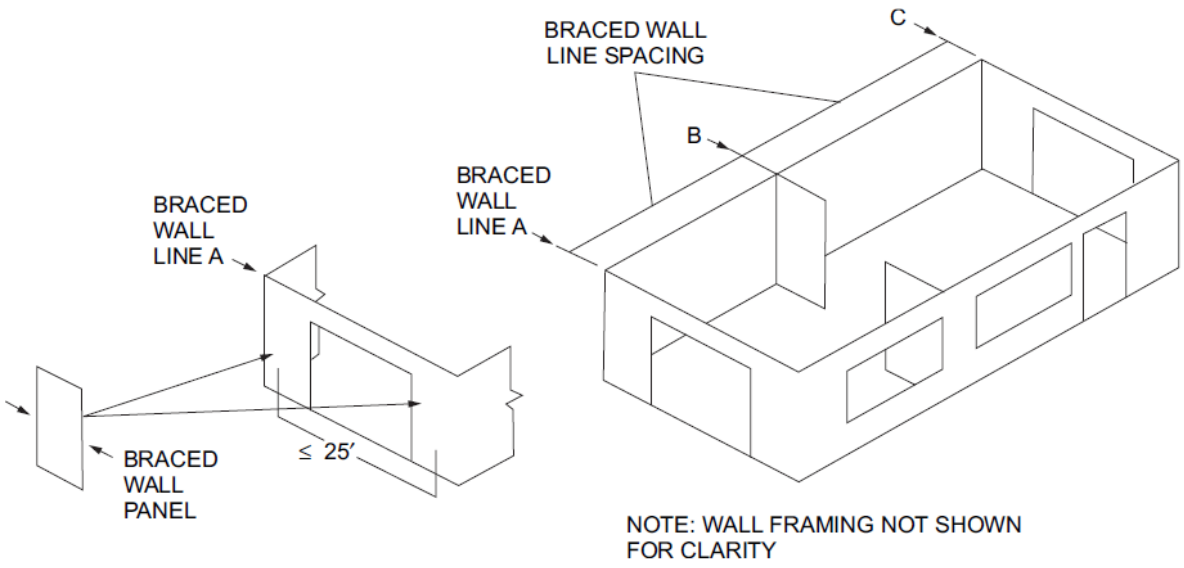


Figure 2: ***Braced Wall Line Layout Rules (Offsets and Ends)***

Braced Wall Line Spacing (R602.10.1.2) – Braced wall line spacing establishes the amount of racking load that must be resisted by the two or more parallel braced wall lines in each plan direction. Figure 3 shows a graphical representation of the relationship between braced wall lines and braced wall line spacing. The racking load must be resisted by incorporating an adequate amount of braced wall panels in each braced wall line. As the spacing between parallel braced wall lines increases, the surface area of the building between the braced wall lines that takes the out of plane wind loading and transfers it to the braced wall lines also increases. Therefore, the required bracing amounts are dependent on the spacing between parallel braced wall lines. This consideration influences the space that is available for wall openings on exterior walls, which may require using interior braced wall lines to help share the bracing load and reduce the amount of bracing required on each of the parallel braced wall lines. While the total bracing load and amount of bracing remains essentially unchanged, the additional braced wall line allows the required bracing amount to be distributed to more braced wall lines. This practice, when used or necessary, has a number of potential benefits.

For example, an interior braced wall line B in Figure 3 is added in between BWL A and BWL C. This reduces the BWL spacing. Since BWL B shares some of the load, BWL A and C require less bracing than when using BWL A and C alone. As a result, use of a particular bracing method may be brought into compliance with the code, more openings may be accommodated, or a more efficient use of energy-saving wall sheathings may be achieved without compromising wall bracing requirements.



For SI: 1 foot = 304.8 mm.

Figure 3: Braced Wall Panels and Braced Wall Lines
(IRC Figure R602.10.1.4(1))

Finally, the 2009 IRC provides minimum required bracing amounts tabulated for braced wall lines spaced apart by up to a maximum of 60' for wind loads (see Table 7 in Section 3). For braced wall line spacing greater than 60', additional braced wall lines or engineering will be required (see Section 4). For example, if the distance between BWL A and BWL C in Figure 3 where greater than 60 feet, then BWL B would be required to allow use the IRC bracing provisions. Finally, it is important to note that the spacing assigned to BWLs A and C is the distance to BWL B; the spacing assigned to BWL B is the greater distance to BWL A or BWL C which generally results in a conservative amount of bracing for BWL B.

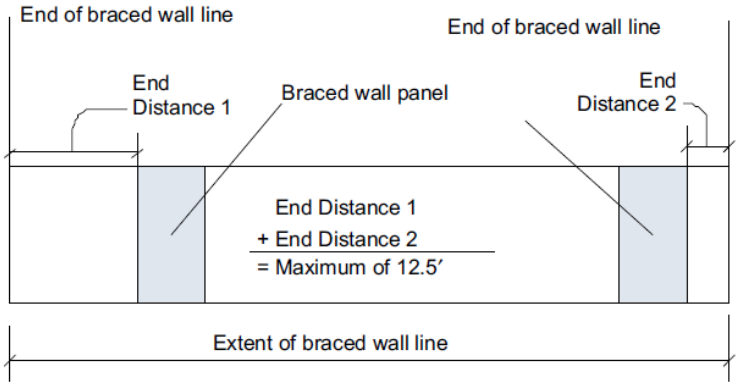
Braced Wall Panel (R602.10.1.1) – Also shown in Figure 3, a braced wall panel (BWP) is a section of a braced wall line that is specifically braced with a code-compliant bracing method (e.g., let-in brace, a wood structural panel, or other bracing methods). The various braced wall panel construction methods are addressed in Section 2 of this Guide. Braced wall panels must meet minimum width requirements (length of wall covered) to count towards the minimum bracing amounts required for each individual braced wall line. The minimum widths required for braced wall panels of the various bracing methods constrain the layout and spacing of wall openings in a code-compliant braced wall line. The 2009 IRC also provides a number of useful options for adjusting braced wall panel widths or specifying narrow panel bracing methods (i.e., portal frames) that will be discussed later in Section 2.

Braced Wall Panel Location (R602.10.1.4) – In addition to being used to meet minimum bracing amounts, the location of braced wall panels along each braced wall line must meet additional constraints:

1. Braced wall panels must be spaced no greater than 25' OC along a braced wall line (see Figure 3),
2. Braced wall panels must begin no more than 12.5' from the end of a braced wall line, and
3. The sum of the distance from each end of the braced wall line to the beginning of the braced wall panel nearest to each end shall be no more than 12.5' (see Figure 4).

: For the continuous sheathing bracing methods (IRC Sections R602.10.4 and R602.10.5), a minimum 24" wood structural panel or 32" structural fiberboard panel must be located at the ends of the braced wall line, including a corner return panel of the same minimum size placed on the adjoining wall at the corner. However, there is a new exception to this rule in the 2009 IRC. A hold-down connection capable of resisting at least 800 pounds can be substituted for these requirements when specific conditions are met as discussed later in Section 2.3.

In addition, all braced wall panels are permitted to be offset from a designated braced wall line as previously discussed and shown in Figure 2.



Braced wall panel shall be permitted to be located away from the end of a braced wall line, provided the total end distance from each end to the nearest braced wall panel does not exceed 12.5′. If braced wall panel is located at the end of the braced wall line, then end distance is 0′.

For SI: 1 foot = 304.8 mm.

Figure 4: Braced Wall Panel End Distance Requirements
(IRC Figure R602.10.1.4(2))

The above requirements ensure that for walls no longer than 16.5', a single 48-inch long braced wall panel can be used. In addition, Section R602.10.1.2 requires a 48-inch minimum total length of bracing in each BWL. Thus, for walls greater than 16.5' in length, generally two or more BWPs or one large BWP will be required to meet the above requirements for BWP location on a BWL.

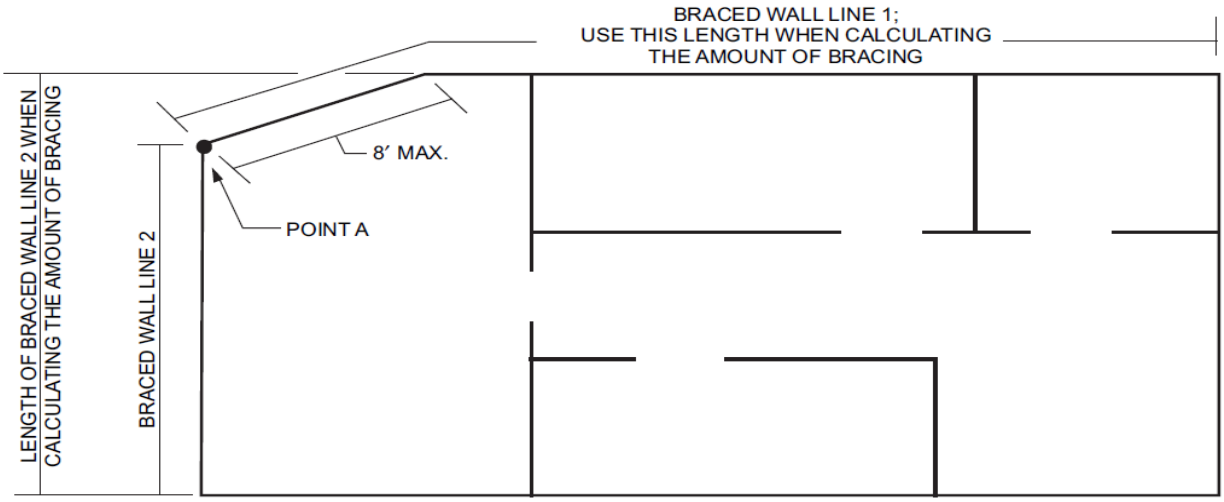
: An expected change for the 2012 IRC includes a reduction of the *BWP end distance to 10' together with the elimination of the cumulative 12.5' end distance requirement discussed above. In addition, the spacing of BWPs is changed from 25'oc to 20' edge-to-edge. Further, braced wall lines 16' or less in length will require a minimum of two braced wall panels of any length or only one braced wall panel of a minimum 48 inches in length. Braced wall lines greater than 16' in length will require a minimum of two braced wall panels. Thus, the minimum 48 inch length of bracing required by the 2009 IRC (see note above) will only apply to the special case of a BWL that is less than 16 feet in length and which has only one BWP.*

Mixing Bracing Methods (R602.10.1.1) – The 2009 IRC includes an explicit but limited ability to mix the various bracing methods on a building plan to maximize cost-effectiveness or other objectives such as energy efficiency (see Section 5 for more detail on this latter concern). In addition, there are a few general provisions that apply to the mixing of intermittent bracing methods on a plan as follows (based on the scope limitation of this Guide):

1. Mixing bracing methods from *story* to *story* is permitted.
2. Mixing bracing methods from *braced wall line* to *braced wall line* within a *story* is permitted.
3. The length of required bracing for a *braced wall line* with mixed bracing types shall be based on the bracing type which requires the greater bracing length (see Section 3, Table 7)
4. No mixing of bracing methods or materials (sheathing types) is permitted within a continuously sheathed braced wall line. However, other braced wall lines on the same or other stories may use other bracing methods.

Angled Corners (R602.10.1.3) - Also new to the 2009 IRC, braced wall panels on angled corners at the end of a BWL may be counted toward the minimum bracing length requirement as follows:

- At corners, *braced wall line*s shall be permitted to angle out of plane up to 45 degrees with a maximum diagonal length of 8 feet.
- The placement of bracing for the *braced wall lines* shall begin at the point where the *braced wall line*, which contains the angled wall adjoins the adjacent *braced wall line* (Point A as shown in Figure 5).
- Where an angled corner is constructed at an angle equal to 45 degrees and the diagonal length is no more than 8 feet, the angled wall may be considered as part of either of the adjoining *braced wall lines*, but not both.
- Where the diagonal length is greater than 8 feet, an angled corner shall be considered its own *braced wall line*.



For SI: 1 foot = 304.8 mm.

Figure 5: Angled Corners
(IRC Figure R602.10.1.3)

Section 2: IRC Wall Bracing Methods

2.1 Overview

In this section, the various bracing methods in the 2009 IRC are presented and discussed. These bracing methods and their associated capabilities are the "building blocks" for arriving at optimal bracing designs that are code compliant, cost effective, and coordinated with other design objectives such as energy efficiency (see Section 5.0). Therefore, it is important to start with a working knowledge of the various bracing methods featured in the 2009 IRC.

In the 2009 IRC bracing provisions, the bracing methods have been renamed and divided into two categories as illustrated in Figure 6:

- Intermittent Braced Wall Panel Construction Methods, and
- Continuous Sheathing Wall Bracing Methods

Within each of these categories are various means to address problems commonly encountered in practice, such as narrow braced wall panels used at garage openings and other similar conditions. Mixing of bracing methods as shown in Figure 6 is also possible with the 2009 IRC provisions.

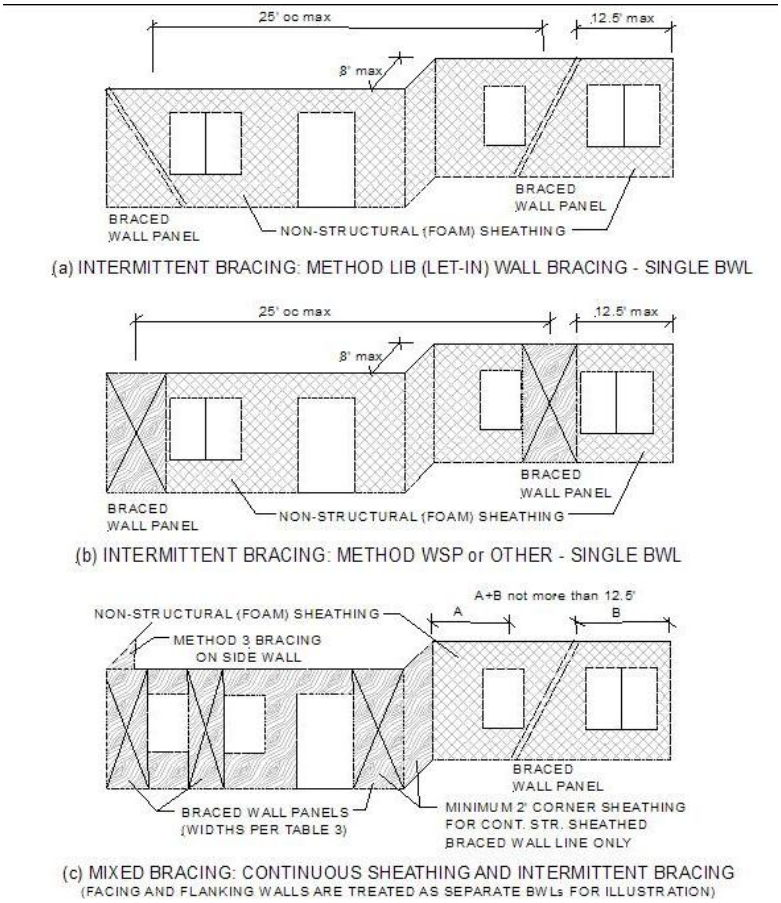


Figure 6: Illustration of intermittent, continuous, and mixed bracing methods.

2.2 Intermittent Braced Wall Panel Construction Methods

The intermittent bracing methods include traditional methods of bracing and are retained and improved in the 2009 IRC to ensure consistency of all bracing methods, including continuous and narrow panel bracing methods addressed later. ***Table 1l***ists the intermittent BWP construction methods included in 2009 IRC Section R602.10.2. The minimum length requirements for BWPs constructed using these methods are referenced in Table 1 along with basic construction requirements. The BWP minimum length requirements vary according to bracing method as well as wall height for most methods as shown in Table 2. In addition, the 2009 IRC includes a "partial credit" approach for many of these methods whereby the braced wall panel length may be reduced to 36 inches from the commonly required minimum of 48 inches. In such cases, the effective braced wall panel length shown in Table 2 is used in lieu of the actual braced wall panel length in determining compliance with required bracing amounts addressed later in Section 3.

In accordance with 2009 IRC Section R104.11, other approved proprietary bracing materials may be used on the basis of equivalency as normally indicated by a code evaluation report for the proprietary bracing method. For example, an approved metal let-in brace may be substituted for the LIB bracing method or a proprietary sheathing may be substituted for one of the bracing methods using a code-recognized sheathing material. Proprietary bracing methods are worth considering because they may offer some advantages over the code-recognized bracing methods in Table 1.

