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FSC Bulletins

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ANSI/SBCA FS 100–2012

Standard Requirements for Wind Pressure Resistance of Foam Plastic Insulating Sheathing Used in Exterior Wall Covering Assemblies

Approved American National Standard
October 2012

Acknowledgements

This *American National Standard* establishes wind pressure resistance requirements for foam plastic insulating sheathing (FPIS) products used as exterior wall sheathing, including use as continuous insulation in exterior wall covering assemblies for the purpose of demonstrating wind pressure performance. This includes performance testing, analysis and quality control procedures.

In this endeavor, SBCA worked in concert with the Foam Sheathing Committee (FSC) of the American Chemistry Council whose mission is to develop solutions to building code issues and promote the proper technical use of foam sheathing to the construction industry. Thanks are extended to the members of FSC and the FS 100 Project Committee for their hard work and commitment to achieving this consensus standard.

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ANSI/SBCA FS 100–2012

Standard Requirements for Wind Pressure Resistance of Foam Plastic Insulating Sheathing Used in Exterior Wall Covering Assemblies

Note: User notes are not mandatory parts of this standard, but are provided to give the user some guidance on the intent of the mandatory language.

1.1 Scope. This standard establishes wind pressure resistance requirements for *Foam Plastic Insulating Sheathing* (*FPIS*) products used as *exterior wall sheathing*, including use as continuous insulation, in *exterior wall covering* assemblies.

1.1.1 *FPIS* products shall resist design transverse wind loads acting on exterior wall assemblies as provided in Section 4.0, except as limited in Section 1.2.

1.1.2 Section 6.0 provides requirements for establishment and use of wind pressure resistance values for *FPIS* products in *blocked* and *unblocked* installations.

1.1.3 Quality assurance shall be provided by an *approved agency* in accordance with Section 7.0.

> *User Note: For information on the definition of continuous insulation, see ASHRAE 90.1.*

1.2 Limitations. The scope of this standard is limited to exterior applications where the *FPIS* product is used as an *exterior wall sheathing* that is required to resist transverse wind loading only. The following applications are excluded from the scope of this standard:

1. Applications of *FPIS* products that are intended to provide structural functions in addition to transverse wind load resistance of a wall assembly, such as in-plane racking shear resistance (wall bracing), in-plane uplift resistance, and buckling restraint of studs or columns.
2. Applications of *FPIS* products used in contact with and over sheathing and its fastening capable of independently resisting wind loads (see *over-sheathing*), used in contact with and under sheathing and its fastening capable of independently resisting wind loads, used on interior building walls, or used on the interior side of exterior walls behind an interior finish material.
3. Applications where *FPIS* is used as part of an *Exterior Insulating Finish System*.

1.3 Additional Considerations. Wall assemblies including *FPIS* products shall comply with the applicable building code.

> *User Note: Refer to Commentary C1.3 for guidance on end use and code compliance considerations related to use of FPIS products on exterior wall assemblies, including:*
>
> *Cladding attachment*
> *Fire safety*
> *Thermal resistance*
> *Water resistive barrier performance*
> *Wind-borne debris resistance*

1.4 Material Requirements. *FPIS* products used in accordance with this standard shall comply with the following material standards, as applicable, and the additional quality assurance requirements of Section 7.0:

- *Expanded polystyrene (EPS)* – ASTM C578
- *Extruded polystyrene (XPS)* – ASTM C578
- *Polyisocyanurate (Polyiso)* – ASTM C1289

1.5 Alternative Methods of Compliance. The provisions of this standard are not intended to prevent use of alternative methods of compliance as permitted by the applicable building code. Alternate methods shall comply with the intent of this standard and shall be at least the equivalent of that prescribed in this standard for wind pressure resistance qualification and quality assurance.

2.0 Reference Standards

ASCE 7-05 – *Minimum Design Loads for Buildings and Other Structures*
ASCE 37-02 – *Design Loads on Structures during Construction*
ASTM C203-5a – *Standard Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation*
ASTM C578-11 – *Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation*
ASTM C1289-11 – *Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board*
ASTM C1396-11 – *Standard Specification for Gypsum Wallboard*
ASTM E330-09 – *Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference*
ASTM E1233-06 – *Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Cyclic Air Pressure Differential*
DOC PS2-10 – *Performance Standard for Wood-Based Structural-Use Panels*

3.0 Definitions

Approved Agency: An established independent, qualified and recognized agency regularly engaged in conducting tests or furnishing independent (third-party) inspection services.

Blocked: Refers to *FPIS* installation practice whereby all edges are supported on a framing member or blocking. See also "unblocked".

Exterior Insulating Finish System (EIFS): A lightweight synthetic wall cladding that includes foam plastic insulation and thin synthetic coatings.

Exterior Wall Covering: A material or assembly of materials applied on the exterior side of exterior walls for the purpose of providing a weather-resisting barrier, insulation or for aesthetics, including but not limited to, veneers, siding, exterior insulation and finish systems, architectural trim and embellishments such as cornices, soffits, fascia, gutters and leaders.

Exterior Wall Sheathing: A material in board or panel form attached directly to wall framing on the exterior side of an exterior wall assembly.

Extruded Expanded Polystyrene (XPS) Thermal Insulation: A cellular plastic product, with or without facings, manufactured in a one-stage process by extrusion and expansion of the base polymer in the presence of blowing agent(s) resulting in a product that is rigid with a closed cellular structure. Refer to ASTM C578 for additional information.

Faced Rigid Cellular Polyisocyanurate (Polyiso) Thermal Insulation: A cellular plastic product formed using polyurethane-modified polyisocyanurate encapsulated between *facer* materials. Refer to ASTM C1289 for additional information.

Facer: An integral material permanently applied to the face of one or both surfaces of the *FPIS* product evaluated in accordance with this standard.

Foam Plastic Insulating Sheathing (FPIS): For the purpose of this standard, Foam Plastic Insulating Sheathing is a wall sheathing material in board or panel form consisting of foam plastic material complying with ASTM C578 or ASTM C1289, including *facers* as applicable, with a minimum thermal resistance of R2 (ft^2 ^oF h/Btu) at 75^{o}F mean temperature.

Mean Roof Height: The average of the height of the roof at the eave and the height at the highest point on the roof surface, except that, for roof angles less than or equal to 10^o, the mean roof height is permitted to be taken as the roof eave height. Height is measured relative to the grade plane.

Molded Expanded Polystyrene (EPS) Thermal Insulation: A cellular plastic product, with or without facings, manufactured from pre-expanded polystyrene beads subsequently molded into desired shapes and sizes resulting in a product that is rigid with closed cellular structure. Refer to ASTM C578 for additional information.

Over-sheathing: Application of *FPIS* over and directly on the surface of wall sheathing material or solid wall construction, such as masonry or concrete, whereby the substrate is capable of resisting the full design transverse wind load required by the applicable building code or latest edition of the ASCE 7 standard.

Sample: A set of *specimens* analyzed together.

Specimen: The individual test piece or assembly.

Transverse Wind Pressure Resistance: Resistance to wind pressure acting perpendicular (transverse) to the plane of a wall as differentiated from other wind load effects, such as in-plane (racking) shear force acting horizontally in the length direction of a wall, or wind uplift force acting vertically on a wall.

Unblocked: Refers to an *FPIS* installation whereby an edge is not supported by blocking or framing members.

4.0 Design Wind Load Requirements

4.1 Prescribed Design Wind Loads. *FPIS* shall resist the component and cladding design wind load shown in Table 1 as applicable to the design wind speed and wind exposure of the intended end-use.

TABLE 1: Components and Cladding Design Wind Pressure Loads (PSF)[1,2,3,4]

Design Wind Speed (mph, gust) and Exposure	85/B	90/B	100/B	110/B	120/B	130/B	140/B	150/B
	-	-	85/C	90/C	100/C	110/C	120/C	130/C
	-	-	-	85/D	90/D	100/D	110/D	120/D
Negative Pressure (Suction) Design Wind Load	-17.4	-19.5	-24.4	-29.1	-34.7	-40.7	-48.6	-57.6
Positive Pressure Design Wind Load	13.0	14.6	18.2	21.8	25.9	30.5	36.3	43.0

TABLE NOTES:

1. Tabulated wind pressures are for *mean roof height* not exceeding 30 feet (measured vertically from grade plane to middle of roof slope, enclosed buildings, and importance factor equal to 1.0. For other conditions of use, calculate wind load in accordance with Section 4.2.
2. Refer to the applicable building code or the ASCE 7 standard for wind exposure descriptions (B = suburban/wooded terrain; C = open flat terrain; D = ocean/lake exposure).
3. Where topographic effects occur (e.g., wind speed up due to hill-top exposure), wind load shall be calculated in accordance with Section 4.2.
4. Tabulated wind pressures are for wall corner zones using an effective wind tributary area of 10 square feet. For lesser design wind pressures away from wall corner zones, refer to the applicable building code or the ASCE 7 standard.

User Note: Table 1 wind speed and wind pressures are based on ASCE 7-05. Wind speed conversions are required for use with codes based on wind speed map in the ASCE 7-10 standard. An appropriate conversion can be achieved by multiplying the wind speed values in the heading of Table 1 by 1.26. Refer to commentary Section C4.0 for additional guidance.

4.2 Calculated Design Wind Loads. As an alternative to prescribed wind loads provided in Section 4.1, the applicable components and cladding wind load shall be permitted to be calculated in accordance with the applicable building code or the ASCE 7 standard using an effective wind tributary area of 10 square feet.

5.0 Installation Conditions

Installation conditions shall comply with the following:

1. Light-frame wall construction shall have a minimum framing member thickness of 1-1/2 inches for wood framing or flange width of 1-1/2 inches for cold-formed steel framing.
2. Wall stud spacing shall not exceed 24 inches on center.
3. All *FPIS* sheathing edges shall be supported by wall framing or blocking unless *unblocked* construction is specifically addressed by *FPIS* manufacturer's installation instructions.
4. For applications of *FPIS* where its fastening is intended to resist full transverse negative design wind load independent of the cladding material and cladding fastening, *FPIS* shall be attached to wall framing in accordance with the *FPIS* manufacturer's installation instructions for this application, and in accordance with Sections 6.6.2 and 7.4.2.

5. For applications where the *FPIS* attachment is not capable of independently resisting negative design wind pressures in accordance with Section 4, exterior cladding shall be provided to secure the *FPIS* to the wall framing. Where cladding is used to secure *FPIS* to the wall framing, the cladding and cladding attachment shall be structurally adequate to resist the negative design wind pressure in accordance with Section 4. Installation of the cladding and its attachment over *FPIS* shall be in accordance with one of the following:
   a) the cladding manufacturer's installation instructions for installation over *FPIS*; or
   b) where vinyl siding manufacturer's installation instruction for vinyl siding certified and labeled as conforming to ASTM D3679 does not address application over *FPIS*, the vinyl siding manufacturer's installation instructions for vinyl siding installed over structural sheathing capable of independently resisting negative design wind pressures shall be permitted when the following conditions are met:
      i) the wind pressure rating of the vinyl siding is reduced to account for the wind load acting on the vinyl siding layer and fasteners securing the vinyl siding and foam sheathing,
      ii) a minimum safety factor of 2 is used in determination of the reduced wind pressure rating, and
      iii) cladding fastener length is adequate to maintain required penetration into the framing; or
   c) engineered design.
6. For applications where furring is installed over *FPIS*, furring shall be attached to wall framing to resist transverse wind load applied to furring from cladding and FPIS, and to support cladding weight.

User Note: Refer to Commentary C1.3 for guidance on installation of cladding and furring over FPIS on light frame wood or steel walls. This standard and typical practice relies primarily on cladding or furring attachments to provide securement for permanent wind load resistance of exterior wall covering *assemblies which include FPIS products as a component.*
Designing FPIS attachments for the full design wind load has some advantages such as improved temporary wind resistance during construction and less reliance on quality of siding installation for wind resistance of the FPIS component and wall covering assembly as a whole.

6.0 Wind Pressure Resistance Requirements

6.1 General. Tests shall be conducted in accordance with Test Method A.2 or A.3 (see Annex A) and Table 2.

TABLE 2: Product Orientation on Test Frame to Address Intended End-Use Installation Conditions[1,2,,3]

FPIS Face Orientation on Test Frame	*FPIS* Length Axis Relative to Wall Framing (Studs)			
	Unblocked		*Blocked*	
	Parallel	Perpendicular	Parallel	Perpendicular
Three tests with each face of *FPIS* oriented toward suction chamber for each *FPIS* length axis orientation option(s) at right. Regardless of face orientation, *FPIS* is always to be located on opposite side of test frame from suction chamber per Test Method A.2. **Exception**: *FPIS* with foam core materials that are homogenous through thickness and, if *facers* are included, have identical *facers* on both sides of *FPIS*, shall not be required to test in both orientations with respect to test chamber.	The test result for this condition shall be permitted to be used for the following conditions: (1) *Unblocked* parallel, (2) *Blocked* parallel, (3) Perpendicular (*blocked*) and Perpendicular (*unblocked*) provided the *FPIS* has bending properties in length direction that are at least equivalent to the width direction.	The test result for this condition shall be permitted to be used for the following conditions: (1) Perpendicular (*unblocked*), (2) Perpendicular (*blocked*), (3) Parallel (*blocked*) and Parallel (*unblocked*) provided the *FPIS* has bending properties in width direction that are at least equivalent to the length direction.	The test result for this condition shall be permitted to be used for the following conditions: (1) Parallel (*blocked*) and (2) Perpendicular (*blocked*) provided the *FPIS* has bending properties in length direction that are at least equivalent to the width direction.	The test result for this condition shall be permitted to be used for the following conditions: (1) Perpendicular (*blocked*) and (2) Parallel (*blocked*) provided the *FPIS* has bending properties in width direction that are at least equivalent to the length direction.

