Foam Sheathing Coalition

Supplement to IRC Wall Bracing Guide: Design Examples

Introduction

This supplement to the IRC Wall Bracing Guide presents two case studies or wall bracing design examples to illustrate the various bracing methods and the provisions in Section R602.10 of the International Residential Code (IRC). Both case studies 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 2 and the bracing worksheet in Appendix A.)*

Case Study #1 illustrates a very simple, affordable home application that presents few challenges in using the IRC wall bracing provisions. Three bracing methods are featured for comparison purposes and to illustrate differences and similarities in requirements.

Case Study #2 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 solution for wall bracing. While these examples apply concepts that are appropriate to a variety of applications, it is advisable to refer to additional resources and use a design professional when in doubt.

For additional information and design details, refer to the *IRC Wall Bracing: A Guide for Builders, Designers and Plan Reviewers with Supplemental Information on Appropriate Use of Foam Sheathing.*

Foam Sheathing Coalition (FSC)

Version 1.0

CASE STUDY #1 – One Story Home (Simple Building Plan)

Objectives

- Evaluate bracing requirements for commonly used 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 4 in the 'Guide' for information on bracing strategies for energy efficient wall assemblies.)*

Given

- Typical one-story entry-level (starter) home with floor plan per Figure 1
- Design wind speed < 110 mph per IRC Table R301.2(1)
- Seismic Design Category C
- Required wall system R-value of R15 or greater per energy code (northern, heating climates)

Wall Assemblies & Bracing Methods Considered

Wall Components	Option #1	Option #2	Option #3
Bracing Method	Method 1 (use USP WBT12 45° steel T-brace)	Method 3 (wood structural panel)	Method 4 (fiberboard)
Framing	2x4 studs at 16"oc or 24"oc	2x6 studs at 16"oc or 24"oc	2x6 studs at 16"oc only
Exterior Sheathing	½" foam backer panels (R3) installed as a combined air/thermal/water barrier	7/16" OSB wood flake sheathing covered with building wrap for water- and air-barrier	½" fiberboard panels covered with building wrap for water- and air-barrier
Siding	Vinyl	Vinyl	Vinyl
Interior Finish	½" gypsum wall board	½" gypsum wall board	½" gypsum wall board
Cavity Insulation & 'warm-in-winter' side vapor retarder	R13 kraft-faced batts (plastic vapor retarder can be eliminated)	R19 kraft-faced batts (plastic vapor retarder may be required)	R19 kraft-faced batts (plastic vapor retarder may be required)
Comments	• Requires least materials and layers on wall to achieve code compliance • Provides energy efficiency comparable to 2x6 walls, but using standard thickness 2x4 wall • Check local supply for material costs	• Uses thicker wall system and larger studs (structurally unnecessary for this plan) • Requires thicker door/window jambs • Check local supply for material costs	• Same as Option #2 • Check local supply for material costs

Application of IRC Bracing Requirements

Due to the small plan size of this home and adequate space for bracing on exterior walls, no interior braced wall lines are required for this plan. As shown in the floor plan below (Figure 1), 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 2c).*

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. In addition, 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. This, however, is not directly considered when applying the IRC wall bracing provisions. 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.