Table 1: Intermittent Bracing Methods and Requirements

(Based on IRC Section R602.10.2)

METHOD	MATERIAL	MINIMUM THICKNESS	CONNECTION CRITERIA	BWP MINIMUM LENGTH & MAXIMUM WALL HEIGHT
LIB	Let-in-bracing	1×4 wood or approved metal straps at 45° to 60° angles for maximum 16″ stud spacing	Wood: 2-8d nails per stud including top and bottom plate Metal: per manufacturer	⮚: Each such brace counts as a "braced wall panel" with actual length dependent on brace angle; refer to Table 2. ⮚: For LIB bracing wall height should not exceed 10 feet.
DWB	Diagonal wood boards	3/4″ (1″nominal) for maximum 24″stud spacing	2-8d (2-1/2″×0.113″) nails or 2 staples, 1-3/4″ per stud	⮚: Refer to Table 2 and "partial credit" allowance of Table 3 ⮚: Maximum wall height of 12'
WSP	Wood structural panel (see Section R604)	3/8″ for maximum 16" stud spacing	6d common (2 x 0.113) nail. 6 inches o.c. at edges and 12 inches in the field. (Limited to wind speed and exposure of 110/B, 90/C, or 85/D – refer to IRC Table R602.3.3)	⮚: Refer to Table 2 and "partial credit" allowance of Table 3 ⮚: Maximum wall height of 12'.
		7/16" for maximum 24" stud spacing	8d Common (2.5" x .131") 6 inches o.c. at edges and 12 inches in the field. (For 24" stud spacing, limited to wind speed and exposure as above; for 16" stud spacing, the limits are 130/B, 110/C, 105/D)	⮚: Refer to Table 2 and "partial credit" allowance of Table 3 ⮚: Maximum wall height of 12'
SFB	Structural fiberboard sheathing	1/2″ or 25/32″ for maximum 16″ stud spacing	1-1/2″ galvanized roofing nails or 8d common (2-1/2″×0.131) nails at 3″ spacing (panel edges) and at 6″ spacing (intermediate supports).	⮚: Refer to Table 2 and "partial credit" allowance of Table 3 ⮚: Maximum wall height of 12'
GB	Gypsum board (one or both sides of a BWP)	1/2"	Nails or screws at 7″ spacing at panel edges and at intermediate supports. For exterior gypsum sheathing at GB braced wall panels, use fastener size and type in accordance with Table R602.3(1). For interior gypsum panels at GB braced wall panels, use fastener size and type in accordance with IRC Table R702.3.5	⮚: Refer to Table 2 only ("partial credit" allowance of Table 3 does not apply to GB) ⮚: Maximum wall height of 12'
PBS	Particleboard sheathing (see Section R605)	3/8″ or 1/2″ for maximum 16″ stud spacing	1-1/2″ galvanized roofing nails or 8d common (2-1/2″×0.131) nails at 3″ spacing (panel edges) and at 6" spacing (intermediate supports)	⮚: Refer to Table 2 and "partial credit" allowance of Table 3 ⮚: Maximum wall height of 12'
PCP	Portland cement plaster	See Section R703.6 for maximum 16″stud spacing	1-1/2″, 11 gage, 7/16″ head nails at 6″ spacing or 7/8″, 16 gage staples at 6″ spacing	⮚: Refer to Table 2 and "partial credit" allowance of Table 3 ⮚: Maximum wall height of 12'
HPS	Hardboard panel siding	7/16″ for maximum 16″ stud spacing	0.092″ dia., 0.225″ head nails with length to accommodate 1-1/2″ penetration into studs at 4″ spacing (panel edges), and at 8″ spacing (intermediate supports).	⮚: Refer to Table 2 and "partial credit" allowance of Table 3 ⮚: Maximum wall height of 12'

ABW	Alternate braced wall	3/8“ wood structural panel sheathing. See IRC Section R602.10.3.2	See IRC Section R602.10.3.2 (special framing, fastening and hardware requirements apply)	⮀: 32” minimum; See Section R602.10.3.2 and discussion below on “Narrow Panel Bracing Methods” ⮁: Maximum wall height of 12’
PFH	Intermittent portal frame (with hold-down brackets)	3/8” wood structural panel; See Section R602.10.3.3	See IRC Section R602.10.3.3 (special framing, fastening and hardware requirements apply)	⮀: 16” minimum (supporting one story); 24” minimum (supporting two stories); See IRC Section R602.10.3.3 and discussion below on “Narrow Panel Bracing Methods” ⮁: Maximum wall height of 10’
PFG	Intermittent portal frame at garage (without hold-down brackets)	7/16” wood structural panel; See Section R602.10.3.4	See IRC Section R602.10.3.4 (special framing, fastening and hardware requirements apply)	⮀: Minimum length based on a 4:1 height to length ratio. For example, 24” minimum for 8’ wall height; See IRC Section R602.10.3.4 and discussion below on “Narrow Panel Bracing Methods” ⮁: Maximum wall height of 10’

IMPORTANT! Section R602.10.2.1 of the 2009 IRC requires all of the above intermittent bracing methods (except GB, ABW, PFG, and PFH) to be used together with interior finish of ½” gypsum wall board (or equal) installed in accordance with IRC Section R702.3 on the inside surface of the wall. Otherwise, required bracing amounts for Methods DWB, WSP, SFB, PBS, PCP and HPS must be increased as addressed in Section 3 of this Guide (see Table 7, footnote ‘f’). The 1.5 adjustment factor in Section R602.10.2.1 is actually an error and should not be used.

Table 2: Minimum Length Requirements for Braced Wall Panels[a]

(Based on IRC Table R602.10.3.1)

METHOD (See Table 1)		MINIMUM LENGTH (in) Wall Height					CONTRIBUTING LENGTH (in)[b]
		8 ft	9 ft	10 ft	11 ft	12 ft	
DWG,WSP,SFB,PBS,PCP,HPS		48	48	48	53	58	Actual (or effective length per Table 3)
GB	One-sided[c]	96	96	96	106	116	0.5 x Actual
	Two-sided	48	48	48	53	58	Actual
LIB	60° brace angle	55	62	69	NP	NP	55 (max)
	45° brace angle	96	108	120	NP	NP	96 (max)
ABW	SDC A, B and C, wind speed <100mph	28	32	34	38	42	48
PFH	Supporting roof only	16	16	16	NP	NP	48
	Supporting one story and roof	24	24	24	NP	NP	48
PFG		24	27	33	NP	NP	1.5 x Actual

NP = Not permitted

a. Linear interpolation shall be permitted.

b. Contributing length is the horizontal length of a BWP along a BWL that can be counted toward the required bracing amount for a BWL (see Section 3). Use actual length when it is greater than or equal to the minimum length.

c. As proposed for IRC 2012 by ICC Ad Hoc Committee on Wall Bracing, the minimum lengths for one-sided GB can be taken as the same for two-sided GB, but the 0.5 x Actual reduction in contributing length still applies to one-sided GB.

"Partial Credit" Allowance for Select Intermittent Bracing Methods

As indicated in Tables 1 and 2 above, the following effective lengths apply when BWPs are less than the required minimum BWP length of 48 inches for Methods DWB, WSP, SFB, PBS, PCP, and HPS. The effective length is the "contributing length" that applies toward the required amount of bracing in a BWL (see Section 3).

Table 3*: Effective Lengths for Braced Wall Panels Less Than 48 Inches in Actual Length*

(Based on IRC Table R602.10.3)

ACTUAL LENGTH OF BRACED WALL PANEL (in)	EFFECTIVE LENGTH OF BRACED WALL PANEL (in)		
	8' wall height	9' wall height	10' wall height
48	48	48	48
42	36	36	N/A
36	27	N/A	N/A

Narrow Panel Bracing for Intermittent Bracing Methods

Table 1 also includes various "narrow panel" bracing methods (i.e., ABW, PFH, and PFG) for use alone or together in braced wall lines with the standard intermittent bracing methods. These special bracing methods require different framing and connection techniques that are beyond typical conventional wood framing practices. They also have use limitations. Therefore, they are discussed in greater detail as follows:

Method PFG (Portal Frame at Garage without hold-down brackets)

- Use only at garage door openings supporting no more than one floor plus a roof.
- Method PFG shall be constructed in accordance with Figure 7 (see also IRC Section R602.10.3.4)
- PFG panels may be used on one or both sides of the door opening as shown in Figure 7 below with a header clear span ranging from 2' to 18'.
- For the purpose of determining provided wall bracing amounts (Section 3), the length of each PFG braced wall panel shall be multiplied by a factor of 1.5.
- Braced wall panel length shall be a minimum of one-fourth the height of the PFG as shown in Figure 7 (see Table 2).
- PFG height shall be a maximum of 10 feet (3048 mm) as shown in Figure 7.
- PFG panels must be installed directly on a foundation.
- In wind exposure categories C and D, the 1,000-lb header straps required in Figure 7 must be increased in size per 2009 IRC Table R602.10.4.1.1.

NOTE: *The limitation of PFG to garage openings only is not justified by the original research supporting this method. Therefore, it may be used for other applications, such as large window or door openings on an intermittent braced wall line provided such use is locally approved.*

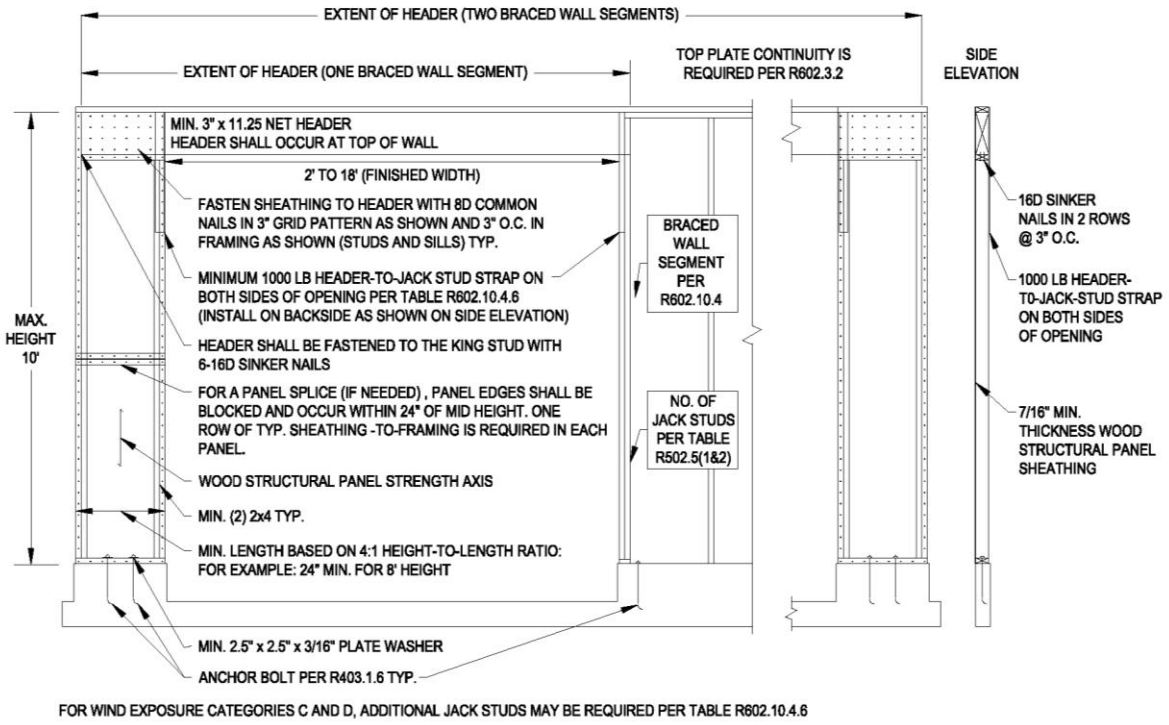
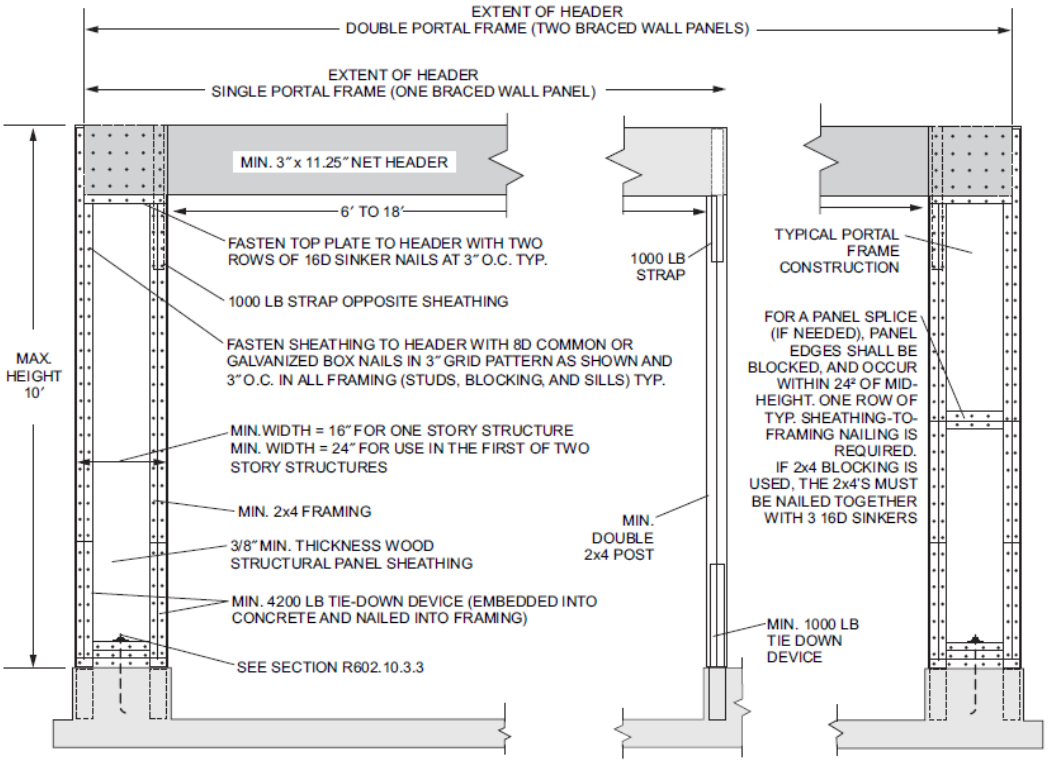


Figure 7: Method PFG Portal Frame at Garage Door Openings
(Similar to 2009 IRC Figure R602.10.3.4)

Method PFH (Portal Frame with Hold-down Brackets)

- Use on any BWL alone or together with intermittent bracing
- Construct per Figure 8 permitting braced wall panels as narrow as 16" wide (supporting roof only) or 24" wide (supporting roof plus one floor)
- For the purpose of determining provided bracing amounts (Section 3), each PFH panel counts as 48 inches of braced wall panel (see Table 2).
- Use for any large opening with header clear span of 6' to 18' (not just limited to garage openings).
- Portal frame braced wall panels must be directly supported on and anchored to a foundation with hold-down straps (use on lowest story only).
- The foundation must be continuous across the entire length of the braced wall line. The foundation shall be reinforced as shown on Figure 9.
- In wind exposure categories C and D, the 1,000-lb header straps required in Figure 8 must be increased in size per 2009 IRC Table R602.10.4.1.1. (This requirement is implied by Section R602.10.3.4, Item 5, but is not specifically stated in Section R602.10.3.3 for Method PFH).



For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound force = 4.448 N.

Figure 8: Method PFH Portal Frame with Hold Downs
(IRC Figure R602.10.3.3)

Method ABW (Alternate Braced Wall Panel with Hold-down Brackets)

The ABW method was one of the original "narrow panel" bracing methods in the IRC; however, the "partial credit" approach and the newer portal framing methods, both discussed above, are generally preferred. Use 32" wide ABW per IRC R602.10.3.2 and Figure 9. Requirements include:

- Can be substituted for any 48" wide panel (counts as 48 inches of braced wall panel length for bracing amount).
- Requires sheathing on both sides of braced wall panel when supporting roof plus one floor; sheathing on one side applies only when supporting roof only.
- Alternate braced wall panels must be directly anchored to foundation with hold-down anchors or straps (use on lowest story only)
- The maximum height and minimum length and hold-down force of each panel shall be in accordance with Table 4:
- The panels shall be supported on a foundation or on floor framing supported directly on a foundation which is continuous across the entire length of the *braced wall line*.
- In the first *story* of two-story buildings, each *braced wall panel* shall meet the conditions above except that the wood structural panel sheathing edge nailing spacing shall not exceed 4 inches (102 mm) on center.

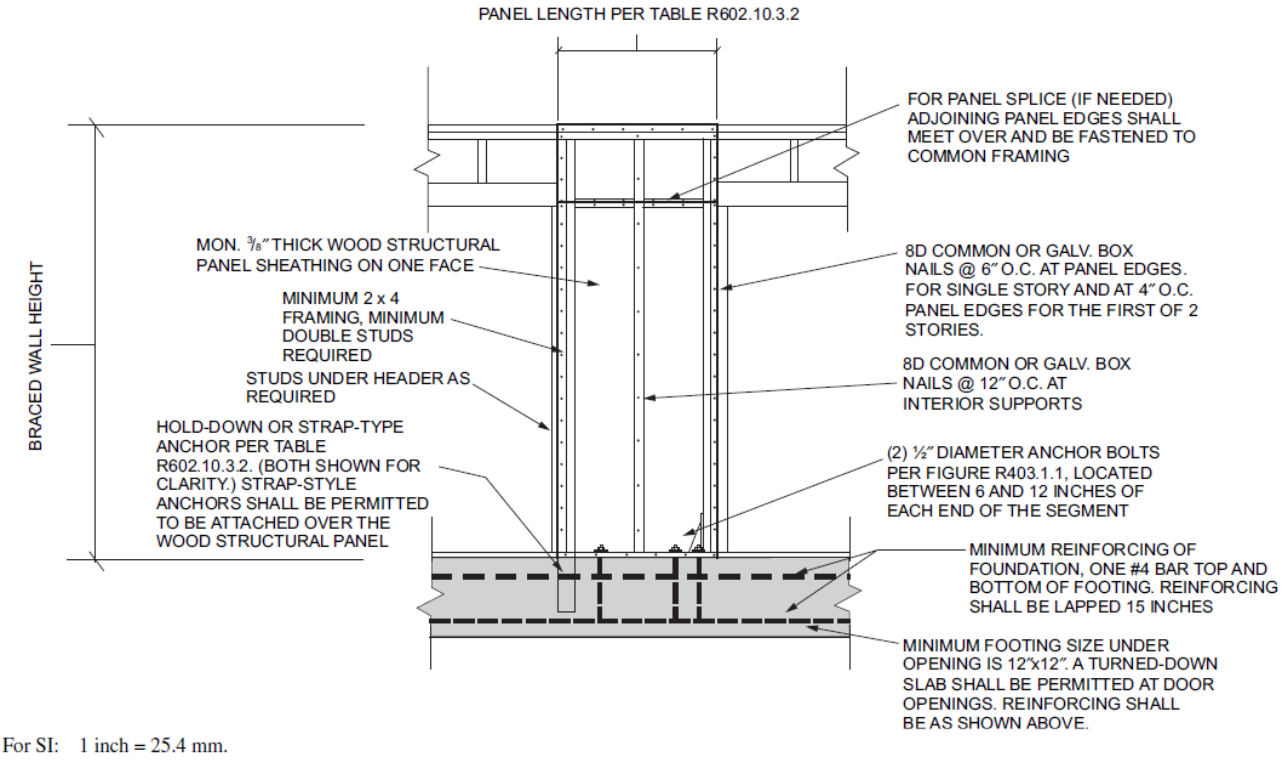


Figure 9: Alternate Braced Wall Panel
(IRC Figure R602.10.3.2)

Table 4*: Hold-Down Forces for Method ABW Braced Wall Panels*
(Excerpt from IRC Table R602.10.3.2)

SEISMIC DESIGN CATEGORY AND WIND SPEED		HEIGHT OF BRACED WALL PANEL				
		8 ft	9 ft	10 ft	11 ft	12 ft
SDC A, B and C Wind speed < 110 mph	Minimum sheathed length	2′ - 4″	2′ - 8″	2′ - 10″	3′ - 2″	3′ - 6″
	R602.10.3.2, item 1 hold-down force (lb)	1800	1800	1800	2000	2200
	R602.10.3.2, item 2 hold-down force (lb)	3000	3000	3000	3300	3600

Fitting Large Openings within Code-Compliant Intermittently Braced Wall Lines

Frequently, building designs include large openings within or at the ends of braced wall lines, especially for entry foyers and 'great rooms'. For the limits shown in Figure 10, the IRC intermittent wall bracing methods can accommodate these types of conditions in code-compliant braced wall lines without requiring use of the narrow panel bracing method discussed above or the continuous sheathing methods discussed next.

