ABTG

Research Report

IRC Wall Bracing:
A Guide for Builders, Designers and Plan Reviewers

ABTG Research Report No. 1601-01

Conducted for the Membership of the Foam Sheathing Committee (FSC)

Report Written by:

Applied Building Technology Group, LLC
appliedbuildingtech.com

Final Report: January 6, 2016
Updated: January 14, 2021

ABTG is an APPROVED SOURCE

This research report is based on practical scientific research (literature review, testing, analysis, etc.). This research report complies with the following sections of the building code:

- *IBC* Section 104.11.1 and Section 1703.4.2 – "**Research reports.** Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from *approved sources*."
- *IBC* Section 202 – "**APPROVED SOURCE.** An independent person, firm or corporation, *approved* by the *building official*, who is competent and experienced in the application of engineering principles to materials, methods or systems analyses."

Table of Contents

Introduction **3**

List of Figures/Tables **4**

Section 1: Basic Concepts for Code-Compliant Wall Bracing **5**

1.1 Why is Wall Bracing Needed? 5
1.2 How does Wall Bracing Work? 5
1.3 When Should I Consider Wall Bracing? 6
1.4 Scope Limitations 6
1.5 Definitions 7
1.6 Key Concepts and Rules 7

Section 2: *IRC* Wall Bracing Methods **11**

2.1 Overview 11
2.2 Intermittent Braced Wall Panel Construction Methods 12
2.3 Continuously Sheathed Methods 19
2.4 Important Construction Requirements for Wall Bracing 26

Section 3: Applying the Code **27**

3.1 Overview 27
3.2 Applying the Code: Step by Step 31
3.3 Calculating the Required Length of Bracing 31
3.4 Verifying the Provided Length of Bracing 33

Section 4: 'Beyond Code' Bracing Solutions **34**

4.1 Overview 34
4.2 Custom Engineered Solutions 34
4.3 Useful Engineering Concepts 34
4.4 Proprietary Bracing Products 37

Section 5: Wall Bracing Options for Foam-Sheathed Walls **37**

5.1 Wall System Design – Bracing and Beyond 37
5.2 Why Use Foam Sheathing? 37
5.3 Meeting Energy Code Requirements 39
5.4 Which Bracing Method(s) to use with Foam Sheathing? 39
5.5 Examples 41
5.6 Interfaces between Materials 42

Section 6: Resources and References **43**

Appendix A: Wall Bracing Design and Plan Check Worksheet **44**

Appendix B: Engineered Design Example Using *IRC* Bracing Provisions **45**

Appendix C: Design Examples **50**

About this Research Report:

Applied Building Technology Group (ABTG) is committed to using sound science and generally accepted engineering practice to develop research supporting the reliable design and installation of foam sheathing. ABTG's work with respect to foam sheathing is provided through a grant by the the Foam Sheathing Committee (FSC) of the American Chemistry Council. Foam sheathing research reports, code compliance documents, educational programs, and best practices can be found at www.continuousinsulation.org.

ABTG Scope of Work:

While the information in this report is believed to be accurate, ABTG cannot and does not warrant the accuracy, correctness, or completeness of any interpretation, research, analysis, or recommendation for a particular use. The report is to be accepted "AS IS" and ABTG makes no representation or warranty, express or implied, of any kind or description in respect thereto, and that any actions taken in reliance on this report shall be an end-user responsibility.

The scope of this research report is as defined herein. This examination, report, and any opinions herein have been conducted and prepared in accordance with standard practice guidelines within the engineering profession, based on the information readily available to ABTG as referenced herein. Where appropriate, ABTG relies on the derivation of design values, which have been codified into law through the codes and standards (e.g., *IRC*, *WFCM*, *IBC*, *SDPWS*, etc.), to undertake review of test data, related research, and analysis, and references such. Also, ABTG may rely upon proprietary research, testing, and analysis, and references such.

ABTG reserves the right to supplement or revise this research report, based on new scientific, testing, or analytical information that becomes available to ABTG. Updates may also be made based on any peer review or critique of any ABTG report.

The most recent version of any ABTG research report will be found at appliedbuildingtech.com.

Appendix D: Technical Guidance for Appropriate Use of Foam Sheathing.....63

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 Version 2.1 of 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.

The prior version of this Guide, Version 2.1, updated 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*. Version 3.0 is provided to make minor revisions and updates pending a future update to the 2015 *IRC* expected to occur in 2016.

The Guide is divided into six sections intended to supplement and enhance the *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. Appendix B demonstrates a simple and efficient engineering-based approach to application of the *IRC* bracing provisions by design professionals. Appendix C of this Guide offers two complete wall bracing design examples. Appendix D provides technical guidance for using foam sheathing in an appropriate manor.

Notice:
Refer to the Disclaimer at the end of this Guide. It is the user’s responsibility to determine fitness of use of any information provided in this guide. The Guide is based on the 2009 Edition of the International Residential Code (*IRC*). However, the concepts and principles and many of the requirements apply similarly for the 2012, 2015, and 2018 editions of the *IRC*.

List of Figures/Tables:

Table 1: Intermittent Bracing Methods and Requirements 14
Table 2: Minimum Length Requirements for Braced Wall Panels[a] 14
Table 3: Effective Lengths for Braced Wall Panels Less Than 48 Inches in Actual Length 15
Table 4: Hold-Down Forces for Method ABW Braced Wall Panels 18
Table 5: Continuous Sheathing Bracing Methods 20
Table 6: Length Requirements for Braced Walls with Continuous Sheathing[a] 21
Table 7: Length of Bracing Requirements 29
Table 8: Tabluated Footnotes for Table 7 30
Table 9: Wall Functions and the Role of Foam Sheathing 38
Table 10: Common IRC Wall Bracing Methods and Foam Sheathing Applications 40

Figure 1: Wall Bracing and Racking Forces 5
Figure 2: Braced Wall Line Layout Rules (Offsets and Ends) 8
Figure 3: Braced Wall Panels and Braced Wall Lines 9
Figure 4: Braced Wall Panel End Distance Requirements 10
Figure 5: Angled Corners 11
Figure 6: Illustration of intermittent, continuous, and mixed bracing methods. 12
Figure 7: Method PFG Portal Frame at Garage Door Openings 16
Figure 8: Method PFH Portal Frame with Hold Downs 17
Figure 9: Alternate Braced Wall Panel 18
Figure 10: Limits for Large Openings in Braced Wall Lines with Intermittent Bracing 19
Figure 11: Corner Framing for Continuous Structural Sheathing 22
Figure 12: Corner Return Detail for Braced Wall Line with Continuous Sheathing 22
Figure 13: Braced Wall Line with Continuous Sheathing and without Corner Return Detail 23
Figure 14: Braced Wall Line with Continuous Sheathing 23
Figure 15: Braced Wall Line with Continuous Sheathing —First Braced Wall 24
Figure 16: Method CS-PF: Continuous Portal Frame Construction 25
Figure 17: Example house plan for bracing length calculation 33
Figure 18: Bracing Transfer 36
Figure 19: Cavity Insulation and Wall Framing 39
Figure 20: Illustration of Bracing Methods with Foam Sheathing 41

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" thus, preventing 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.

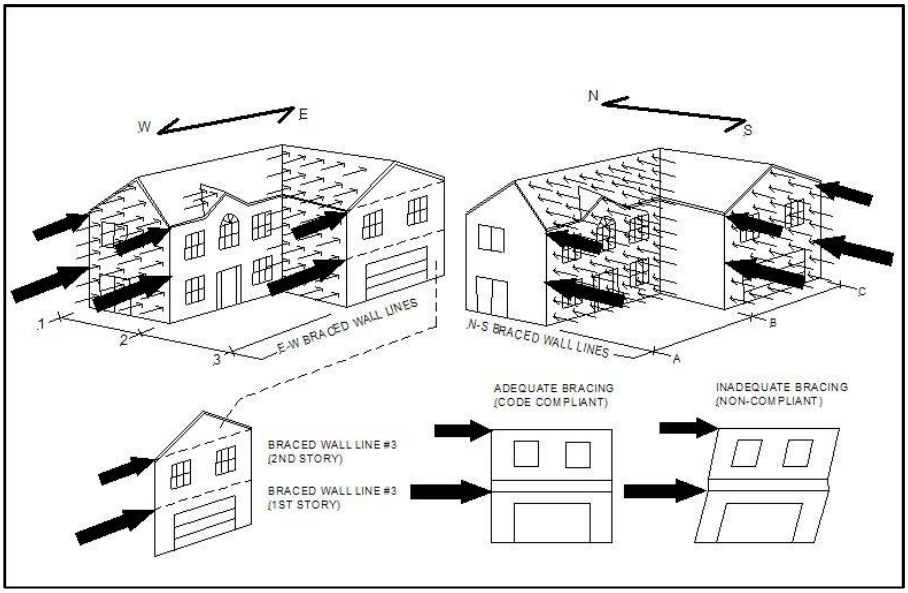


Figure 1: Wall Bracing and Racking Forces

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 lines[1]". 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 *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 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 factors listed:

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

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 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[2]. 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 *IRC* requires information to be included within building plans to obtain a building permit:

> ***IRC* Section 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 bracing 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 *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[3]
- Conventional wood frame construction
- One- and two-family dwellings of no more than three-stories[4]
- Design wind speed of less 110 mph (3 second gust)
- Seismic Design Category (SDC) of A/B/C per *IRC* Section R301.2(2)

[2] Use of continuous wood structural panel bracing or proprietary insulated structural sheathing panels are often used to avoid conflicts with use of foam sheathing and a sufficient amount of intermittent braces, although this may not be an issue for many small, affordable homes.

[3] Much of the content of this guide is also relevant to the 2012, 2015, and 2018 editions of the *IRC*; however, section number referencing and possible technical changes should be verified.

[4] 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.

This Guide is intended to be a helpful companion to the *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 *IRC* Figure R301.2(2) Seismic Design Categories and *IRC* Figure R301.2(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) 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.

1.5 Definitions

The following definitions explain some important terms used throughout the *IRC* bracing requirements and this Guide. Refer also to *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 Panels. 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 (*IRC* Section 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 Figure 2. Generally, all exterior walls are considered to be part of a braced wall line (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 (*IRC* Section 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 (*IRC* Section 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.

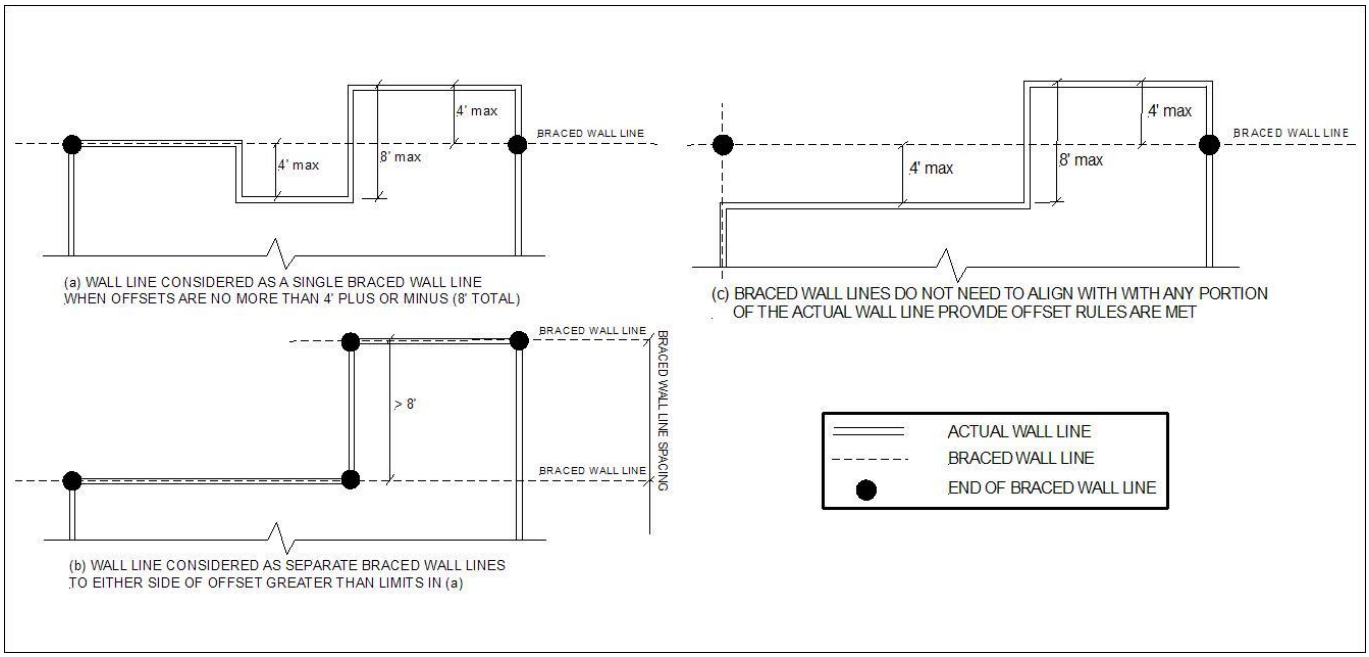
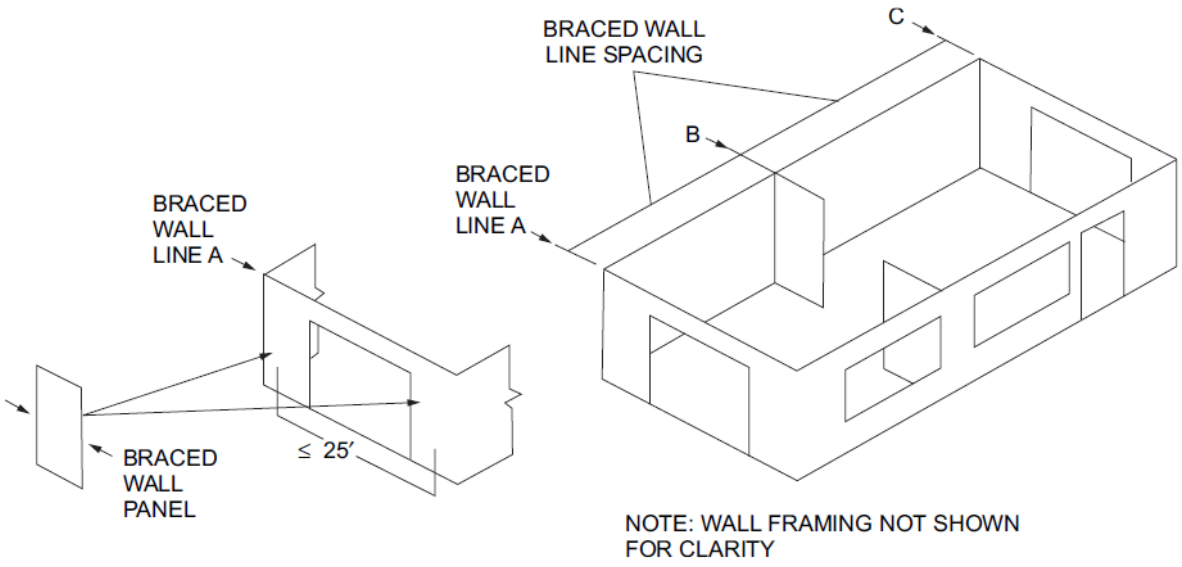


Figure 2: Braced Wall Line Layout Rules (Offsets and Ends)

Braced Wall Line Spacing (*IRC* Section R602.10.1.3) – 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 *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). 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.