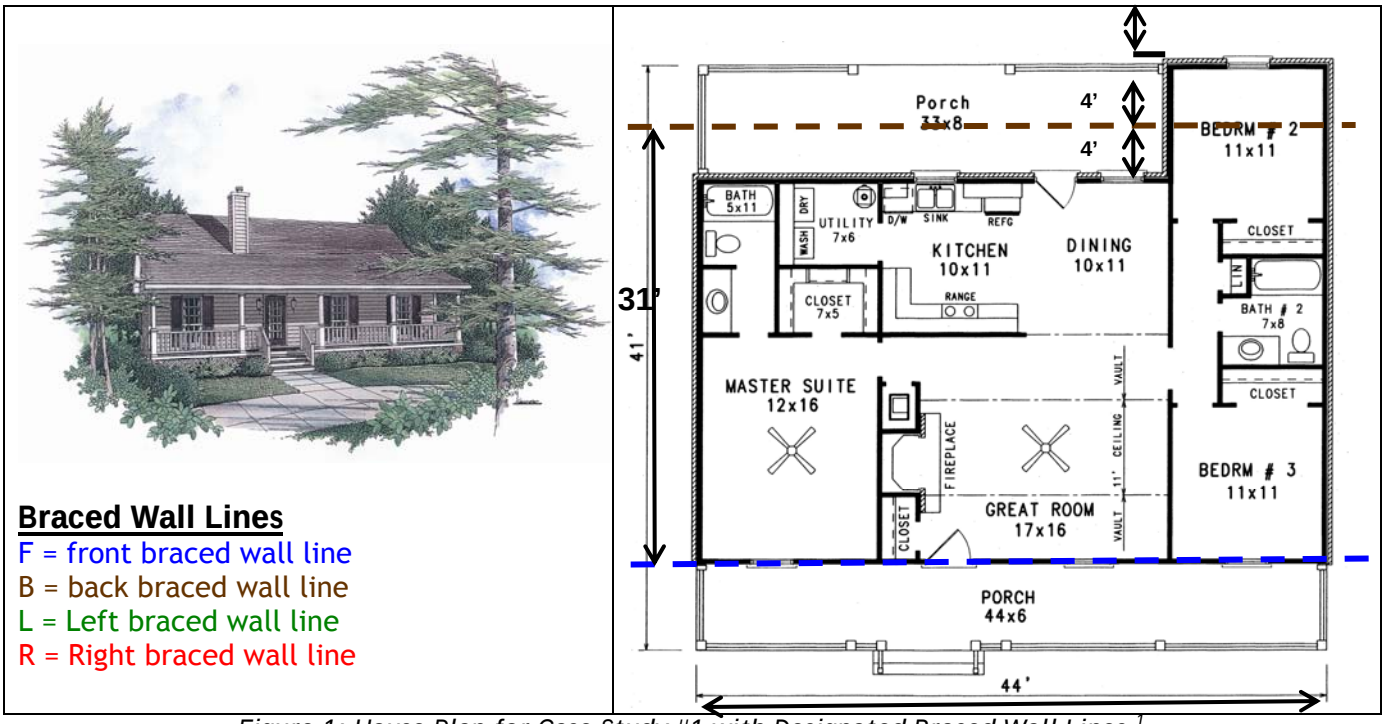


Figure 1: House Plan for Case Study #1 with Designated Braced Wall Lines [1]

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

Table 1: Wall Bracing Worksheet for Case Study #1

A			B	C	D	E	F	G	H	I	J	
STEP 1 - Braced Wall Line ID	Support Condition	Maximum Offset in Braced Wall Line ≤ 4'?	STEP 2 - Braced Wall Line Spacing (feet)	STEP 3 - Bracing Method	STEP 3 - Braced Wall Line Length (inches)	STEP 3 - Required Bracing Percentage (Table 3)	STEP 3 - Required Total Length of Braced Wall Panels (inches)	STEP 4 - Total Length of Braced Wall Panels Provided (inches)	STEP 4 - Value in Column F ≥ Value in Column E?	STEP 5 - Brace wall panels begin within 12.5' of ends of braced wall line?	STEP 5 - Braced wall panels spaced along braced wall line at 25'oc maximum?	COMMENTS
F (three options for front braced wall line)	Roof only	OK	31'	Method 1 (use USP WBT12 45° T-Brace)	44'	N/A (amount based on columns K & L)	N/A	Minimum of 2 braces needed to meet brace location requirements per columns I & J	N/A	OK	OK	Place each of 2 braces to inside of left and right windows on front wall line starting no more than 12.5' from ends of wall (results in spacing between braces < 25' oc).
				Method 3 (use 7/16" OSB)	44'	16% (see Table 3b in 'Guide')	44 x 0.16 = 7'	Minimum of 2 braced wall panels required if spaced as above for Method 1 braces	8' min. OK	OK	OK	Place minimum of two 4' Method 3 braced wall panels as above for Method 1 braces; if panels placed at corners, three panels are required.
				Method 4 (use ½" fiberboard)	44'	25%	44 x 0.25 = 11'	Minimum of 3 braced wall panels required	12' min. OK	OK	OK	Place two 4' Method 4 braced wall panels within 12.5' of ends of wall and one additional panel to right of entry door.
B (three options for back braced wall line)	Roof only	OK	31'	Method 1 (use USP WBT12 45° T-Brace)	44'	N/A (amount based on columns K & L)	N/A	Minimum of 2 braces needed to meet brace location requirements per columns I & J	N/A	OK	OK	Requirements same as front wall. Brace locations differ. May require a 60° brace (e.g., USP S365 T-brace) at bedroom #2 if 45° brace angle can't fit. Alternatively, substitute a Method 3 panel.
				Method 3 (use 7/16" OSB)	44'	16% (see Table 3b in 'Guide')	44 x 0.16 = 7'	Minimum of 2 braced wall panels required if spaced as above for Method 1 braces	8' min. OK	OK	OK	See comment for front braced wall line.
				Method 4 (use ½" fiberboard)	44'	25%	44 x 0.25 = 11'	Minimum of 3 braced wall panels required	12' min. OK	OK	OK	Place three 4' panels similar to direction in comment for front braced wall line.