TABLE NOTES:

1. Parallel and perpendicular (*unblocked*) conditions correspond to conditions where the horizontal edges are not continuously supported and vertical edges are continuously supported. Parallel and perpendicular (*blocked*) conditions correspond to conditions where all edges are continuously supported.
2. Each stud spacing condition intended for end-use shall be tested or alternatively the allowable wind pressure resistance value established from testing the maximum stud spacing intended for end-use shall be permitted to be used for smaller stud spacing.
3. The minimum number of stud bays spanned continuously by a single *FPIS* in the required wind pressure qualification test *specimens* shall be consistent with the manufacturer's installation instructions. For example, if installation instructions do not restrict the size of *FPIS* (or minimum number of stud bays that must be spanned), then qualification testing shall be conducted with at least one stud bay in the test *specimen* spanned by an individual *FPIS* cut to match the center-to-center width of the stud bays.

User Note: Wind pressure resistance values obtained from this testing apply only to the FPIS *product's ability to resist bending load from wind pressure with orientation and blocking specified in Table 2 and with other support conditions specified in Test Methods A.2 or A.3, as applicable. Other components such as siding and framing or connections may limit the allowable design wind pressure resistance of the exterior wall or* exterior wall covering *assembly.*

6.2 Nominal Wind Pressure Resistance (P_{nom}). A product's nominal wind pressure resistance value for each condition tested in accordance with Table 2 shall be taken as the lowest value of the maximum test pressures recorded from the required test repetitions.

6.3 Yield Wind Pressure Resistance (P_y). A product's yield wind pressure resistance value for each condition tested in accordance with Table 2 shall be taken as the smallest yield test pressure from the required test repetitions. The value of P_y shall be determined in accordance with the following criteria:

1. Determine initial slope of load-deflection plot by determining the slope of a line defined by points on the load deflection plot at 10% and 30% of the nominal load.
2. Offset the above line such that the X-axis intercept equals the deflection recorded at 10% of nominal load.
3. P_y is the pressure associated with the point where the offset line intersects the load-deflection plot.

6.4 Pressure Equalization Factor (PEF). A PEF of 1.0 shall be required for *exterior wall sheathing* applications.

Exceptions:

1. For conditions where the design negative wind pressure load determined in accordance with Section 4.0 does not exceed 30 psf, a PEF of 0.9 shall be permitted to determine negative wind pressure resistance only for *exterior wall sheathing* on wall assemblies having an interior finish of at least 0.5-inch-thick gypsum wall board (ASTM C1396) or any material of at least equivalent bending strength, rigidity and air permeability.

6.5 Allowable Design Wind Pressure Resistance (P_{all}). For each nominal wind pressure resistance value determined in accordance with Section 6.2 addressing end-use installation conditions in accordance with Section 6.1 and each PEF factor condition addressed in accordance with Section 6.4, a design wind pressure resistance value shall be determined in accordance with the following equation:

$$P_{all} = P_{nom} / [(SF)(PEF)] \leq P_y \qquad \text{[Eq. 1]}$$

where:

P_{all} = allowable design wind pressure resistance for the *FPIS* product and appropriate wall assembly condition corresponding with the PEF factor and nominal wind pressure resistance value

P_{nom} = nominal wind pressure resistance value determined in accordance with Section 6.2

P_y = pressure at which yielding behavior is considered to initiate due to a relatively rapid decrease in *FPIS* product stiffness during uniform pressure testing (see Section 6.3)

User Note: An approved agency *shall determine P_y based on test results using Test Method A.2; refer to commentary Section C6.3 for additional guidance.*

SF (safety factor) = 1.5

PEF = pressure equalization factor determined in accordance with Section 6.4

Exception: P_{nom} shall not be required to be limited to P_y provided that P_{nom} is taken as the least maximum test pressure from tests in accordance with Test Method A.3 (see Annex A).

6.6 Conditions of Use

6.6.1 The allowable design wind pressure for the *FPIS* product determined in accordance with Section 6.5 shall meet or exceed the positive and negative design wind pressure determined in accordance with Section 4.0.

> **Exception:** *FPIS* is permitted to be selected using positive pressure only when the *FPIS* product is restrained from outward movement by cladding which is installed directly in contact with the surface of the *FPIS* product, is capable of resisting the full design wind load without reduction for pressure equalization, and has bending stiffness under uniform pressure loading that is greater than that of the *FPIS* product.

6.6.2 For applications where the foam sheathing is attached to the wall with fasteners capable of resisting the design negative wind pressure load independent from and without reliance on the cladding material and its attachment, the *approved agency* and manufacturer shall incorporate qualification testing and quality assurance procedures for fastener head or washer pull-through resistance of the *FPIS* product.

> *User Note: ASTM E330 and ASTM E1233 are examples of suitable methods to evaluate capacity and determine design values for* FPIS *connections in accordance with Section 6.6.2. While qualification testing in accordance with specific requirements of Test Method A.2 and A.3 are intended to evaluate bending failure of foam sheathing under fully supported conditions (bearing on test frame members), modification of these methods is the recommended approach for evaluation of failure modes associated with fastener head or washer pull-through resistance of the* FPIS *product. For quality assurance purposes, individual fastener head or washer pull-through tests may be conducted in accordance with an appropriate test method, such as ASTM D1037, Section 15 coupled with periodic follow-up testing in accordance with modified Test Method A.2 or A.3 as applicable.*

7.0 Quality Assurance and Product Labeling

7.1 Quality Control. *FPIS* products complying with this standard shall be produced under a quality assurance program administered by an *approved agency*. An approved quality assurance manual shall be developed in collaboration with the *approved agency*. The quality assurance manual shall specify quality assurance testing and process control requirements in accordance with Sections 7.2 and 7.3.

7.2 Quality Assurance Testing

7.2.1 Test equipment shall be properly maintained, calibrated, and evaluated for precision, accuracy and adequacy at a frequency satisfactory to the *approved agency* and consistent with the applicable standards.

7.2.2 The frequency of tests as required by Section 7.1 shall be chosen to yield quality assurance performance that supports design capacities assigned to the product.

7.3 Process Control

7.3.1 Data from tests outlined in 7.1 shall be evaluated prior to shipment of the material represented by the *sample*. Analytical procedures shall determine if product capacities are in statistical control. The control levels selected shall support current design capacities.

7.3.2 When the analysis described in 7.3.1 indicates that the product is below the control level, the associated portion of production shall be subject to re-examination in accordance with the acceptance procedures provided in the approved quality assurance manual.

7.3.3 All pertinent records shall be maintained and be available for review by both in-house and *approved agency* personnel. At a minimum, such records shall include:

> 7.3.3.1 All inspection reports and records of test equipment calibration, whether accomplished by in-house or by *approved agency* personnel.
>
> 7.3.3.2 All test data, including retests and data associated with rejected production.
>
> 7.3.3.3 Details of any corrective actions taken and the disposition of any rejected production resulting from tests or inspection**.**

7.4 Specific Requirements for *FPIS* Products

7.4.1 Reference values for quality and process control purposes shall be established using Test Method A.1 (Annex A) and *FPIS* material sampled from the same lot of material used for qualification testing in accordance with Section 6.2. In addition, the correlation between reference values per 7.4.1 and qualification testing in accordance with Section 6.2 shall be monitored for quality and process control purposes.

7.4.2 For applications where the intent of the manufacturer's installation instructions for the *FPIS* product and its attachment is to resist the design wind load independent of the cladding material and its fastening, quality assurance for *FPIS* attachment to resist wind load shall be provided in accordance with Section 6.6.2.

7.4.3 In addition to quality control testing based on correlated reference values, the quality assurance program shall include periodic follow-up testing in accordance with Test Method A.2 (Annex A).

7.5 Labeling

7.5.1 *FPIS* products shall be labeled with the name and identification of an *approved agency* responsible for verifying conformance to the requirements of this standard.

7.5.2 Product shall be labeled to indicate conformity with this standard and a notation referencing manufacturer's literature for finding wind pressure rating, pressure equalization factor and attachment method for wind pressure resistance.

7.5.3 Product label shall also include a coding to trace the product back to manufacturing plant and date of manufacture.

7.5.4 An example of a label meeting the requirement of Section 7.5.2: "Complies with ANSI/FS 100; refer to manufacturer for wind pressure rating."

ANNEX A – Test Methods

(Mandatory ANNEX)

A.1 Bending Strength Behavior and Quality Control Test Method ("Test Method A.1")

A.1.1 Bending tests shall be conducted in accordance with Section 10.5 of ASTM C203 using Method 1 (refer to Sections 1.1.1, 4.1.1 and 5.2 of ASTM C203) and Procedure D (refer to Sections 1.2.4 and 4.3.4 of ASTM C203) with the following modifications:

> *SPECIMEN* ORIENTATION: *Specimens* shall be cut from *FPIS samples* with test *specimen* span dimension oriented in the cross-machine or width direction of the board. *Specimen* shall be placed in test apparatus such that the crosshead applies downward force and deflection to the exterior side (if applicable) of the *FPIS*.
>
> *SPECIMEN* SIZE: The test *specimen* shall be full thickness with facings (if any) intact. In lieu of the range of permissible test specimen dimensions in Section 8 of ASTM C203, the test *specimen* span-to-thickness ratio (L/d) shall be 10 (except 16 shall be used for ½" thick *specimens*) and the *specimen* shall be not more than 2 inches greater in length than the required span. *Specimen* width-to-thickness ratio (b/d) shall be at least 4.
>
> *SPECIMEN* CONDITIONING: In lieu of conditioning requirements of ASTM C203 Section 9, *specimens* shall be equilibrated to and tested with an ambient air temperature of 75^{o}F +/- 4^{o}F.
>
> DEFLECTION: In lieu of deflection requirements in ASTM C203 Sections 4.2 and 10.1 or 10.2 and the crosshead speed requirement in Section 10.5.2 of ASTM C203, the *specimen* shall be deflected at a constant crosshead rate of 0.625 inches/min up to a maximum mid-span deflection of 1.6 inches or to a mid-span deflection at which the applied load drops by 50% from the peak applied load, with or without the occurrence of rupture. Deflection shall not be limited by 5% strain in accordance with ASTM C203 Sections 4.2 (Note 1) and Sections 10.1.6 and 10.2.6 of ASTM C203 shall not apply. Deflection measurement shall be based on cross-head movement without accounting for *specimen* compression at support and loading points as discussed in Sections 10.1.5 and 10.2.5 of ASTM C203.
>
> REFERENCE VALUE: The reference value for the *sample* shall be the calculated value from Equation (6) of ASTM C203 Section 11.1 using the lowest value of maximum cross-head force (load) recorded for all required test *specimens* for the bending stress direction associated with each qualification test value.

A.1.2 Test method modifications shall be permissible provided an at least equivalent correlation to wind pressure qualification tests (Section A.2) is achieved subject to the review and approval of the *Approved Agency*.

> A.1.2.1 The span dimension of the *specimen* shall be indicated as corresponding with the length or width direction of the *FPIS* as appropriate for the intended use of the test results. The side of the product or *facer* subjected to tension due to bending load application shall be as appropriate for the intended use of the test data.

A.2 Wind Pressure Qualification Test Method ("Test Method A.2")

A.2.1 Wind pressure resistance tests shall be conducted in accordance with ASTM E 330 and Sections A.2.2 through A.2.4. Alternatively, uniform pressure tests conducted in accordance with the test method described in Section 7.2 of DOC/PS 2-10 shall be permitted, except deflection measurements shall be read at mid-span of the sheathing at mid-height of the wall in the two outer stud bays and averaged for construction of a load-deflection plot for each *specimen*.

> *User Note: If the DOC/PS 2-10 test method is used, horizontal sheathing joints are* unblocked *and thus the qualification test results are applicable to installation conditions where horizontal sheathing joints are not supported on framing or blocking.*

A.2.2 Construct a minimum 4-ft x 8-ft (1.2 m x 2.4 m) test frame in accordance with ASTM E330 with stud framing members fully supported. The *FPIS* product shall be of the desired thickness for testing and shall be placed on the side of the test frame opposite the suction pressure chamber. Assembly conditions (framing spacing, product orientation on framing and test frame size) shall be representative of the intended conditions of use including presence of *FPIS* joints, single span and multiple span conditions as applicable per manufacturers' installation instructions. Width of bearing on studs at *FPIS* edges shall not be greater than ¾ inches. Faces of the *FPIS* shall be oriented relative to the test apparatus suction chamber such that results correspond with positive or negative wind pressure loading directions for products that have non-identical *facer* material on opposite faces of the *FPIS* and which are labeled to identify which *facer* material faces outward from the wall. Separate testing is required to address *FPIS* installation parallel or perpendicular to studs, unless the weaker condition is used for the purpose of wind pressure qualification.

> *User Note: Testing in accordance with specific requirements of A.2.2 is intended to evaluate bending failure of foam sheathing where foam sheathing bears on stud framing. Where it is intended to evaluate the* FPIS *product and its attachment for wind pressure resistance independent of cladding and cladding fasteners, the* FPIS *product shall be placed on the side of the frame facing the suction chamber. Support of studs shall be provided in a manner to limit stud deflection without restraining movement of the* FPIS *product or reducing load resisted by the attachment of the* FPIS *product to the frame. Assembly conditions (framing spacing and product orientation on framing) shall be representative of the intended conditions of use including presence of panel joints, single span and multiple span conditions as applicable per manufacturers' installation instructions.*

A.2.3 A uniform suction pressure load shall be applied in accordance with ASTM E330, Method B, except deflection measurements shall be read at mid-span of the sheathing at mid-height of the wall in the two outer stud bays and averaged for construction of a load-deflection plot for each *specimen*. The maximum test pressure shall be recorded for each *specimen*.

A.2.4 Studs of the test frame shall be fully supported in accordance with A.2.2 to prevent failure of framing members or frame connections prior to bending failure of foam sheathing. Frame supports shall not interfere with response of foam sheathing to the applied uniform pressure load.

A.2.5 *FPIS* test *specimens* shall be equilibrated to and tested in an ambient temperature condition of 75^{o}F +/- 4^{o}F.