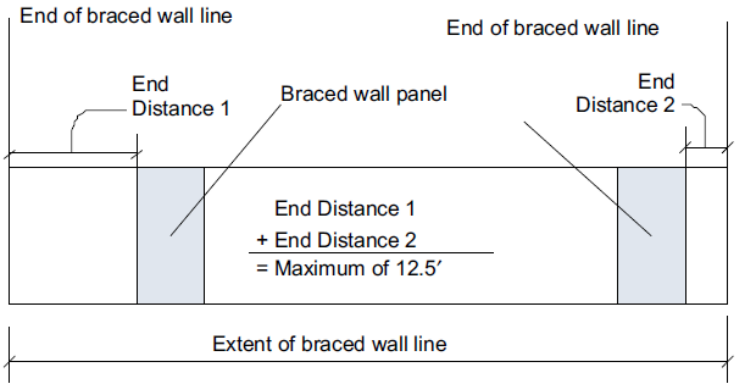
Braced Wall Panel (*IRC* Section R602.10.1.1) – Also shown in Figure 3, a braced wall panel (BWP) is a section of a braced wall line that is specifically braced with a code-compliant bracing method (e.g., let-in brace, a wood structural panel, or other bracing methods). The various braced wall panel 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 *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 (*IRC* Section 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 *IRC* Section 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, *IRC* 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.

International Residential Code 2012, 2015, and 2018 includes:

- A reduction of the BWP end distance to 10' and the elimination of the cumulative 12.5' end distance
- Spacing of BWPs is changed from 25'oc to 20' edge-to-edge
- 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* 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 (*IRC* Section R602.10.1.1)– The *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 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 (*IRC* Section R602.10.1.3) **–** 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 lines 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.

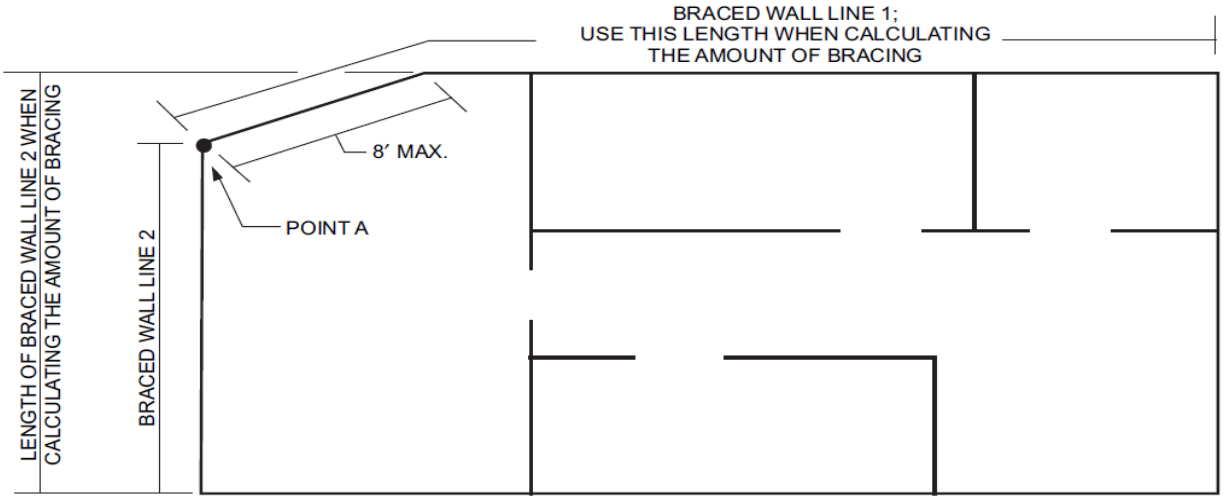


Figure 5: Angled Corners - *IRC* Figure R602.10.1.3

Section 2: *IRC* Wall Bracing Methods

2.1 Overview

In this section, the various bracing methods in the *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 and affordability (see Section 5). Therefore, it is important to start with a working knowledge of the various bracing methods featured in the *IRC*.

Beginning in the 2009 *IRC* bracing provisions, the bracing methods were renamed and divided into two categories as illustrated in Figure 6:

- Intermittent Braced Wall Panel Construction Methods
- 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 *IRC* provisions.

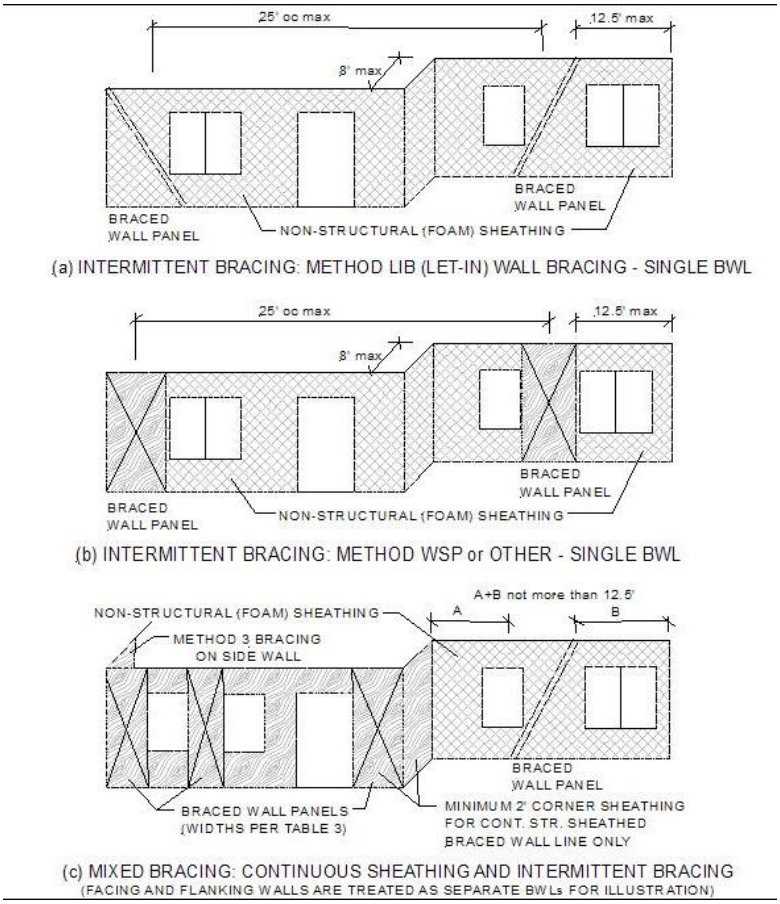


Figure 6: Illustration of intermittent, continuous, and mixed bracing methods.

2.2 Intermittent Braced Wall Panel Construction Methods

The intermittent bracing methods include traditional methods of bracing and are retained and improved in modern editions of the *IRC* to ensure consistency of all bracing methods, including continuous and narrow panel bracing methods addressed later. Table 1 lists 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 *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, such as composite panels known as structural insulated sheathing.

Method	Material	Minimum Thickness	Connection Criteria	BWP Minimum Length & Maximum Wall Height
LIB	Let-in-bracing	1×4 wood or approved metal straps 45° to 60° angles 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 see Table 2 : For LIB bracing wall height should not exceed 10 feet
DWB	Diagonal wood boards	3/4" (1"nominal) maximum 24"stud spacing	2-8d (2-1/2"×0.113") nails or 2 staples, 1-3/4" per stud	: See Table 2 and "partial credit" allowance of Table 3 : Maximum wall height of 12'
WSP	Wood structural panel *IRC* Section R604	3/8" for maximum 16" stud spacing	6d common (2 x 0.113) nail 6 inches o.c. at edges 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 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 3" spacing (panel edges) 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 BWP)	1/2"	Nails or screws at 7" spacing at panel edges and at intermediate supports Exterior gypsum sheathing at GB braced wall panels, use fastener size and type in accordance with *IRC* Table R602.3(1) 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" of Table 3 does not apply to GB : Maximum wall height of 12'
PBS	Particleboard sheathing *IRC* 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 3" spacing (panel edges) 6" spacing (intermediate supports)	: Refer to Table 2 and "partial credit" allowance of Table 3 : Maximum wall height of 12'

PCP	Portland cement plaster	*IRC* 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 4" spacing (panel edges) 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 *IRC* Section R602.10.3.2	See *IRC* Section R602.10.3.2 for special framing, fastening and hardware requirements	: 32" minimum; See *IRC* 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 *IRC* Section R602.10.3.3	See *IRC* Section R602.10.3.3 for special framing, fastening and hardware requirements	: 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 *IRC* Section R602.10.3.4	See *IRC* Section R602.10.3.4for special framing, fastening and hardware requirements	: Minimum length based on a 4:1 height to length ratio ex. 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'

Table 1: Intermittent Bracing Methods and Requirements

IMPORTANT *IRC* Section R602.10.2.1 of the 2009 *IRC* (and also the 2012, 2015, and 2018 *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 (Table 7, footnote 'f').

The 1.5 adjustment factor in 2009 *IRC* Section R602.10.2.1 is actually an error and should not be used

Method (See Table 1)		Minimum Length (in)					Contributing Length (in)[b]
		Wall Height					
		8 ft	9 ft	10 ft	11 ft	12 ft	
DWG, WSP, SFB, PBS, PCP, HPS		48	48	48	53	58	Actual (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

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

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).

Actual Length OF Braced Wall Panels (in)	Effective Length OF Braced Wall Panels (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

Table 3: Effective Lengths for BWP Less Than 48 Inches in Actual Length - *IRC* Table R602.10.3

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 and 2009 *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 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.

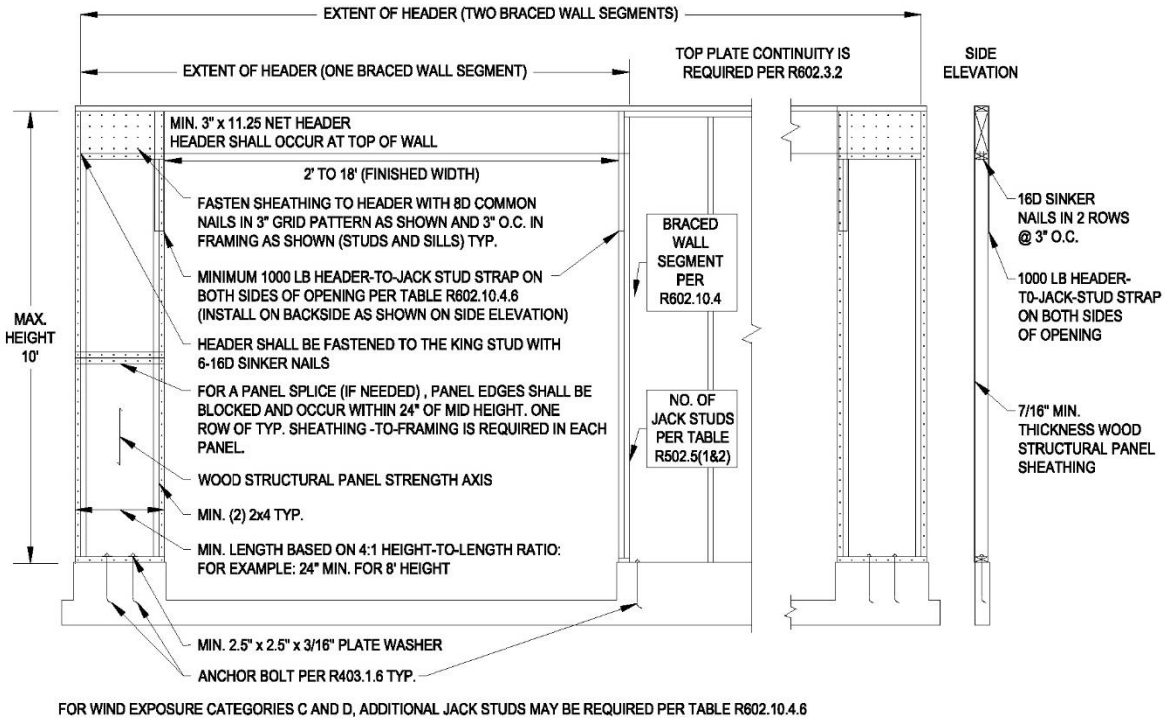
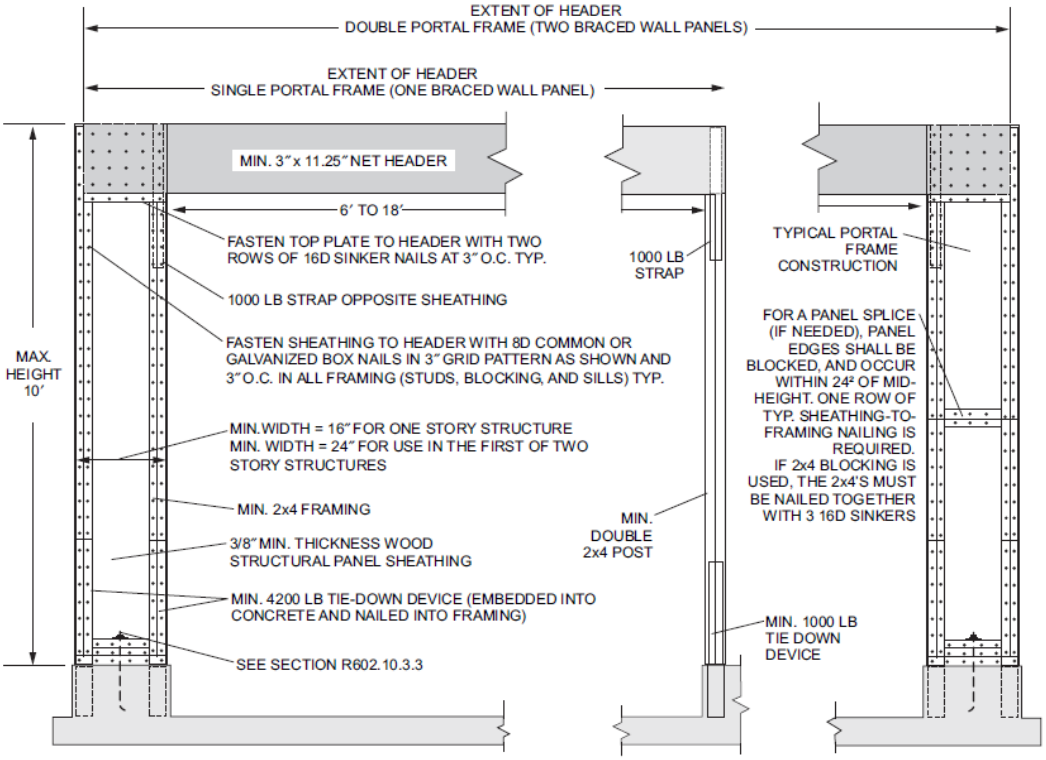