R (three options for right braced wall line)	Roof only	OK	44’	Method 1 (use USP WBT12 45º T-Brace)	35’	N/A (amount based on columns K & max 20’oc spacing per Table 3b in ‘Guide’)	N/A	Minimum of 2 braces needed to meet brace location requirements per Columns K & L	N/A	OK	OK Max 20’oc per Table 3b in ‘Guide’	Place each of two braces starting no less than 3.5’ from each end of right side wall and no more than 12.5’. This arrangement results in brace spacing of < 20’ oc.
	Roof only	OK	44’	Method 3 (use 7/16” OSB)	35’	21% (see Table 3b in ‘Guide’ for 45’ braced wall line spacing)	35’ x 0.21 = 7’-4”	Minimum of 2 braced panels required	8’ min. OK	OK	OK	If two panels used start each panel no less than 3’ from each end of right side wall and no more than 12.5’ to provide a panel spacing of no more than 25’oc.
	Roof only	OK	44’	Method 4 (use ½” fiberboard)	35’	32% (see Table 3b in ‘Guide’ for 45’ braced wall line spacing)	35’ x 0.32 = 11’-2”	Minimum of 3 braced panels required	12’min. OK	OK	OK	Place 4’ brace panels at ends and at center of right side wall.
L (left braced wall line)	The 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. Notice that in taking this approach, the length of wall used to determine the amount of bracing in the 27’ long left side wall is the overall length of the building side including the 8’ extension of bedroom #2 (e.g., 27’ + 8’ = 35’). Some may interpret the 8’ wall segment at bedroom #2 as a separate braced wall line which is not necessarily the intent of the IRC bracing provisions. Such an interpretation reflects 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. Always use sound judgment when using the 4’ offset criteria to define separate braced wall lines to ensure the code intent is met.											

CASE STUDY #2 – Two-Story Home (Complex Building Plan)

Objectives

- Code compliant wall bracing and energy efficiency
- Minimize cost to comply with energy and structural requirements in base plan
- Maximize energy savings in base plan without requiring dual sheathing (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 ½" structural panels and 1" foam sheathing where appropriate
    - Detail foam sheathing to serve as secondary weather-barrier (eliminating building wrap/paper because foam sheathing serves a three-fold purpose as water barrier, air-barrier and thermal barrier)
    - Maximize use of 1" foam sheathing coverage by using Method 1 bracing where possible in lieu of Method 3 or continuous structural panel bracing

Given

- Typical model house plan
- Two-story with basement and attached garage (including several architectural plan options)
- Wind Speed – 100 mph or less per local jurisdiction and IRC Table R301.2(1)
- Seismic Design Category – SDC A or B per local jurisdiction and IRC Table R301.2(1)

Bracing Methods Used on Plan

Method 1 (indicated locations and braced wall lines only)
USP S365 T-brace (60^o angle) installed per manufacturer instructions and as shown on plans (NER Report #505).