A.3 Wind Pressure Qualification Test Method ("Test Method A.3")

A.3.1 Wind pressure resistance tests for determining structural performance under cyclic air pressure differential shall be conducted in accordance with requirements of ASTM E1233 and the requirements of this Annex.

A.3.2 The test frame shall be permitted to be in accordance with Section A.2.2 except 1x2 battens shall be applied to the outside face of the *FPIS* product at each stud location on the test frame. Battens shall be fastened to studs to provide a 1.5 inch bearing width for withdrawal restraint under negative pressure loading cycles. Any modifications to allow cyclic air pressure testing shall be reported. *FPIS* test *specimens* shall be conditioned in accordance with A.2.5.

> *User Note: Testing in accordance with specific requirements of A.3.2 is intended to evaluate bending failure of foam sheathing where bearing of foam is on stud framing and battens. Where it is intended to evaluate the* FPIS *product and its attachment for wind pressure resistance independent of cladding and cladding fasteners, the* FPIS *product shall be fastened to the frame in accordance with the intended end use application in lieu of use of battens. Support of studs shall be provided in a manner to limit stud deflection without restraining movement of the* FPIS *product or reducing load resisted by the attachment of the* FPIS *product to the frame. Assembly conditions (framing spacing and product orientation on framing) shall be representative of the intended conditions of use including presence of panel joints, single span and multiple span conditions as applicable per manufacturers' installation instructions.*

A.3.3 The general loading sequence shall be in accordance with Section X1.2.1 or X1.2.2 of ASTM E1233. Prior to application of the maximum test load, the observed condition of test *specimens* including visible damage and permanent set in sheathing deformation shall be recorded.

A.3.4 The maximum test pressure in accordance with ASTM E1233 shall be reported. For purposes of establishing the nominal wind pressure resistance value per Section 6.2.4, the maximum test pressure shall not exceed 1.5 times values of P_{pos} and P_{neg} as applicable.

Commentary for
ANSI/SBCA FS 100–2012

Standard Requirements for Wind Pressure Resistance of Foam Plastic Insulating Sheathing Used in Exterior Wall Covering Assemblies

(Non-Mandatory)

C1.1 Scope. No commentary.

C1.2 Limitations. The standard applies to applications of *foam plastic insulating sheathing (FPIS)* only where wind pressure resistance is required or is not already addressed by other industry standards. For example, wind pressure resistance is not required where *FPIS* is placed over a solid sheathing material that is able to resist the required wind load, and is also covered by a siding material that is able to resist the required wind load. In this manner the *FPIS* is used as insulation and, in some cases, a water resistive barrier. Structural wind pressure loads are resisted by other materials that constrain the *FPIS*. *Exterior insulating finish systems* are excluded from the scope of this standard because wind pressure resistance of this *exterior wall covering* assembly (which uses *FPIS*) is addressed in other standards. This standard also does not apply to structural sheathing composites including *FPIS*. Such products must be appropriately qualified for wind pressure resistance and other structural functions (e.g., wall bracing) using requirements that may differ from those indicated in this standard for *FPIS*. For example, refer to the discussion on safety factors in Section C6.5.

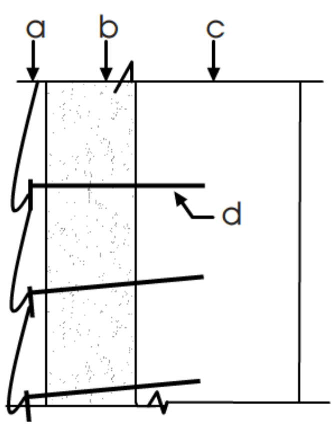
C1.3 Additional Considerations. Wall assemblies are systems and, therefore, require consideration and integration of various code requirements. For example, *FPIS* products can address wind pressure, water resistance, and insulation requirements. Other products must be used to address other code requirements for wall assemblies, such as wall bracing and framing to support structural loads and finishes. This section is intended to help ensure that wall assemblies using *FPIS* meeting the requirements of this standard also address other code requirements for exterior walls and foam plastics.

Cladding Attachments Over Foam Sheathing – Two approaches for attaching cladding over *FPIS* are shown in Figures C1 and C2 below. For guidance on appropriate cladding and furring connections over *FPIS*, refer to the "Guide to Attaching Exterior Wall Coverings through Foam Sheathing to Wood or Steel Wall Framing" (fsc.americanchemistry.com). Also, consult the cladding manufacturer and cladding fastener manufacturer for available data and installation instructions. In no case should the fastener type, size and penetration requirement be less stringent than required by the locally applicable building code or the siding manufacturer's installation instructions.

FPIS fasteners are not shown in Figures C1 and C2. *FPIS* shall be fastened to framing in accordance with the *FPIS* manufacturer's installation instructions. The cladding or furring fasteners are typically intended to provide attachments of the wall covering assembly, including *FPIS*, to resist negative (suction) wind pressure. Unless otherwise evaluated in accordance with Section 6.6.2 and addressed in the *FPIS* manufacturer's installation instructions, *FPIS* fastening is intended for temporary installation conditions only and cladding or furring is intended to provide for permanent fastening.

Use of *FPIS* as the sole exterior sheathing material on exterior walls clad with vinyl siding must comply with requirements in Section R703.11.2 of the 2009 or 2012 editions of the International Residential Code (IRC) for adjustment (reduction) of vinyl siding wind pressure ratings unless the *FPIS* product is attached in accordance with Section 6.6.2 in a manner capable of resisting the full design wind load. The IRC reduction factors are applied as multipliers to vinyl siding wind pressure ratings to increase the pressure equalization factor from 0.36 (ASTM D3679, Annex A) to 0.7 (for walls with minimum ½" gypsum board interior finish) or 1.0 (for walls without an interior surface to share the net wind load). The principle of pressure equalization or load-sharing in multi-layered building envelope assemblies is discussed in ASCE 7-10 commentary, Section C30.1.5 (also see discussion in Section C6.4 in relation to the PEF used for foam sheathing qualification per this standard). In addition, the reduction factors in the IRC increase the safety factor of 1.5 for vinyl siding to a safety factor of 2.0 for the vinyl siding and foam sheathing *exterior wall covering* assembly. Thus, the net adjustment factors (multipliers) for vinyl siding wind pressure ratings in the IRC are (0.36/0.7)(1.5/2.0) = 0.39 for walls with minimum ½" gypsum board interior finish and (0.36/1.0)(1.5/2.0) = 0.27 for use on walls without interior finish. With these adjustments, the vinyl siding wind pressure rating is effectively de-rated by a factor of about 2.5 and 3.7, respectively. As mentioned, these adjustments do not apply to foam sheathing when installed over a sheathing or solid wall system capable of separately resisting the full wind load. Furthermore, these adjustments may be subject to change based on future research and building code and standards development related to vinyl siding wind pressure ratings. Also, use of aluminum siding over *FPIS* products as the sole sheathing material on exterior walls should be avoided unless wind pressure resistance of the assembly is evaluated for code compliance or the *FPIS* product is attached in accordance with Section 6.6.2 in a manner capable of resisting the full design wind load. Aluminum sidings utilize the same pressure equalization principles to determine wind pressure resistance for the siding, yet appropriate adjustments for use over foam sheathing as an *exterior wall covering* assembly have not been determined or codified as of this writing.

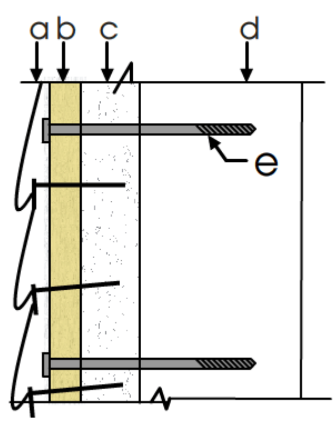
FIGURE C1: Exterior Wall Covering Assembly with Cladding Installed Directly Over FPIS Product



Cladding material

a. Cladding
b. *FPIS* product
c. Wall framing per code (i.e., wood or steel studs)
d. Cladding fastener

FIGURE C2: Exterior Wall Covering Assembly with Cladding and Furring Installed Over FPIS Product



Cladding material and fasteners

a. Cladding
b. Wood or steel furring
c. *FPIS* Product
d. Wall framing per code (i.e., wood or steel studs)
e. Furring fastener

Foam Plastics and Fire Safety Requirements – Fire-safety-related requirements for foam plastics are addressed in Chapter 26 of the International Building Code (IBC) and Section R316 of the IRC. Any use of *FPIS* products in accordance with this standard must also comply with fire-related requirements for foam plastics in the locally applicable building code, including requirements for thermal barriers, ignition barriers, flame spread resistance, limited smoke development, and other factors as relevant to the particular application. For additional information, see the *FPIS* manufacturer's literature and the following supplemental information as applicable:

TER No. 1202-03: Foam Plastic Insulating Sheathing Products in Type V Construction
TER No. 1202-04: Foam Plastic Insulating Sheathing Products in Type I, II, III or IV Construction

Energy Efficiency and Thermal Resistance Requirements – Requirements for use of *FPIS* as thermal insulation are addressed in locally adopted energy codes. In particular, use of *FPIS* products for building energy efficiency design are addressed in the International Energy Conservation Code (IECC) and in ASHRAE standards 90.1 and 90.2. In addition, minimum material requirements, including thermal resistance properties, are addressed in ASTM C578 and ASTM C1289 for the types of *FPIS* addressed in this standard. Furthermore, for home insulation products, the Federal Trade Commission's R-value Rule regulates the measurement and labeling of insulation R-values.

Moisture Vapor Control – As with any wall sheathing component, *FPIS* has moisture vapor permeability properties that should be considered in the strategy for controlling moisture vapor transmission through the wall assembly and limit the potential for condensation. Properties will vary by *FPIS* product type and composition. Because *FPIS* is an insulation material, it can be used to control wall temperatures such that risk of condensation is reduced. All walls act as a system in controlling moisture vapor transmission and preventing condensation. Therefore, the amount of *FPIS* insulation, its location on the wall assembly, the climate conditions, and the moisture vapor transmission properties of other materials comprising a wall assembly should all be considered as part of a moisture vapor control strategy. Refer to the moisture vapor retarder requirements of the 2009 and 2012 editions of the IBC and IRC for more information.

Water Resistive Barrier Performance – Some *FPIS* products also serve as code-compliant water resistive barriers. In general, a code evaluation report by an *approved agency* and approval of the local building official are pre-requisites for this application. Consult the *FPIS* manufacturer for relevant data for code acceptance. Also, use of *FPIS* as a water resistive barrier generally entails strict adherence to installation details addressing flashing and sealing of joints and penetrations.

Wind-debris Resistance – In all but southern Florida's high hurricane hazard areas, building exterior wall constructions are not required by Code to resist wind-borne debris impacts. In southern Florida or other areas were wind-borne debris resistance is desirable, it should be anticipated that *FPIS* products need to be combined with impact-resistant sheathing materials (e.g., *over-sheathing* application) or claddings to achieve required or desired wind-borne debris impact resistance levels.

C1.4 Material Requirements. No commentary.

C1.5 Alternative Methods of Compliance. The various provisions of the standard provide a minimum standard of care in conducting tests, evaluations, and assessments for wind pressure performance qualification and quality assurance to demonstrate and maintain code compliance for *FPIS* products. These provisions are not the only means by which code compliance can be successfully demonstrated and maintained. For example, test methods may be modified or other suitable test methods may be employed provided they result in an at least equivalent measure of performance qualification and quality assurance. In addition, any alternative to or modification of any part of this standard should be considered and approved as equivalent by an *approved agency*.

C2.0 Reference Standards. The provisions of this standard are dependent on the various listed reference standards addressing matters such as material quality, test methods, and design wind loads. Use of updated versions of these standards is not explicitly prohibited, but should be done only when verified as appropriate for use with this standard by an *approved agency*.

C3.0 Definitions. No commentary.

C4.0 Design Wind Load Requirements. Design wind loads provided in this standard are based on consensus standard, "Minimum Design Loads for Buildings and Other Structures," ASCE 7-05. Locally applicable building code requirements or the latest edition of the ASCE 7 standard are also permitted as a means to determine wind load. Pre-calculated design wind loads in this standard are based on common worst-case conditions (i.e., wall corner zone, effective wind area of 10 square feet, and 30-foot building height) for a range of wind speed and exposure conditions. For applications that address wall interior zones only, building heights greater than 30 feet, or design wind speeds other than tabulated, design wind loads must be determined in accordance with Section 4.2 of the standard.

When using the 2012 IBC and ASCE 7-2010 which use a newer form of design wind speed map, wind speeds in the header of Table 1 must be converted to an "ultimate" wind speed basis from the "allowable" design wind speed basis of Table 1 as used in prior building codes and standards. To make this conversion, wind speeds in the header of Table 1 can be multiplied by 1.26. Alternatively, conversion tables or guidance provided in the ASCE 7-2010 standard or the 2012 IBC may be used. Care must be taken, however, to avoid confusion of wind speed basis. For example, the 2012 IRC also uses an updated wind speed map from ASCE 7-2010, but the IRC wind speed map was converted back to the former "allowable" design wind speed basis. Therefore, conversions of wind speeds reported in Table 1 of this standard do not need to be converted for use with the 2012 IRC. Also be aware of the wind speed basis when using other codes and standards as referenced in R301.2.1.1 of the 2012 IRC for use in high-wind regions.

C5.0 Installation Conditions. Section 5.0 of the standard lists specific installation conditions for the intended use of *FPIS* products in accordance with this standard. In accordance with the user note, this standard and typical practice relies primarily on cladding or furring attachments to provide securement for permanent wind load resistance of *exterior wall covering* assemblies which include *FPIS* products as a component. For example, Item 5 provides requirements for cladding use to secure *FPIS* to address this typical practice. Designing *FPIS* attachments for the full design wind load, without reliance on cladding for securement, has some advantages such as improved temporary wind resistance during construction and less reliance on quality of siding installation for wind resistance of the *FPIS* component and wall covering assembly as a whole. For additional information on cladding installation over *FPIS*, refer to Section C1.3.