Figure 7: Method PFG Portal Frame at Garage Door Openings Similar to 2009 - *IRC* Section R602.10.3.4

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 *IRC* Section R602.10.3.4, Item 5, but is not specifically stated in *IRC* 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.

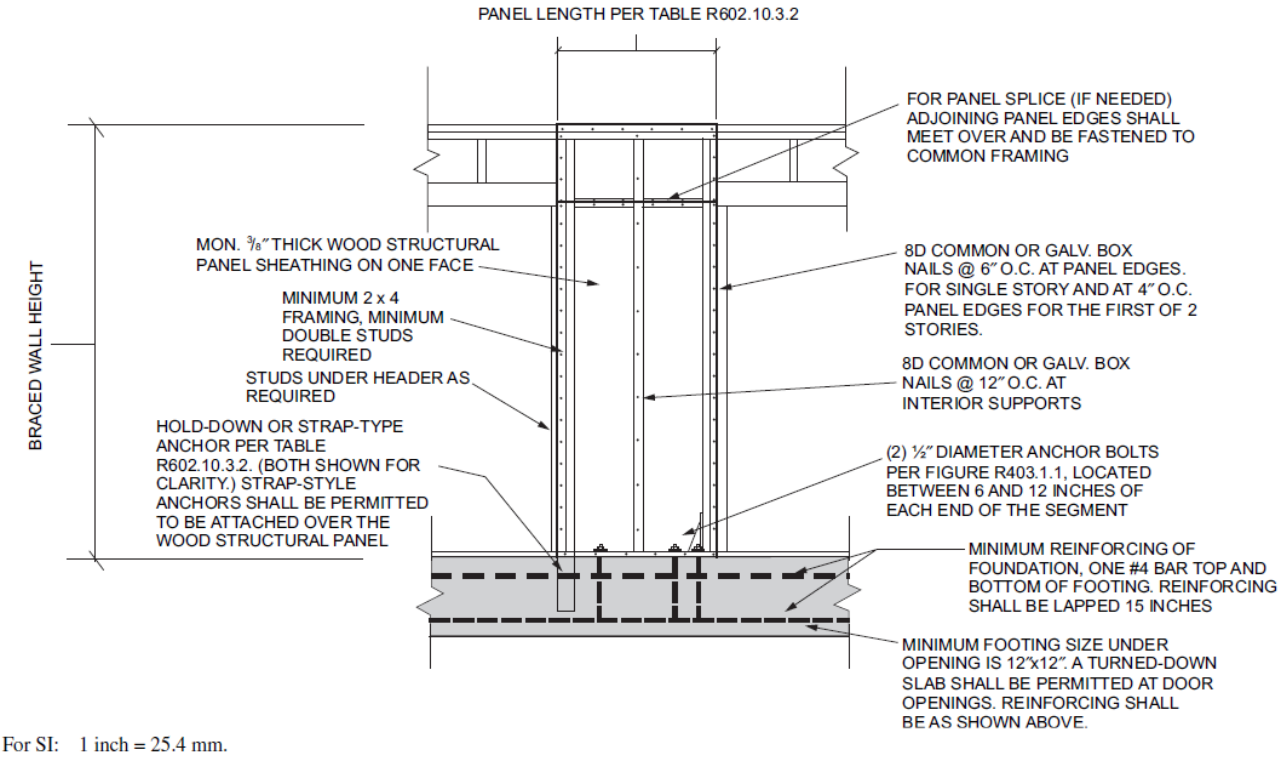
Figure 8: Method PFH Portal Frame with Hold Downs - *IRC* Figure R602.10.3.3

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* Section 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



For SI: 1 inch = 25.4 mm.

Figure 9: Alternate Braced Wall Panel - *IRC* Figure 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

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

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.

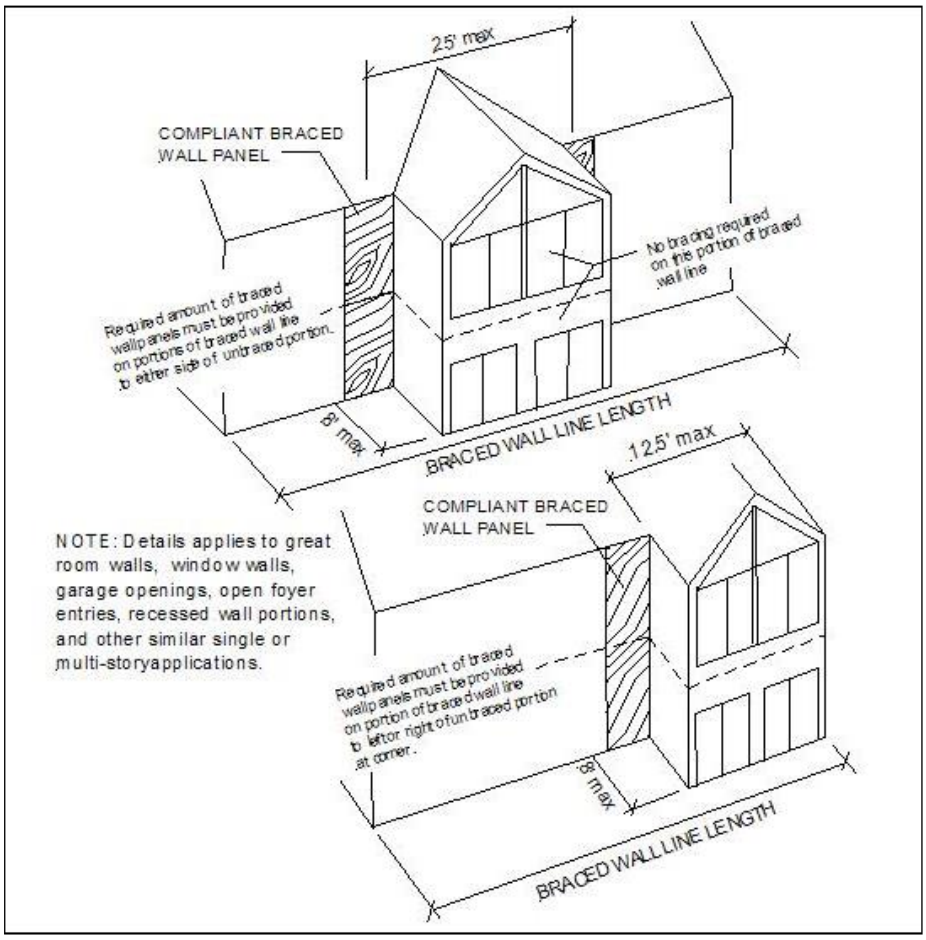


Figure 10: Limits for Large Openings in Braced Wall Lines with Intermittent Bracing

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.

Method	Sheathing Material	Minimum Thickness	Connection Criteria	BWP Minimum Length & Maximum Wall Height
CS-WSP (*IRC* Sections R602.10.4)	Wood structural panel	3/8"	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 (*IRC* Section R602.10.4.1.1)	Continuously sheathed portal frame	7/16"	*IRC* 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 (*IRC* Section R602.10.5)	Structural fiber board	½"	Table 1, Method SFB	:Refer to Table 6 :Maximum wall height of 12 feet

Table 5: Continuous Sheathing Bracing Methods

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 (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 Figure 11 and Figure 12 or, alternatively, one of the optional framing conditions in Figures 13 through Figure 15 shall be provided.

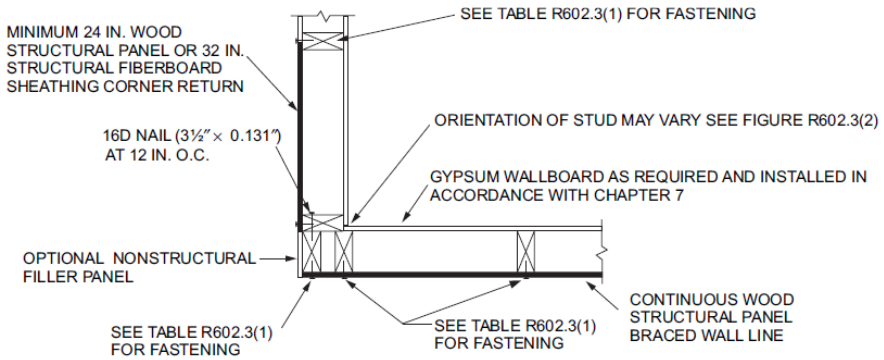
For additional restrictions on Method CS-PF, see section on narrow wall options.

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	

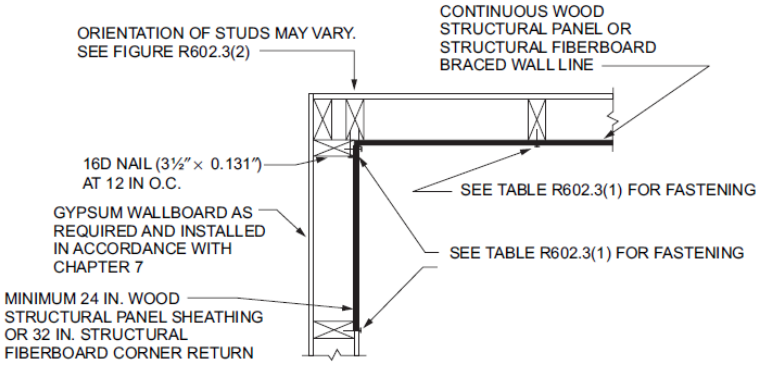
NP = Not permitted
a. Linear interpolation shall be permitted.
b. Contributing length is the length of a BWP along a BWL that can be counted toward the required bracing amount for a BWL (see Section 3). Use actual length when it is greater than or equal to the minimum length.

Table 6: Length Requirements for Braced Walls with Continuous Sheathing[a]

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

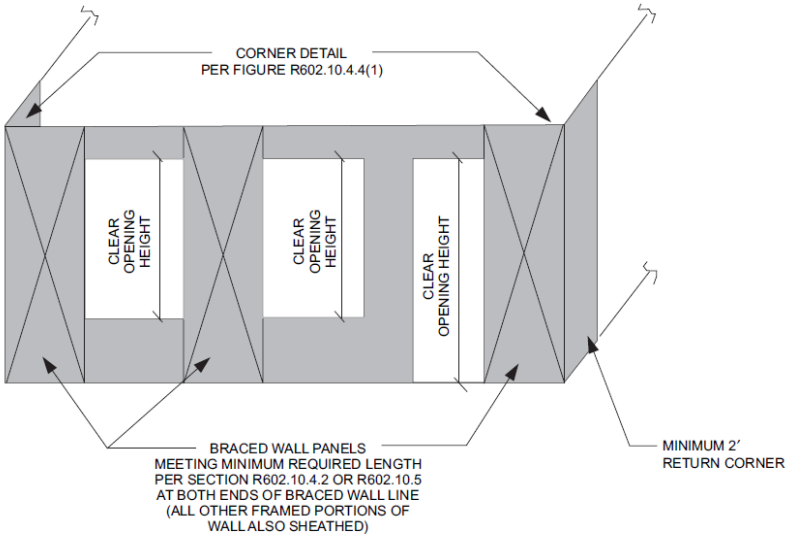


(a) OUTSIDE CORNER DETAIL



(b) INSIDE CORNER DETAIL

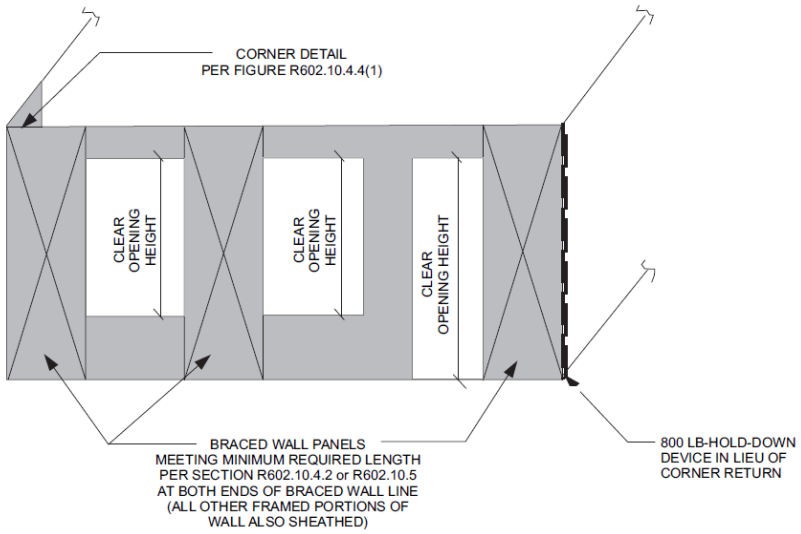
Figure 11: Corner Framing for Continuous Structural Sheathing - *IRC* Figure R602.10.4.4(1)



For SI: 1 foot = 304.8 mm.