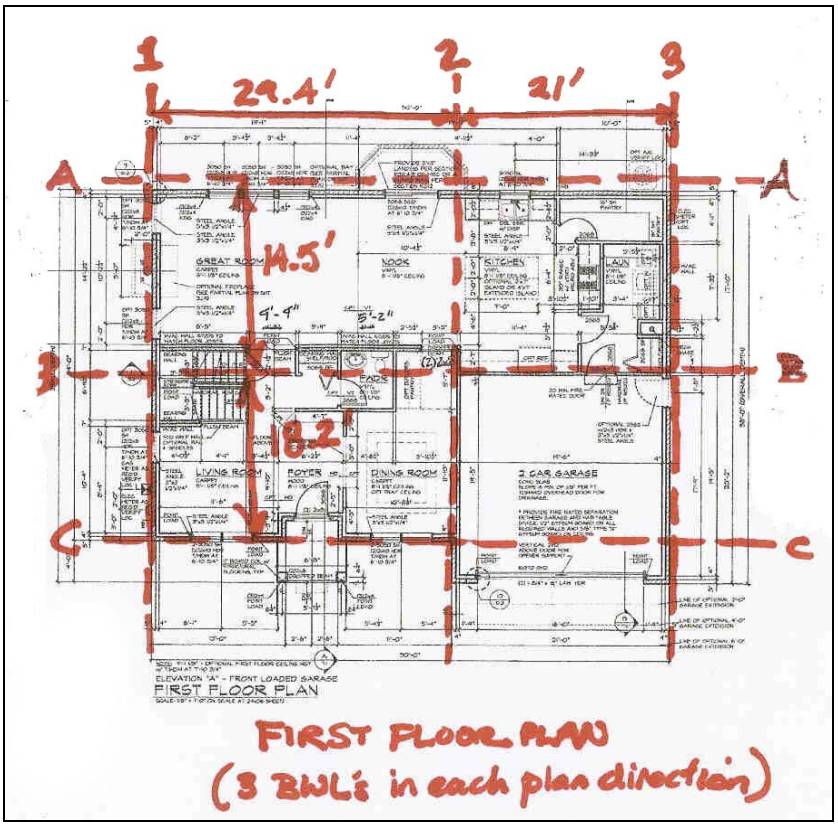
Method 3 (indicated locations only)
7/16" OSB panels installed in accordance with IRC Section R602.10.3

R602.10.5 Continuous Structural Sheathing (indicated braced wall lines only)
7/16" OSB panels installed in accordance with Section R602.10.5 on all sheathable areas of indicated braced wall lines (i.e., street-facing lower and upper story wall lines)

Narrow Braced Wall Panels for Garage Opening Supporting Roof Only
Garage is braced as a continuous structural sheathed wall except panel width of 24" for garage opening braced wall panels is used in accordance with footnote b of Table R602.10.5. *(Refer to Figure 6a in the 'Guide'.)*

Application of IRC Bracing Requirements

As shown in Figure 2 and Figure 3, 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.