C6.0 Wind Pressure Resistance Requirements

C6.1 General. Wind pressure qualification tests are required to be conducted using Test Method A2 or A3 in Annex A. Test Method A2 is based on the ASTM E330 test method with modification as noted for the purpose of qualifying the wind pressure resistance of the *FPIS* product. Test Method A3 provides an alternate cyclic wind pressure qualification procedure based on ASTM E1233, and is also referenced in an exception statement in Section 6.5. The intent of Test Methods A2 and A3 is to primarily determine bending resistance to wind pressure on *FPIS* products, or in some cases (as in 6.6.2) to additionally determine fastener resistance to wind pressure for *FPIS* products independent of siding, but not the wall framing assembly or *exterior wall covering* attachments which may vary according to code requirements and assembly conditions. Therefore, *FPIS* products qualified for wind pressure resistance in accordance with this standard are applicable for use on any code compliant wall assembly with exception that the spacing of the framing or supports is limited to the maximum spacing of framing used for purposes of qualifying the *FPIS* product's wind pressure resistance.

Table 2 provides a matrix of end-use conditions for which wind pressure resistance qualification testing is required depending on the complexity of bending strength behavior of the *FPIS* product. Wind pressure resistance may be qualified for each end-use condition separately or more generally for all end-use conditions in Table 2 if the worst case condition is used for determining a single nominal wind pressure resistance value.

C6.2 Nominal Wind Pressure Resistance (P_{nom}). For each tested end use condition (see Table 2), the nominal wind pressure resistance is determined as the lowest peak or lowest maximum uniform pressure value achieved using Test Method A2 or A3, as applicable, and three test repetitions. This constitutes the basis for a strength-based performance criterion for wind pressure resistance. When using Test Method A2, an additional yield-based criterion is separately applied as explained in Section C6.3.

In general, deflection is not considered as a limiting serviceability criterion for wall sheathing applications. Furthermore, a sheathing material is not necessarily required behind cladding materials constructed in accordance with the applicable building code where wall bracing is provided by other means in accordance with the building code. For example, walls clad with Portland cement stucco, wood lap siding, and others do not require the use of sheathing in the 2009 IRC. Thus, strength of the siding and/or sheathing material, when present, is the primary consideration for wind pressure performance. This emphasis on strength is also echoed for other wall sheathing materials. For example, DOC PS2-10 Performance Standard for Wood-Based Structural-Use Panels does not require deflection limitations for wood structural panel wall sheathing.

Similarly, the ASTM C208 standard for regular and structural types of cellulosic fiber insulating board does not apply deflection criteria for out-of-plane wind pressure bending (flexural) resistance. Instead, the average maximum flexural strength is determined from 3"x15" strips of fiberboard sheathing in accordance with ASTM C209 Section 10. The average maximum flexural strength is then used to calculate wind pressure resistance without consideration of deflection.[1]

By precedent and accepted practice, deflection criteria have not been applied to code-compliant wall coverings including cladding and sheathing. However, the total wall framing assembly (with or without an exterior sheathing material as permitted by code) is required by code to meet deflection criteria (e.g., 2009 IRC Section R301.7 or 2009 IBC Section 1604.3.1). The code deflection requirements exclude any requirement for wall sheathing. Furthermore, *FPIS* products qualified in accordance with this standard are intended for application on code-compliant wall framing providing a code-compliant level of overall wall deflection and strength. Stiffness of code-compliant wall framing assemblies, with or without the presence of *FPIS*, is beyond the scope of this standard.

C6.3 Yield Wind Pressure Resistance (P_y). Design wind pressure resistance values determined in accordance with Section 6.5 are limited or "capped" by a yield wind pressure resistance, P_y. Plastics and many other materials or composites are not linear in load-deflection behavior (i.e., yielding is a progressive process without a clear delineation between linear elastic and non-linear inelastic behavior).

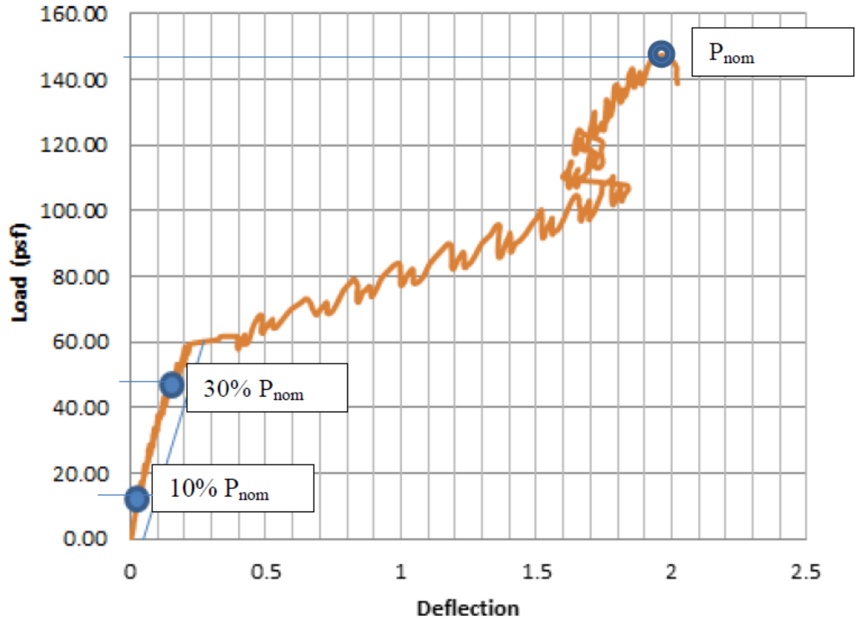
[1]Special Design Provisions for Wind and Seismic, American Forest & Paper Association, American Wood Council, Washington, D.C. 2005, pp 8-9.

This creates some difficulty in defining a meaningful yield point or proportional limit. In some cases, yielding may be associated with a region where stiffness (slope of load-deflection plot) decreases abruptly in a relative sense. Other standards, such as ASTM D198, suggest that a proportional limit for wood members in flexure “can be determined using a threshold value of the slope deviation or other suitable criteria.” The yield wind pressure resistance, P_y, in Section 6.3 uses criteria based on the project committee’s review of similar criteria for other materials and bending load-deflection behavior of *FPIS* products from industry-representative testing of a variety of *FPIS* products.[2,3] Determination of P_y is illustrated in Figure C.3 for an actual *FPIS* product. Other *FPIS* products may behave differently, but the criteria are applied in the same manner.

Other methods of determining P_y are permissible, but the expectation is that P_y should not exceed that determined in accordance with Section 6.3.

[2] Wind Pressure Testing of Wall Assemblies with Foam Sheathing and Vinyl Siding Products (Report #4107003013108), NAHB Research Center, Inc., Upper Marlboro, MD. January 31, 2008. (Available at fsc.americanchemistry.com.)
[3] Positive Wind Pressure Testing of Foam Sheathed Wall Assemblies (Report #4108007062508), NAHB Research Center, Inc., Upper Marlboro, MD. July 10, 2008. (Available at fsc.americanchemistry.com.)

FIGURE C3: Illustration of Recommended Criteria to Determine P_y



	Load (psf)	Deflection (in)
Max Test Load (Pnom)	147.3	1.96
10% of Pnom	14.73	0.034
30% of Pnom	44.19	0.14

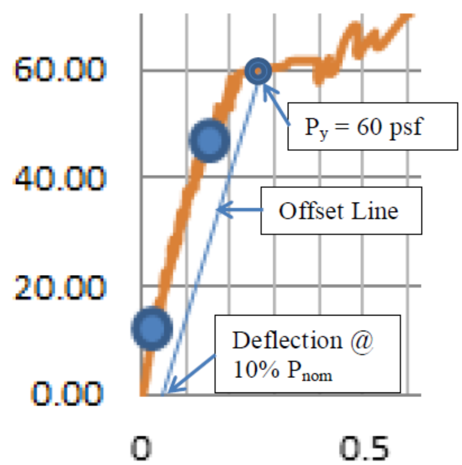
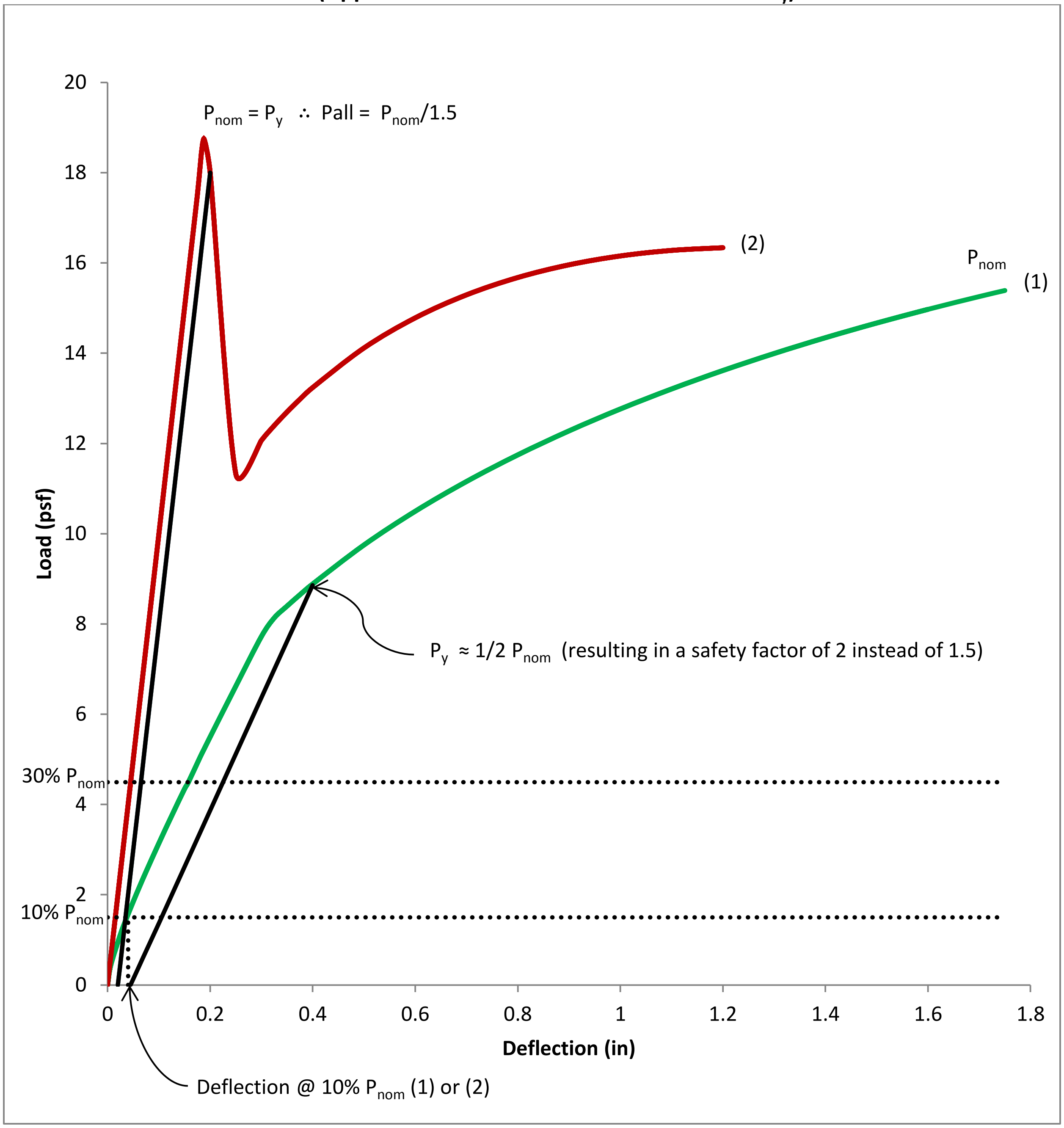
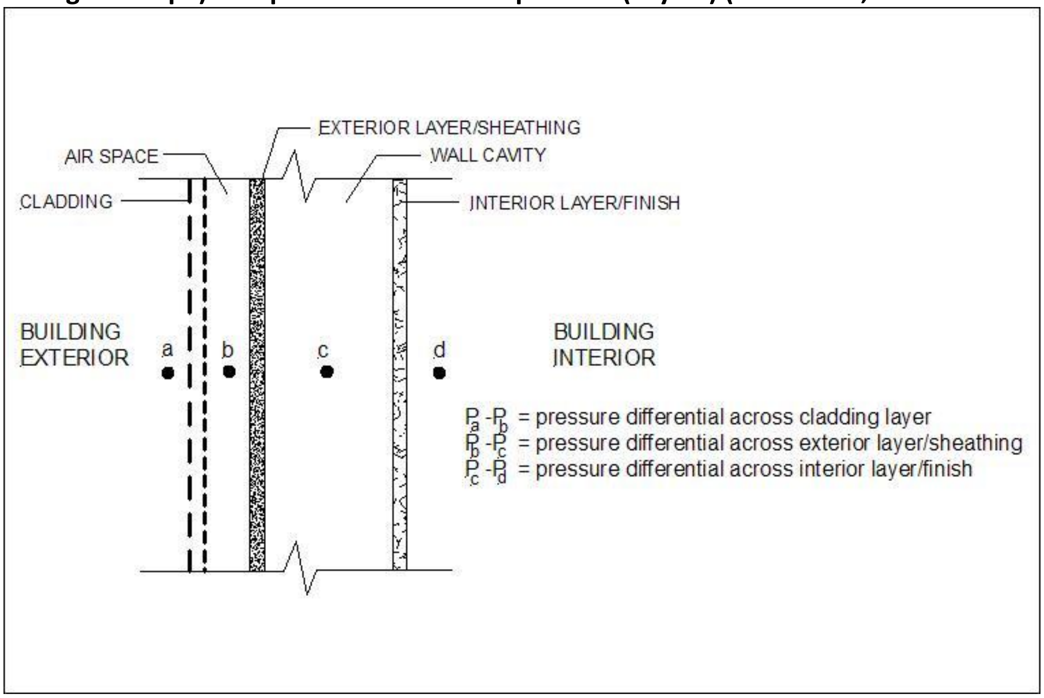


FIGURE C4: Examples from Extremes in FSC Test Data (Applications of Yield Criteria to Determine P_y)



C6.4 Pressure Equalization Factor (PEF). A pressure equalization factor (PEF) of 1.0 represents a baseline condition for evaluation of *FPIS* wind pressure resistance. It is a common design assumption whereby 100% of the wind load acting across an entire wall assembly is considered to act on the exterior sheathing layer. If there is only one layer on a wall assembly then that layer will indeed experience 100% of the wind load. However, if there are multiple layers in a wall assembly (cladding, exterior sheathing, interior sheathing), those layers share the wind load for reasons discussed in ASCE 7-10 Commentary, Section C30.1.5 as illustrated in the figure below. Consequently, the exception statement in Section 6.4 permits use of a 0.9 PEF for a limited condition where an additional layer (i.e., gypsum wall board interior finish) is present to share a portion of the total wind pressure acting across the entire wall assembly. The 0.9 PEF is based on the project committee's judgment from review of relevant full-scale wind tunnel test data with actual wind flow conditions creating temporally- and spatially-varying wind pressure.[4,5] This data suggests a maximum 0.6 PEF for the foam sheathing layer when used in combination with siding such as vinyl siding; however, a conservative 0.9 PEF was selected for the purpose of qualifying foam sheathing resistance to bending stress from wind pressure. The same data also confirmed use of a 0.7 PEF for vinyl siding and foam sheathing *exterior wall covering* assembly as discussed in Section C1.3. Such pressure equalization effects cannot be reliably determined under conventional static or cyclic wind pressure test methods that produce a spatially uniform pressure condition.