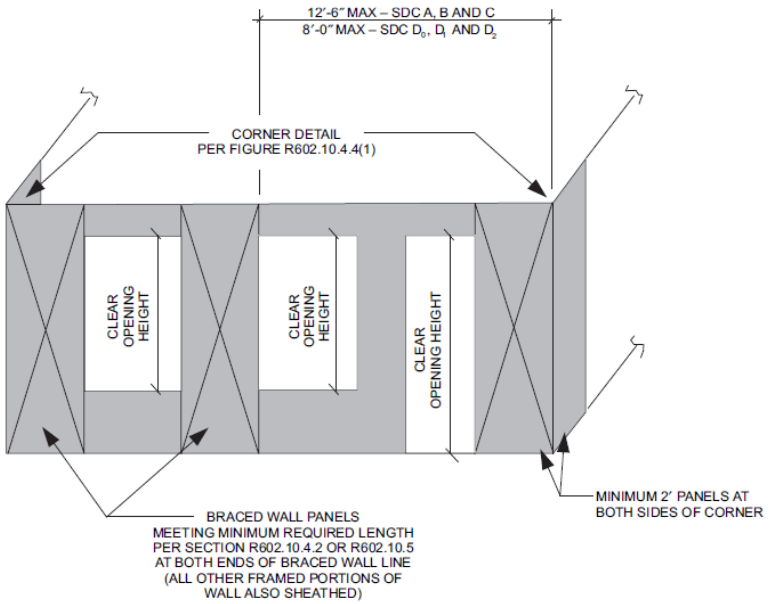
Figure 12: Corner Return Detail for Braced Wall Line with Continuous Sheathing - *IRC* Figure R602.10.4.4(2)

Figures 13 through Figure 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).



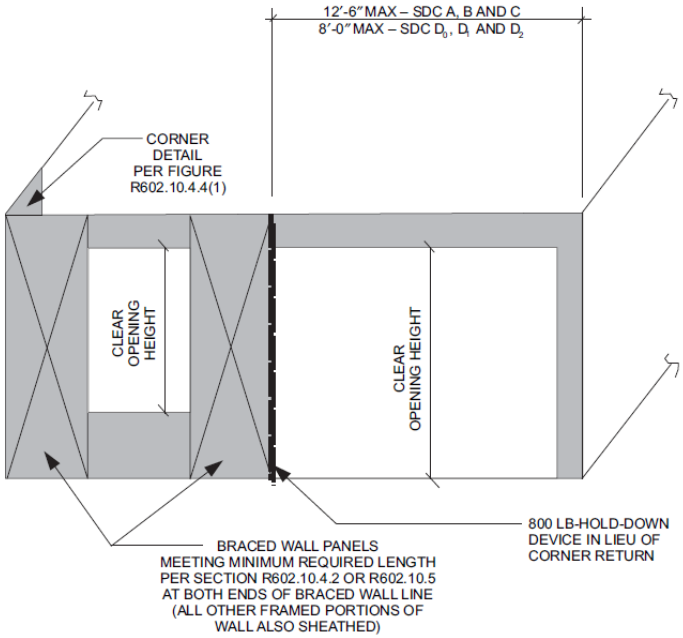
For SI: 1 inch = 25.4 mm, 1 pound = 4.448 N.

Figure 13: Braced Wall Line with Continuous Sheathing without Corner Return Detail



For SI: 1 inch = 25.4 mm.

Figure 14: Braced wall line with continuous sheathing - First BWP away from end of wall line, without tie down



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

Figure 15: Braced wall line with continuous sheathing — First BWP away from end of wall line with tie down

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

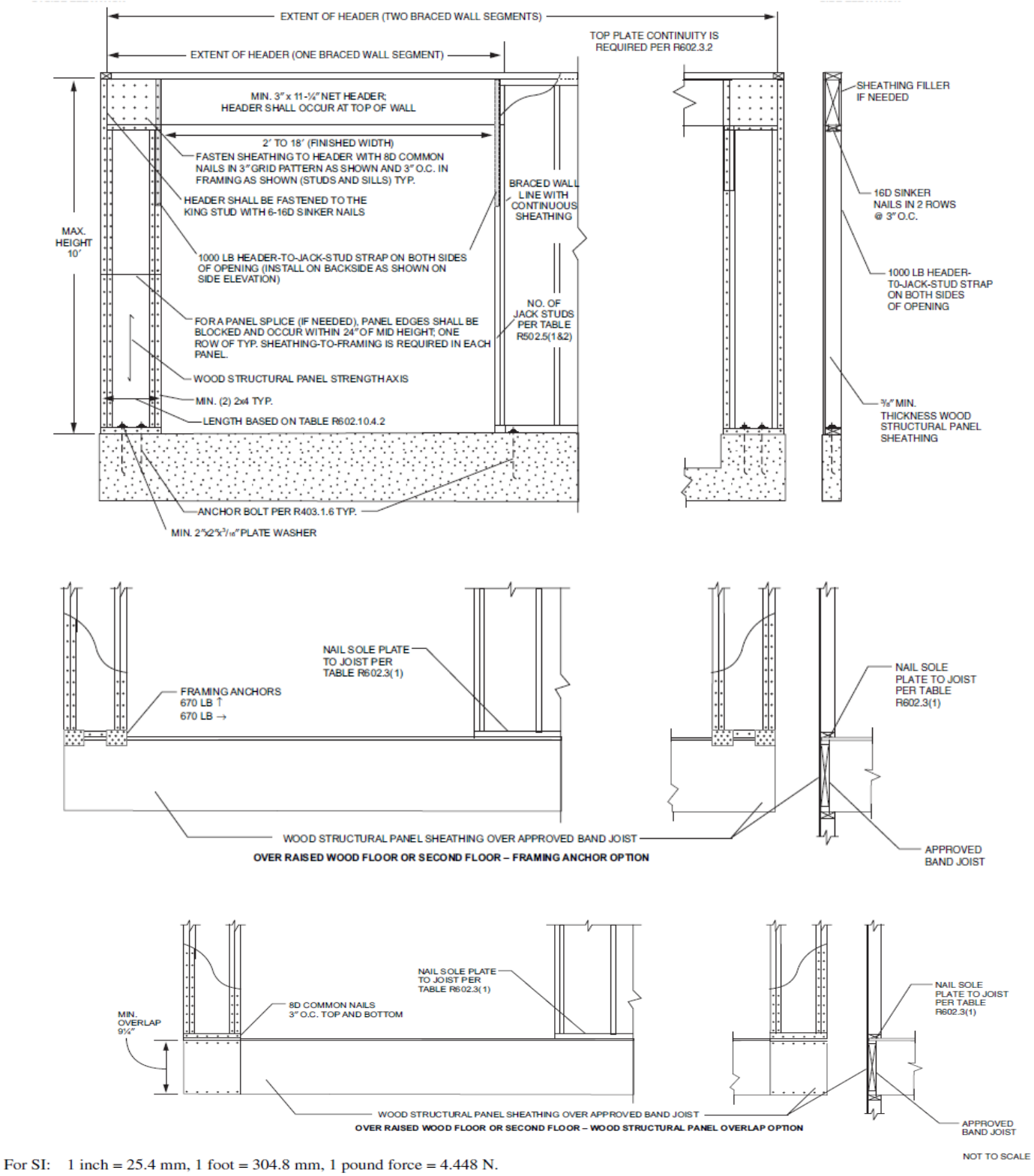
A special exception to Table 6 provides for CS-WSP braced wall panel widths as narrow as 2 feet for limited use in a garage opening wall per Table 6. Restrictions include:

- 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 Figure 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 for increased size for the 1,000 lbs. 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

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 Table 4 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 *IRC* Tables R602.10.1.2(1) and *IRC* Table 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 the 2012 *IRC*).

- 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 and later editions of *IRC* contain 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 were first added in 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 *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. Improved (more efficient) wind uplift load requirements are now included in *IRC* Section R802.11 of the 2012, 2015, and 2018 *IRC*.

Braced Wall Panel Support
IRC 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

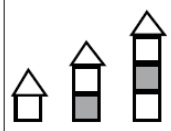
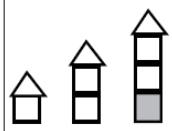
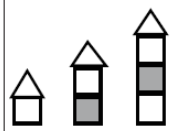
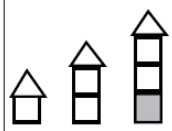
Refer to Section 1 of this Guide for important information on basic concepts and requirements related to braced wall lines, braced wall panels, braced wall panel location, braced wall line spacing, mixing of bracing methods, and angled corners.
Refer to Section 2 of this Guide for specific requirements 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 *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 Section 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)
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.

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)

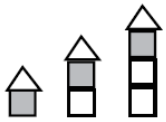
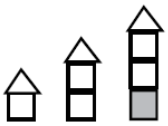
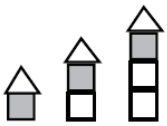
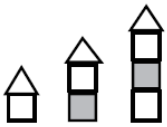
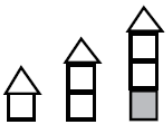
EXPOSURE CATEGORY B, 30 FT MEAN ROOF HEIGHT, 10 FT EAVE TO RIDGE HEIGHT, 10 FT WALL HEIGHT, 2 BRACED WALL LINES			MINIMUM TOTAL LENGTH (feet) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE			
Basic Wind Speed (mph)	Story Location	Braced wall Line Spacing (feet)	Method LIB[f, h]	Method GB (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

Table 7: Length of Bracing Requirements - *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

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* and is consistent with newer requirements in the 2012, 2015, and 2018 *IRC*.

Table 8: Tabulated Footnotes for Table 7 Length of Bracing Requirements

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 or methods for each braced wall line (see Section 2) and record the braced wall line length in feet.

Step 4: Determine the tabulated bracing amount for each BWL (see Table 7) and multiply by all appropriate adjustment factors in footnotes in 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 locate 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
- 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 Table 7) 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.

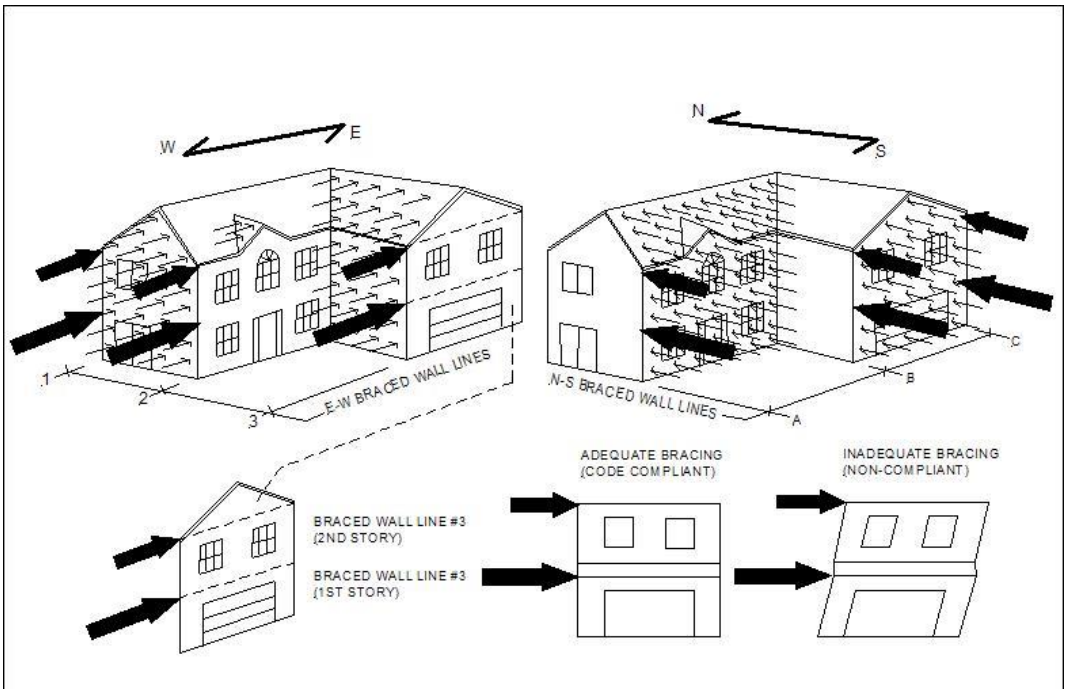


Figure 17*:* Example house plan for bracing length calculation

In Appendix C of 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:

> Using the example from 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). 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 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). 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 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 Appendix C of 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)
- 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, Section R104.11 and Section 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 – 2000 Edition* (*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. 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 – 2000 Edition* (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 on (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.