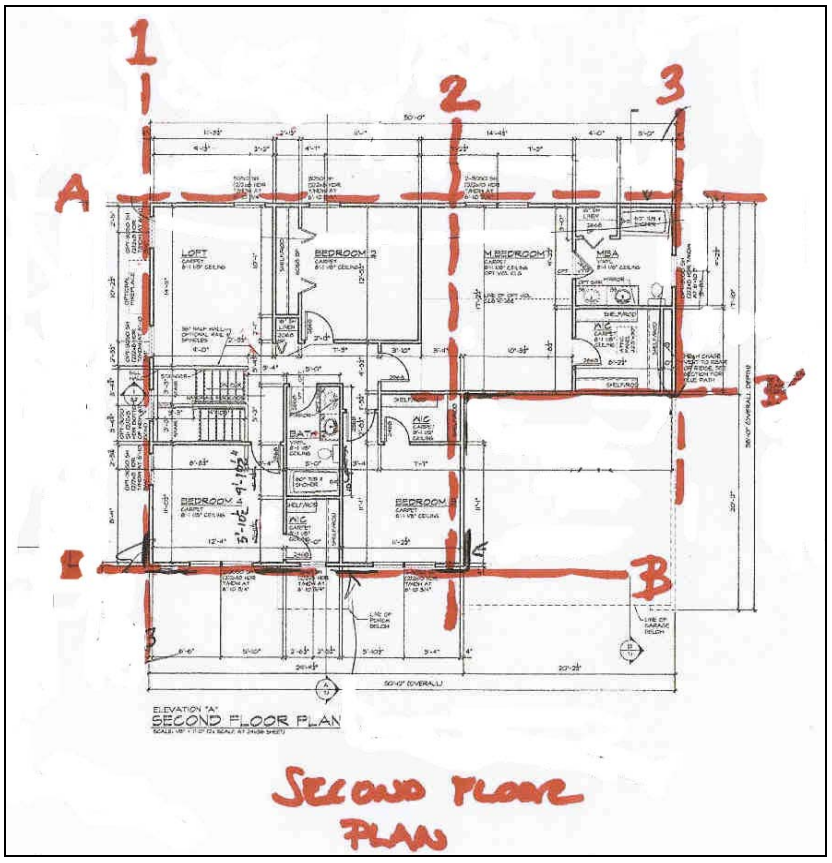


Figure 2: First and Second Story Floor Plans For Case Study #2 with Designated Braced Wall Lines

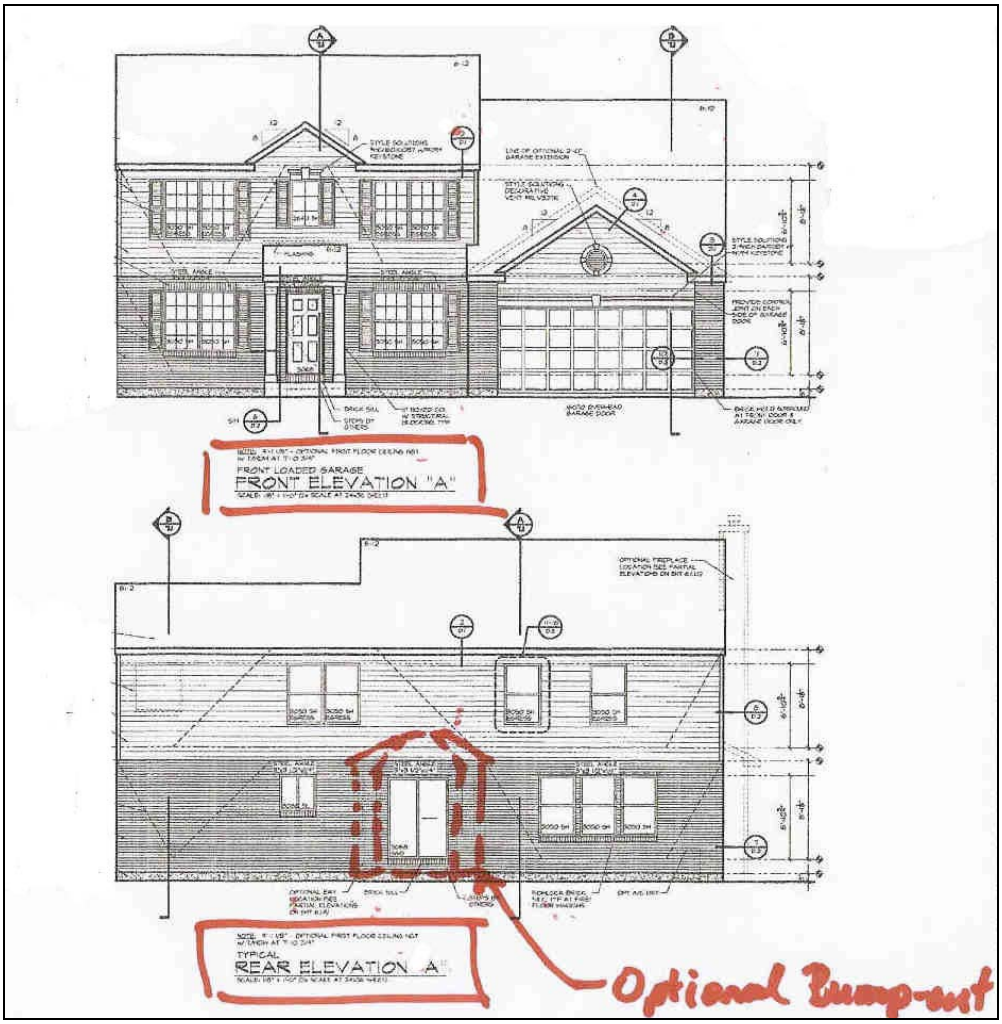


Figure 3: Plan Elevations Showing Front and Rear Braced Wall Line Conditions and Optional Plan Features.