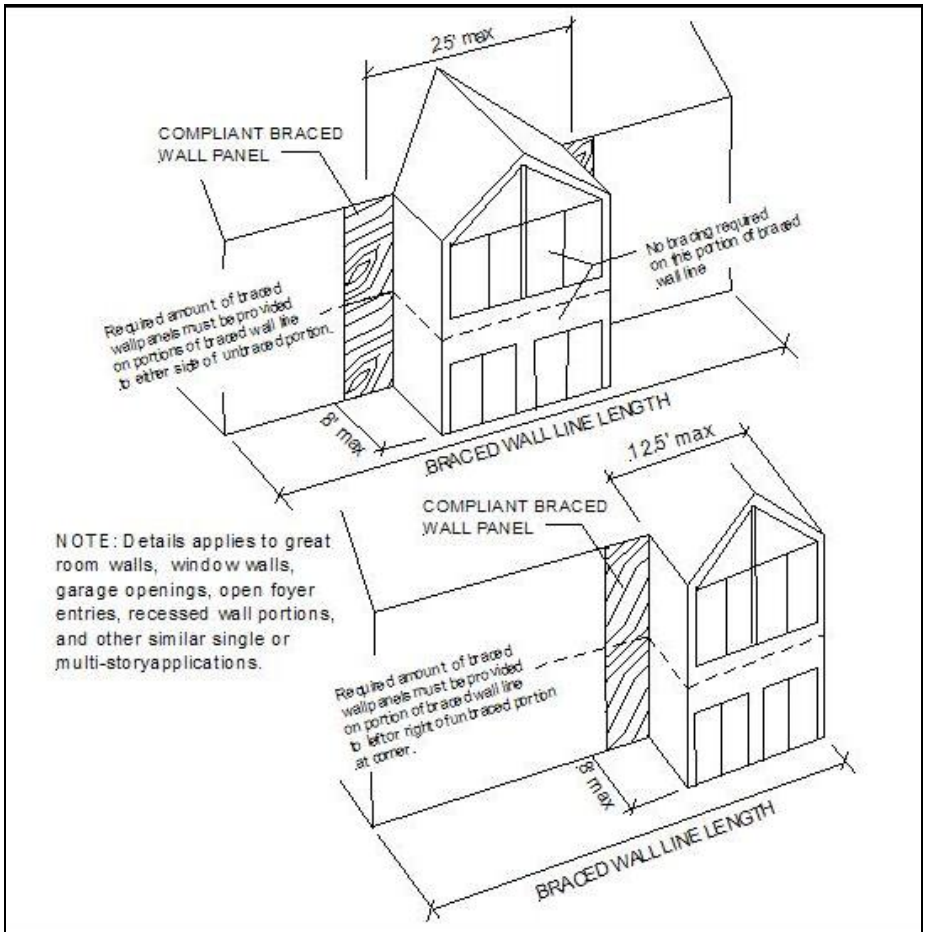


Figure 10: Limits for Large Openings in Braced Wall Lines with Intermittent Bracing

2.3 Continuously Sheathed Methods

Continuous sheathing methods are relatively new to the IRC and they offer some advantages relative to the more traditional intermittent bracing methods while providing at least equivalent performance. The primary advantages include a lesser required length of bracing and smaller braced wall panel widths than generally possible with the intermittent bracing methods. However, these walls must be continuously sheathed with either wood structural panels or structural fiberboard sheathing (or other proprietary sheathings approved for this purpose). In addition, a number of stipulations affect the appropriate use of these methods.

As shown in Table 5, three methods apply to continuous sheathing with wood structural panels and one with structural fiberboard sheathing.

Table 5: *Continuous Sheathing Bracing Methods*
(IRC Table R602.10.4.1, Section R602.10.4 and Section R602.10.5)

METHOD	SHEATHING MATERIAL	MINIMUM THICKNESS	CONNECTION CRITERIA	BWP MINIMUM LENGTH & MAXIMUM WALL HEIGHT
CS-WSP (R602.10.4)	Wood structural panel	3/8”	See Table 1, Method WSP [also 16ga x1-3/4” staples at 3”oc (panel edges) and 6”oc (intermediate supports)]	:Refer to Table 6 :Maximum wall height of 12 feet
CS-G (adjacent to garage openings only on one side of garage)	Wood structural panel	7/16”	See Method CS-WSP	:Refer to Table 6 :Maximum wall height of 12 feet
CS-PF (R602.10.4.1.1)	Continuously sheathed portal frame	7/16”	See Section R602.10.4.1.1 and discussion below on “narrow panel bracing”	:Refer to Table 6 :Maximum wall height of 10 feet
CS-SFB (R602.10.5)	Structural fiber board	½”	See Table 1, Method SFB	:Refer to Table 6 :Maximum wall height of 12 feet

IMPORTANT! The CS-WSP and CS-SFB bracing methods are intended to be used in the IRC together with interior finish of ½” gypsum wall board (or equal) installed in accordance with IRC Section R702.3 on the inside surface of the wall. If such interior finish is not used, required bracing amounts (addressed in Section 3) must be increased as addressed in Section 3 of this Guide (see Table 7, footnote ‘f’, and use the 1.4 bracing length adjustment factor for methods WSP and SFB).

Continuous Sheathing Method General Provisions

Regardless of the continuous sheathing method used, they all share some common requirements as follows:

- All of the continuous sheathing methods require the same structural panel sheathing material (wood structural panels or structural fiberboard sheathing) to be used on all sheathable surfaces on one side of a braced wall line including areas above and below openings.
- Different bracing methods, other than those listed in Table 5, shall not be permitted along a braced wall line with continuous sheathing.
- Only those full-height braced wall panels complying with the length requirements of Table 6 shall be permitted to contribute to the minimum required length of bracing (see Section 3).
- Corner studs at the ends of a continuous sheathed braced wall line shall be fastened together in accordance with Figure 11
- Corners located at the ends of a continuous sheathed braced wall shall include a minimum 24" braced wall panel on each side of the corner (minimum 32" braced wall panels for CS-SFB) as shown in Figures 11 and 12 or, alternatively, one of the optional framing conditions in Figures 13 through 15 shall be provided.

For additional restrictions on Method CS-PF, see below section on narrow wall options.

Table 6: *Length Requirements for Braced Walls with Continuous Sheathing*[a]
(Based on IRC Table R602.10.4.2 and Table R602.10.5.2)

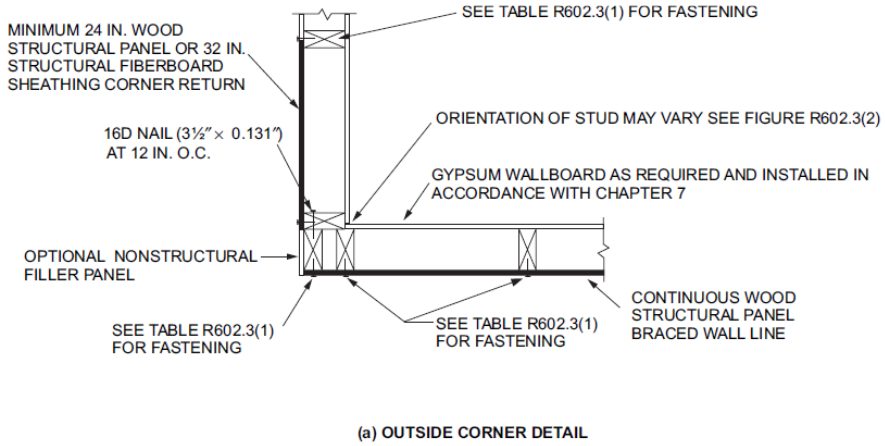
METHOD (See Table 5)		MINIMUM LENGTH (in) Wall Height					CONTRIBUTING LENGTH (in)[b]
		8 ft	9 ft	10 ft	11 ft	12 ft	
CS-G		24	27	30	NP	NP	Actual
CS-PF		16	18	20	NP	NP	Actual
CS-WSP, CS-SFB	Adjacent Clear Opening Height (in)						
	≤ 64	24	27	30	33	36	Actual
	68	26	27	30	33	36	
	72	27	27	30	33	36	
	76	30	29	30	33	36	
	80	32	30	30	33	36	
	84	35	32	32	33	36	
	88	38	35	33	33	36	
	92	43	37	35	35	36	
	96	48	41	38	36	36	
	100		44	40	38	38	
	104		49	43	40	39	
	108		54	46	43	41	
	112			50	45	43	
	116			55	48	45	
	120			60	52	48	
	124				56	51	
	128				61	54	
	132				66	58	
	136					62	
	140					66	
	144					72	

NP = Not permitted

a. Linear interpolation shall be permitted.

b. Contributing length is the length of a BWP along a BWL that can be counted toward the required bracing amount for a BWL (see Section 3). Use actual length when it is greater than or equal to the minimum length.

Figures 11 and 12 show typical corner framing requirements (including corner return panels) for the continuous sheathing methods.



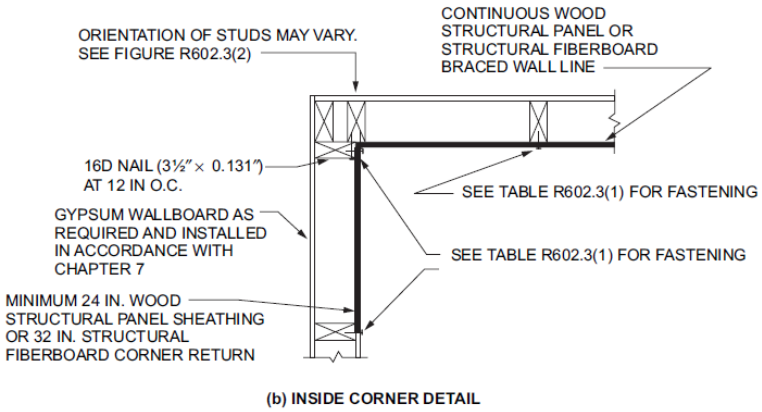
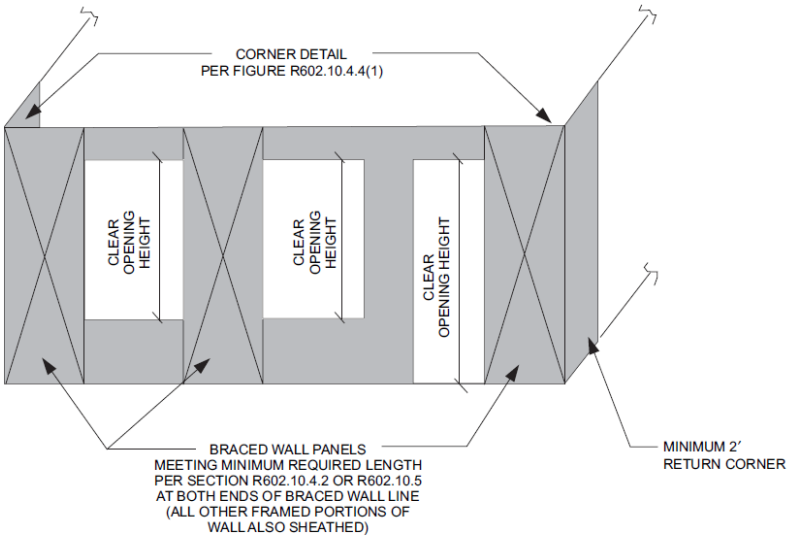


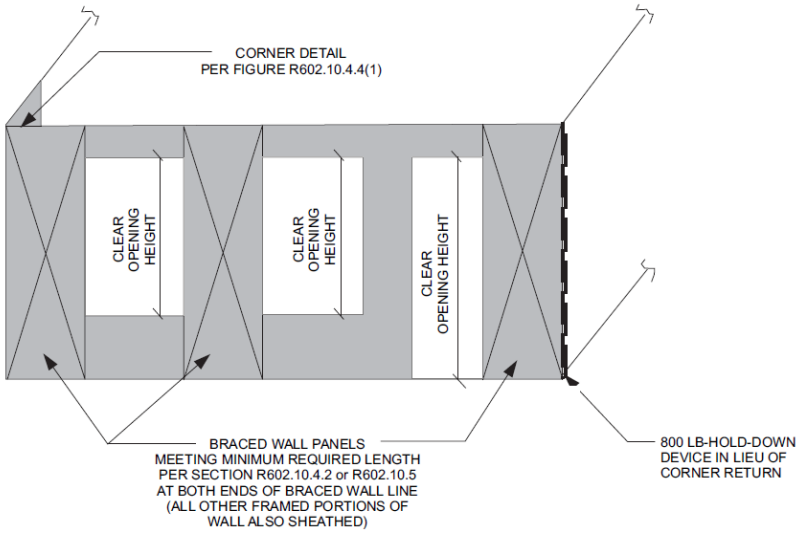
Figure 11*: Corner Framing for Continuous Structural Sheathing*
(IRC Figure R602.10.4.4(1))



For SI: 1 foot = 304.8 mm.

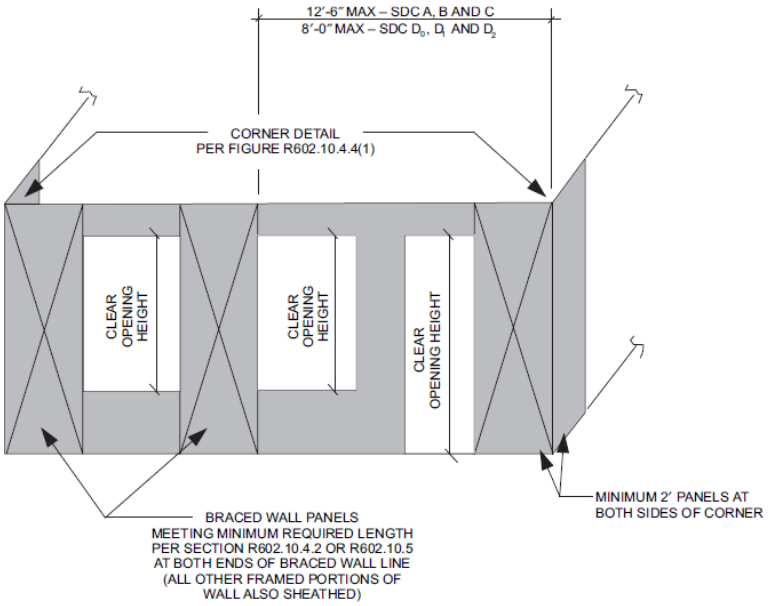
Figure 12*: Corner Return Detail for Braced Wall Line with Continuous Sheathing*
(IRC Figure R602.10.4.4(2))

Figures 13-15 show various options to address different corner situations that may arise when using the continuous sheathing methods. These options give the user greater flexibility in the design of code compliant braced wall lines. For example, Figure 13 eliminates the corner return panel in exchanged for a 800 lb hold-down at the corner and the option shown in Figure 15 allows a door or window opening to be placed in close proximity to a corner (as is permitted with the intermittent bracing methods discussed earlier).



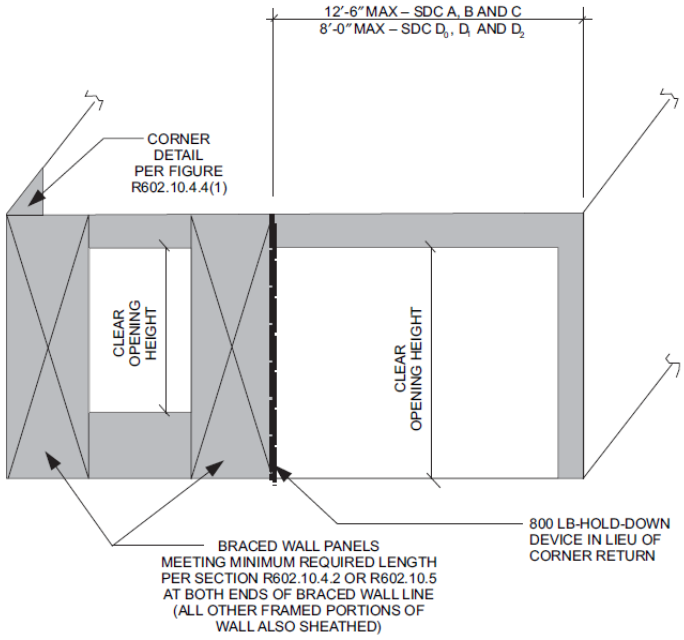
For SI: 1 inch = 25.4 mm, 1 pound = 4.448 N.

Figure 13*: Braced Wall Line with Continuous Sheathing and without Corner Return Detail*
(IRC Figure R602.10.4.4(3)



For SI: 1 inch = 25.4 mm.

Figure 14: BRACED WALL LINE WITH CONTINUOUS SHEATHING-
FIRST BRACED WALL PANEL AWAY FROM END OF WALL LINE WITHOUT TIE DOWN
(IRC Figure R602.10.4.4(4))



For SI: 1 foot = 305 mm. 1 pound = 4.448 N.