FIGURE C5: Distribution of Net Components and Cladding Pressure Acting on a Building Surface (Building Envelope) Comprised of Three Components (Layers) (ASCE 7–10, FIGURE C30.1-1)



C6.5 Allowable Design Wind Pressure Resistance (P_{all}). Allowable wind pressure resistance is determined using the nominal wind pressure resistance (Section 6.2), the yield wind pressure resistance (Section 6.3), a PEF factor (Section 6.4), and a safety factor. Based on the intended application of *FPIS* as a wall insulation sheathing, a safety factor of 1.5 is used in the standard together with a minimum value of the peak tested wind pressure resistance (nominal wind pressure resistance). This safety factor may be compared with precedents for other wall components as follows:

[4] Cope, Anne D., et al., "Wind pressure performance evaluation and building code improvements for energy efficient exterior wall assemblies including continuous insulation – Phase 1," Advances in Hurricane Engineering Conference, Applied Technology Council and Structural Engineering Institute of ASCE, Miami, FL. October 24-26, 2012. (Accepted paper.)
[5] Kopp, Gregory A. and Eri Gavanski, "Effects of pressure equalization on the performance of residential wall systems under extreme wind loads," Journal of Structural Engineering. August 5, 2011.

TABLE C1: Comparison of Safety Factors

Product Type	Use	Safety Factor	Reference
Exterior Windows and Doors	Building Envelope Component	1.5 (applied to single proof test)	AAMA/WDMA/CSA 101/I.S.2/A440 and ASTM E330 (Section 5.3)
Garage Doors	Building Envelope Component	1.5 (applied to a single proof test)	ANSI/DASMA 108 and ASTM E330 (Section 5.3)
Vinyl Siding	Cladding Material	1.5 (applied to average of three pressure tests)	ASTM D3679 and ASTM D5206
Regular Cellulosic Insulating Fiber Board	Wall Insulation	1.6 (applied to average of three small-scale bending tests for each board direction)	ASTM C208, ASTM C209, and AWC/SDPWS
Structural Cellulosic Insulating Fiber Board	Wall Insulation and Bracing	1.6 (applied to average of three small-scale bending tests for each board direction)	ASTM C208, ASTM C209, and AWC/SDPWS
Backerboard Cellulosic Insulating Fiber Board	Wall Insulation/Backer for Siding	Undefined	ASTM C208
Wood Structural Panel	Wall Sheathing, Fastener Base and Bracing	1.6 (applied to lowest value 10 tests)	DOC PS 2-04 and AWC/SDPWS
		1.3 (applied to lower-bound statistic from 60 or more tests)	ASTM D7033 (with safety factor isolated from load duration adjustment)
Engineered Wood Panel Siding	Wall Cladding and Bracing	SF unspecified; Qualification to 150 psf capacity based on five tests; inspection reference values based on lowest of five bending tests in both panel directions	APA/PRP 210-2008

For structural design, safety margins as low as 1.5 are considered adequate for structures such as retaining walls (e.g., 2009 IBC Section 1807.2.3). For wall bracing against wind loads, a safety factor of 2 on minimum values is commonly used for in-plane racking shear resistance of sheathing and other bracing materials. For structural connections under withdrawal load in wood, a safety factor of 3.125 (applied to average withdrawal strength and assuming load duration factor of 1.6 does not apply to fasteners in withdrawal such that the safety factor is effectively 5/1.6 = 3.125) is used to account for the large variability in withdrawal capacity of nail fasteners in wood. For lumber structural materials, which are highly variable in properties relative to other materials, a safety factor of 1.3 is applied to a lower bound statistical representation of bending strength (lower 5th percentile value). For steel structural members, the safety factor is 1.6 which is applied to a nominal (minimum) bending stress value and relatively low material variability.

Based on the above survey of precedents for safety margins applied to building envelop components and structural materials, a safety factor of 1.5 (applied to the lowest value of three full-scale wind pressure tests) was considered appropriate by the project committee for the intended function of *FPIS* as a building envelope component. A larger safety factor would provide little overall building envelope performance benefit relative to the performance of other key building envelope components (e.g., windows, doors, and sheathing such as fiber board). Conversely, a lesser safety factor would potentially create a weak link in the overall building envelop performance.

C6.6 Conditions of Use. No commentary.

C7.0 Quality Assurance and Product Labeling. The quality assurance provisions of Sections 7.1 through 7.3 are modeled after ASTM D7033 with modifications deemed appropriate by the project committee. For each *FPIS* product with wind pressure resistance qualified and determined in accordance with Section 6.0, a correlated l bending strength value (reference bending strength) must also be determined for quality control purposes in accordance with Section 7.4. This procedure ensures that the stiffness and strength of the material is maintained above an acceptable minimum tolerance during production.

The product labeling requirements of Section 7.5 are in addition to those otherwise already required and provided to demonstrate building code compliance for requirements beyond the scope of this standard.

ANNEX A – Test Methods

CA.1 Bending Strength Behavior and Quality Control Test Method ("Test Method A.1"). This test method is based on the ASTM C203 Method 1, Procedure D. Modifications to the *specimen* preparation and displacement rate were made to ensure applicability as a structural property test that correlates to full-scale wind pressure performance as determined by Test Method A.2 or A.3.

CA.2 Wind Pressure Qualification Test Method ("Test Method A.2"). The wind pressure test method is based on the ASTM E330 standard, which is typically used to assess the wind pressure resistance of entire wall assemblies. However, its use in the ANSI standard is to assess the wind pressure resistance of a foam sheathing layer in bending. The amount of design wind load resistance is then determined as described in Section 6.0.

FPIS should be attached to framing according to *FPIS* manufacturer installation instructions or with adequate attachment to prevent movement of the *FPIS* material relative to the test frame. However, the intent of the test as required by Table 2 of the standard is not to test *FPIS* attachments. Thus, the tests are conducted with suction pressure only causing the *FPIS* to bear against framing. Table 2 addresses orientation of panel faces relative to suction pressure chamber to address *FPIS* products with asymmetric bending behavior (usually due to use of non-identical *facers* on opposite faces of a panel) resulting in differences in performance under a positive or negative wind loading direction experienced in end-use. The User Note in Section A.2.2 addresses the use of ASTM E330 for testing *FPIS* attachment, when qualification is desired for *FPIS* wind pressure resistance independent of cladding and cladding fasteners. In this case, *FPIS* will not bear against framing or battens (unless the battens are the intended means of *FPIS* attachment to resist wind load independently), and will be placed adjacent to the suction chamber relative to the test frame.

CA.3 Wind Pressure Qualification Test Method ("Test Method A3"). This test method is based on ASTM E1233 and is provided as an alternative to the application of P_y in Section 6.3 as a cap to design pressure. Use of this test method is referenced in the exception statement of Section 6.5. User Notes in Section A.3.2 address use of ASTM E1233 for testing *FPIS* attachment, when qualification is desired for *FPIS* wind pressure resistance independent of cladding and cladding fasteners. In this case, *FPIS* will not bear against framing or battens (unless the battens are the intended means of *FPIS* attachment to resist wind load independently), and will be placed adjacent to the suction chamber relative to the test frame.

Construction Details for the Use of Foam Plastic Insulating Sheathing (FPIS) in Light-Frame Construction

TER No. 1205-05

Issue Date: July 9, 2012
Updated: November 15, 2012

Foam Sheathing Committee (FSC) Members

Atlas Roofing Corporation – www.atlasroofing.com
Dow Chemical Company – www.dow.com
GAF – www.gaf.com
Hunter Panels – www.hpanels.com
Johns Manville – www.jm.com
Owens Corning – www.owenscorning.com
Rmax Operating, LLC – www.rmax.com

DIVISION: 07 00 00 – THERMAL AND MOISTURE PROTECTION
Section: 07 21 00 – Thermal Insulation
Section: 07 24 00 – Exterior Insulation and Finish Systems
Section: 07 25 00 – Water-Resistive Barriers/Weather Barriers

1. Products Evaluated:

1.1. Foam plastic insulating sheathing (FPIS) from the following manufacturers, up to and including 4" thickness when used as insulating material in exterior wall assemblies

1.1.1. Atlas Roofing Corporation – "Energy Shield®", "Energy Shield® Plus", "RBoard®", "Stucco Shield®", "Falcon Foam®", "ThermalStar®", Elevation™" and Stacatto™ T&G

1.1.2. Dow Chemical Company – "TUFF-R™", "Super TUFF-R™", "THERMAX™", "Isocast™ R Thermal", "STYROFOAM™" and "STYROFOAM™ SIS

1.1.3. Johns Manville – "AP Foil Faced Foam Sheathing"

1.1.4. Owens Corning – "FOAMULAR®"

1.1.5. Rmax Operating, LLC – "R-Matte® Plus-3", DuraSheath®-3", "TSA-FA-3", "Thermasheath®-3", "TSX 8500", "TSX-8510", "TSP-3" and "Eco-Max®"

2. Applicable Codes:[1]

2.1. *2006*, *2009* and *2012 International Building Code* (*IBC*)[2]

2.2. *2006*, *2009* and *2012 International Residential Code* (*IRC*)

2.3. *2006, 2009 and 2012 International Energy Conservation Code (IECC)*

> ***TER NOTE***
>
> Details in this Technical Evaluation Report (TER) only illustrate solid wood structural framing members. However, the same principles apply for typical shapes used for cold-formed steel light-frame construction.

[1] All references are to the 2012 version of the codes, unless otherwise noted.
[2] International Code Council, Inc.

3. Evaluation Scope:

3.1. This Technical Evaluation Report (TER) addresses general construction details to facilitate code-compliant use of FPIS. The details provided in this report shall be reviewed and modified (as needed) by the user of this TER for the specific field application.

3.2. It is the users' responsibility to ensure that use of these details is compliant with the applicable local code jurisdiction's requirements and manufacturers' installation instructions for the specific wall assembly components. These details are intended to assist the user in complying with relevant building code requirements, including the following code sections listed here from the 2012 editions:

3.2.1. *IRC* Sections R318, R507, R602, R603, R702, R703, R903, R905 and N1100

3.2.2. *IBC* Sections 720, 1300, 1400, 1500, 1604.8.3, 2211, 2300, 2500 and 2600

3.3. This TER addresses the general construction framing details for applying FPIS over wood or steel light-frame construction, including cladding, water-resistive barrier (WRB) installation and location, vapor permeable membranes and air barriers. Note: Details only illustrate solid wood structural framing members. However, the same principles apply for typical shapes used for cold-formed steel light-frame construction.

3.4. Specific code compliance issues including but not limited to wind pressure resistance, WRB, air barriers, thermal resistance or fire endurance, and flame spread characteristics are outside the scope of this TER.

4. Product Description and Materials:

4.1. FPIS products listed in Section 1 and used in accordance with this TER shall comply with the following material standards:

4.1.1. Expanded polystyrene (EPS) manufactured in compliance with ASTM C578

4.1.2. Extruded polystyrene (XPS) manufactured in compliance with ASTM C578

4.1.3. Polyisocyanurate (Polyiso) manufactured in compliance with ASTM C1289

4.2. FPIS products are produced under proprietary manufacturing processes and are formed into rigid insulation panels.

4.3. EPS and XPS foam plastic sheathing complying with ASTM C578 are used with:

4.3.1. No facings

4.3.2. Facings on one side

4.3.3. Facings on both sides

4.4. Polyiso foam plastic sheathing complying with ASTM C1289 must have facings on both sides.

4.5. FPIS products are typically available in the following sizes:

4.5.1. Thicknesses range from ½" to 6".[3]

4.5.2. The standard product width is 48".

4.5.3. Standard lengths include 96", 108" and 120".

4.6. Consult manufacturer for availability of product in non-standard widths or lengths.

4.7. Consult FPIS manufacturer and manufacturers of other wall components for material property data regarding vapor permeability, WRB qualification, air barrier qualification, fire performance properties, and other matters required to ensure an overall code-compliant wall assembly. See the References Section of this document for additional information.

[3] For FPIS thicknesses over 2" or 3", it is preferable to layer FPIS and off-set the joints. If FPIS is specified as the WRB in a layered application, only the outer layer of FPIS functions as the WRB.