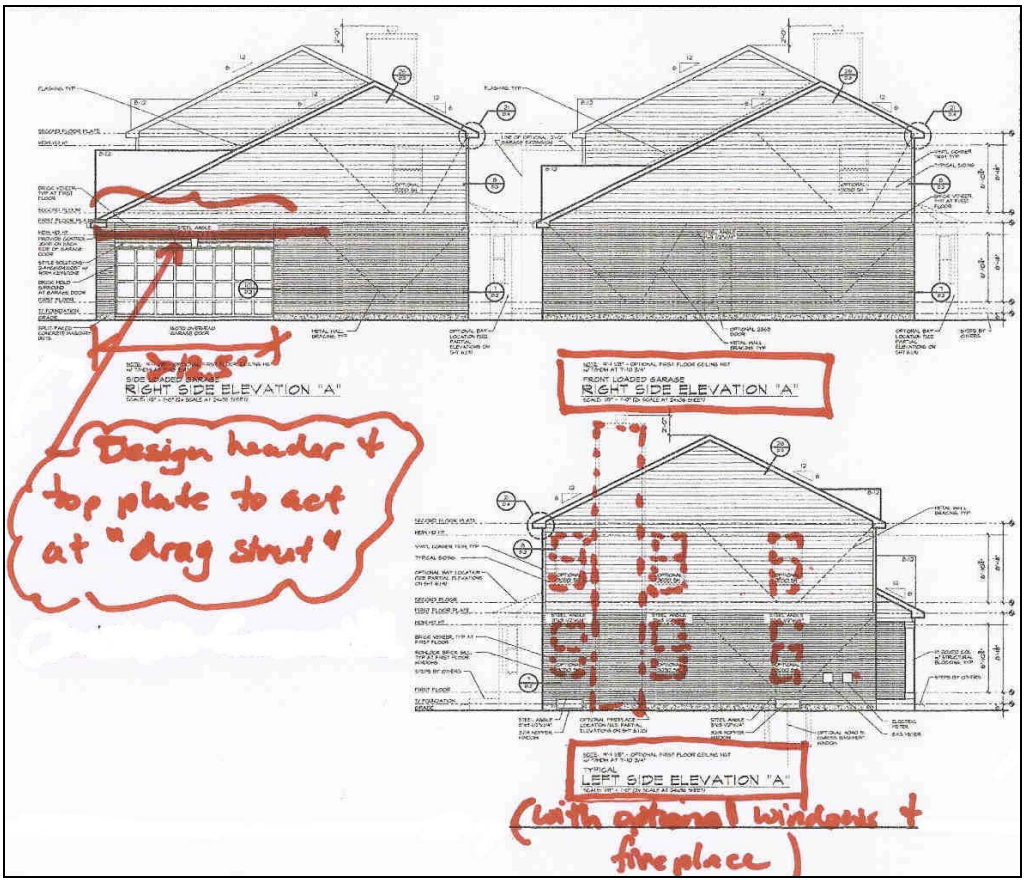


Figure 4: Plan Elevations Showing Side Exterior Braced Wall Line Conditions and Optional Plan Features.