Figure 15: BRACED WALL LINE WITH CONTINUOUS SHEATHING—FIRST BRACED WALL PANEL AWAY FROM END OF WALL LINE WITH HOLD-DOWN
(IRC Figure R602.10.4.4(5)

Narrow Panel Bracing for Use with Continuous Wood Structural Panel Sheathing

Table 5 also includes two "narrow panel" bracing methods (i.e., CS-G and CS-PF) for use alone or together in braced wall lines with the continuous wood structural panel sheathing (i.e., CS-WSP). These special bracing methods require different framing and connection techniques that are beyond typical conventional wood framing practices. They also have use limitations. Therefore, they are discussed in greater detail as follows:

Method CS-G

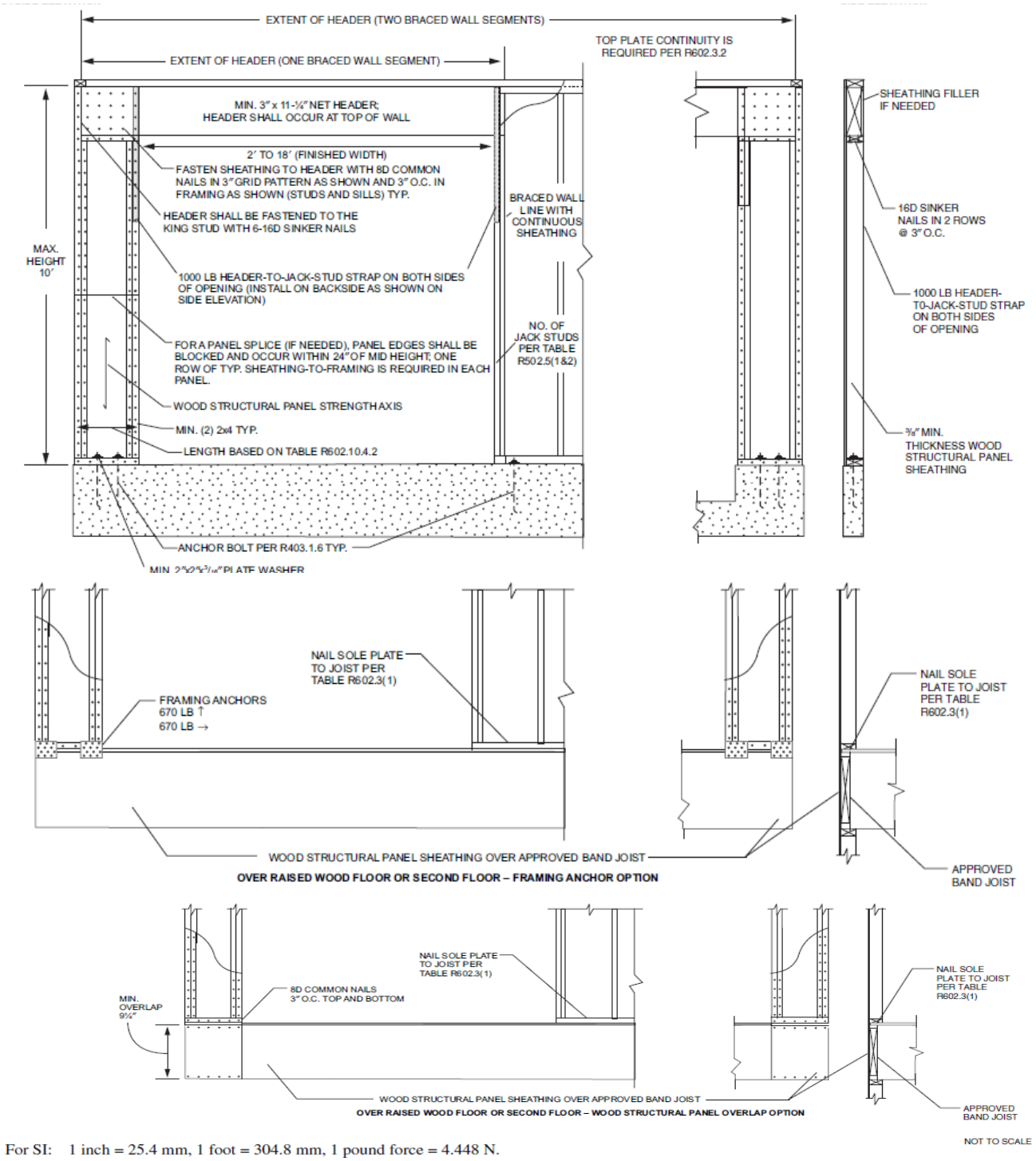
A special exception to Table 6 provides for CS-WSP braced wall panel widths as narrow as 2 feet for limited use in a garage opening wall per Table 6. Restrictions include:

- Must meet the requirements of the continuous sheathing method general provisions above and is limited to the CS-WSP bracing method.
- Must be adjacent to a garage opening that supports a roof only (single story garage); limited to use on one side of garage only.
- Garage opening wall is braced with the continuous structural sheathing method (including corner detail per Figures 11 through 15).
- Wall height is less than or equal to 10'.

Method CS-PF

Use a portal frame without hold-down brackets that permits braced wall panels as narrow as 16" wide per Figure 16. Restrictions include:

- Must meet the requirements of the continuous sheathing method general provisions above.
- Continuous portal frame *braced wall panels* shall be constructed in accordance with Figure 16. The number of continuous portal frame panels in a single *braced wall line* shall not exceed four.
- There shall be a maximum of two braced wall segments per header and header clear span shall not be less than 2 feet or greater than 18 feet.
- Wall height shall not exceed 10 feet measured from the top of the header to the bottom of the bottom plate as shown in Figure 16.
- Where a "pony wall" is constructed above the CS-PF header to accommodate an increased wall height, refer to 2009 IRC Table R602.10.4.1.1 for increased size for the 1,000 lb header strap shown in Figure 16. The strap provides uplift restraint to the CS-PF header as well as out-of-plane stability to resist wind loads.



For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound force = 4.448 N.

Figure 16: Method CS-PF: Continuous Portal Frame Construction
(IRC Figure R602.10.4.1.1)

2.4 Important Construction Requirements for Wall Bracing

Basic Connection Requirements for Braced Wall Panels

- Attach bracing panels or braces to wall framing in accordance with bracing method descriptions per Table 1 or 4 above or IRC Section R602.10.2.
- Support and attach all horizontal and vertical joints of sheathing used as braced wall panels to wall framing or minimum 2x blocking per IRC Section R602.10.8. Blocking is not required at horizontal sheathing joints under the following exceptions:

    1. Blocking at horizontal joints shall not be required in wall segments that are not counted as *braced wall panels*.
    2. Where the bracing length provided is at least twice the minimum length required by Tables R602.10.1.2(1) and R602.10.1.2(2) blocking at horizontal joints shall not be required in *braced wall panels* constructed using Methods WSP, SFB, GB, PBS or HPS.
    3. When Method GB panels are installed horizontally, blocking of horizontal joints is not required.
    4. Vertical joints of panel sheathing shall be permitted to occur over double studs, where adjoining panel edges are attached to separate studs with the required panel edge fastening schedule, and the adjacent studs are attached together with 2 rows of 10d box nails (3"x0.128") at 10" o.c. (This exception is based on a pending 2012 IRC code change).

- Adhesive (glue) attached braced wall panels are not permitted in SDC C or D per IRC Section R602.10.2.2 (not applicable to the scope of this Guide).
- Connect sole plates at braced wall panel locations to wood floor framing (joists or blocking) with 3-16d box nails (3-1/2" x 0.135") at 16" o.c. per 2009 IRC Table R602.3(1) or to foundations using ½" anchor bolts (or equivalent) per 2009 IRC Section R403.1.6 (includes clarification for anchor bolt placement in BWL sole plates).

Blocking Requirements for Floor and Roof Framing at Braced Wall Panel Locations

Where braced wall panels are not aligned with floor and roof framing members, the 2009 IRC contains new and expanded blocking requirements to ensure the proper transfer of lateral loads into and out of the braced panels (refer to 2009 IRC Section R602.10.6). Like a continuous load path to resist wind uplift loads, a continuous load path is also required to transfer racking loads from the building roof and floor framing into and out of braced wall panels. However, where the distance between the BWP top plate and roof sheathing at eaves is 9-1/4" or less, blocking between roof rafters or trusses at BWP locations "need not be installed."

Braced Wall Panel Wind Uplift Connections

The following provisions are new to the IRC 2009 and are required to ensure that braced wall panels perform adequately when subjected to roof uplift loads while also resisting lateral (racking) load from wind:

> **R602.10.1.2.1 Braced wall panel uplift load path.** *Braced wall panels* located at exterior walls that support roof rafters or trusses (including stories below top *story*) shall have the framing members connected in accordance with one of the following:
>
> 1. Fastening in accordance with Table R602.3(1) where:

1.1. The basic wind speed does not exceed 90 mph (40 m/s), the wind exposure category is B, the roof pitch is 5:12 or greater, and the roof span is 32 feet (9754 mm) or less, or

1.2. The net uplift value at the top of a wall does not exceed 100 plf. The net uplift value shall be determined in accordance with Section R802.11 and shall be permitted to be reduced by 60 plf (86 N/mm) for each full wall above.

2. Where the net uplift value at the top of a wall exceeds 100 plf (146 N/mm), installing *approved* uplift framing connectors to provide a continuous load path from the top of the wall to the foundation. The net uplift value shall be as determined in Item 1.2 above.

3. Bracing and fasteners designed in accordance with accepted engineering practice to resist combined uplift and shear forces.

Note: *While not specifically required by the 2009 IRC, it also is advisable to follow the above uplift connection requirements for portions of walls that are not BWPs to ensure a continuous load path from the roof, through bearing walls, to the foundation or to a point where the uplift load is 100 plf or less. However, meeting this new uplift requirement can be overly conservative in low wind hazard regions of the U.S. unless improved wind uplift load requirements proposed for Section R802.11 of the 2012 IRC are applied (refer to ICC code proposal RB156-09/10 available at www.iccsafe.org)*

Braced Wall Panel Support

Section R602.10.7 of the 2009 IRC contains the following requirements for support of braced wall panels:

- Floor cantilevers supporting braced wall lines shall have solid blocking at the nearest bearing wall location except when the floor cantilever is not more than 24 inches, a full-height rim joist is provided at the end of the cantilevered floor joists, and the Seismic Design Category is A, B, or C.
- Elevated post and pier foundations supporting braced wall line must be laterally braced in accordance with accepted engineering practice (i.e., the IRC does not provide a prescriptive bracing solution for this type of foundation system)
- Masonry stem walls less than 48 inches in length supporting braced wall panels must be reinforced per 2009 IRC Figure R602.10.7. Also, masonry stem walls shall not be used to support ABW or PFH braced wall panels which require embedded hold-down devices.

Section 3: Applying the Code

Refer to Section 1 of this Guide for important information on basic concepts and requirements related to *braced wall lines*, *braced wall panels*, *braced wall panel location*, *braced wall line spacing*, *mixing of bracing methods*, *and angled corners*. Refer to Section 2 of this Guide for specific requirements related to the various braced wall panel construction methods. Section 3 relies on information from these previous sections.

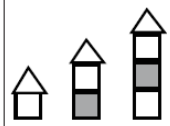
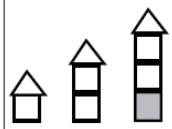
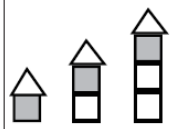
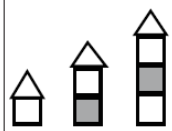
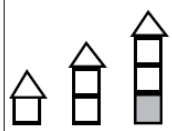
3.1 Overview

The primary objective of the 2009 IRC wall bracing provisions – to ensure that dwellings are adequately braced to prevent collapse – is summed-up in Table 7 and its required minimum bracing length requirements. Thus, Table 7 must be applied in unison with the various concepts and detailed requirements found in Sections 1 and 2 of this Guide. To assist in integrating all the relevant information for a code-compliant wall bracing design, this section:

1. provides a comprehensive step-by-step procedure for applying the code (Section 3.2),
2. demonstrates how to calculate the required length of bracing using Table 7 and its many footnoted adjustment factors or multipliers (Section 3.3), and
3. shows how to determine the length of bracing provided by code compliant braced wall panels within a braced wall line (Section 3.4).

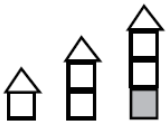
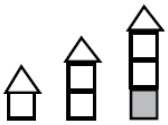
In the end, a code-compliant bracing plan will contain an acceptable arrangement of braced wall lines, each with an acceptable arrangement of braced wall panels having a total length that meets or exceeds the minimum length of bracing required by Table 7, including all applicable adjustment factors found in footnotes to Table 7.

Table 7*: Length of Bracing Requirements*
(IRC Table R602.10.1.2(1))
BRACING REQUIREMENTS BASED ON WIND SPEED
(as a function of braced wall line spacing)

EXPOSURE CATEGORY B, 30 FT MEAN ROOF HEIGHT, 10 FT EAVE TO RIDGE HEIGHT, 10 FT 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[f, h]	Method GB (double sided)[g]	Methods DWB, WSP, SFB, PCP, HPS[f, i]	Continuous Sheathing
≤ 85 (mph)		10	3.5	3.5	2.0	1.5
		20	6.0	6.0	3.5	3.0
		30	8.5	8.5	5.0	4.5
		40	11.5	11.5	6.5	5.5
		50	14.0	14.0	8.0	7.0
		60	16.5	16.5	9.5	8.0
		10	6.5	6.5	3.5	3.0
		20	11.5	11.5	6.5	5.5
		30	16.5	16.5	9.5	8.0
		40	21.5	21.5	12.5	10.5
		50	26.5	26.5	15.0	13.0
		60	31.5	31.5	18.0	15.5
		10	NP	9.0	5.5	4.5
		20	NP	17.0	10.0	8.5
		30	NP	24.5	14.0	12.0
		40	NP	32.0	18.0	15.5
		50	NP	39.0	22.5	19.0
		60	NP	46.5	26.5	22.5
≤ 90 (mph)		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

(continued)

BRACING REQUIREMENTS BASED ON WIND SPEED
(as a function of braced wall line spacing)

EXPOSURE CATEGORY B, 30 FT MEAN ROOF HEIGHT, 10 FT EAVE TO RIDGE HEIGHT, 10 FT 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[f, h]	Method GB (doubled sided)[g]	Method DWB, WSP, SFB, PCP, HPS[f, i]	Continuous Sheathing
≤ 100 (mph)		10	4.5	4.5	2.5	2.5
		20	8.5	8.5	5.0	4.0
		30	12.0	12.0	7.0	6.0
		40	15.5	15.5	9.0	7.5
		50	19.0	19.0	11.0	9.5
		60	22.5	22.5	13.0	11.0
		10	8.5	8.5	5.0	4.5
		20	16.0	16.0	9.0	8.0
		30	23.0	23.0	13.0	11.0
		40	29.5	29.5	17.0	14.5
		50	36.5	36.5	21.0	18.0
		60	43.5	43.5	25.0	21.0
		10	NP	12.5	7.5	6.0
		20	NP	23.5	13.5	11.5
		30	NP	34.0	19.5	16.5
		40	NP	44.0	25.0	21.5
		50	NP	54.0	31.0	26.5
		60	NP	64.0	36.5	31.0
≤ 110 (mph)		10	5.5	5.5	3.0	3.0
		20	10.0	10.0	6.0	5.0
		30	14.5	14.5	8.5	7.0
		40	18.5	18.5	11.0	9.0
		50	23.0	23.0	13.0	11.5
		60	27.5	27.5	15.5	13.5
		10	10.5	10.5	6.0	5.0
		20	19.0	19.0	11.0	9.5
		30	27.5	27.5	16.0	13.5
		40	36.0	36.0	20.5	17.5
		50	44.0	44.0	25.5	21.5
		60	52.5	52.5	30.0	25.5
		10	NP	15.5	9.0	7.5
		20	NP	28.5	16.5	14.0
		30	NP	41.0	23.5	20.0
		40	NP	53.0	30.5	26.0
		50	NP	65.5	37.5	32.0
		60	NP	77.5	44.5	37.5

TABULATED FOOTNOTES FOR TABLE 7 (IRC TABLE R602.10.1.2(1)):

FOOTNOTE DESCRIPTION	SUPPORT/STORY APPLICATION	CONDITION	ADJUSTMENT FACTOR	APPLICABLE BRACING METHODS
(b) Exposure Category	One story structure	B C D	1.0 1.2 1.5	All methods
	Two-story structure	B C D	1.0 1.3 1.6	
	Three-story structure	B C D	1.0 1.4 1.7	
(c) Roof eave-to-ridge height	Roof only	≤ 5 ft 10 ft 15 ft 20 ft	0.7 1.0 1.3 1.6	
	Roof + 1 floor	≤ 5 ft 10 ft 15 ft 20 ft	0.85 1.0 1.15 1.3	
	Roof + 2 floors	≤ 5 ft 10 ft 15 ft 20 ft	0.9 1.0 1.1 Not permitted	
(d) Wall height adjustment	Any story	8 ft 9 ft 10 ft 11 ft 12 ft	0.9 0.95 1.0 1.05 1.1	
(e) Number of braced wall lines (per plan direction)	Any story	2 3 4 ≥5	1.0 1.3 1.45 1.6	
(f,h) Interior gypsum board finish	Any story	Omitted from inside face of BWPs	1.4	DWB, WSP, SFB, PBS, PCP, HPS, CS-WSP, CS-G, CS-SFB
(g) Gypsum board fastening	Any story	4"oc at panel edges, including top and bottom plates and all horizontal joints blocked	0.7	GB
(i) Inclusion of 800-lb hold-downs	Supporting roof only (top story)		0.8	DWB, WSP, SFB, PBS, PCP, HPS

NOTES:

- Linear interpolation shall be permitted.
- The total adjustment factor is the product of all applicable adjustment factors.
- For the purposes of this Guide, the amount of GB bracing required by Table 7 is not doubled when GB is applied to one side of the wall. Instead, this Guide requires that the length of bracing provided by one-sided GB be multiplied by 0.5 when determining the bracing length provided on a BWL (see Section 3.4). This approach is consistent with the intent of the 2009 IRC based on a pending code proposal for the 2012 IRC.

3.2 Applying the Code: Step by Step

Applying the wall bracing provisions of the IRC to a building plan is best approached like a routine and methodical accounting task. Follow the steps below, capturing your information on the attached worksheet (see **Appendix A**) to arrive at a code-compliant wall bracing plan.

Step 1: Designate and label BWLs on the building plan for each story level and plan direction (N-S and E-W); identify BWL endpoints and check BWL offsets for compliance with the 4' offset rule (see Section 1.6).

Step 2: Determine the BWL support condition (roof only, roof plus one floor, or roof plus two floors) and assign a BWL spacing value (feet) to each BWL based on the greatest distance to the adjacent parallel BWLs (see Section 1.6).

Step 3: Select a braced wall panel construction method ormethods for each braced wall line (see Section 2).

Step 4: Determine the tabulated bracing amount for each BWL (see Table 8 of Section 3) and multiply by all appropriate adjustment factors in footnotes to Table 8. After all required adjustments, the amount of bracing for each BWL shall not be taken as less than 48 inches.

Step 5: Determine the total length of code-compliant BWPs provided in each BWL (verify compliance with BWP minimum length and adjustments to contributing length as appropriate to the specific BWP construction method – see Section 2).

Step 6: Verify that the provided total length of bracing from Step 5 meets or exceeds the minimum required length of bracing from Step 4.

Step 7: Verify that the BWP spacing limit (e.g., maximum 25'oc) and cumulative end distance (e.g., maximum 12.5 feet) of BWPs from the ends of a BWL are met. Also verify that special corner framing and end panel conditions are provided with the continuous sheathing methods (see Section 2.3).