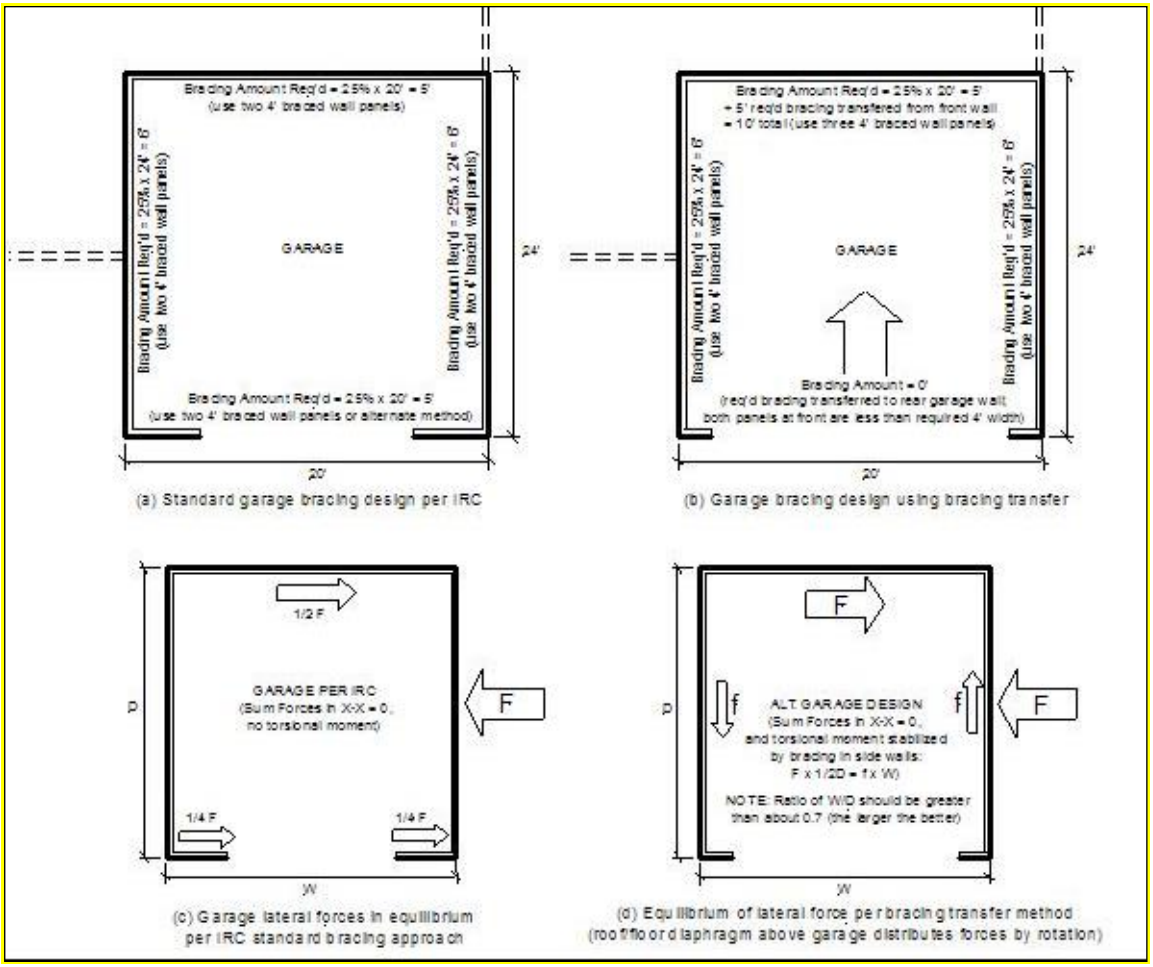


Figure 18: Bracing Transfer

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 first introduced wind uplift connection requirements for braced wall panels that support roof members, 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. In addition, supplemental wind uplift straps generally are still required at edges of wall openings where uplift forces are concentrated. 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. 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.

Contact the proprietary brace manufacturer for additional guidance and requirements.

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.

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 *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 9 and Figure 19. Foam sheathing can serve 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 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.

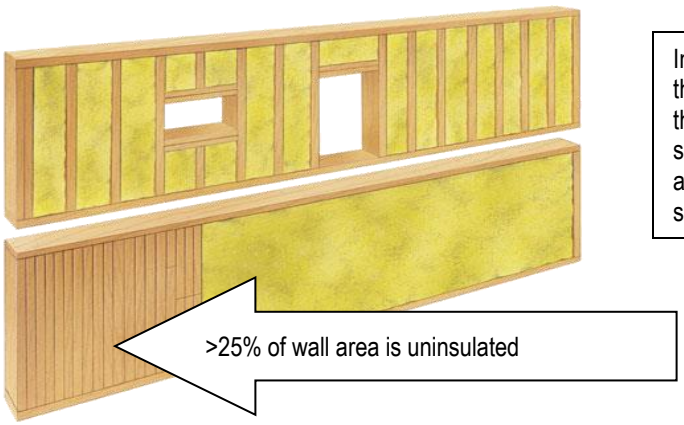
Although foam sheathing is NOT an acceptable wall bracing material on its own, the additional benefits – especially for energy efficiency and moisture resistance – and the range of available of compatible bracing techniques – makes it a preferred choice in many wall configurations.

Wall Function*	Foam Sheathing Role in Wall Function	*IRC* Code Reference[5]	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	Section 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 ANSI/SBCA FS 100 standard for foam sheathing wind rating when not use as oversheathing.
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). Also, may help 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	Most foam sheathing products are air barrier materials and can be used as such with taped joints and other installation details for continuous of the air barrier assembly.
Control rain penetration	Can qualify as a water resistive barrier	R703.2 Table R703.4	Approved foam sheathing materials and accessories (e.g., joint tape and flashing tapes) can be used as a water-resistive barrier and does not need a separate WRB/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. When specified at an appropriate R-value, foam sheathing reduces the potential for condensation in walls by helping to keep the inside of the wall above the "dew point" temperature.

** from Hutcheon*
** from Hutcheon*

Table 9: Wall Functions and the Role of Foam Sheathing in Above-Grade Residential Walls

[5] 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. 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 moderately cold climates where R20 cavity insulation or R13 cavity insulation plus R5 continuous foam sheathing insulation is required (e.g., see Climate Zones 4 and greater 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 (R20 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 provide a beneficial long-term pay-back.

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

As summarized in Table_10, 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.

Bracing Method[6]	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**: Not practicable for 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.

Table 10: Common Wall Bracing Methods and Foam Sheathing Applications

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.

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

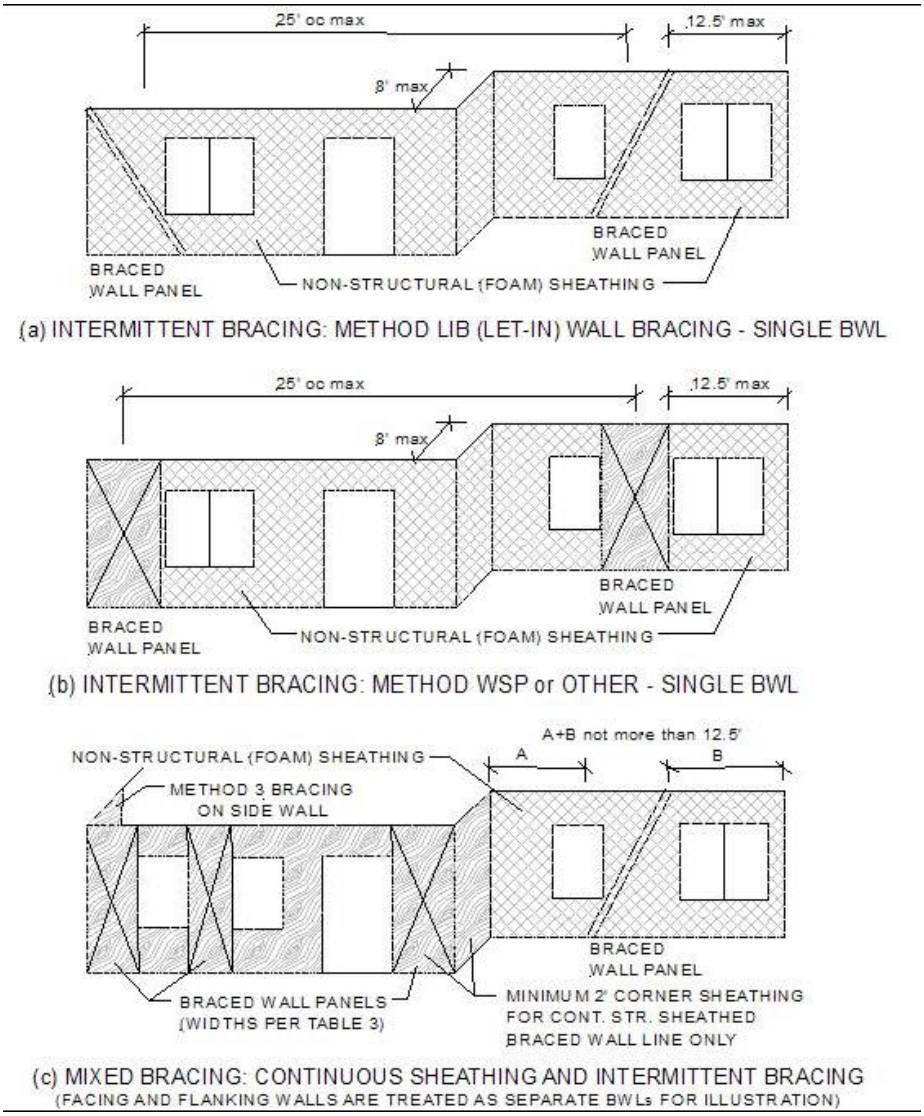


Figure 20: Illustration of Bracing Methods with Foam Sheathing

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.

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)

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

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 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 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 3: Continuous, Variable Thickness Foam Sheathing over 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).

Example 4: Foam Sheathing Only Between Intermittent Brace Panels

NOTE: The energy code allowance to use reduced thickness of foam sheathing over intermittent bracing panels only applies to walls where no more than 40% of the gross area of the wall is covered with structural panels.

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; 2012; 2015; 2018) – www.iccsafe.org

Chapters 16 and 23 of the *International Building Code* (ICC, 2006-2018) – www.iccsafe.org

Minimum Design Loads for Buildings and Other Structures (ASCE, 2005; 2010; 2016) – www.asce.org

National Design Specification for Wood Construction (AF&PA, 2005; 2008; 2012; 2015; 2018) – www.awc.org

Special Design Provisions for Wind and Seismic (AF&PA, 2005; 2008; 2012; 2015; 2018) – www.awc.org

Standard for Residential Construction in High-Wind Regions, ICC 600-2008; 2014 – www.iccsafe.org

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

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.appliedbuildingtech.com

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

Proprietary Bracing Products:

- Composite structural insulated panels (various manufacturers/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)

Appendix A:
Wall Bracing Design and Plan Check Worksheet

STEP 1		STEP 2		STEP 3		STEP 4		STEP 5	STEP 6	STEP 7		Comments
Braced Wall Line ID	Maximum BWP Offset from BWL ≤4'? (Yes or No)	Support Condition Roof only Roof+1 floor Roof +2 floors	BWL Spacing (feet)	Selected Bracing Method(s)	Braced Wall Line Length (feet)	Tabulated Bracing Length from Table 7 (inches)	Adjusted Bracing Length Table 8 (inches)	Bracing Length Provided by BWPs (inches)	Is Value in STEP 4 ≥ Value in STEP 5 (Yes or No)	Is BWP cumulative distance from ends of BWL ≤12.5? (Yes or No)	Do BWPs comply with maximum 25'oc spacing along BWP? (Yes or No)	

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_8:

  Main Building Portion
  - 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)

  Wings (Conservatory and Suite)
  - 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)

  General
  - # of BWLs adjustment (not applicable – bracing based on total for overall plan dimensions)
  - All bracing has interior GWB finish per *IRC* Chapter 7

Figure 21: Elevation Views of Example House

Bracing Analysis

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

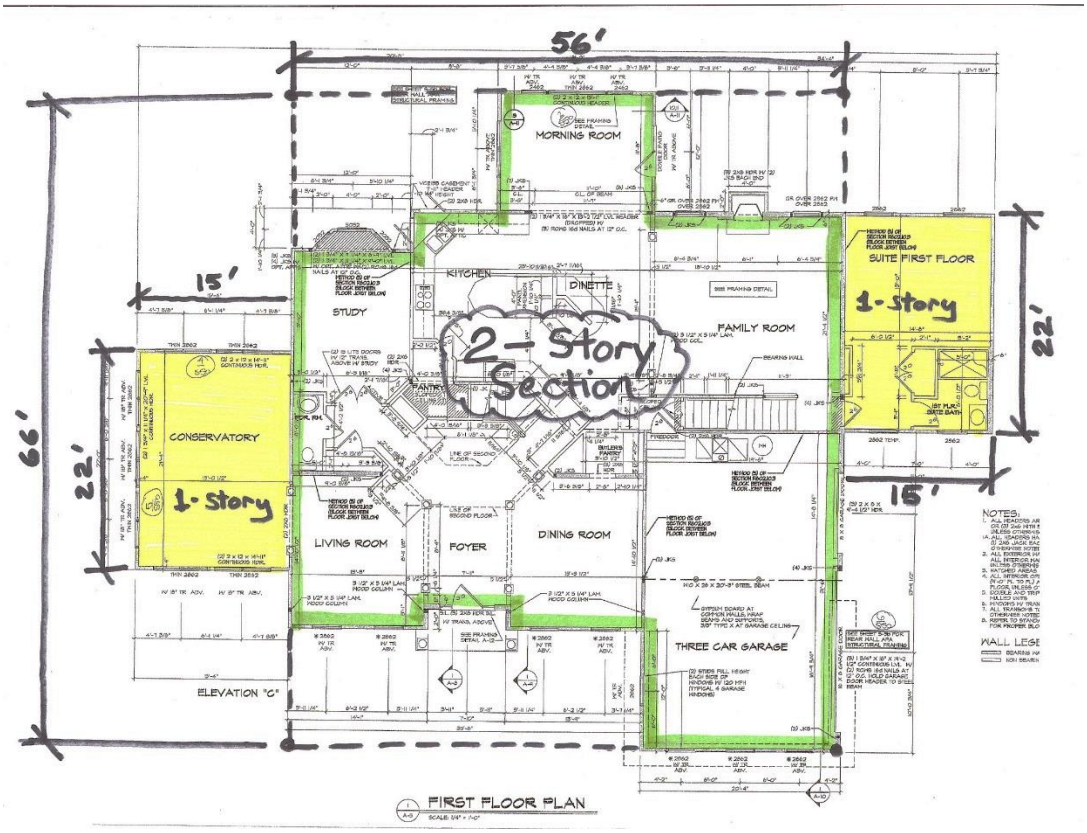


Figure B2: Plan View of Example House Plan

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.