Table 2: Wall Bracing Worksheet for Case Study #2

A			B	C	D	E	F	G	H	I	J	
STEP 1 - Braced Wall Line ID / Description	STEP 1 Support Condition 0-roof 1- one st 2- two st.	Maximum Offset in Braced Wall Line ≤ 4'?	STEP 2 - Braced Wall Line Spacing (feet)	STEP 3 - Bracing Method	STEP 3 - Braced Wall Line Length (inches)	STEP 3 - Required Bracing Percentage (Table 3)	STEP 3 - Required Total Length of Braced Wall Panels (inches)	STEP 4 - Total Length of Braced Wall Panels Provided (inches)	STEP 4 - Value in Column F ≥ Value in Column E?	STEP 5 - Brace wall panels begin within 12.5' of ends of braced wall line?	STEP 5 - Braced wall panels spaced along braced wall line at 25'oc maximum?	COMMENTS
Lower Story – Longitudinal Braced Wall Lines (Parallel To Left-To-Right Plan Direction)												
A (rear wall)	1	OK	14.5' + .5' = 15' (see comments)	Method 1 (Use USP S365 Steel T-Braces)	50'	25'oc and start no more than 12.5' from ends	N/A	Minimum of 3 braces needed to meet brace location requirements	N/A	OK	OK	For purpose of determining bracing amount, the braced wall line location for rear wall line is shifted 0.5' outward which increases the braced wall line spacing, but reduces the effective offset of the bump-out to 4' (e.g., not required to be braced as a separate braced wall line within the rear wall.
B (interior wall)	1	OK	18.2' (measured to front entry wall)	Method 5 (one side and two side as indicated)	50'	25% (based on both sides)	12.5'	18.2' (both sides) at rear garage wall, plus 8' (one side) at left side stair well to meet 25'oc and 12.5' from ends of wall	OK	OK	OK	Lap interior braced wall line top plates with exterior wall top plate or use equivalent strap.
B-alt (alternate bracing for interior wall)	1	OK	18.2'	Interior partition wall with ½" GWB on both sides installed per IRC Table R702.3.5	50'	50%	25'	39.3' (along entire braced wall line, excluding door openings and any segments less than 4' long)	OK	OK	OK	See Bracing Guide, Part 3 for justification to use interior partition wall as bracing; engineering approval may be required.
C1 (front entry wall)	1	OK (4' offset between C1 and C2)	34'	R602.10.5 Continuous Structural Sheathing	29.4'	16%	4.1'	11.5'	OK	OK	OK	Use 48" Method 3 panel on side walls at corners at ends of BWL C1 and C2 (minimum 2' corner return panels are required at ends of R602.10.5 walls).

A			B	C	D	E	F	G	H	I	J	
C2 (garage opening wall)	0	OK	20' (measured to rear wall of garage)	Table R602.10.5, footnote b, minimum 24" wide wood structural panels	25'-2"	N/A	4'	4'	OK	OK	OK	See comment above for BWL C1 with regard to sheathing panels at ends/corner on flanking braced wall lines.
Lower-Story Transverse Braced Wall Lines (Parallel To Front-To-Back Plan Direction)												
1 (left exterior side wall)	1	OK	29.4' (measured to garage left side interior wall)	Method 1	34'	25'oc and start no more than 12.5' from ends	N/A	Minimum 2-braces required; use 2 USP S365 braces in V shape between middle two optional window locations plus an additional Method 3 brace at front corner for end restraint of BWL C1	N/A	OK, except when both options for windows and fireplace are used (see comment 4 below on plan options)	OK	1. Method 3 panel provides additional bracing to this wall and gives mounting surface for electric service meter. 2. When window and fireplace option executed, the brace closest to rear corner will be 14.5' from the corner – Design Required regardless of bracing method used.
2 (garage left interior side wall)	1	OK	29.4' (measured to left exterior side wall)	Method 5 (one side) – ½" GWB on garage interior face also required for fire separation from living area.	34' (see comments)	50%	17'	19.2'	OK	OK	OK	Length of braced wall line is based on the depth of the building, not just the length of the garage interior wall line. Even though BWL 2 does not extend across building to rear wall, it effectively does so through connection to the floor/roof diaphragm that ties together the first story walls.
3 (right side wall)	1	OK	21' (measured to garage left side interior wall)	Method 3 and Method 1	38'	25'oc and start no more than 12.5' from ends	N/A	Minimum 3-braces required; use 1 USP S365 at rear end of wall and Method 3 panels at front corner and next to garage exterior egress door	N/A	OK	OK	Number of braces required is based on Method 1 bracing requirements. Method 3 braces are substituted for 2 of the required braces based on equivalency.