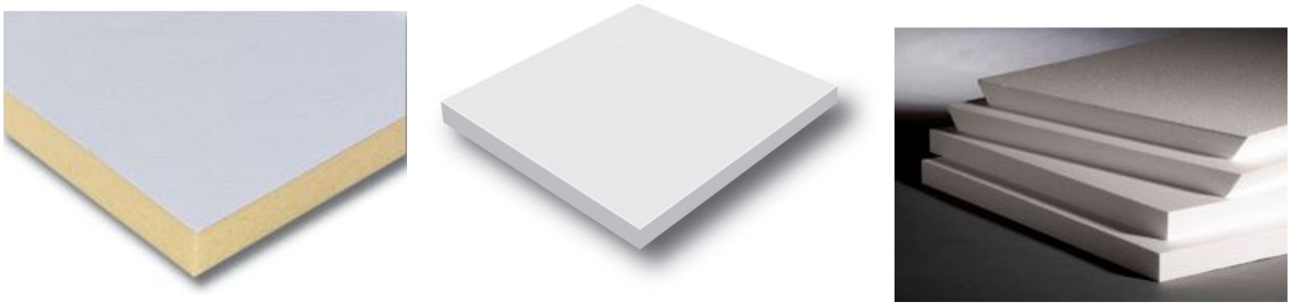


Photo 1: Examples of Polyiso, XPS & EPS Foam Plastic Insulating Sheathings

5. Applications:

5.1. General Requirements:

5.1.1. Minimum installation requirements for foam plastic sheathing products listed in Section 1 when applied to light-frame wall framing members[4]

5.1.1.1. Light-frame wood framing members supporting FPIS products shall have a nominal thickness of not less than 2" (1.5" actual). Light-frame cold-formed steel (CFS) members supporting FPIS products shall have a flange width of not less than 1.5".

5.1.1.2. Framing members shall be spaced a maximum of 24" o.c. Check specific manufacturer's installation instructions for product thicknesses required to resist the required wind pressures.

5.1.1.2.1. FPIS products shall be attached to the wall framing in accordance with the manufacturer's installation instructions

5.1.1.2.2. Cladding materials and accessories, such as furring, shall be attached through foam plastic sheathing by design capable of supporting the cladding dead load and transverse loads caused by wind or seismic forces. Refer to the cladding manufacturer's installation instructions and design data as applicable.

5.1.1.2.3. All sheathing edges shall be supported by wall framing or blocking. Blocking at horizontal sheathing joints located between the top and bottom plates of a wall shall not be required where allowed by the manufacturer's installation instructions. Where the foam sheathing panel is rated for wind pressure resistance without horizontal edges supported on blocking, this installation practice shall be permitted. Refer to the manufacturer installation instructions and wind pressure resistance data.

5.2. Terminology:

5.2.1. **Back dam** – Blocking or beveled wood siding installed at window sill to provide positive drainage to exterior. Pan flashing is typically installed over.

5.2.2. **Sealant** – High-quality caulking or spray foam product used to seal gaps between components in wall assemblies. Sealant selection depends on gap size and other factors.

5.2.3. **Continuous Insulation (CI)** – FPIS products as applied to the exterior side of exterior walls to comply with or exceed energy code requirements.

5.2.4. **Drip cap** – Flashing product used to assist in diverting water away from window/door at head. Requirement for use is dependent upon siding type and location of window in wall system.

5.2.5. **Flange flashing** – Formable self-adhesive membrane installed over nailing flange (when used) at head and jamb.

5.2.6. **Furring** – Typically minimum 1x3 wood furring or suitable steel shape (e.g., tube or hat channel) installed over the WRB layer to provide a means of attaching cladding and to provide ventilation and drainage behind cladding.

5.2.7. **Head flashing** – Formable self-adhesive membrane installed over WRB layer and framing after window/door is installed.

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[4] Different foam sheathing materials may have different properties affecting appropriate use with this document and compliance with the applicable building code. Refer to the manufacturer's specific data in all cases.

5.2.8. **Jamb flashing** – Formable self-adhesive membrane installed over WRB and framing after window/door is installed.

5.2.9. **Let-in-Bracing (LIB)** – Code prescribed wall bracing method using let-in bracing such as a 1x4 wood member cut into wood studs or approved alternative metal T-braces or flat strap braces. For steel framing, flat steel strap X-braces are similar in function.

5.2.10. **Nailing flange** – Window/door component used to attach unit to the structure from the exterior, Refer to window/door manufacturer's installation instructions.

5.2.11. **Pan flashing** – Either pre-formed or formable self-adhesive membrane or metal at sill installed before window or door.

5.2.12. **Strap anchor** – Window/door attachment component used to attach unit to the structure typically from the inside. Typically required to secure mulled units to framing; refer to window/door manufacturer installation instructions.

5.2.13. **Panel-type Bracing** – All code prescribed wall bracing methods using structural panels or boards approved for use as shear walls or braced wall panels.

5.2.14. **Water-Resistive Barrier (WRB)** – A material behind an exterior wall covering assembly or cladding that is intended to resist liquid water that has penetrated behind the exterior covering from further intruding into the *exterior wall* assembly. Function may be provided by taped joints and penetrations of FPIS if tested by the manufacturer and installed per the manufacturer's installation instructions. A separate WRB membrane may also be placed to the inside or outside of the FPIS.

5.2.15. **Vapor Permeable Membrane** – A material or covering having a permeance rating of 5 perms (2.9 _ 10-10 kg/Pa _ s _m2) or greater, when tested in accordance with the desiccant method using Procedure A of ASTME 96. A vapor permeable material permits the passage of moisture vapor. For additional information, see *IBC* Section 1405.3 and *IRC* Section R702.7.

5.3. General Conditions:

5.3.1. Details illustrate generic lapsiding materials with solid dimensional (rectangular) trim elements. See individual siding manufacturer's installation instructions for cladding-specific details. The user of this TER shall be responsible to adapt cladding installation details appropriately.

5.3.2. A means of drainage as required by *IRC* Section R703.1.1 may be created by placing the WRB in-bound or out-bound of the FPIS layer. Regardless of location of the WRB, materials outbound of the WRB should be moisture-resistive or have sufficient ventilation provided to promote drying of exterior wall covering elements after wetting (rainfall) episodes (see Figure 1d). Regardless of location of the WRB layer in the exterior wall covering, penetrations must be flashed to the WRB layer such that water drains around penetrations and out of the exterior wall covering assembly.

5.3.3. Unless cladding weight is separately supported (e.g., anchored masonry veneer), attachment of cladding and other components through FPIS to framing must take into account weight of the product and the thickness of the FPIS or other materials between the cladding and the framing. Fasteners shall be selected to penetrate framing by the required amount (see FSC Tech Matters: *Guide to Attaching Exterior Wall Coverings through Foam Sheathing to Wood or Steel Wall Framing* for guidance on selection of fasteners for a given cladding type and thickness of foam sheathing. These charts are based on foam sheathing materials with a minimum 15 psi compressive strength per ASTM C578 or ASTM C1289.

6. Installation:

6.1 Basic Wall Assembly Variations

6.1.1 Generic wall assembly showing: structural component, interior sheathing, cavity insulation, exterior sheathing (structural and/or insulating), WRB, and exterior finish (siding and trim).

6.1.1.1 Light-Frame Wall with LIB Bracing, FPIS, WRB (no furring), lap siding

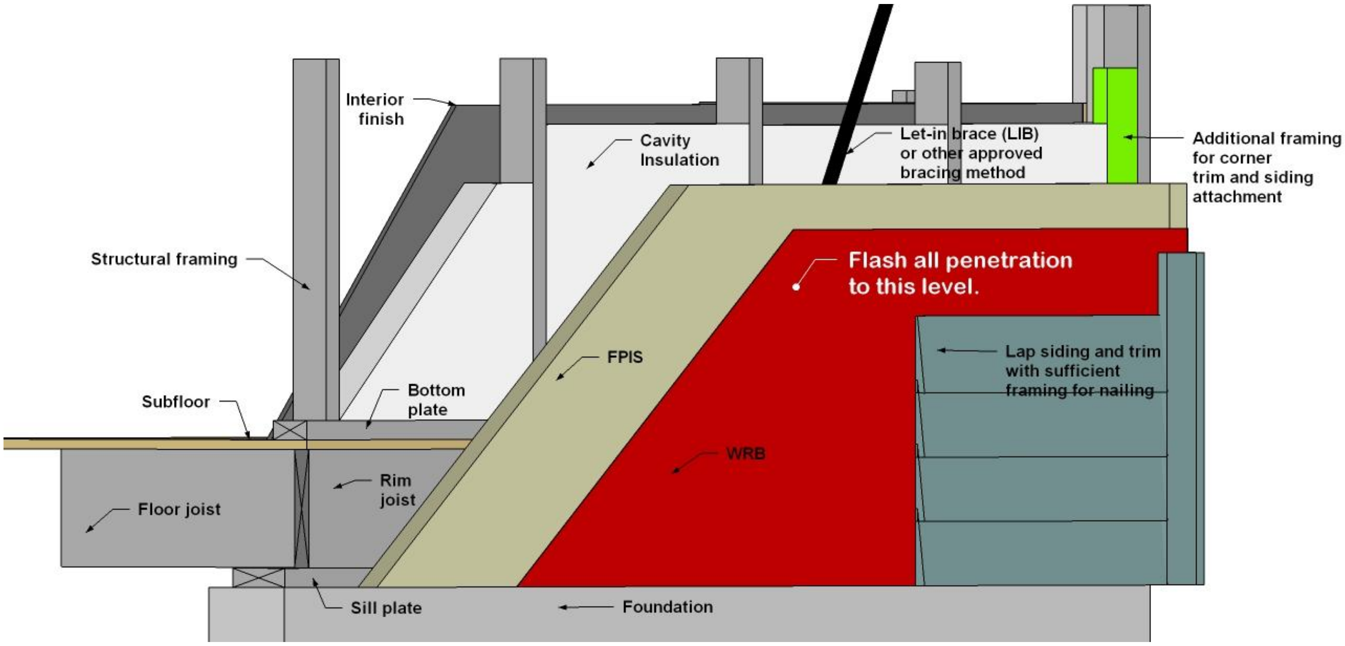

Figure 1a: Generic Wood Frame Wall (LIB) with Exterior Finish of FPIS, WRB & Lap Siding

6.1.2 Light-Frame Wall with LIB Bracing, FPIS (joints taped) as WRB, furring

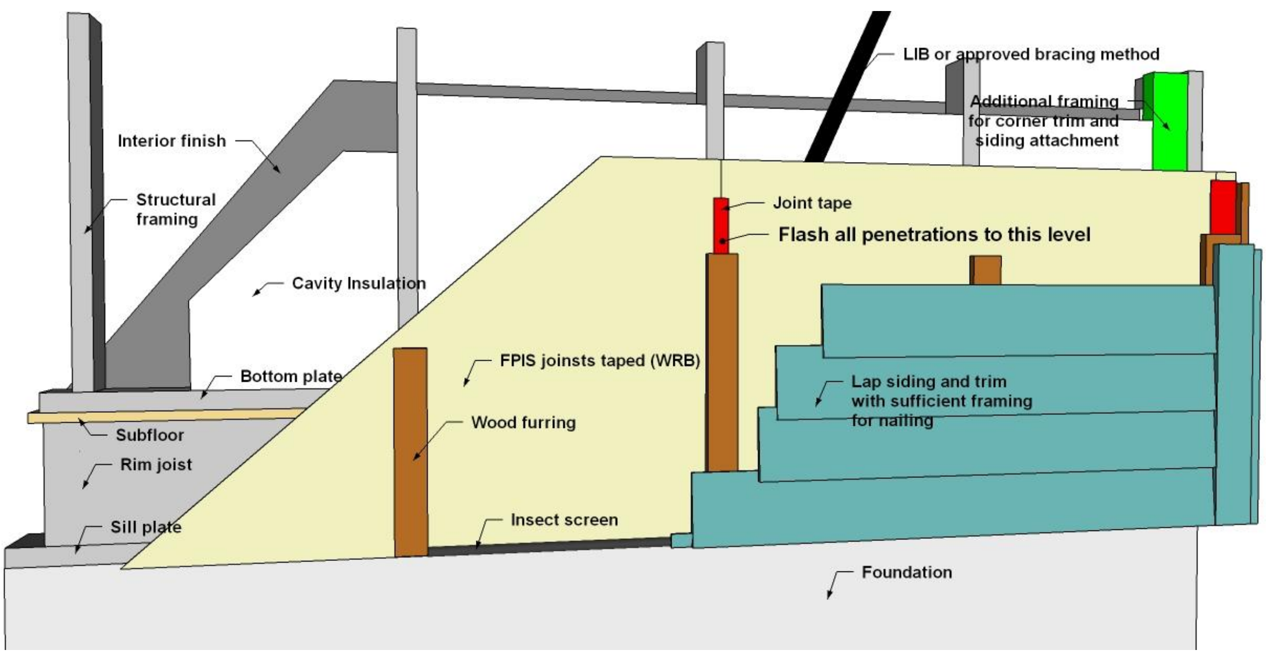

Figure 1b: Generic Wood Frame Wall (LIB), FPIS as WRB, Furring & Lap Siding

6.1.3 Light-Frame Wall with LIB Bracing, FPIS, WRB and furring

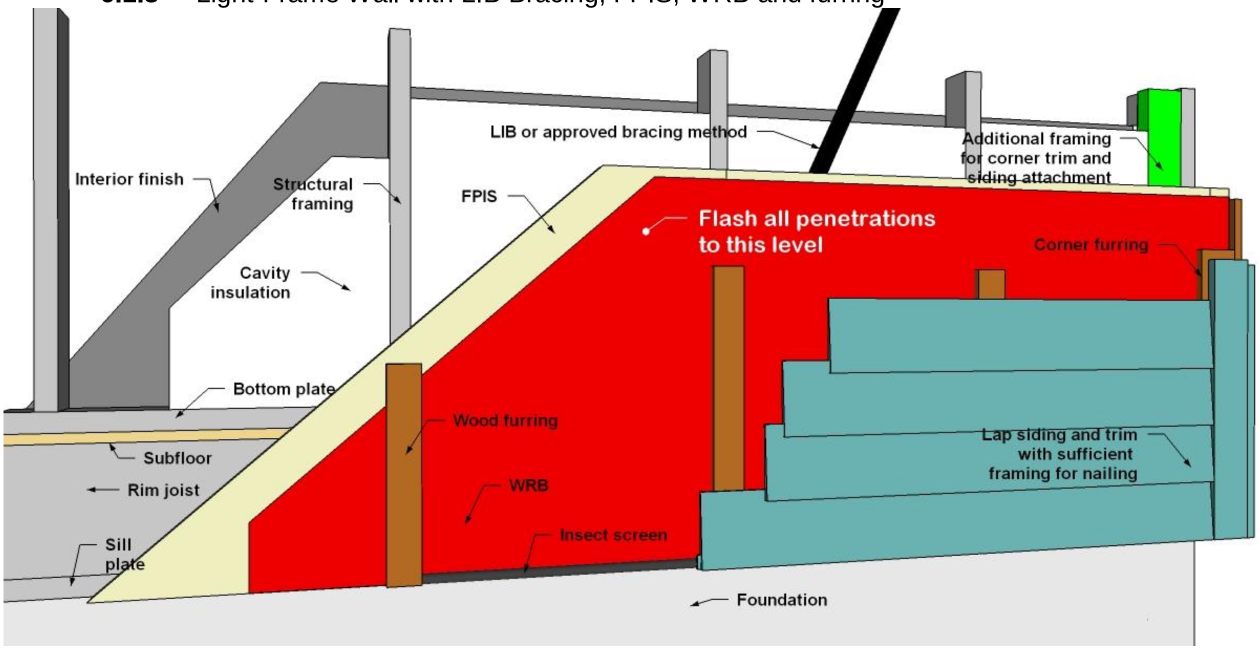

Figure 1c: Generic Wood Frame Wall (LIB) with Exterior Finish of FPIS, WRB, & Lap Siding