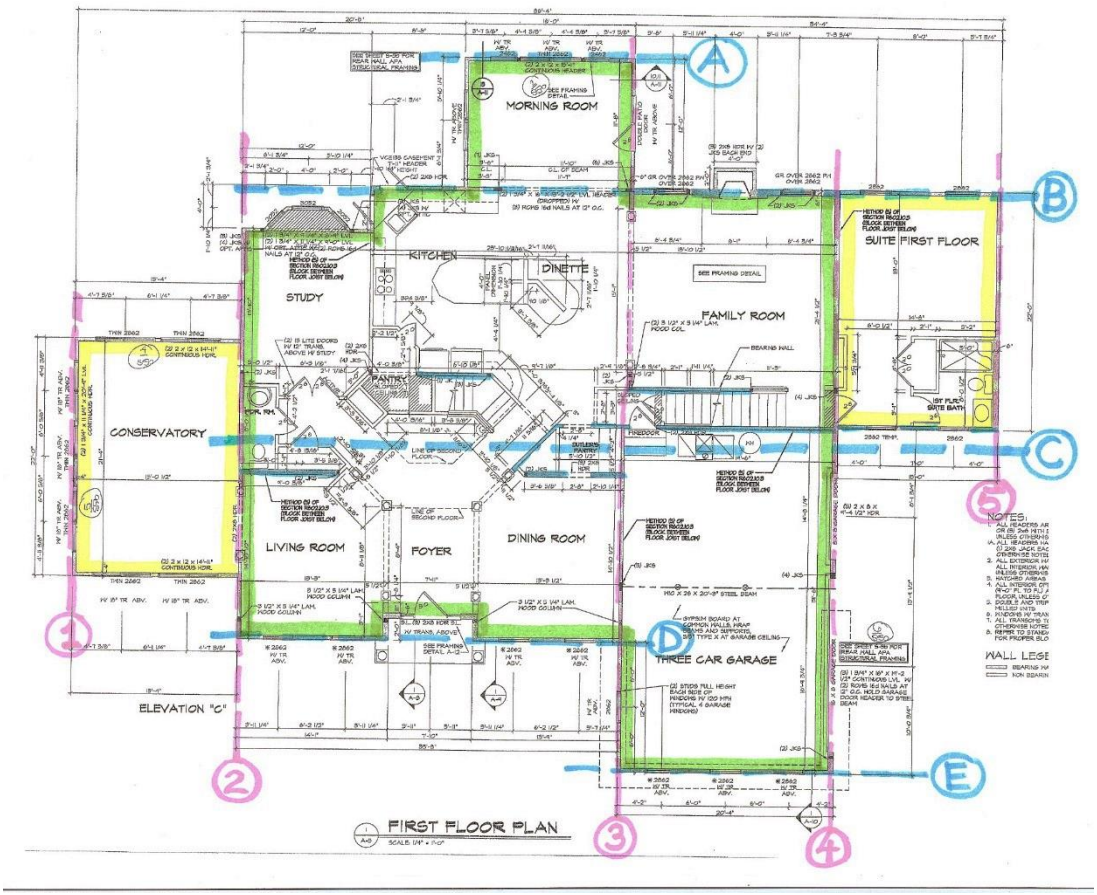


Figure B3: Plan View with Braced Wall Lines

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:
Design Examples

This supplement presents two complete wall bracing design examples to illustrate application of the various bracing methods and the provisions in *IRC* Section R602.10. These examples are also generally applicable to the 2012, 2015, and 2018 editions of the IRC. Both examples demonstrate the use of a simple step-by-step design method as explained in the *IRC* Wall Bracing: A Guide for Builders, Designers and Plan Reviewers ('Guide') – Refer to Section 3 and the bracing worksheet in Appendix A of the Guide

Example #C1 illustrates a very simple, affordable home application that presents few challenges. Two representative bracing methods are featured for comparison purposes and to illustrate differences and similarities in requirements.

Example #C2 represents a more complicated building plan that requires some effort to achieve code compliance, regardless of the IRC bracing method used. This example also illustrates how to implement some of the more advanced recommendations found in the 'Guide' to address difficult conditions or challenging design objectives. For example, combining multiple bracing methods or techniques on the same plan clearly highlight the design flexibility in selecting wall assemblies that best serve structural, cost, durability and energy performance objectives of a given project.

Because each building plan may present unique challenges or design objectives that require a careful consideration of code compliance in a variety of ways, it is impossible to illustrate every conceivable application or code-compliant solution for wall bracing. While these examples apply concepts that are appropriate to a variety of applications, it is advisable to verify compliance with the locally-applicable building code, refer to additional resources as needed, and use a design professional when in doubt.

Free resources at http://www.continuousinsulation.org/ and www.appliedbuildingtech.com − For additional information and design details referenced in this Supplement, refer to *IRC Wall Bracing: A Guide for Builders, Designers and Plan Reviewers with Supplemental Information on Appropriate Use of Foam Sheathing*.

EXAMPLE #C1 – One Story Home (Simple Building Plan)

Objectives

- Evaluate bracing requirements for two basic (or traditional) wall bracing methods
- Allow wall systems to be compared with respect to first cost, energy efficiency (monthly cost), and requirements (depends on local climate, materials costs, etc.).
  Refer to Section 5 for information on bracing strategies for energy efficient wall assemblies using foam sheathing.

Given

- Typical one-story entry-level (starter) home with 8' ceiling height (see Figure 1)
- Design wind speed = 90 mph (Exposure B, no topographic effect) per *IRC* Section 301.2
- Seismic Design Category A, B, or C (exempt from IRC seismic provisions)
- Required wall system R-value of R19 (cavity) or R13 (cavity) + R5 (continuous) as common to northern, heating climates per IRC Chapter 11 Energy Conservation

Wall Assemblies	Bracing Methods	
Wall Components	**Option #1**	**Option #2**
Bracing Method	LIB – 1x4 wood let-in braces (use USP S365 60º or WBT12 45º T-braces)	WSP - wood structural panel braces (use 7/16" OSB)
Framing	2x4 studs at 16"oc	2x6 studs at 16"oc or 24"oc
Exterior Sheathing	~1" continuous R5 foam sheathing installed as a combined air/thermal/water barrier	7/16" OSB sheathing (covered with separate building wrap for air/water barrier)
Siding	Vinyl (see IRC R703.11.2 for installation over foam sheathing)	Vinyl (see IRC R703.11 and Table R703.4 for installation over wood structural panels)
Interior Finish	½" gypsum wall board	½" gypsum wall board
Cavity Insulation & 'warm-in-winter' side vapor retarder	R13 kraft-faced batts (kraft vapor retarder may be eliminated with use of foam sheathing – see IRC R601.3)	R19 kraft-faced batts (in limited cases kraft vapor retarder may be eliminated with use of vented siding – see IRC R601.3)
Comments	• Requires least materials and layers on wall to achieve overall code compliance • Provides energy efficiency comparable to 2x6 walls, but using standard 2x4 wall framing	• Uses thicker wall system and larger studs (structurally unnecessary for this plan) • Requires thicker door/window jambs • ½" foam sheathing may be applied over required OSB bracing panels and 1" foam sheathing between OSB panels to meet energy code and allow use of 2x4 wall framing with R13 cavity insulation

Table C1: Wall Assemblies & Bracing Methods Considered

Application of *IRC* Bracing Requirements

Due to the small plan size of this home (less than the 60' maximum plan dimension) and adequate space for bracing on exterior walls, no interior braced wall lines are required for this plan. As shown in the floor plan in Figure_C1, four exterior braced wall lines are identified. The rear braced wall line is drawn to split the offset in the rear wall line. Refer to Section 1 of the 'Guide', in particular the definition for 'braced wall line' and Figure 2.

Note that even though interior walls are not specifically designed as 'braced wall lines', they will contribute substantially to the racking strength of the whole building. Portions of the exterior walls where braced wall panels (or braces) are not located, but which include interior gypsum wall board finishes, also contribute additional racking strength to the building. These "non-structural" systems (from the standpoint of how the code defines bracing) may actually provide adequate bracing of this particular home plan even in the absence of specified braced wall panels on the exterior walls. However, always ensure that the required bracing is provided in compliance with the *IRC*.

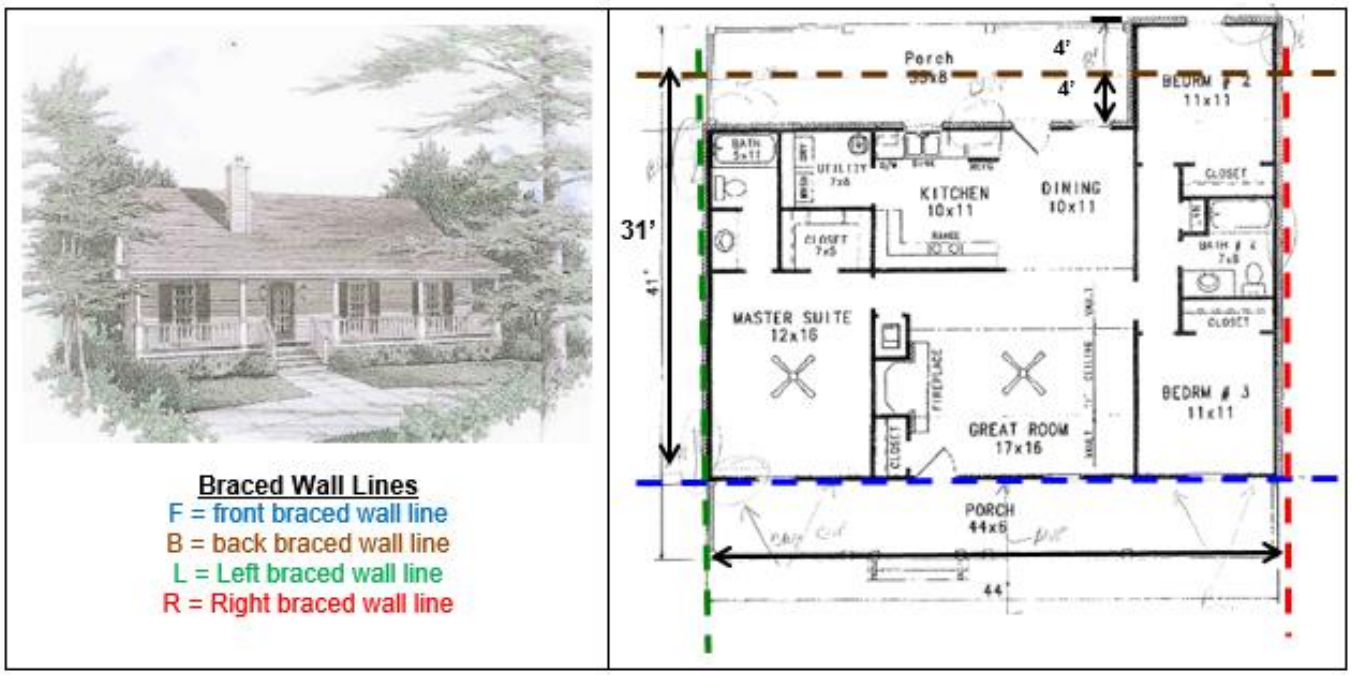


Figure C1: House Plan for Example #C1 with Designated Braced Wall Lines [7]

Refer to Table C2 for a detailed analysis of bracing requirements and two solutions (options) for each braced wall line in Example #C1.

[7] House plan #3435VL: "Starter Home with Two Covered Porches" courtesy of **www.architecturaldesigns.com"**

STEP 1		STEP 2		STEP 3		STEP 4		STEP 5	STEP 6	STEP 7		COMMENTS
Braced Wall Line ID	Max Offset in Braced Wall Line ≤ 4'?	Support Condition	Braced Wall Line Spacing (feet)	Selected Bracing Method	Braced Wall Line Length (feet)	Tabulated Bracing Length per Table 7 (feet)	Adjusted Bracing Length Required per Table 7 footnotes (feet)	Total Length of Braced Wall Panels Provided (feet)	Required Bracing Length ≥ Provided Length?	Sum of BWP panel end distances ≤12.5'?	BWP spacing 25'oc maximum?	
F (front BWL)	OK	Roof Only	31'	Method LIB (use USP S365 60° T-Brace)	44'	9.8'	9.8' x 0.9 = 8.8' (0.9 adjustment factor per footnote 'd' for 8' wall height)	13.8' provided (3 braces, each 60° brace provides 4.6' of bracing length along the wall)	OK	OK	OK	Two braces provide adequate bracing length placed at each end of wall; the third brace should be placed in the middle of the wall to meet the 25'oc requirement.
				Method WSP (use 7/16" OSB)	44'	5.7'	5.7' x 0.9 = 5.1' (0.9 adjustment factor per footnote 'd' for 8' wall height)	12.0' provided (3 brace panels, each provides 4' of bracing length)	OK	OK	OK	Two brace panels provide adequate bracing length placed at each end of wall; the third panel should be placed in the middle of the wall to meet the max. 25'oc requirement
B (back braced wall line)	OK	Roof Only	31'	Method LIB (use USP S365 60° T-Brace)	44'	9.8'	9.8' x 0.9 = 8.8'	13.8' provided (3 braces)	OK	OK	OK	Place one brace at left end, one between kitchen door and sink window, and one at bedroom #2.
				Method WSP (use 7/16" OSB)	44'	5.7'	5.7' x 0.9 = 5.1'	12.0' provided (3 brace panels)	OK	OK	OK	Place one panel at left end, one either just to the left or just to the right of the kitchen window, and one at the bedroom.
R (right braced wall line)	OK	Roof Only	44'	Method LIB (use USP WBT12 45° T-Brace)	35'	13.7'	13.7' x 0.9 = 12.3'	16.0' provided (2 braces, each 45° brace provides 8' of bracing length)	OK	OK	OK	Place each of two braces starting at 1' from wall ends to meet the 25'oc requirement.
				Method WSP (use 7/16" OSB)	35'	8.1'	8.1' x 0.9 = 7.3'	8.0' provided (2 brace panels, each provides 4' of bracing length)	OK	OK	OK	Place each of two panels starting at 3' from the wall ends to meet the 25'oc requirement (use 4' end distance to align panel edge with layout studs).
L (left braced wall line)	Bracing amounts and location determined for braced wall line R may be used for braced wall line L. The required bracing can be located completely in the 27' long side wall and not along the 8' segment of wall that is offset due to the projection of bedroom #2 at the rear of the plan. The only limitation is that the sum of the end distances must not exceed 12.5'. Since the panel at the left end of line R (at the master bath) will have a 4' end distance (as measured from the intersection of BWL B and BWL L), the panel at the right end can begin no more than 8.5' from the right end of the wall (at the corner at the porch). Some may interpret the 8' wall segment at bedroom #2 as a separate braced wall line requiring at least one BWP, but this interpretation is not consistent with the intent of the *IRC* bracing provisions. Such interpretations do reflect the difficulty of developing prescriptive code language that adequately explains bracing requirements for buildings that have even a minor variation from a perfectly rectangular floor plan.												