A			B	C	D	E	F	G	H	I	J	
Upper Story – Longitudinal Braced Wall Lines (Parallel To Left-To-Right Plan Direction)												
A (2nd story rear wall)	0	OK	34’	Method 1	50’	25’oc and start no more than 12.5’ from ends	N/A	Minimum 3-braces (same as BWL 3 for 1st story rear wall)	N/A	OK	OK	NOTE: Can use Method 3 braces for all 2nd story walls (except BWL A) as a complete substitute for Method 1 braces or just at corners. However, best to use Method 1 at corner where Tub/Shower is located to allow for exterior foam insulation for warmer wall and comfort.
B (2nd story front wall)	0	OK	34’	R602.10.5 (same as BWL C1 on first story)	29.4’	13%	6.5’	12.1’	OK	OK	OK	Inadequate space for Method 3 or Method 1 bracing to work (may be able to use Method 3 with approval of “partial credit” for narrower than 48” panel widths); use 48” Method 3 panels at corners on flanking walls.
B’ (2nd story front offset at rear of garage)	0	OK	34’	Method 1	20.2’	N/A	N/A	Place one brace near center of this short offset wall segment at rear of garage on second story	N/A	OK	OK	

A			B	C	D	E	F	G	H	I	J	
Upper Story – Transverse Braced Wall Lines (Parallel To Front-To-Back Plan Direction)												
1 (2nd story left exterior side wall)	0	OK	29.4’	Method 1	34’	25’oc and start no more than 12.5’ from ends	N/A	Minimum 2-braces required; use 2 USP S365 braces in V shape between middle two optional window locations plus an additional Method 3 brace at front corner for end restraint of BWL B	N/A	OK	OK, except when both options for windows and fireplace are used (see comments)	When window and fireplace option executed, the brace closest to rear corner will be 14.5’ from the corner – Design Required (same comment for BWL 1 on first story).
2 (2nd story center wall to left of garage roof)	0	OK	29.4’	Method 1 and Method 3	34’ (see comments)	25’oc and start no more than 12.5’ from ends	N/A	2-braces, one each end (substitute Method 3 brace required at front corner of BWL 2 as restraint to BWL B – R602.10.5 method)	N/A	OK	OK	The length used for the braced wall line for purpose of determining bracing amount is based on the entire depth of the building as thought the wall line extended completely through the building. However, the bracing amount is placed only on the wall portion adjacent to the garage.
3 (2nd story right side wall)	0	OK	20’	Method 1 or Method 3	17.8’ depth)	25’oc and start no more than 12.5’ from ends	N/A	2 braces, one at each corner	N/A	OK	OK	

Comments on Plan Options Affecting Bracing Strategy

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

This plan option is problematic for all Method 1 bracing used on the lower story unless window and door placement is modified in some locations. Method 3 bracing would still work as a substitute for all Method 1 braces, but where required braces cannot be located within 12.5' from ends of walls (e.g., installing windows and a fireplace on the left side wall), an engineered solution is required. This same issue also applies if the left side wall was braced with continuous structural sheathing because of the window location closer than 2' from the corner. The front walls with R602.10.5 continuous structural sheathing will not be affected.

Method 1 bracing manufacturer's data appears limited to 8' or 10' wall heights unless RWB style flat straps are used, making intermediate wall heights difficult unless a different product is specified for the 9' wall height option. However, the RWB strap brace requires a 45^{o} angle and a double-V configuration which requires much more wall space than the S365 60^{o} T-brace selected for this example design problem. Finally, Method 5 bracing for interior braced wall lines is unaffected by this option.

In summary, if the 9' first story wall height option is used, all Method 1 bracing on the first story level should be switched to Method 3 braces. Front walls with continuous structural sheathing will be unaffected, but the garage opening bracing panels will need to be increased in width from 24" to 27" to not exceed the maximum permitted 4:1 aspect ratio (panel height : panel width), in accordance with Table R602.10.5, footnote b of the IRC. (*Refer to Figure 6a in the 'Guide'.) Alternatively, the portal framing approach for bracing of the garage opening wall may be used in accordance with footnote 'c' in Table R602.10.5 of the IRC 2006.*

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 3 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 <u>both</u> 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 require a modest increase in nailing of top plate splices for the affected wall portion. Note that this applies when either Method 1 or Method 3 braces are used. Also, if a continuous structural panel sheathed wall is used, a similar designed solution will be required because the

minimum 2' panel required at ends cannot be achieved with the corner window option. *(Refer to Section 3 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" 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. *(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. In fact, this meets the intent of the IRC code – a maximum 8' out-to-out offset in any given braced wall line.

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Be sure to visit the FSC Website www.foamsheathing.org (available Oct. '06)
for a downloadable copy of this Supplement and for other important information.

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