6.1.4 Light-Frame Wall with LIB Bracing, WRB, FPIS, furring, lap siding

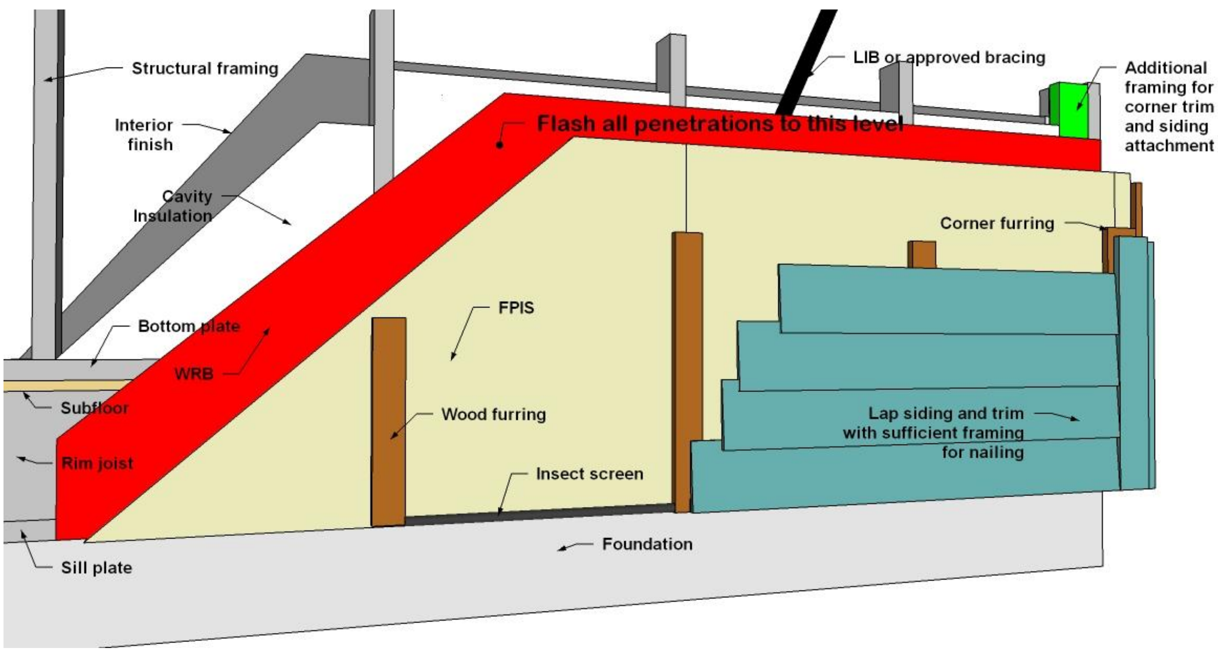

Figure 1d: Generic Wood Frame Wall (LIB) with Exterior Finish of WRB, FPIS[5], Furring & Lap Siding

[5] When FPIS is out-bound of the WRB, special consideration must be given regarding how penetrations will be dealt with after installation.

6.1.5 Light-Frame Wall with LIB Bracing, FPIS, brick veneer (anchored, separately supported)

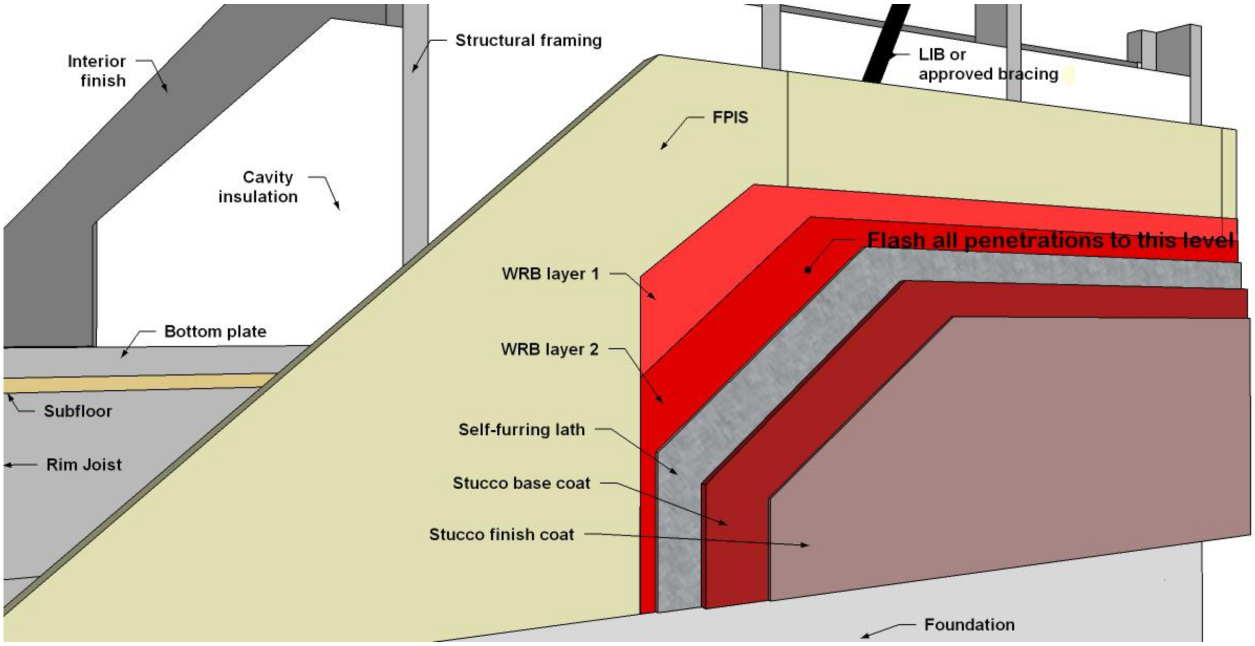

Figure 1e: Generic Wood Frame Wall (LIB), FPIS Taped (WRB), Air Space, Brick Veneer

6.1.6 Light-Frame Wall with LIB Bracing, FPIS, 2 layers WRB, stucco

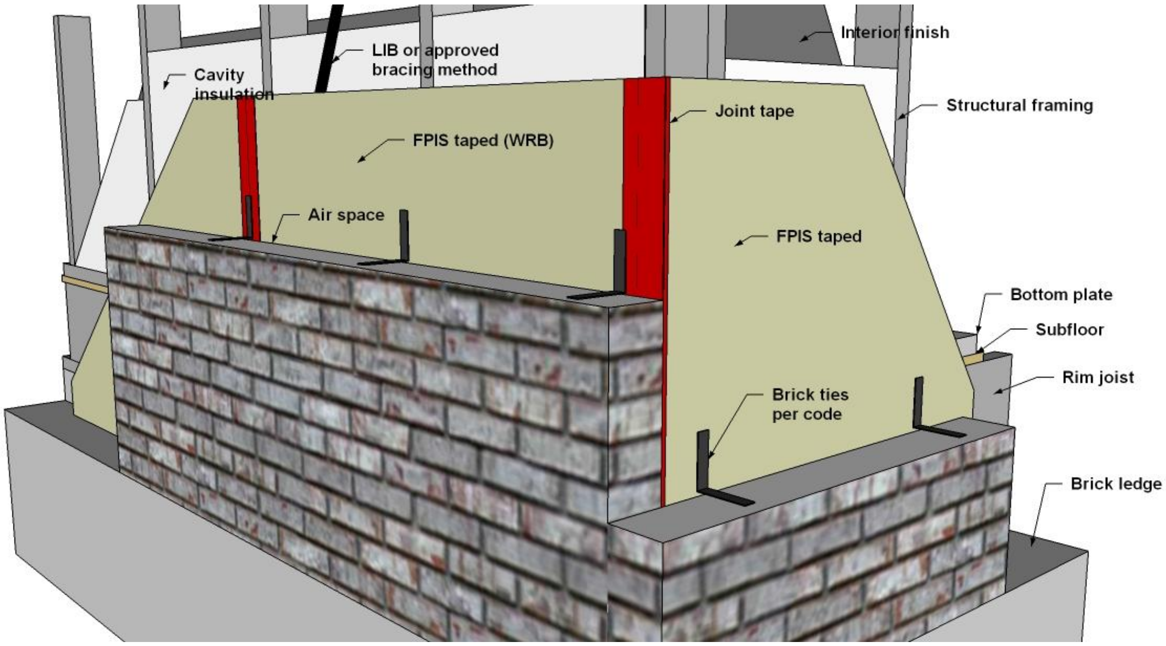

Figure 1f: Generic Wood Frame Wall (LIB), FPIS, 2 Layers WRB[6], Stucco

[6] See the stucco provisions in *IBC* Section 2510.6 regarding WRB application. The WRB layer would not be required if the FPIS were specified as a WRB and joints taped.