Table C2: Wall Bracing Worksheet for Example #C1

EXAMPLE #C2 - Two-Story Home (Complex Building Plan)

Objectives

- Code compliant wall bracing and energy code compliance
- Minimize cost to comply with energy and structural requirements in base plan
- Maximize energy savings in base plan without specifying dual sheathing for the entire building (i.e., foam sheathing over structural sheathing)
- Provide a wall bracing strategy to permit an optional plan upgrade for energy efficiency and moisture protection:
    - Include ½" water-resistant foam sheathing continuously over 7/16" wood structural panels and 1" foam sheathing in between panels
    - Detail foam sheathing to serve as secondary weather-barrier (eliminating building wrap/paper because foam sheathing can serve a three-fold purpose as water barrier, air-barrier and thermal barrier)
    - Maximize use of continuous 1" foam sheathing coverage by using Method LIB bracing where possible in lieu of Method WSP or CS-WSP

Given

- Typical model house plan with (see Figures C2 and C3)
- Two-story with basement and attached garage (several architectural plan options)
- 8' ceiling heights; 6:12 roof pitch (8' roof eave-to-ridge height)
- Wind Speed – 100 mph or less per local jurisdiction and *IRC* Table R301.2(1)
- Seismic Design Category – SDC A, B, or C per local jurisdiction and *IRC* Table R301.2(1)

Bracing Methods Used on Plan

Method LIB (indicated locations and braced wall lines only)
USP S365 (60º angle) and S366 (45º angle) metal T-braces installed per manufacturer instructions and as shown on plans (NER Report #505).

Method WSP (indicated locations only)
7/16" OSB panels installed in accordance with *IRC* Section R602.10.2

Method CS-WSP (indicated braced wall lines only)
7/16" OSB panels installed in accordance with *IRC* Sections R602.10.4 on all sheathable areas of indicated braced wall lines (i.e., street-facing lower and upper story wall lines)

Method CS-G (at garage opening only)
Garage opening wall is braced as a continuous structural sheathed wall except special allowance for panel width of 24" next to garage opening supporting roof only is used in accordance *IRC* Sections R602.10.4. *(Refer to Section 2.3).*

Application of IRC Bracing Requirements

As shown in Figures C2 and C3, a number of braced wall lines are required for this plan, including two interior braced wall lines on the first floor in the left-to-right and front-to-back plan directions.

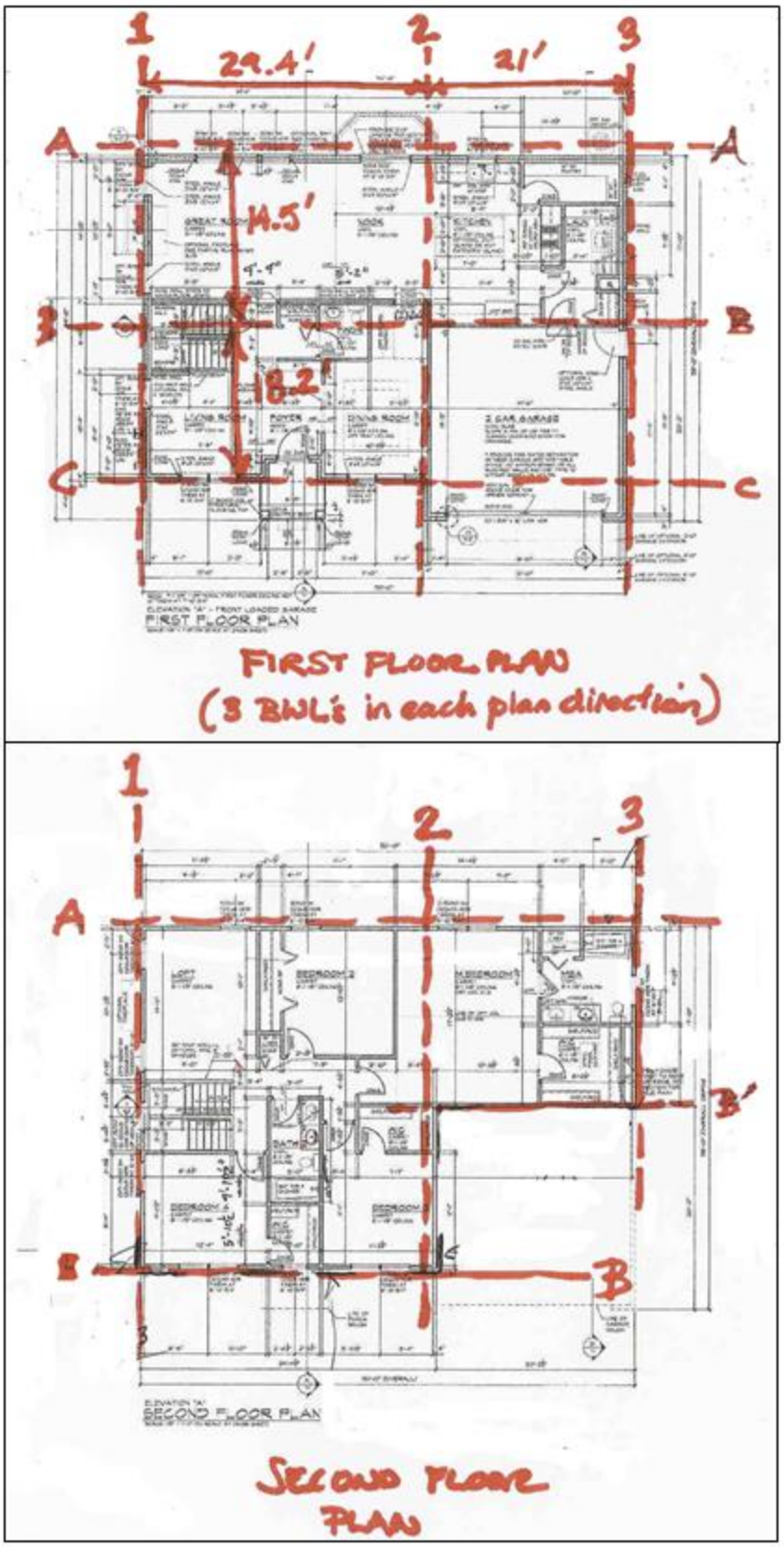


Figure C2: First and Second Story Floor Plans for Example #C2 with Designed Braced Wall Lines

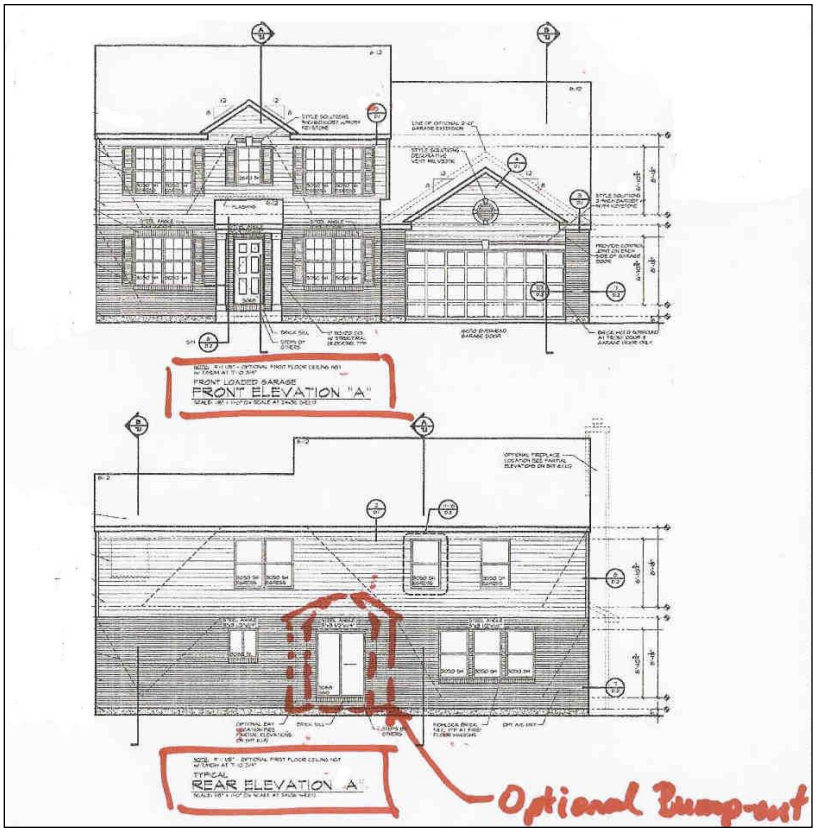


Figure C3: Plan Elevations Showing Front and Rear Braced Wall Line Conditions and Optional Plan Features

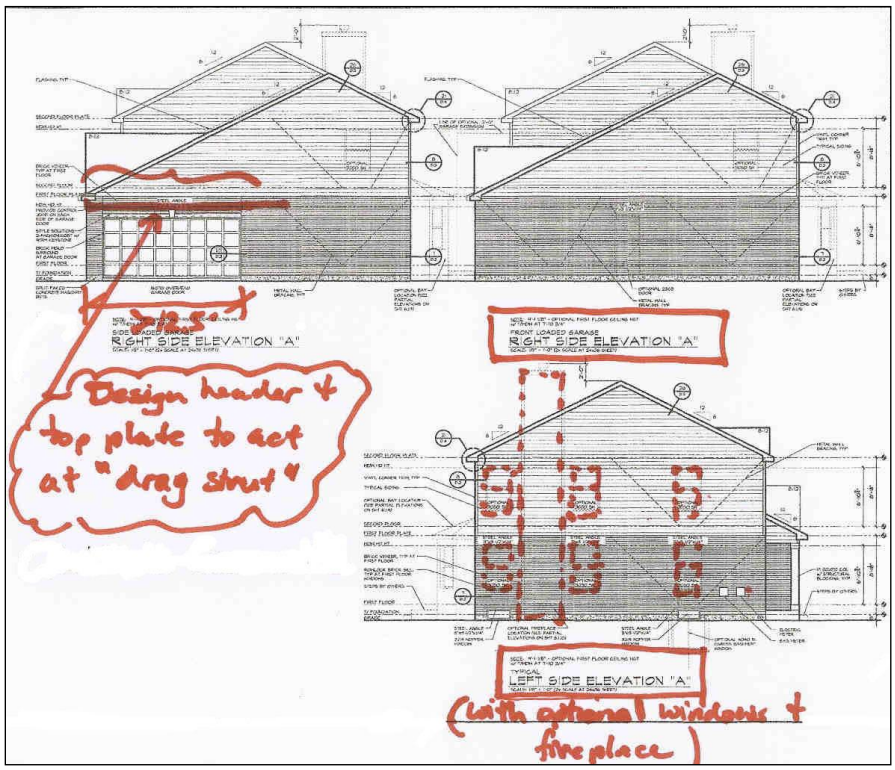


Figure C4: Plan Elevations Showing Side Exterior Braced Wall Line Conditions and Optional Plan Features

STEP 1		STEP 2		STEP 3		STEP 4		STEP 5	STEP 6	STEP 7		COMMENTS
Braced Wall Line ID	Max Offset in Braced Wall Line ≤ 4'?	Support Condition	Braced Wall Line Spacing (feet)	Selected Bracing Method	Braced Wall Line Length (feet)	Tabulated Bracing Length per Table 7 (feet)	Adjusted Bracing Length Required per Table 8 (feet)	Total Length of Braced Wall Panels Provided (feet)	Required Bracing Length ≥ Provided Length?	Sum of BWP panel end distances ≤12.5'?	BWP spacing 25'oc maximum?	
Lower Story – Longitudinal Braced Wall Lines (Parallel To Left-To-Right Plan Direction)												
A (rear wall)	OK	Roof + 1 floor	14.5' + .5' = 15'	Method LIB (Use USP S365 60º Steel T-Braces)	50'	12.3'	12.3' x 0.94 x 0.9 x 1.3 = 13.5' 0.94 – footnote 'c' for 8' roof eave-to-ridge height 0.9 – footnote 'd' for 8' wall height; or 0.95 if 9' ceiling option used 1.3 – footnote 'e' for 3 BWLs in this plan direction	13.8' provided (3 braces, each 60º brace provides 4.6' of bracing length along the wall)	OK	OK	OK	The braced wall line location for rear wall line is shifted 0.5' outward which conservatively increases the braced wall line spacing, but reduces the effective offset of the bump-out to 4' eliminating the need to treat the optional bump out as a separate BWL.
B (interior wall)	OK	Roof + 1 floor	18.2' (to front entry wall for max spacing)	Method GB (one side and two side as indicated)	50'	14.7' (based on GB both sides)	14.7' x 0.94 x 0.9 x 1.3 = 16.2' for GB two sided	22.2' provided (18.2' of GB both sides plus 8' of GB one side counted at 50% = 18.2 + 4' = 22.2' of bracing length)	OK	OK	OK	Lap interior braced wall line top plates with exterior wall top plate or use equivalent strap. NOTE: The 8' of GB one-sided is necessary to meet the 25'oc rule (not needed otherwise)
B-alt (alternate bracing for interior wall)	OK	Roof + 1 floor	18.2'	Interior partition wall with ½" GWB on both sides installed per IRC Table R702.3.5	50'	14.7' (based on GB both sides)	14.7' x 0.94 x 0.9 x 1.3 = 16.2 for GB two sided	19.7' provided (39.3' of wall excluding door openings and segments less than 4' long; counted at 50% value of GB two sided = 39.3 x 0.5 = 19.7')	OK	OK	OK	See 'Guide', Section 4 for justification to use interior partition wall as bracing as shown; engineering approval may be required.