NOTE: If the bracing requirements are NOT met in the above steps, consider the following options to find a compliant solution for each non-compliant BWL:

- Reduce or shift braced wall line openings to allow space for required BWPs.
- Reduce BWL spacing (or use interior braced wall lines) to reduce the minimum required bracing amount.
- Limit braced wall line offsets to minimize the number of BWL endpoints which trigger the need to location BWPs within 12.5 feet (cumulative) of each BWL endpoint.
- Select a different bracing method which requires less bracing or use one of the various means to reduce BWP widths as discussed in Section 2.
- Use a supplemental solution (See **Section 4: 'Beyond Code' Bracing Solutions**)

3.3 Calculating the Required Length of Bracing

Step 4 of Section 3.2 directs the code user to determine the required length of bracing using Table 7 and its many adjustment factors (footnotes). The minimum total length of braced wall panels required on a given braced wall line depends on:

- the design wind speed for the building site (per Chapter 3 of the IRC, including consideration of the site wind exposure and topographic effects, if any)
- the number of stories supported by the BWL under consideration,
- the spacing of adjacent BWLs,
- the braced wall panel construction method used, and
- various adjustment factors in footnotes to Table 7 which "fine tune" bracing amounts to a specific building application.

In addition, IRC Section R602.10.1.2 requires that the minimum total length of bracing in a braced wall line not be taken less than 48 inches.

Determining the required bracing length for each braced wall line can be easily achieved with the use of a hand-held calculator and the following formula:

Minimum Required Bracing = (Tabulated Bracing Length per Table7) x (applicable adjustments in footnotes to Table 7)

OR

L' = L x (b) x (c) x (d) x (e) x (f,h) x (g) x (i)

where,
L' = the adjusted minimum required length of bracing
L = the tabulated (unadjusted) length of bracing from Table 7
(b)-(i) = various adjustment factors (footnotes) to Table 7 – use as applicable

For example, consider the house in Figure 17 and BWL #2 in the East-West plan direction supporting one floor and the roof (i.e., the bottom story street-facing entry wall line). Assume the following conditions:

Design Wind Speed:	90 mph, Exposure B (no topographic effects)	
BWL Supporting:	roof + 1 floor	
BWL Spacing:	30'	(maximum distance to BWL #1 or #3)
Bracing Method:	WSP	(intermittent bracing)
L (Table 7):	10.5'	(tabulated length of bracing, unadjusted)
Factor (b):	1.0	(exposure B, 2 stories)
Factor (c):	1.1	(roof eave-to-ridge height of 13', interpolated)
Factor (d):	0.95	(9' ceiling height)
Factor (e):	1.3	(three braced wall lines in E-W plan direction)
Factor (f,h):	1.0	(gypsum board finish provided on interior side)
Factor (g):	1.0	(N/A, GB bracing method not used)
Factor (i):	1.0	(N/A, 800# hold-down not used on BWPs)

Plugging the numbers into the bracing length equation and multiplying yields:

L' = 10.5' x (1.0) x (1.1) x (0.95) x (1.3) x (1.0) x (1.0) x (1.0) = 14.26 feet

The calculated decimal feet of bracing required can be converted to feet-inches as follows using a hand-held calculator:

14.26 feet = 14 feet + ? inches

0.26 feet x 12 inches per foot = 3 inches (rounded to nearest inch)

14.26 feet = 14 feet – 3 inches

Thus, a total of 14'-3" of bracing is required on BWL#2 for the bottom story of the example house shown in Figure 17 for the conditions as given above.

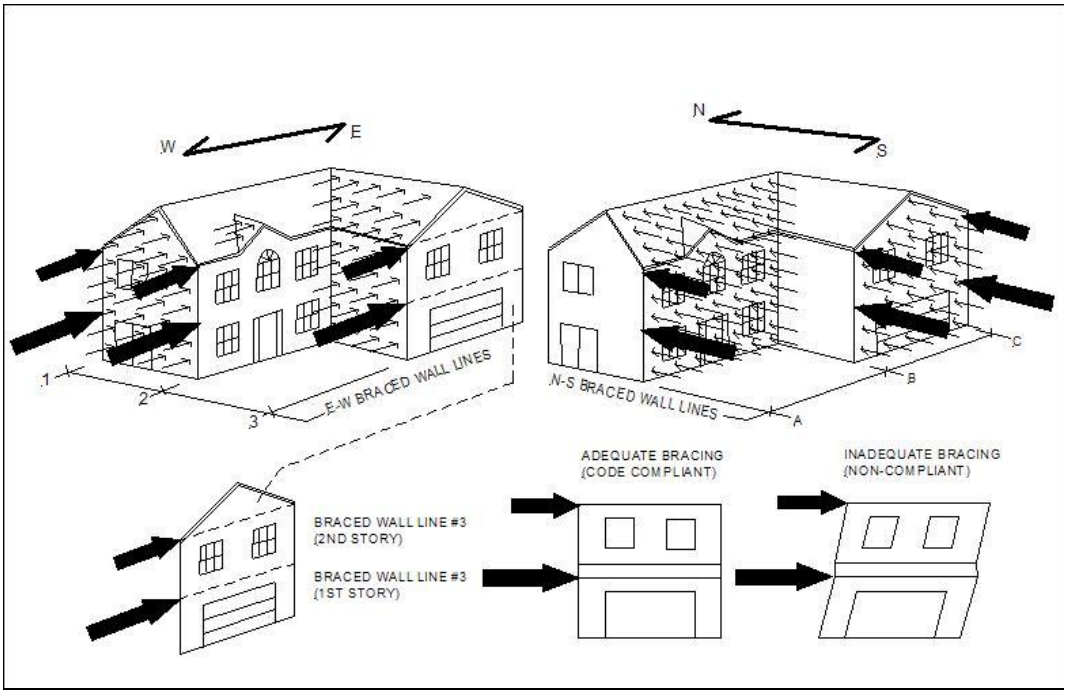


Figure 17*:* Example house plan for bracing length calculation

In the ***Design Example Supplement*** to this Guide, calculation of the required bracing lengths is demonstrated for a variety of bracing methods and conditions on two typical house plans.

3.4 Verifying the Provided Length of Bracing

In Section 3.2, Step 5 prompts the user to determine the length of bracing provided in a braced wall line by counting the total length of code-compliant braced wall panels. In Step 6 of Section 3.2, this amount is then compared to the required amount of bracing (as determined in the previous section or Step 4 of Section 3.2) to verify compliance. This process is repeated for each braced wall line in a building. The provided length of bracing (cumulative length of braced wall panels) within a braced wall line is determined as follows:

> In the previous example (Figure 17, Section 3.3), the required amount of bracing for BWL #2 (first story level) was determined to be 14'-3" of WSP bracing method. In Figure 17, there are four potential locations for BWPs on the exterior wall line designated as BWL #2 (assuming the wall does not continue through the garage). Thus, the width of each of these four wall segments must be roughly 43 inches (14'-3" divided by 4, or 171"/4 = 43" rounded to the nearest inch) assuming equal panel widths. However, this BWP length is less than the minimum BWP length required for the WSP bracing method (see Table 2, Section 2.1). Therefore, a 48" BWP width is required for each wall segment for a total of 4 panels x 4 feet per panel = 16 feet of total bracing. This amount of bracing, if feasible, exceeds the required 14'-3" of WSP bracing. If insufficient space exists for 48-inch-long BWPs, other alternatives must be considered such as the CS-WSP or CS-SFB bracing methods. Using the "partial credit" approach for braced wall panels less than 48 inches in length (see Section 2.1, Table 3) can also be considered but, in this case, would only result in the allowance for 46" braced wall panel actual length giving an effective length of 43" (by interpolation using Table 3). Thus, using four 46" BWPs panels would barely exceed the required bracing amount of 14'-3" (i.e., 4 panels x 43" effective length per panel = 172" or 14'-4"). For this particular example, using the continuous sheathing methods (or a code-approved proprietary bracing method) appears to be more practical for the lower story BWL #2, but it also would require verifying acceptable BWP lengths for each wall segment based on adjacent opening clear heights (see Table 6, Section 2.3). For other braced wall lines, however, the intermittent bracing methods would generally present few challenges, especially on the 2nd story level.

In the ***Design Example Supplement*** to this Guide, determination of braced wall panel lengths provided by use of various braced wall panel construction methods is demonstrated for two typical house plans and a variety of conditions.

Section 4: 'Beyond Code' Bracing Solutions

4.1 Overview

When the IRC bracing methods fail to provide a workable or code-compliant solution for a given braced wall line or for a dwelling as a whole, consider:

- Custom engineered solutions (Section 4.2),
- Useful engineering concepts (Section 4.3), and
- Code approved proprietary bracing products (Section 4.4).

4.2 Custom Engineered Solutions

Using custom engineered bracing solutions for an entire dwelling or for a non-compliant portion of a dwelling is permitted per IRC Sections R104.10, R104.11 and R301.1.3.

In general, an engineered solution must comply with accepted engineering practice using the building code resources and standards listed in Section 6 of this Guide. Accepted engineering practice may also involve use of recognized design resources such as the *Residential Structural Design Guide* (*HUD, 2000*) which provides data and insights beyond those found in building codes, design standards and typical textbooks (see **Section 6: Resources and References**) .

Remember, though, all of these sources of "accepted engineering practice" do not replace the need for practical engineering judgment in designing a wall bracing solution for a conventional wood frame dwelling. In part, this is because the structural performance of conventional light-frame construction - particularly at a system level - is not easily or accurately predicted by current conventions of engineering theory and analysis (*Crandell and Kochkin, 2003*). Therefore, it is important to employ a design professional or engineer that has a practical understanding of residential wood frame construction and structural design.

Unfortunately, in many cases the application of accepted engineering practice as regulated in the building code generally results in a very conservative design for lateral bracing in comparison to the IRC wall bracing provisions. However, for buildings within the scope of the IRC, the engineering approach used to develop the IRC bracing requirements (i.e., Table 7) may be considered as an acceptable engineering practice (in fact, it is recognized as such by its use as the basis for the IRC bracing provisions). The IRC engineering approach for "braced walls" (as different from "shear walls" – the term for traditionally engineered walls) is detailed in Crandell (2007) and Crandell and Martin (2009); refer to **Section 6: Resources and References**. This method, however, must be applied by a registered design professional in conformance with locally applicable laws for the practice of engineering. The design professional must also determine design loads as required by the locally applicable building code. While this may add design fees to the cost of construction, a specific analysis using the IRC engineering procedure can result in significant cost-savings and construction efficiencies.

As an alternative to the above described method, it is also possible to apply the IRC bracing provision in a manner consistent with engineering principles. An example design showing a fairly efficient solution for a reasonably complex house plan is included in ***Appendix B – Engineered Design Example Using IRC Bracing Provisions***. The design example was developed by the

author of this guide as a result of the ICC Ad Hoc Wall Bracing Committee's interest in exploring various ways to configure and implement the IRC's wall bracing provision.

4.3 Useful Engineering Concepts

In many cases, an engineered bracing solution may meet the intent of the building code for a specific bracing problem and also address a common bracing design issue with a solution that can be used repetitively on different plans with similar conditions.

Use of these engineering concepts may require local building official approval and will generally require the services of a design professional.

Interior Partition Walls as a Bracing Method – Because standard interior partition walls are constructed in much the same manner as Method GB wall bracing (except for the fastening schedule), these types of interior walls can be considered for their contribution to the bracing of a residential building. However, standard interior finishes on the inside face of exterior braced wall lines should not be additionally considered because its contribution is already factored into the prescribed bracing amounts in the IRC.

A double-sided interior partition wall with a minimum ½" gypsum wall board on both faces and using standard fastening per IRC Table R702.3.5 provides approximately one-half the bracing strength of Method GB with panels on 'both sides'. As a rule of thumb, interior partition walls with segments of at least 48" width and a minimum ½" thick gypsum panels on both wall faces may be counted as a braced wall line (i.e., Method GB with gypsum panels on one side is approximately equivalent to a standard interior partition wall with gypsum panels on both sides).

Altering Braced Wall Panel Location Requirements – The IRC requirement to locate braced wall panels no further than 12.5' from the ends of braced wall lines and no more than 25'oc comes from a traditional practice (i.e., the 25'oc requirement was intended for high seismic regions in the 1958 HUD *Minimum Property Standards* where additional bracing is required at more than just at the ends of exterior wall lines). However, design calculations show that panels can be spaced further apart - provided the wall top plate and its splices are designed to collect in-plane or parallel shear (racking forces) along the top of the wall and transfer them to the braced wall panels. In fact, a system of elements (including more than just the top plate) transfers these forces along wall lines and into braced wall panels. This consideration and a general approach to designing collectors (e.g., top plates and top plate splices) are presented in the *Residential Structural Design Guide* (HUD, 2000). As a result, in specific cases, braced wall panels can be designed to begin further than 12.5' from the ends of a braced wall line and spaced greater than 25'oc along a braced wall line provided that:

- an adequate overall bracing amount is maintained for a braced wall line and,
- the collector (top plate) is designed to accommodate the additional in-plane tension or compression forces that result from a wider spacing of braced wall panels. Typically this only affects the number or size of fasteners used in lap-splices of the top plate.

Allowance for Bracing Transfer – Buildings that are adequately braced on three sides are stable against lateral loads due to the ability of racking forces (shear) to be redistributed by torsional (twisting) response of the building (see Figure 18). Therefore, bracing amounts for braced wall lines on the longer side of a dwelling or on a garage may be reduced to the minimum required in Table 7 or less. In these cases, the amount of bracing equivalent to that which was removed must be placed (transferred to) the opposite side of the building. This approach provides an easy and practical solution when addressing bracing of garages where little or no bracing is provided at the garage opening wall line, but ample space is provided for additional bracing on the rear wall as well as the side walls of the garage.

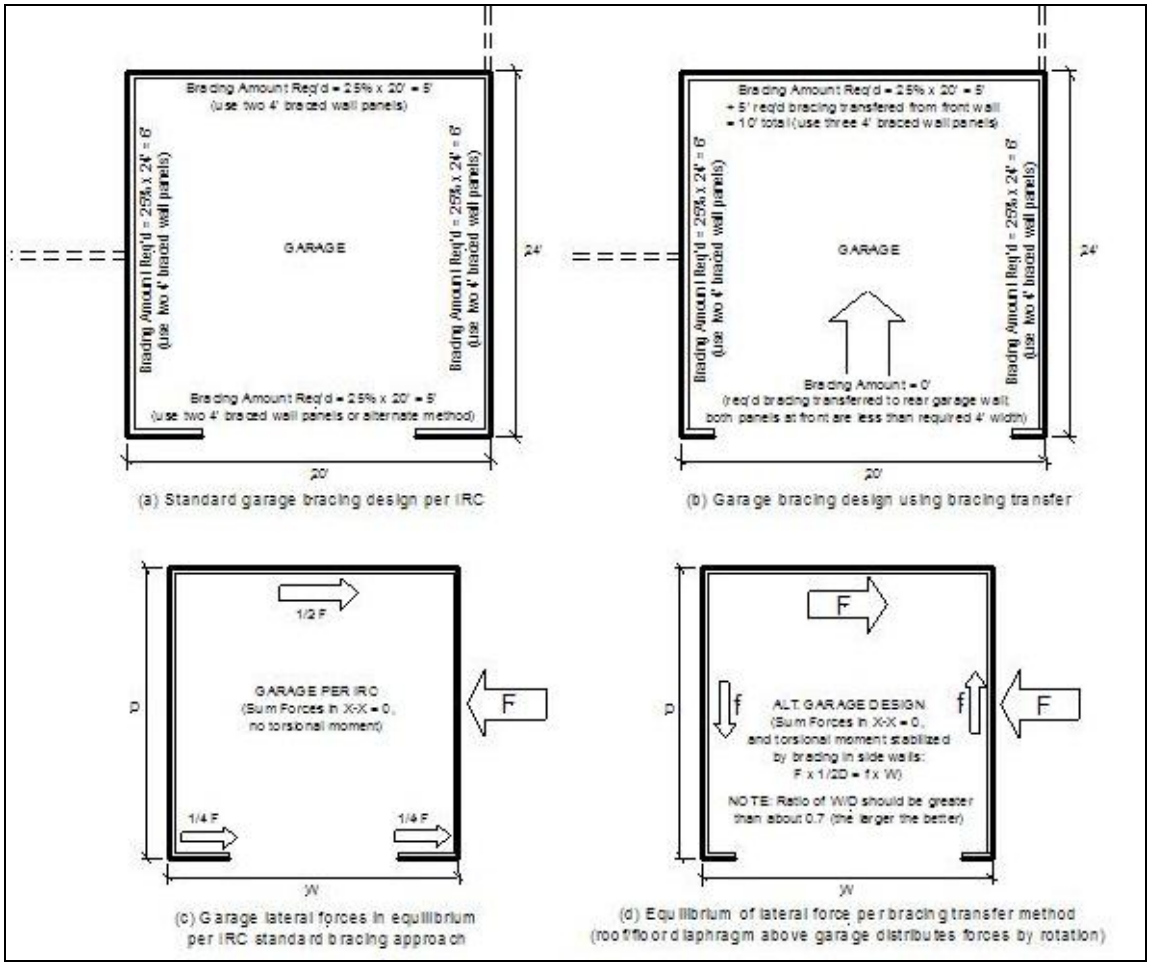


Figure 18: Bracing Transfer

Allowance for > 4' ± limit for Offsets within a Braced Wall Line – The 4' offset limit for braced wall lines in the IRC is not based on analysis or specific data. However, data from the Northridge earthquake, as well as whole-building tests, have demonstrated that the existing 4' offset limit is conservative and somewhat arbitrary (see Section 6: Resources and References).

For example, whole building tests have shown the ability of conventional homes to distribute loads adequately to braced wall lines that have offsets of 6' (HUD, 2001). In addition, no measurable difference in performance of homes with and without 4' offsets in braced wall lines was observed in carefully studied damage statistics for single family detached homes (HUD, 1999). Use engineering judgment with applying the existing 4' offset limit.

Combined Roof Uplift and Shear Load Path – As mentioned, the 2009 IRC bracing provisions introduce wind uplift connection requirements for braced wall panels that support roof members (see Section 2.4). The additional connections, when required, may be provided by metal strapping or by appropriate installation of wall sheathing that is also used for bracing. Appropriate installation for combined uplift and shear resistance generally requires that additional fasteners be added to the horizontal edges of sheathing panels and that the panels lap over horizontal joints in wall and floor framing to resist the calculated roof uplift wind force less the resistance provided by dead load (as factored according to code). The sheathing fasteners used to resist roof uplift forces are in addition to the fasteners required to resist shear loads or racking. One procedure for design of wood structural panels to resist combined uplift and shear is found in Section 307 of the ICC 600 *Standard for Residential Construction in High-Wind Regions*; refer to Section 6: Resources and References. The same principles apply to residential construction in lower wind regions as addressed by the IRC.