STEP 1		STEP 2		STEP 3		STEP 4		STEP 5	STEP 6	STEP 7		COMMENTS
Braced Wall Line ID	Max Offset in Braced Wall Line ≤ 4'?	Support Condition	Braced Wall Line Spacing (feet)	Selected Bracing Method	Braced Wall Line Length (feet)	Tabulated Bracing Length per Table 7 (feet)	Adjusted Bracing Length Required per Table 8 (feet)	Total Length of Braced Wall Panels Provided (feet)	Required Bracing Length ≥ Provided Length?	Sum of BWP panel end distances ≤12.5'?	BWP spacing 25'oc maximum?	
C (front entry wall and garage opening wall)	OK	Roof + 1 floor	18.2'	Method CS-WSP (entry wall) Method CS-G (garage wall)	54.6'	7.4'	7.4' x 0.94 x 0.9 x 1.3 = 8.1'	15.5' provided (11.5' of CS-WSP with panels of sufficient width next to openings and two 2' CS-G BWPs which count because garage portion supports roof only)	OK	OK	OK	Use 48" Method WSP panel on side walls at corners at ends of BWL to meet CS-WSP corner requirements (see 'Guide' Section 2.3); also provides BWP for BWLs 1 and 3.
Lower-Story Transverse Braced Wall Lines (Parallel To Front-To-Back Plan Direction)												
1 (left exterior side wall)	OK	Roof + 1 floor	29.4' (measured to garage left side interior BWL 2)	Method LIB (Use USP S366 45° Steel T-Braces)	34'	22.6' Method CS-WSP: 12.4'	22.6' x 0.94 x 0.9 x 1.3 = 24.9' 1.3 adjustment factor for 3 BWLs in this plan direction also Method CS- WSP: 12.4' x 0.94 x 0.9 x 1.3 = 13.6'	**NG!** – only room for two 45° LIB braces with window option Use CS-WSP and re-calculate: Method WSP: ~15' provided	NG OK	OK (see comments)	OK	With the window and fireplace option executed, the BWP closest to rear corner will be 14.5' from the corner with requires a designed collector (top plate) – see 'Guide' Section 4. Also, 800# strap is needed at CS-WSP panel closest to rear corner – see 'Guide' Section 2.3

STEP 1		STEP 2		STEP 3		STEP 4		STEP 5	STEP 6	STEP 7		COMMENTS
Braced Wall Line ID	Max Offset in Braced Wall Line ≤ 4'?	Support Condition	Braced Wall Line Spacing (feet)	Selected Bracing Method	Braced Wall Line Length (feet)	Tabulated Bracing Length per Table 7 (feet)	Adjusted Bracing Length Required per Table 8 (feet)	Total Length of Braced Wall Panels Provided (feet)	Required Bracing Length ≥ Provided Length?	Sum of BWP panel end distances ≤12.5'?	BWP spacing 25'oc maximum?	
2 (garage left interior side wall)	OK	Roof + 1 floor	29.4' (measured to left exterior side wall for maximum spacing)	Method GB (both sides) ½" GWB on garage interior face also required for fire separation from living area.	18.2'	22.6'	22.6' x 0.94 x 0.9 x 1.3 x 0.7= 17.4' 0.7 factor is used for GB with fasteners at 4"oc on edges and blocked at horizontal joints per footnote 'g'	19.7' provided	OK	OK (based on BWL end as defined by garage interior corner)	OK	Though BWL 2 does not extend across building to the rear wall, it effectively does so through connections to the floor diaphragm above as required by new provisions in the 2009 IRC – see 'Guide' Section 2.4
3 (right side wall)	OK	Roof + 1 floor	21' (measured to interior BWL 2)	Method LIB (Use USP S366 45° Steel T-Braces) + Method WSP	38'	16.7'	16.7' x 0.94 x 0.9 x 1.3 = 18.4'	20' provided (insufficient room for three LIB braces; use two 45° LIB braces and one 4' WSP panel = 8'+ 8'+ 4' = 20')	OK	OK	OK	Method WSP braced wall panel substitutes for one Method LIB as permitted by IRC "mixing" rules; brace length is based on Method LIB (see 'Guide' Section 1.6)

STEP 1		STEP 2		STEP 3		STEP 4		STEP 5	STEP 6	STEP 7		COMMENTS
Braced Wall Line ID	Max Offset in Braced Wall Line ≤ 4'?	Support Condition	Braced Wall Line Spacing (feet)	Selected Bracing Method	Braced Wall Line Length (feet)	Tabulated Bracing Length per Table 7 (feet)	Adjusted Bracing Length Required per Table 8 (feet)	Total Length of Braced Wall Panels Provided (feet)	Required Bracing Length ≥ Provided Length?	Sum of BWP panel end distances ≤12.5'?	BWP spacing 25'oc maximum?	
Upper Story – Longitudinal Braced Wall Lines (Parallel To Left-To-Right Plan Direction)												
A (2nd story rear wall)	OK	Roof only	14.5' (measured to line of action for BWL B' in Fig 2)	Method LIB (Use USP S365 60° Steel T-Braces)	50'	6.3'	6.3' x 0.9 x 0.88 x 1.3 = 6.5'	13.8' provided (use three 60° LIB braces instead of two to meet STEP 7 requirements)	OK	OK	OK	Place one brace each end of wall and one left of MBR window. (NOTE: could replace with Method WSP panels, but LIB allows for thicker foam sheathing at corner where bath tub is located).
B (2nd story front wall)	OK	Roof only	34'	Method CS-WSP (same as BWL C on first story)	29.4'	6.6'	6.6' x 0.9 x 0.88 x 1.3 = 6.8' 0.88 – footnote 'c' for 8' roof eave-to-ridge height 0.9 – footnote 'd' for 8' wall height 1.3 – footnote 'e' for 3 BWLs in this plan direction	12.1' provided (all panels meet minimum CS-WSP BWP width requirements next to the windows)	OK	OK	OK	Inadequate space for Method WSP or Method LIB bracing to work (may be able to use Method WSP with approval of "partial credit" for narrower than 48" panel widths) use 48" Method WSP panels at corners on flanking walls or apply 800# hold-down strap at corner see 'Guide', Section 2.3.
B' (2nd story front offset at rear of garage)	OK	Roof only	15.0'	Method LIB (Use USP S366 45° Steel T-Braces)	20.2'	6.5'	6.5' x 0.9 x 0.88 x 1.3 = 6.7'	8' provided (only one 45° LIB required for this short wall)	OK	OK	OK	Place brace anywhere along length of wall.

STEP 1		STEP 2		STEP 3		STEP 4		STEP 5	STEP 6	STEP 7		COMMENTS
Braced Wall Line ID	Max Offset in Braced Wall Line ≤ 4'?	Support Condition	Braced Wall Line Spacing (feet)	Selected Bracing Method	Braced Wall Line Length (feet)	Tabulated Bracing Length per Table 7 (feet)	Adjusted Bracing Length Required per Table 8 (feet)	Total Length of Braced Wall Panels Provided (feet)	Required Bracing Length ≥ Provided Length?	Sum of BWP panel end distances ≤12.5'?	BWP spacing 25'oc maximum?	
Upper Story – Transverse Braced Wall Lines (Parallel To Front-To-Back Plan Direction)												
1 (2nd story left exterior side wall)	OK	Roof only	29.4'	Method LIB (Use USP S365 and S366 Steel T-Braces)	34'	11.8'	11.8' x 0.9 x 0.88 x 1.3 = 12.1'	12.6' provided (use one 45° and one 60° brace: 8' + 4.6' = 12.6')	OK	OK	OK	Place 60° brace between optional windows at left side (behind optional chimney chase) and place 45° brace at front corner. Note a minimum 24" WSP is also required for end restraint of BWL B unless 800# hold-down strap is used at corner
2 (2nd story center wall to left of garage roof)	OK	Roof only	29.4' (measured from BWL 1 for max spacing)	Method LIB (Use USP S366 45° Steel T-Braces) Interior partition wall with ½" GWB on both sides installed per IRC Table R702.3.5	18.2' (based on ends at intersect with BWLs B and B')	11.8'	11.8' x 0.9 x 0.88 x 1.3 = 13.5'	13.5' provided (use one 45° LIB brace and count interior partition wall at BDRM #2 discounted by 50% = 8' + 0.5 x 11' = 13.5')	OK	OK	OK	Note a minimum 24" WSP is also required for end restraint of BWL B (CS-WSP) unless 800# hold-down strap is used at corner . See 'Guide', Section 4 for justification of interior partition use – local approval/engineer may be required
3 (2nd story right side wall)	OK	Roof only	20'	Method LIB (Use USP S365 and S366 Steel T-Braces)	17.8'	8.5'	8.5' x 0.9 x 0.88 x 1.3 = 8.8'	12.6' provided (one 45o and one 60o LIB brace = 8' + 4.6' = 12.6')	OK	OK	OK	Place 60° LIB brace between corner and optional window and 45° LIB brace in remaining length of full-height wall.

Table C3: Wall Bracing Worksheet for Example #C2

Comments on Plan Options Affecting Bracing Strategy

9' first story walls in lieu of standard 8' walls (applies to lower story walls only):

If this plan option is used the bracing adjustment factor for wall height (footnote 'd' of Table 8) will increase from 0.9 to 0.95 which will increase bracing lengths required by about 6%. In a couple of marginal cases, the bracing provided on some BWLs for the lower story may need to be slightly revised. Also, most metal LIB braces come in sizes appropriate for use on 8' and 10' wall heights. Thus, a different brace manufacturer or model number will be required where LIB is used in the bracing plan (Table 2). Where metal LIB braces are used, be sure that they are not just appropriate for temporary bracing applications (not all metal brace types are equivalent to LIB bracing in the IRC). As an alternative, use of WSP braces can be easily substituted where LIB is specified. While structurally feasible, such substation will impact the thickness (insulating value) of foam sheathing where placed over a WSP brace. Thus, energy efficiency and related energy code requirements may be impacted and should be considered.

In summary, if the 9' first story wall height option is used, LIB bracing on the first story level may become slightly more difficult to use and use of WSP or CS-WSP or CS-SFB and other similar bracing methods or proprietary bracing materials should be considered. In addition, the garage opening CS-G bracing panels will need to be increased in width from 24" to 27" to comply with minimum width requirements; refer to Table 6 in the bracing 'Guide'. Alternatively, the CS-PF portal framing method may be used – see Section 2.3 of the 'Guide'.

Side load and three car garage option (lower story, front wall and right side wall):

In this case, the garage opening is part of a much longer braced wall line on the right side of the building. However, the garage door is located at one end of the wall such that a braced wall panel must be placed approximately 18' from the end of the wall line (exceeding the 12.5' prescriptive limit). This can be resolved simply by designing the garage door header and wall top plate to act as a "drag-strut" by ensuring that these members are adequately tied together at joints and splices to "drag" shear load into the rest of the wall line where the required amount of wall bracing is located. This is a simple task, but requires the services of an engineer. However, a standard detail for repetitive use should be feasible. (Refer to Section 4 of the 'Guide' for additional information.)

Window and Fireplace Option (left, lower-story wall):

These optional plan features are adequately addressed in the bracing requirements detailed in Table 2 above, except when both options (windows and fireplace) are included. If both are included, engineering will be needed to approve a 14.5' distance of the brace from rear end of BWL #3 on the first and second story. If a design is required, follow the same procedure for "drag struts" as described above. In many cases, the resulting solution may only require a modest increase in nailing of top plate splices for the affected wall portion. Note that this design solution applies for any IRC bracing method that might be used on BWL #3. (Refer to Section 4 of the 'Guide' for additional information.)

Bump-out bay window (4.5' wall line offset created in rear wall line at bump-out):

Care should be taken when applying the "4' offset rule" (see Section 1.6) when identifying wall lines that are considered to be separate braced wall lines. In this case, if braced wall line 'A' is located on an imaginary line 0.5' outward from rear wall, then the bump out does not create more than 4' offset from the indicated braced wall line location. To allow for this approach and the optional use of the bump-out bay window, the amount of bracing for BWL 'A' should be based on the actual braced wall line spacing to the interior braced wall line B plus 0.5'. This situation does not require that the bump-out walls be considered as a separate braced wall line as permitted by 2009 *IRC* Section R602.10.1.4. *(Refer to* Figure 2 *in the 'Guide'.)* Therefore, the bump-out can be considered as a part of the rear braced wall line without requiring separate bracing of the bump-out portion. This approach was used for BWL A on the first story of Example #C2 (Table C2).

Appendix D:
Technical Guidance for Appropriate Use of Foam Sheathing

For additional technical data, construction resources, and design tools to assist in the appropriate, code-compliant use of foam sheathing, refer to http://www.continuousinsulation.org/ and www.appliedbuildingtech.com.

Resources provided include code-approval reports, research reports, designer tools, construction details, and installation guidelines for windows, cladding attached through foam sheathing, and other similar topics. Designer tools address energy code compliance, moisture control design, and applications of foam sheathing in fire-resistant wall assemblies.