4.4 Proprietary Bracing Products

A variety of proprietary bracing materials and pre-fabricated braced wall panels or frame products are available that provide efficient solutions where racking loads are high and wall space is limited; refer to Section 6: Resources and References. Some of these bracing products are "in-wall" systems that fit within the thickness of wall framing and allow the use of a continuous thickness of insulating foam sheathing on all wall surfaces (similar to Method LIB). Typically these types of braces are more expensive than "site-built" braced wall panels and require a greater level of coordination between foundation and framing phases. In addition, engineering support may be required, especially for anchorage and foundation design. In some localities, special inspections may be required.

For these proprietary products, minimum braced panel or frame widths range from 12" to 24" or more; allowable racking (shear) loads range from under 1,000 lbs to over 10,000 lbs per brace depending on width and type of panel construction. In some cases, these products can be directly substituted for braced wall panels required in the IRC provided the proprietary panel has at least equivalent allowable shear strength. Alternatively, required bracing lengths can be adjusted as a means of provided equivalent performance.

Contact the proprietary brace manufacturer for additional guidance and requirements.

Section 5: Wall Bracing Options for Foam-Sheathed Walls

5.1 Wall System Design – Bracing and Beyond

When used properly, various wall bracing methods included in 2009 IRC Section R602.10 provide equivalent and code-compliant minimum performance. Being able to select from among different bracing methods on the basis of equivalent performance facilitates a competitive market in which both cost and performance of wall assemblies can be optimized by the code user. Thus, the code user is able to arrive at code-compliant solutions that strike the best overall balance between various wall design decisions including:

- Resistance to structural loads,
- Energy efficiency,
- Support of wall coverings,
- Moisture resistance,
- Architectural appearance and function (e.g., size and distribution of windows and doors, interior and exterior wall layout, etc.), and
- Affordability or cost-effectiveness.

5.2 Why Use Foam Sheathing?

The functions of a wall assembly and the advantages of using insulated foam sheathings are well known and highlighted in ***Table 8*** and ***Figure 19***. Foam sheathing serves **many** different functions in a wall design – continuous insulation, water resistant barrier, siding backer board, etc - so it is important that the designer is aware that bracing requirements are only one of the many functions that must be considered in the design of a code-compliant (or "code plus") wall assembly. For example, with energy costs high and energy conservation becoming increasingly important and marketable for a variety of reasons, the insulation value of continuous foam sheathing makes it an ideal wall component. Fortunately, racking requirements can be easily addressed to compliment the use of insulation sheathing which is not intended to provide bracing.

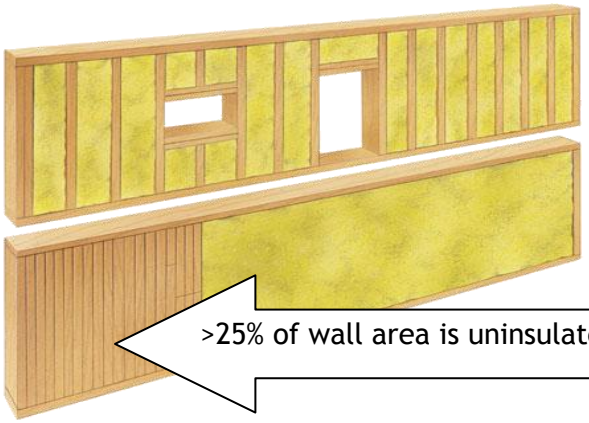
Although foam sheathing is NOT an acceptable wall bracing material on its own, the additional benefits – especially for energy efficiency and moisture resistance – and the range of available of compatible bracing techniques – makes it a preferred choice in many wall configurations.

Table 8: Wall Functions and the Role of Foam Sheathing in Above-Grade Residential Walls

Wall Function *	Foam Sheathing Role in Wall Function	IRC Code Reference[3]	Comments
Provide strength and rigidity	Use with approved bracing methods Use with approved load path methods Use with appropriate siding requirements to resist wind pressure	R602.10 Table 602.3(1), R802.10.5, R802.11 Table R703.4, R703.11.2	All sheathings must comply with structural requirements of the code, as detailed in this document. Refer to **Appendix C: Technical Information for Appropriate Use of Foam Sheathing** for sizing and siding attachment information
Control heat flow	Reduces thermal shorts by Insulating the entire wall surface, not just between studs	Chapter 11	Continuous foam sheathing insulation reduces heat loss through wall framing by insulating the whole wall (see Figure 19). May be able to meet energy requirements with lower cost 2x4 walls instead of 2x6 walls.
Control air flow	Fasten foam sheathing directly to studs to reduce air infiltration through the wall; better than house wrap over OSB sheathing.	N1102.1	Because foam sheathing conforms to irregularities on the surface of framing lumber, it forms a gasket that reduces air infiltration through the wall. Especially effective with sheathing joints sealed/taped for water resistance.
Control rain penetration	Can qualify as a water resistive barrier	R703.2, Table 703.4	Foam sheathing that has passed AC 71 qualifies as an approved water resistive barrier and does not need to be covered with house wrap.
Control water vapor flow	Can control water vapor flow through the wall and reduce the potential for condensation in the wall	R601.3	Water vapor becomes a problem in walls when it condenses into liquid water. Foam sheathing reduces the potential for condensation in walls by controlling the relative humidity in the wall and/or controlling the temperature in the wall.

** from Hutcheon*

[3] *In accordance with IRC 2009.*



In a typical framed wall with only cavity insulation, over 25% of the wall area is uninsulated wood framing, forming a large thermal short. By installing foam insulation sheathing over the studs, a full insulation 'envelop' provides energy efficiency as well as a moisture resistant barrier for the wall system - something structural panels are unable to provide.

Figure 19: Cavity Insulation and Wall Framing

Remember that bigger does not necessarily mean stronger; using larger studs (e.g., 2 x 6 vs. 2 x 4) does not affect or improve resistance to lateral loads and may not provide the most efficient, code-compliant means of insulating a wall and supporting the structure. Try to think of the wall as a system where all functions need to be addressed and optimized.

5. 3 Meeting Energy Code Requirements

Always confirm that applicable energy code requirements are being met, regardless of the type of bracing method and insulation strategy used. In many locations, installing insulated foam sheathing will easily provide the required wall R-values. For example, in northern climates where R19 cavity insulation or R13 cavity insulation plus R5 continuous foam sheathing insulation is required (e.g., see Zones 4 marine, Zone 5, and Zone 6 in Chapter 11 of the IRC), use of a 1-inch thickness of foam sheathing can readily meet the building code requirements. Thus, the foam sheathing allows use of traditional 2x4 studs (R13 cavity insulation) in lieu of 2x6 studs (R19 cavity insulation) while still meeting the structural requirements for wall framing in Chapter 6 of the IRC. In addition, the foam sheathing may serve as the water resistive barrier (if approved – check with manufacturer) and air-barrier, eliminating the need for a separate building wrap. Clearly foam sheathings can result in efficient wall assemblies that conserve natural resources with a low first cost and a long-term pay-back.

5.4 Which Bracing Method(s) to use with Foam Sheathing?

As summarized in Table 9, different bracing methods can be used to construct code-compliant, foam-sheathed walls. Remember that more than one bracing method can be used on a dwelling – or even within a braced wall line.

Table 9: Common IRC Wall Bracing Methods and Foam Sheathing Applications
(Based on IRC Section R602.10.2, Section R602.10.3-6)

Bracing Method[4]	Foam Sheathing Applications
LIB: 1x4 wood let-in brace or approved metal brace	***Pros:*** Use foam sheathing continuously and of uniform thickness on exterior of building. ***Cons:*** May not be preferable to braced wall lines with substantial wall opening amounts for windows and doors; limited to one- or two-story structures
WSP: Wood structural panels **SFB:** Structural Fiberboard	***Pros:*** Use ½" foam sheathing over brace panels and 1" foam in-between braced wall panels for improved energy efficiency. ***Cons:*** Braced wall panels less than 48" wide (or 36" wide with "partial credit") do not count toward required bracing amounts so these methods may not be applicable to braced wall lines with substantial wall opening amounts for windows and doors.
GB: Gypsum board	***Pros:*** Use single side, interior application with exterior foam sheathing on wall lines where minimum 96" lengths are uninterrupted by openings (e.g., end walls). Use on interior braced wall lines (both sides) to meet braced wall line spacing limits or to reduce bracing amount required on parallel exterior braced wall lines. ***Cons:*** Must attach gypsum panels using more stringent fastening schedule than standard for interior finishes. Single side applications may not be applicable to walls with substantial wall opening amounts for windows and doors.
CS-WSP Continuous wood structural panel sheathing (R602.10.4); **CS SFB Continuous structural fiber board sheathing** (R602.10.5) .	***Pros:*** Place foam sheathing over wood structural panels for both insulation and as a weather-resistant barrier behind siding when properly detailed (taped joints, flashed at wall system penetrations); in cold climates, properly sized foam sheathing can serve to protect wood sheathing and framing from condensation by creating a "warm wall". ***Cons:*** Size and install siding fasteners to adequately penetrate studs through exterior sheathing layers. Consider drainable siding installations, especially in wind-driven rain climates (e.g., wood or cement lap siding on furring, vinyl siding, brick veneer, etc.).
Method ABW Alternate braced wall panels (R602.10.3.2)	***Pros*:** Allows for minimum 32" braced wall panel but otherwise similar to Method WSP and SFB in terms of foam sheathing applications. ***Cons*:** Requires additional framing expense for hold-down brackets and additional fastening of sheathing.
Method PFH or PFG Intermittent Portal Frame (with hold downs)	***Pros:*** Use at Garage doors or other larger openings where there are limited wall areas adjacent to the openings. Allows a minimum 16" or 24" braced wall panel; otherwise similar to Method WSP and SFB in terms of foam sheathing applications. ***Cons:*** *Framing methods are non-typical and require special attention for proper assembly*.

[4] *Refer to Section 2 of this guide for a more complete listing of bracing methods and details.*

Because a variety of bracing methods can be used – even along one wall – optimizing the wall design can be achieved on a BWL-by-BWL basis as shown in Figure 20.

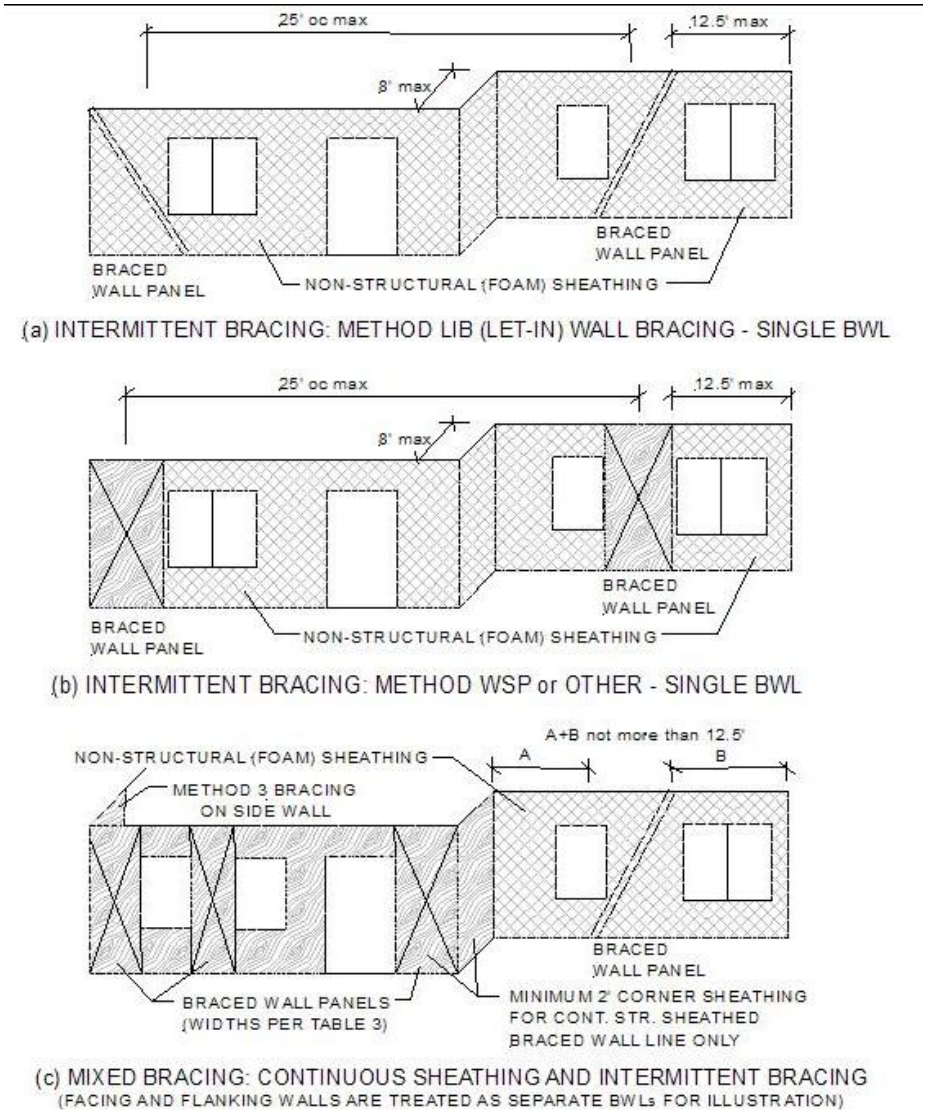


Figure 20: Illustration of Bracing Methods with Foam Sheathing

5.5 Examples

Generally, when using a foam-sheathed wall assembly, the following bracing approaches are commonly used to maximize the benefits of foam sheathing and minimum cost while still complying with wall bracing requirements. These approaches can be applied to an entire building or to different exterior wall lines for more complex building plans.

Example 1: *Continuous Foam Sheathing with Internal or Inset Wall Bracing* **(Method LIB)**

Benefit	Installation Details
• Maximizes energy efficiency • Minimizes cost • Allows use of 2x4 vs. 2x6 studs • Allows use of less expensive normal density batt insulation to meet energy code (e.g., in northern climates were required wall insulation exceeds R13). • Foam sheathing serves multiple functions (siding backer, air-barrier, and water barrier).	• Apply foam sheathing of selected thickness (½" minimum, 1" common, and up to as much as 2" or more) continuously over the entire framed wall area. • Detail foam to act as an air and/or water barrier (e.g., joints taped and/or seams flashed at window and door edges) and to replace building paper or wrap under siding. • Use bracing methods that are inset or "internal" to the wall framing, such as the traditional Method LIB wood let-in bracing or code-approved equivalent metal braces (See **Section 6: Resources and References**).

Example 2: *Continuous Foam Sheathing over Continuous Bracing Panels*

Benefit	Installation Details
• Maximizes energy efficiency • Provides a thermal blanket to reduce thermal short-circuiting through studs • Reduces moisture condensation during cooler months that may occur with non-insulating exterior sheathing in mixed and cold climates	• Place foam-sheathing directly over a fully or continuously sheathed wall, using a code-compliant structural panel ('over sheathing'). • Use OSB or plywood panels, fiberboard sheathing (Method SFB) or other proprietary products (e.g., laminated cellulosic panels - Thermo-ply or Energy brace). • Detail foam to act as an air and/or water barrier (e.g., joints taped and/or seams flashed at window and door edges) and to replace building paper or wrap under siding.

Example 3: *Continuous, Variable Thickness Foam Sheathing over Intermittent Brace Panels*

Benefit	Installation Details
• Maximizes energy efficiency • Provides a thermal blanket to reduce thermal short-circuiting through studs • Reduces moisture condensation during colder months that may occur with non-insulating exterior sheathing in mixed and cold climates	• Place foam-sheathing directly over intermittent brace panels in the braced wall line (e.g., install ½" foam over brace panel and 1" foam between brace panel). • Detail foam to act as an air and/or water barrier (e.g., joints taped and/or seams flashed at window and door edges) and to replace building paper or wrap under siding.

Example 4: *Foam Sheathing Only Between Intermittent Brace Panels*

Benefit	Installation Details
• Provides high insulation value to meet or exceed energy code requirements • If structural sheathing panels comprise 25% or less of the wall square footage the building is considered to be fully sheathed with continuous insulation.	• Install ½" foam insulation sheathing to flush wall line to 7/16" OSB or plywood panels. • Cover all wood panels with a moisture resistant barrier (house wrap) or tape all joints in the foam sheathing. • If foam sheathing is applied on end gables (without structural sheathing underneath), ensure **proper wind pressure performance** in accordance with **Appendix B**. Also, an appropriate ignition barrier may be required on the interior of the gable end (see IRC Section R316.5.3).

5.6 Interfaces between Materials

Because many different types of bracing and materials may be used on a single dwelling, care must be taken at these interfaces. For example, if one wall uses foam sheathing with metal bracing and another wall uses wood sheathing with house wrap, the designer has three options:

1. Continue the house wrap over the foam sheathing and tape all seams securely.
2. Wrap the house wrap at least 6" over the foam insulation and securely tape the house wrap to the foam sheathing.
3. Continue the foam sheathing over the wood sheathing (use ½") called "oversheathing" and detail the foam sheathing as the weather barrier using tape at the joints.

Section 6: Resources and References

Wall Bracing Design Resources:

International Residential Code (ICC, 2009) – www.iccsafe.org

Chapters 16 and 23 of the *International Building Code* (ICC, 2006) – www.iccsafe.org

Minimum Design Loads for Buildings and Other Structures (ASCE, 2005) – www.asce.org

National Design Specification for Wood Construction (AF&PA, 2005) – www.awc.org

Special Design Provisions for Wind and Seismic (AF&PA, 2005) – www.awc.org

Standard for Residential Construction in High-Wind Regions, ICC 600-2008 – www.iccsafe.org

The Story behind IRC Wall Bracing Provisions, Jay H. Crandell, P.E. (Wood Design Focus, Summer 2007), www.foamsheathing.org

The Story Behind the 2009 IRC Wall Bracing Provisions (Part 2: New Wind Bracing Requirements), Jay H. Crandell, P.E. and Zeno Martin, P.E. (*Wood Design Focus*, Spring 2009), www.foamsheathing.org

Common Engineering Issues in Conventional Construction, Jay H. Crandell, P.E. and Vladimir Kochkin, P.E. (*Wood Design Focus*, Vol. 13, No. 3, Fall 2003).

Evaluation of Housing Performance and Seismic Design Implications in the Northridge Earthquake, U.S. Department of Housing and Urban Development, Washington, DC. 1999 – available as free download at www.huduser.org

Residential Structural Design Guide – 2000 Edition (HUD, 2000) – available as free download at www.huduser.org

A Guide to the 2009 IRC® Wood Wall Bracing Provisions (ICC, 2009) - www.iccsafe.org

See the background, research, testing and reasoning that was used to develop code change proposal FS156-09/10 submitted to the ICC for the 2009/2010 code cycle. - Technical Justification of FSC Code Proposals for Integrated Design of Exterior Wall Covering Assemblies with Foam Sheathing (FS156-09/10)

Exterior wall assemblies built in accordance with the 2006 International Residential Code (IRC), International Building Code (IBC), and International Energy Conservation Code (IECC) must be designed and built to meet or exceed minimum requirements for structural performance, energy efficiency, and moisture resistance, among other factors. - Overview of Wall Sheathing Options. The Value of Foam Sheathing as a Wall Covering

The Story Behind IRC Wall Bracing Provisions - Wood Design Focus

Proprietary Bracing Products:

- T metal wall braces (www tamlyn.com)
- L and T metal wall braces (www.uspconnectors.com)
- Inset Wood Shear Panel (www.tamlyn.com)
- Strong-Wall Panels (www.strongtie.com)
- Hardy Frame (www.hardyframe.com)
- Shear Max Panels (www.shearmax.com)
- TJ Shear Panels (www.ilevel.com)

Disclaimer

The information contained in this guide is provided for educational purposes only. FSC does not assume any warranty, expressed or implied, related to any use of this guide. The user assumes all liability for use of this information and should consult the locally applicable building code or a design professional as appropriate.

Appendix A: Wall Bracing Design and Plan Check Worksheet

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'? (Yes or No)	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of Braced Wall Line (feet)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length from Table 7 (inches)	STEP 4 Adjusted Bracing Length per Table 7 footnotes (inches)	STEP 5 Bracing Length Provided by BWPs (inches)	STEP 6 Is Value in Column G ≥ Value in Column F? (Yes or No)	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 12.5? (Yes or No)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP? (Yes or No)	*Comments*

APPENDIX B: Engineered Design Example Using IRC Bracing Provisions

Perhaps one of the most efficient methods of designing a house is to use the IRC bracing provisions together with an engineering-based approach. The design principles and approach used to develop the IRC bracing provisions may also be employed to determined engineered solutions in a manner consistent with the IRC provisions (refer to Crandell and Martin, 2009). The following example demonstrates an engineering-based approach to applying the IRC's prescriptive (pre-engineered) bracing requirements.

Objectives

- Apply IRC 2009 wall bracing provisions to an example plan (1st story level only)
- Demonstrate a simple and effective engineering-based method of meeting bracing requirements whereby the total wall bracing amount required for each story level and plan direction is determined and then the total bracing amount is distributed evenly to selected braced wall lines.

Given

- Typical large production house plan 2-1/2 story with basement and integral/attached garage (see Figure B1)
- Wind Speed – 90 mph (Exposure B)
- Seismic Design Category – SDC A/B (exempt)
- Special wind bracing amount adjustment factors (Table 7 footnotes):
  - <u>Main Building Portion</u>
  - Wind Exposure B & 3 story – 1.0 (based on rear elevation)
  - Roof eave-to-ridge height, 13 ft – 1.1 factor
  - 9' Wall height: 0.95 (main building)
  - <u>Wings (Conservatory and Suite)</u>
  - Wind Exposure B & 2 story – 1.0 (based on rear elevation)
  - Roof eave-to-ridge height, 10 ft – 1.0 factor
  - 10' Wall height: 1.0 (conservatory and 1st floor suite)
  - <u>General</u>
  - # of BWLs adjustment (not applicable – bracing based on total for overall plan dimensions)
  - All bracing has interior GWB finish per IRC Chapter 7

Figure B1: Elevation Views of Example House

Bracing Analysis

STEP 1: Determine Dimensions of Two-Story and One-Story Portions of 1st Story Floor Plan

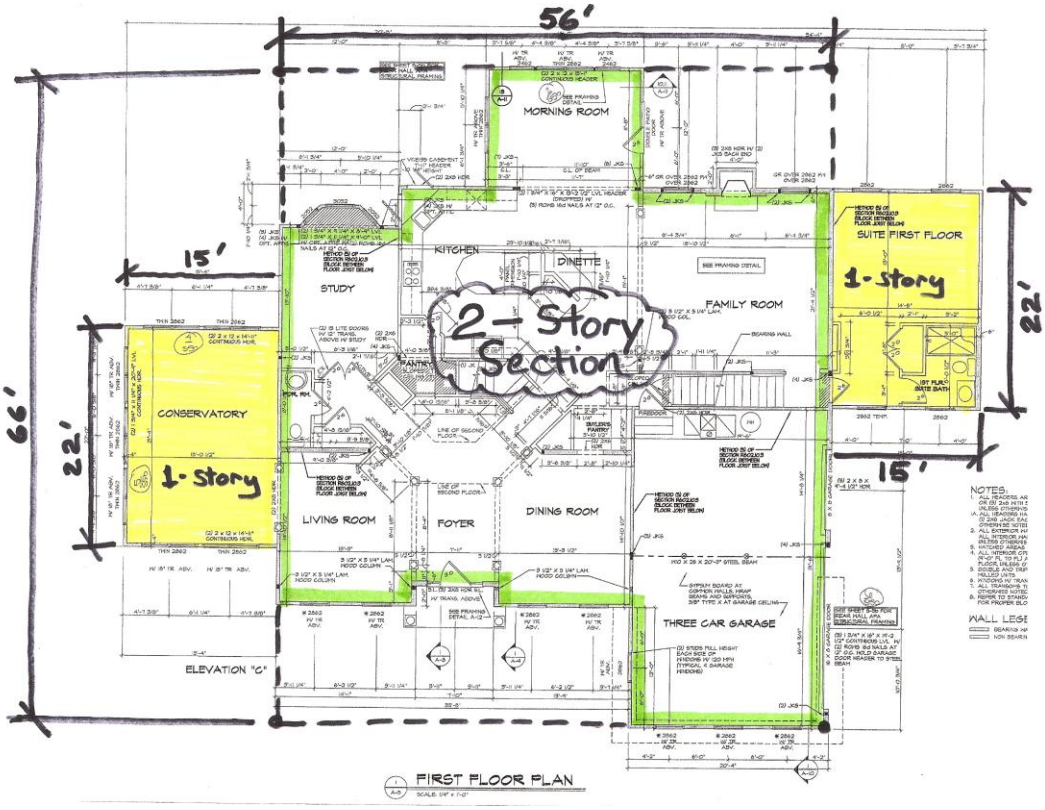


Figure B2: Plan View of Example House Plan

STEP 2: Determine Total Amount of Bracing Required for 1st Story Portions

Main Building (2-story Portion, 56' x 66')

Front-to-Back Direction: 2* x (19' WSP)(1.0)(1.1)(0.95) = **40 feet WSP** (total required)
Left-to-Right Direction: 2* x (22' WSP*)(1.0)(1.1)(0.95) = **46 feet WSP** (total required)

Conservatory & Suite (1-story Portions, 15' x 22' ea.)

Front-to-Back Direction: 2* x (3' WSP)(1.0)(1.0)(1.0) = **6 feet WSP** (total required)
Left-to-Right Direction: ~~2* x (4.3' WSP)(1.0)(1.0)(1.0)) = 9 feet WSP (total required)~~ NOT APPLICABLE, plan area is in "shadow" of sail area for main building in this wind loading direction.

**NOTE: factor of 2 doubles tabulated bracing which is based on two braced wall lines to result in a total amount of bracing for the building portion/story level. Also, for 66' BWL spacing in left-to-right loading direction for main building portion, the 22' length for WSP is derived by linear*

proportioning relative to the 60' BWL spacing limit (i.e., 66'/60' x 20' = 22') - same result as if Table 7 had been calculated for the larger BWL spacing.

STEP 3: Select & Identify First Story BWLs for Even Distribution of Required Bracing

Five wall lines in each plan direction are selected.

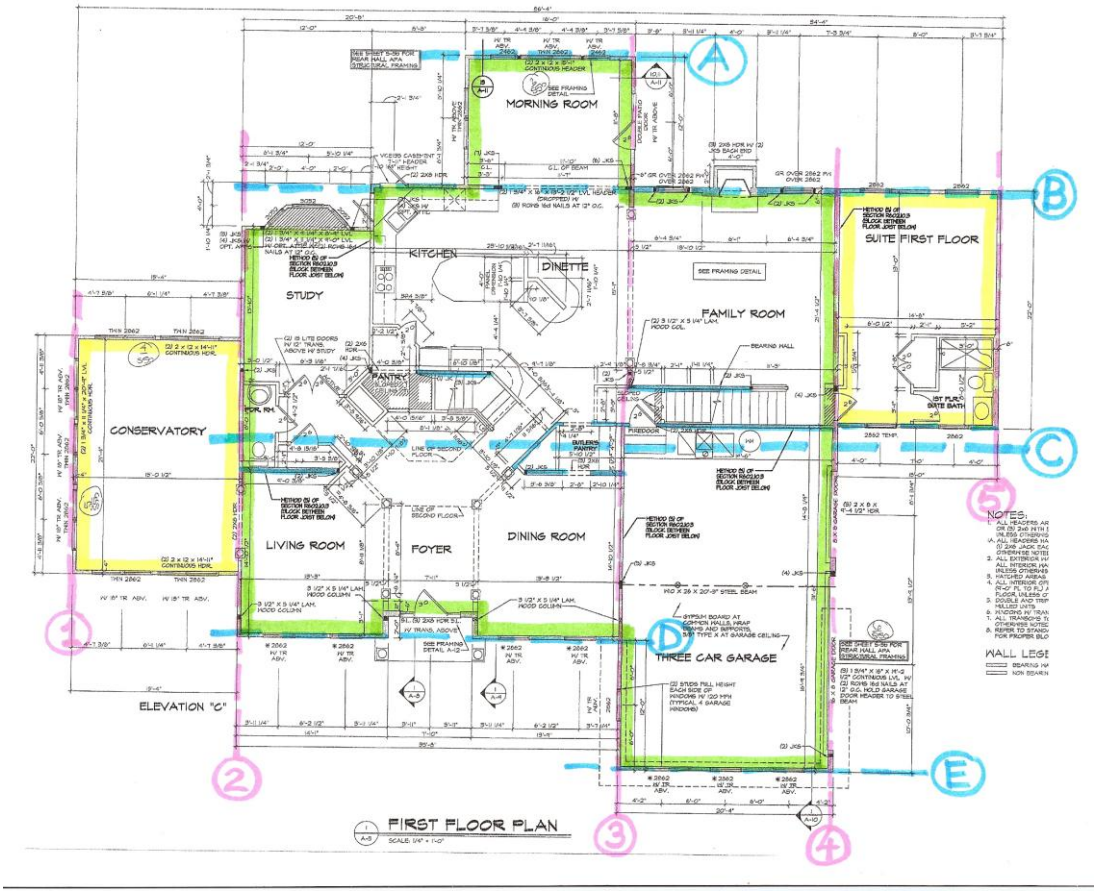


Figure B3: Plan View with Braced Wall Lines

STEP 4: Evenly Distribute Bracing to Selected Wall Lines & Check Compliance

Front-to-Back Wall Lines

Wall Line 1: 3' of WSP bracing required (50% of 6' WSP total required for conservatory)

➔ **OK**, 4' provided as CS-WSP (2' of bracing provided at each end with 2' corner returns). Could also use CS-PF if necessary to achieve 18" panel widths for a total of exactly 3' of bracing.

Wall Line 2: 3' WSP (50% of conservatory bracing) + 1/3(40' WSP, main building) = 16.3 ft WSP required

➔ **OK**, ~16 of WSP bracing provided on exterior wall plus additional 22' of GWB interior wall not counted. One third of main building bracing is distributed to each of three Wall Lines (2, 3, and 4).

Wall Line 3: 1/3 (40' WSP, main building) = 13.3 ft WSP required

➔ **OK**, 9.5' WSP + 6' WSP (2-3.5' segments at partial credit) = 15.6 feet provided plus additional 20' of interior wall not counted.

Wall Line 4: Same as Wall Line 2 = 16.3 ft WSP required.

➔ 5' of WSP is provided adjacent to one garage opening. Thus, 11.3' of WSP or equivalent must be provided on the interior wall line between suite and main building. Based on WSP (700 plf) and GB, 2-sided (400 plf) per Crandell and Martin (2009), the equivalent amount of GB, 2-sided required on the interior wall portion is (700/400)x11.3' = (1.75)x11.3' = 19.8'. 19' of interior wall is available (< 19.8', barely not OK). Therefore, use GB-2sided with 4"oc fastening so required length is 0.7 x 19.8' GB-2sided (7"oc) = 14' required of GB-2sided, 4"oc fastening. In summary, wall line has 5' of WSP on exterior portion and 19' of GB-2sided (4"oc fastening) on interior portion which is more than required. **OK.**

Wall Line 5: Same as Wall Line 1 = 3' of WSP required.

➔ *Use two 4-foot WSP panels at corners. 8' WSP provided.* ***OK****.*

Left-to-Right Wall Lines

Distribute total bracing length required (46' WSP or equivalent) to the five wall lines as follows:

Wall Line A: 8% x 46'WSP = 3.7 feet WSP
Wall Line B: 17% x 46'WSP = 7.8 feet WSP
Wall Line C: 50% x 46'WSP = 23 feet WSP
Wall Line D: 17% x 46'WSP = 7.8 feet WSP
Wall Line E: 8% x 46'WSP = 3.7 feet WSP
100% x 46' WSP = 46' WSP

NOTE: The above distribution can be taken to represent a maximal inward distribution of wall bracing to interior Wall Line C rather than to exterior Wall Lines A, B, D, or E. However, this still results in 25% of bracing on the front and back exterior building elevations with 50% on the interior (much like a simple tributary area bracing distribution). If the building had fewer interior walls (more interior open space) and less openings on the front and rear facing exterior walls, then more of the bracing could have been distributed toward Wall Lines A, B, D, and E rather than C.

Verify adequate bracing is provided in each wall line to meet the distribution targets above:

Wall Line A: 3.7 feet of WSP required.

➔ **OK.** Use 4' of CS-WSP (2' of bracing provided at each end with 2' corner returns). Could also use CS-PF if necessary to achieve 22" panel widths for a total of exactly 3.7' of bracing.

Wall Line B: 7.8 feet of WSP required.

➔ **OK.** ~16' of WSP provided.

Wall Line C: 23 feet of WSP required.

➔ **OK.** Use 8' of CS-WSP on suite exterior wall portion. Thus, (23'- 8') = 15' of WSP equivalent is required on interior walls along Wall Line C. If GB 2-sided is used, the equivalent amount required for the interior wall portions is 1.75 x 15' = 26.25' GB, 2-sided (7"oc fastening). The amount of GB, 2-sided provided is 20' along garage wall plus 4' along pantry plus 9' along living room for a total of 33' feet provided > 26.25' required. Other interior wall segments (single sided GB and double sided) are ignored. The wall line has more than adequate capacity to resist 50% of the story shear and provide 50% of required story bracing.

Wall Line D: 7.8 feet of bracing required.

➔ **OK.** Two 4-foot WSP panels provided for 8 feet total. Could use partial credit for other panels along front entry wall if it had been needed.

Wall Line E: 3.7 feet of bracing required.

➔ **OK.** Use two 3-foot braced wall panels each worth partial credit of 27 inches or 54 inches (4.5 feet) total which is more than the required 3.7 feet of WSP.

APPENDIX C: Technical Guidance for Appropriate Use of Foam Sheathing

Overview

This appendix provides state-of-the-art technical information for appropriate use of foam sheathing in three important ways:

1. proper sizing of foam sheathing thickness to resist wind pressure,
2. adequate fastening of siding to resist wind suction pressure acting on wall covering assemblies with foam sheathing, and
3. adequate sizing of fasteners to support siding weight when foam sheathings of thicknesses up to 3 inches are installed between the siding and framing (substrate).

These provisions are based on ICC code proposal FS156-09/10, Part 2 (IRC) which has been approved by the IRC Code Development Committee. Based on on-going research and broad interest, it is expected that this proposal (and also Part 1 for the IBC) will be expanded in scope by way of a Public Comment for consideration at the ICC Final Action hearing in May 2010.

Proposal FS156-09/10 was written as a change to the 2009 IRC provisions for the 2012 edition of the IRC. Therefore, it may be used together with the 2009 IRC. Local approval for use should not be difficult (check with your local code authority); the requirements herein are more restrictive than current requirements in the 2009 IRC (even for many sidings not backed by foam sheathing). In addition, the design basis used exceeds the wind pressure requirements of the IRC and IBC as applied to similar non-structural exterior wall components such as siding, windows, and doors. Finally, foam sheathings have been tested and analyzed for wind pressure resistance; siding fasteners have been analyzed and tested to ensure adequate withdrawal resistance and support of siding weight when spanning through foam sheathing of thicknesses up to 3 inches. For additional technical information on appropriate use of foam sheathing, including a complete disclosure of the research and engineering analysis behind the provisions in Appendix C, go to www.foamsheathing.org.

Technical Data (Code Proposal) for Appropriate Use of Foam Sheathing

FS156-09/10 (IRC)

Code Sections/Tables/Figures Proposed for Revision (3.3.2):

R703.3 (New), R703.4, Table R703.4, R703.5.1, R703.6.1, R703.7.4.1, R703.11.2

Proponent: Jay H. Crandell, P.E., d/b/a ARES Consulting, representing the Foam Sheathing Coalition

Revise as follows:

Add new Section R703.3 (renumber remaining subsections accordingly):

R703.3 Foam plastic sheathing. Foam plastic sheathing used in exterior wall covering assemblies shall comply with this section, Section R316, Chapter 11 and the manufacturer's installation instructions.

R703.3.1 Minimum thickness. The thickness of foam plastic sheathing shall comply with Table R703.3.1.

Exception: Where foam plastic sheathing is applied directly over or behind wall sheathing or other solid substrate capable of separately resisting the required wind pressure, the limitations of Table R703.3.1 shall not apply.

TABLE R703.3.1
REQUIREMENTS FOR FOAM PLASTIC SHEATHING
IN EXTERIOR WALL COVERING ASSEMBLIES[1,2]

Foam Plastic Sheathing Material[3]	Foam Sheathing Thickness (in)[3]	Maximum Wind Speed (mph) – Exposure B[4]			
		Walls with Interior Finish[5]		Walls without Interior Finish	
		16"oc framing	24"oc framing	16"oc framing	24"oc framing
Siding Attached Directly Over Foam Plastic Sheathing per Section R703.3.2.1					
EPS	¾"	110	NP	90	NP
	1"	130	100	125	NP
	≥1-1/2"	130	130	130	125
Polyiso-cyanurate	½" (faced)	130	90	115	NP
	¾" (faced)	130	120	130	100
	1" (faced)	130	130	130	110
	≥1-1/2" (faced)	130	130	130	115
XPS	½" (faced)	125	85	105	NP
	¾"	110	NP	90	NP
	1"	130	95	120	NP
	≥1-1/2"	130	130	130	115
Siding Offset from Foam Sheathing per Section R703.3.2.2					
EPS	¾"	95	NP	NP	NP
	1"	125	85	105	NP
	≥1-1/2"	130	130	130	105
Polyiso-cyanurate	½" (faced)	120	NP	100	NP
	¾" (faced)	130	100	130	85
	1" (faced)	130	110	130	95
	≥1-1/2" (faced)	130	120	130	100
XPS	½" (faced)	110	NP	90	NP
	¾"	95	NP	NP	NP
	1"	125	85	105	NP
	≥1-1/2"	130	120	130	100

For SI: 1 inch = 25.4 mm, 1 mile per hour = 1.609 km/h
NP = not permitted

1. Tabulated maximum wind speed values are based on a mean roof height of 30-feet (9.1 m). Multiply maximum wind speed by 0.95 for a mean roof height of 45 feet (13.7 m).
2. Foam plastic sheathing panels shall be permitted to be oriented parallel or perpendicular to framing members.
3. Foam plastic sheathing shall meet or exceed the following material standards: Expanded Polystyrene (EPS) – ASTM C578 (Type II, min.1.35 lb/ft^3 density), Polyisocyanurate – ASTM C1289 (Type 1, min.), and extruded polystyrene (XPS) – ASTM C578 (Type X, min. 1.30 lb/ft^3 density). Where a "faced" product is indicated, a facer shall be provided on both faces of the foam plastic sheathing. Where facing is not indicated in the table, faced and unfaced foam plastic sheathing shall be permitted. For all foam plastic sheathing products, approved manufacturer data shall be permitted in lieu of the table requirements.
4. Multiply tabulated maximum wind speed by 0.85 for wind exposure C or by 0.78 for wind exposure D.
5. Interior finish shall be minimum 1/2-inch (12.7 mm) thick gypsum wall board or an approved product with equivalent or greater out-of-plane bending strength and stiffness.

R703.3.2 Siding attachment over foam sheathing. Siding shall be attached over foam sheathing in accordance with Section R703.3.2.1, Section R703.3.2.2, or an approved design. In no case shall the siding material be used in a manner that exceeds its application limits.

Exception: Where the siding manufacturer has provided installation instructions for application over foam sheathing, those requirements shall apply.

R703.3.2.1 Direct siding attachment. Siding installed directly over foam sheathing without separation by an air space shall comply with Table R703.3.2.1 in regard to nail diameter, penetration, and nail spacing for the applicable foam sheathing thickness and wind speed condition. The siding fastener and siding installation shall otherwise comply with Section R703.4 and Table R703.4.

Exceptions:
1. For vinyl siding, refer to Section R703.11.2.
2. For exterior insulation and finish systems, refer to Section R703.9.
3. For adhered veneer, refer to Section R703.12.

TABLE R703.3.2.1
FASTENING REQUIREMENTS FOR DIRECT SIDING ATTACHMENT OVER FOAM PLASTIC SHEATHING[1,2]

Minimum Nail Diameter[3] (inches)	Nail Spacing along Stud[4] (inches)	Maximum Foam Sheathing Thickness[5] (inches)	16"oc WALL FRAMING Maximum Wind Speed (mph)			24"oc WALL FRAMING Maximum Wind Speed (mph)		
			Exposure B	Exposure C	Exposure D	Exposure B	Exposure C	Exposure D
0.113	6	2	140	120	110	120	100	90
	8	2	130	110	100	100	85	DR
	12	1	100	85	DR	85	DR	DR
0.120	6	3	140	120	110	120	100	90
	8	2	130	110	100	110	90	85
	12	1.5	110	90	85	90	DR	DR
0.135	6	3	140	120	110	130	110	100
	8	3	140	120	110	110	90	85
	12	2	110	90	85	90	DR	DR

For SI: 1 inch = 25.4 mm; 1 mph = 1.609 km/h
DR = design required

1. Maximum wind speed values are based on a minimum 1-1/4 inch (31.8 mm) penetration of a smooth shank nail fastener into wood framing of Spruce-Pine-Fir or any wood species with a specific gravity of 0.42 or greater in accordance with AFPA/NDS.
2. Tabulated maximum wind speed values are based on a mean roof height of 30-feet (9.1 m). Multiply maximum wind speed by 0.95 for a mean roof height of 45 feet (13.7 m).
3. Nail fasteners shall comply with ASTM F1667, except nail length shall be permitted to exceed ASTM F1667 standard lengths to provide a minimum 1-1/4 inch (31.8 mm) penetration into wood framing. Specified nails in accordance with Section R703.4 or the siding manufacturer's installation instructions shall meet all other requirements in ASTM F1667 or be otherwise approved for the intended application.
4. 'Nail spacing along stud' refers to spacing of siding fasteners in the vertical direction. A minimum of one fastener shall be applied at each intersection of an individual siding member with a wall stud.
5. Maximum foam sheathing thickness values are based on a maximum 24-inch (0.6 m) stud spacing and a maximum siding dead load of 11 psf (0.53 kPa) based on 7/8-inch (22 mm) thick Portland cement plaster, For Seismic Design Category D2, the maximum siding dead load shall be 8 psf.

R703.3.2.2 Offset siding attachment. When an airspace separates the siding from direct contact with the foam plastic sheathing, the siding shall be attached in accordance with Section R703.4 and Table R703.4 to minimum 1x3 wood furring strips placed over the foam sheathing. Furring shall be attached through the foam sheathing to wall framing in accordance with Table R703.3.2.2. When placed horizontally, wood furring strips shall be preservative treated wood or naturally durable wood and fasteners shall be corrosion resistant in accordance with Section R317.

Exception: Furring strips shall not be required over foam plastic sheathing located behind anchored stone and masonry veneer installed in accordance with Section R703.7. Veneer ties shall be installed in accordance with Section R703.7.4.1.

TABLE R703.3.2.2
FASTENING REQUIREMENTS FOR WOOD FURRING OVER FOAM PLASTIC SHEATHING[1,2,3]

Fastener Type	Minimum Penetration into Wall Framing (inches)	Fastener Spacing in Furring[4] (inches)	Maximum Thickness of Foam Sheathing[5] (inches)	16"oc FURRING Maximum Wind Speed (mph)			24"oc FURRING Maximum Wind Speed (mph)		
				Exposure B	Exposure C	Exposure D	Exposure B	Exposure C	Exposure D
0.120" diameter smooth shank nail	1-1/4	8	2	130	110	100	110	90	85
		12	1.5	110	90	85	90	DR	DR
		16	1	90	DR	DR	DR	DR	DR
0.135" diameter smooth shank nail	1-1/4	8	3	130	110	100	110	90	85
		12	2	110	90	85	90	DR	DR
		16	1.5	100	85	DR	DR	DR	DR
#8 wood screw	1	12	3	140	120	110	140	120	110
		16	2	140	120	110	140	120	110
¼" lag screw[6]	1-1/2	24	3	140	120	110	140	120	110

For SI: 1" = 25.4 mm; 1 mph = 1.609 km/h
DR = design required

1. Furring strips shall be spaced a maximum of 24"oc in a vertical or horizontal orientation. Table values are based on minimum ¾-inch (19.1 mm) thick furring strip and wood studs of Spruce-Pine-Fir or any wood species with a specific gravity of 0.42 or greater per AFPA/NDS.
2. Tabulated maximum wind speed values are based on a mean roof height of 30-feet (9.1 m). Multiply maximum wind speed by 0.95 for a mean roof height of 45 feet (13.7 m).
3. Where minimum required siding fastener penetration exceeds ¾ inch (19.1 mm), a minimum 2x furring strip shall be used unless approved deformed shank siding nails or siding screws are used to provide equivalent withdrawal strength.
4. In a vertical orientation, furring strips shall be located over wall studs and attached with the required fastener spacing. In a horizontal orientation, furring strips shall be fastened at each stud intersection with a number of fasteners equivalent to the required fastener spacing. In no case shall fasteners be spaced more than 24 inches (0.6 m) apart.
5. Maximum foam sheathing thickness values are based on a maximum 24-inch (0.6 m) stud spacing and a maximum siding dead load of 11 psf (0.53 kPa) based on 7/8-inch (22 mm) thick Portland cement plaster. For Seismic Design Category D2, the maximum siding dead load shall be 8 psf.
6. Lag screws shall be installed with a standard cut washer and shall be pre-drilled in accordance with AF&PA NDS-05. Approved self-drilling screws of equal or greater shear and withdrawal strength shall be permitted without pre-drilling.

Revise existing Section R703.4 as follows:

R703.4 Attachments. Unless specified otherwise, all wall coverings shall be securely fastened in accordance with Table R703.4 or with other *approved* aluminum, stainless steel, zinc-coated or other *approved* corrosion-resistive fasteners. Additional requirements in accordance with Section R703.3.2 shall apply when siding is installed over foam sheathing. Where the basic wind speed per Figure R301.2(4) is 110 miles per hour (49 m/s) or higher, the attachment of wall coverings shall be designed to resist the component and cladding loads specified in Table R301.2(2), adjusted for height and exposure in accordance with Table R301.2(3).

Add a new footnote 'aa' to 'Foam plastic sheathing into stud' column heading in Table R703.4 as follows:

aa. Refer to Section R703.3 for additional requirements.

Add a new footnote 'bb' to 'Number or spacing of fasteners' column heading in Table R703.4 as follows:

bb. For siding application over foam sheathing, fastener spacing shall comply with the more stringent requirement of this table or Section R703.3.2.

Revise footnote 'd' of Table R703.4 as follows:

d. Nails or staples shall be aluminum, galvanized, or rust-preventative coated and shall be driven into the studs where ~~for~~ fiberboard, ~~or~~ gypsum, or foam plastic sheathing backing is used.

Revise footnote 'j' of Table R703.4 as follows:

j. Wood board sidings applied vertically shall be nailed to horizontal nailing strips or blocking set 24 inches on center. Nails shall penetrate 1 1/2 inches into studs, studs and wood sheathing combined or blocking. For application over foam sheathing, refer to Section R703.3.2.2.

Revise footnote 'm' of Table R703.4 as follows:

m. Minimum shank diameter of 0.092 inch, minimum head diameter of 0.225 inch, and nail length must accommodate sheathing and penetrate framing 1 1/2 inches. For application over foam sheathing, minimum shank diameter and penetration into framing shall comply with Section R703.3.2.

Revise footnote 'o' of Table R703.4 as follows:

o. Minimum shank diameter of 0.099 inch, minimum head diameter of 0.240 inch, and nail length must accommodate sheathing and penetrate framing 1 1/2 inches. For application over foam sheathing, minimum shank diameter and penetration into framing shall comply with Section R703.3.2.

Revise footnote 'r' of Table R703.4 as follows:

r. Fasteners shall comply with the nominal dimensions in ASTM F 1667. For application over foam sheathing, refer to Section R703.3.2

Revise footnote 'v' of Table R703.4 as follows:

v. Minimum nail length must accommodate sheathing and penetrate framing 11/2 inches. For application over foam sheathing, refer to Section R703.3.2

Revise footnote 'y' of Table R703.4 as follows:

y. Minimum fastener length must accommodate sheathing and penetrate framing .75 inches or in accordance with the manufacturer's installation instructions. For application over foam sheathing, fastener penetration into framing shall comply with Section R703.3.2.

Revise existing Section R703.5.1 as follows:

R703.5.1 Application. Wood shakes or shingles shall be applied either single-course or double-course over nominal 1/2-inch (13 mm) wood-based sheathing or to furring strips over nominal 1/2-inch (13 mm) non-wood sheathing.

> **Exception:** Wood shakes or shingles over foam plastic sheathing, shall be applied to wood furring strips in accordance with Section R703.3.2.2.

A ~~permeable~~ water-resistive barrier shall be provided in accordance with Section R703.2 ~~over all sheathing, with horizontal overlaps in the membrane of not less than 2 inches (51mm) and vertical overlaps of not less than 6 inches (152 mm)~~. Where furring strips are used, they shall be 1 inch by 3 inches or 1 inch by 4 inches (25mmby 76 mm or 25mm by 102 mm), and shall be fastened horizontally to the studs with 7d or 8d box nails. For application over foam plastic sheathing, furring strips shall be fastened in accordance with Section R703.3.2.2. ~~and~~ Furring strips shall be spaced a distance on center equal to the actual weather exposure of the shakes or shingles, not to exceed the maximum exposure specified in Table R703.5.2. The spacing between adjacent shingles to allow for expansion shall not exceed 1/4 inch (6 mm), and between adjacent shakes, it shall not exceed 1/2 inch (13 mm). The offset spacing between joints in adjacent courses shall be a minimum of 11/2 inches (38 mm).

Revise existing Section R703.6.1 as follows:

R703.6.1 Lath. All lath and lath attachments shall be of corrosion-resistant materials. Expanded metal or woven wire lath shall be attached with 1 1/2-inch-long (38 mm), 11 gage nails having a 7/16-inch (11.1 mm) head, or 7/8-inch-long (22.2 mm), 16 gage staples, spaced at no more than 6 inches (152 mm), or as otherwise *approved*. For application of maximum 7/8-inch-thick Portland cement plaster over foam plastic sheathing, nail length and shank diameter shall comply with Section R703.3.2.

Revise existing Section R703.7.4.1 as follows:

R703.7.4.1 Size and spacing. Veneer ties, if strand wire, shall not be less in thickness than No. 9 U.S. gage [(0.148 in.) (4 mm)] wire and shall have a hook embedded in the mortar joint, or if sheet metal, shall be not less than No. 22 U.S. gage by [(0.0299 in.)(0.76 mm)] 7/8 inch (22 mm) corrugated. Each tie shall be spaced not more than 24 inches (610 mm) on center horizontally and vertically and shall support not more than 2.67 square feet (0.25 m2) of wall area. For application over foam plastic sheathing, corrugated metal ties shall be fastened through the foam plastic sheathing using a 10d common nail with a minimum penetration of 1 1/2 inches (38 mm) into wood framing for a maximum wind condition of 90 miles per hour (40 m/s) in wind exposure B. For a basic wind speed not exceeding 110 miles per hour (49 m/s) in any wind exposure and in Seismic Design Categories C, D0, D1, and D2, a #8 wood screw with a minimum 1 inch (25.4 mm) penetration into wood wall framing shall be used in each tie. Alternatively, an approved fastener with equivalent withdrawal strength shall be permitted.

> **Exception:** In Seismic Design Category D0, D1 or D2 or townhouses in Seismic Design Category C or in wind areas of more than 30 pounds per square foot pressure (1.44 kPa), each tie shall support not more than 2 square feet (0.2 m2) of wall area.

Revise existing Section R703.11.2 as follows:

R703.11.2 Foam plastic sheathing. Vinyl siding used with foam plastic sheathing shall be installed in accordance with Section R703.11.2.1, R703.11.2.2, or R703.11.2.3.

Exception: Where the foam plastic sheathing is applied directly over wood structural panels, fiberboard, gypsum sheathing or other *approved* backing capable of independently resisting the design wind pressure, the vinyl siding shall be installed in accordance with Section R703.11.1.

R703.11.2.1 Basic wind speed not exceeding 90 miles per hour and Exposure Category B. Where the basic wind speed does not exceed 90 miles per hour (40 m/s), the Exposure Category is B and gypsum wall board or equivalent is installed on the side of the wall opposite the foam plastic sheathing, the minimum siding fastener penetration into wood framing shall be 11/4 inches (32 mm) using minimum 0.120-inch diameter nail (shank) with a minimum 0.313-inch diameter head, 16 inches on center. The foam plastic sheathing minimum thickness shall comply with Section R703.3.1 and shall not exceed a maximum thickness of 1.5 inches (38 mm) for a 0.120-inch diameter nail or 2.0 inches (51 mm) for a 0.135-inch diameter nail. ~~shall be 1/2-inch-thick (12.7 mm) (nominal) extruded polystyrene per ASTM C578, 1/2-inch-thick (12.7 mm) (nominal) polyisocyanurate per ASTM C1289, or 1-inch-thick (25 mm)(nominal) expanded polystyrene per ASTM C578.~~ Vinyl siding shall be permitted to be installed on furring strips in accordance with Section R703.3.2.2 using the siding manufacturer's installation instructions when foam plastic sheathing thickness complies with Section R703.3.1.

R703.11.2.2 Basic wind speed exceeding 90 miles per hour or Exposure Categories C and D. Where the basic wind speed exceeds 90 miles per hour (40 m/s) or the Exposure Category is C or D, or all conditions of Section R703.11.2.1 are not met, the adjusted design pressure rating for the assembly shall meet or exceed the loads listed in Tables R301.2(2) adjusted for height and exposure using Section R301.2(3). The design wind pressure rating of the vinyl siding for installation over solid sheathing as provided in the vinyl siding manufacturer's product specifications shall be adjusted for the following wall assembly conditions:

1. For wall assemblies with foam plastic sheathing on the exterior side and minimum ½-inch-thick gypsum wall board or equivalent on the interior side of the wall, the vinyl siding's design wind pressure rating shall be multiplied by 0.39.
2. For wall assemblies with foam plastic sheathing on the exterior side and no gypsum wall board or equivalent on the interior side of wall, the vinyl siding's design wind pressure rating shall be multiplied by 0.27.

Exception: The above adjustments shall not apply when vinyl siding is attached to wood furring strips installed over the foam plastic sheathing in accordance with Section R703.3.2.2 and such installation is in accordance with the vinyl siding manufacturer's installation instructions.

R703.11.2.3 Manufacturer specification. Where the vinyl siding manufacturer's product specifications provide an *approved* design wind pressure rating for installation over foam plastic sheathing, use of this design wind pressure rating shall be permitted and the siding shall be installed in accordance with the manufacturer's installation instructions