6.1.7 Light-Frame Wall with LIB Bracing, FPIS as WRB, furring, lath, stucco veneer

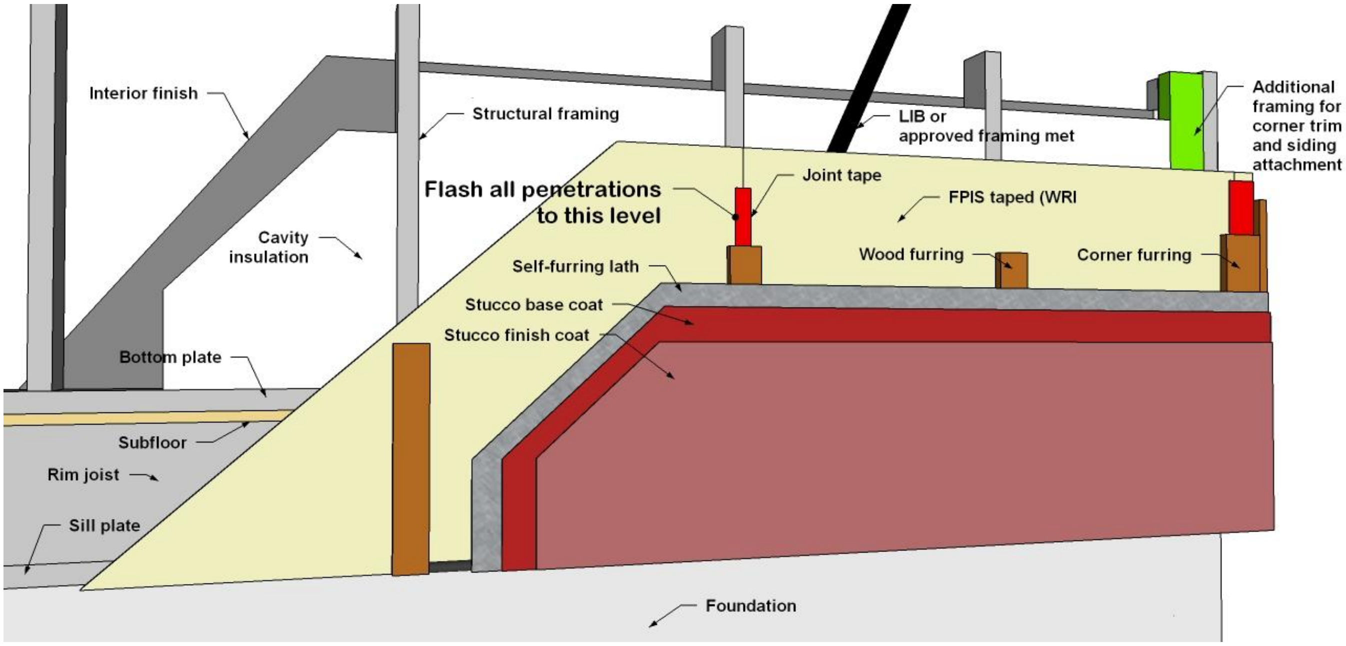

Figure 1g: Generic Wood Frame Wall (LIB), FPIS, Drainage Mat, Stucco

6.2. Inside corner – Light-Frame Wall, FPIS, WRB, No Furring

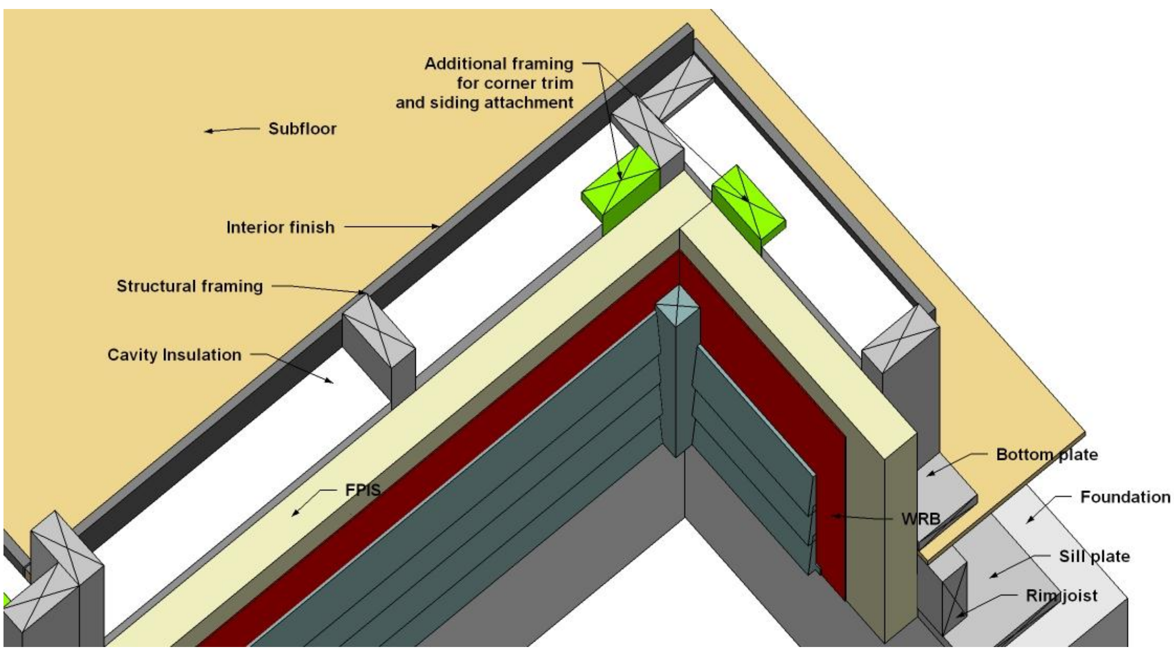

Figure 2a: ISC Generic Wood Frame Wall with Continuous Insulation, FPIS, WRB, & Lap Siding
Provide sufficient framing to attach siding trim & siding as well as interior finish.

6.3. Inside corner – Light-Frame Wall, FPIS taped for WRB, furring

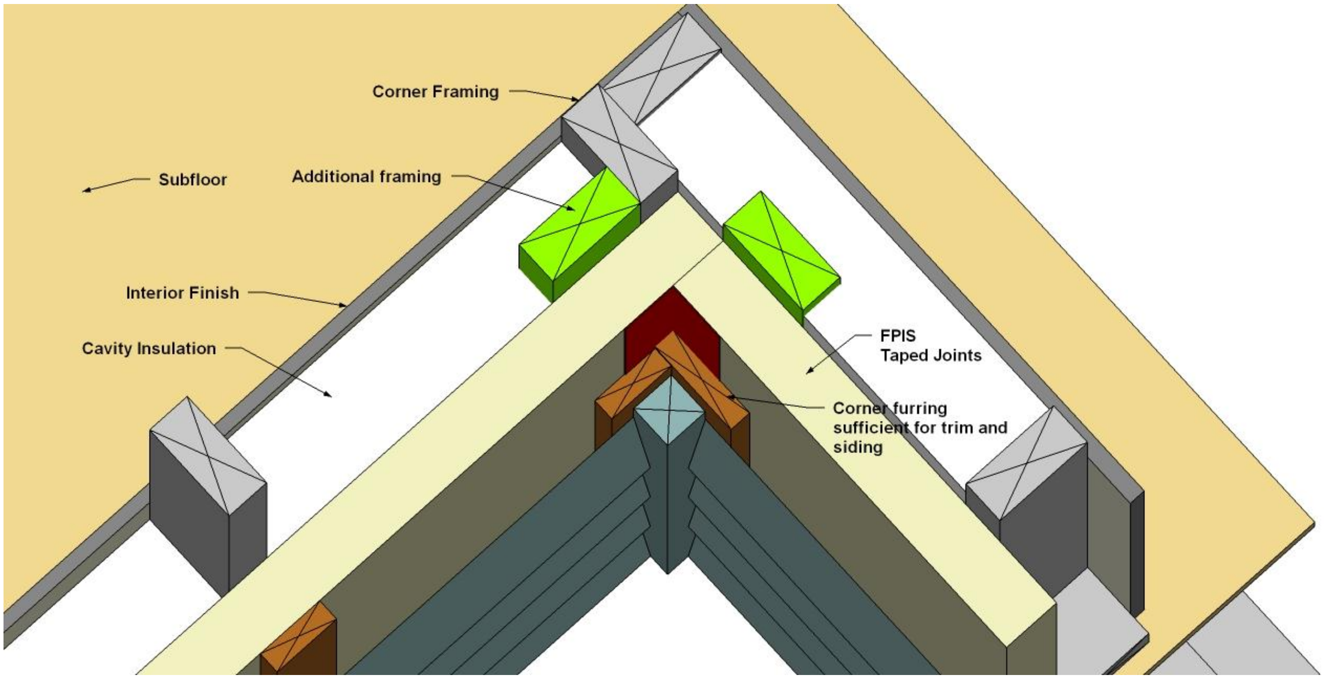

Figure 3: ISC Generic Wood Frame Wall with Continuous Insulation, FPIS Taped as WRB, Furring, Lap Siding
Provide sufficient framing to attach siding trim & siding as well as interior finish.

6.4. Outside corner – Light-Frame Wall, FPIS, WRB, Siding

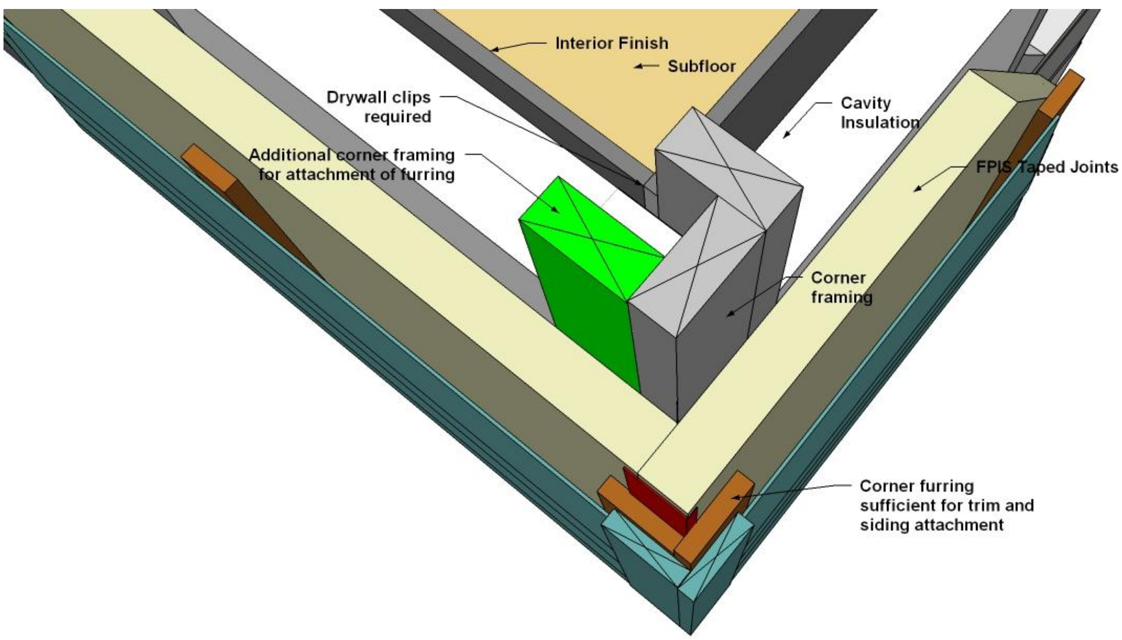

Figure 4: OSC Generic Wood Frame Wall with Continuous Insulation, FPIS Taped (WRB), Furring, & Lap Siding
Provide sufficient framing to attach siding trim & siding as well as interior finish.

6.5. FPIS at bottom of wall (not code required and typically recommended with FPIS thickness over 1"

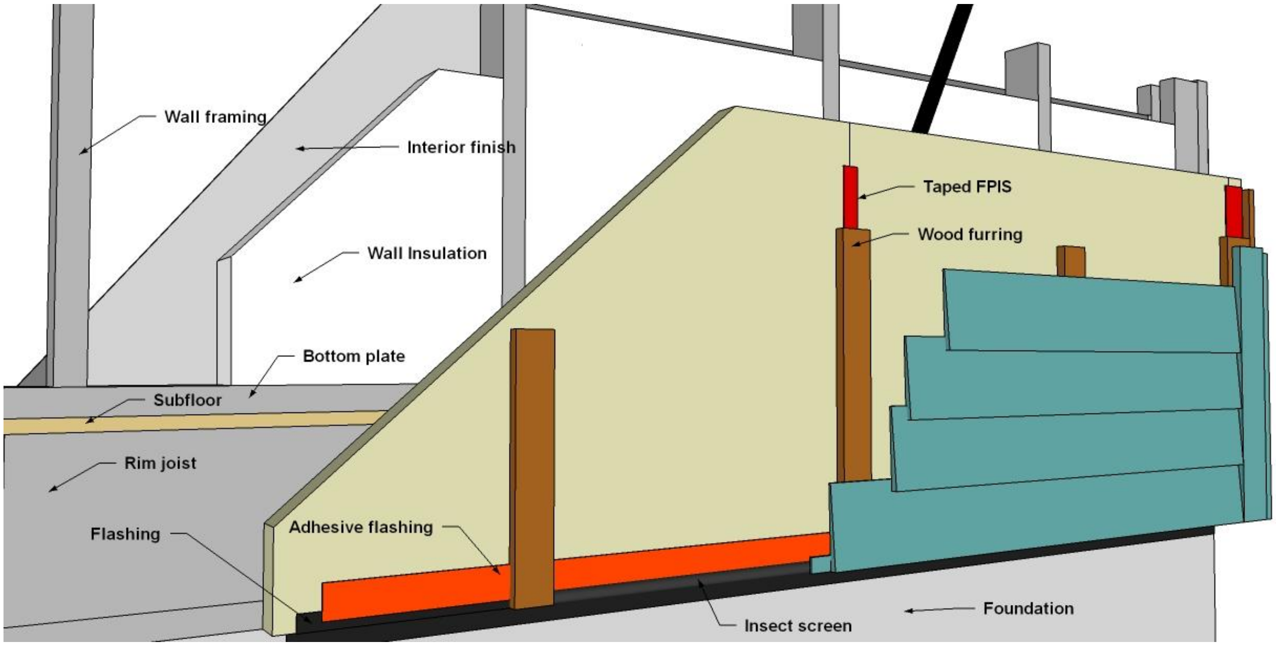

Figure 5a: Bottom of FPIS Covered with Flashing & Extending Down Foundation

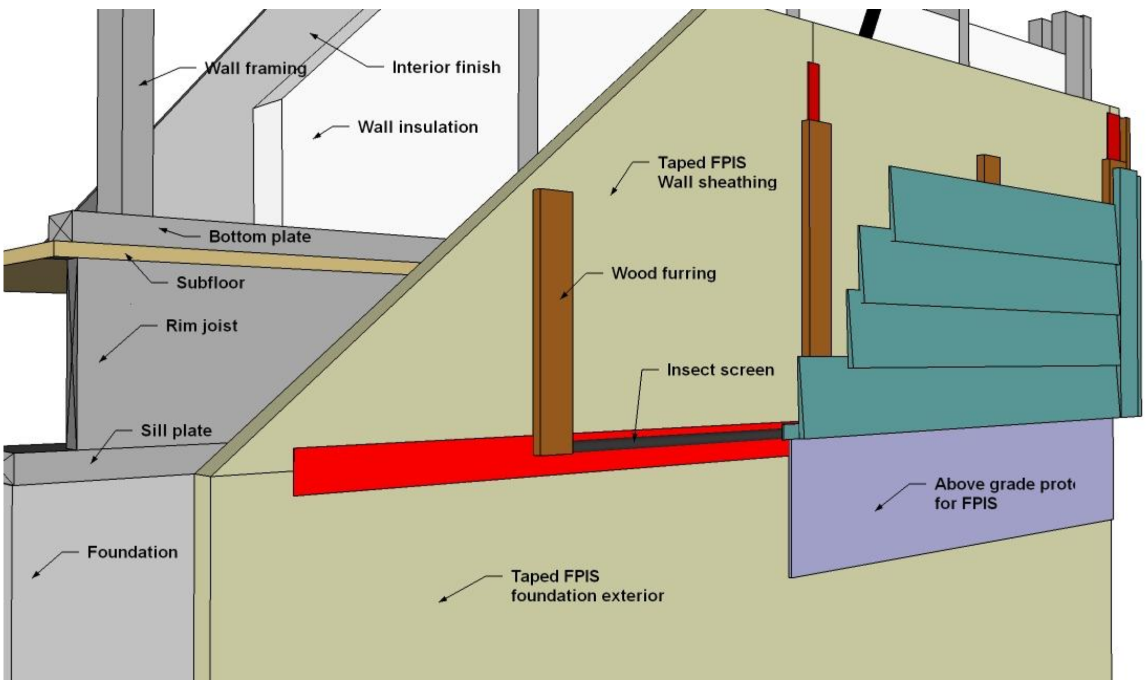

Figure 5b: FPIS Extending over Foundation with Protection Board where Exposed above Grade

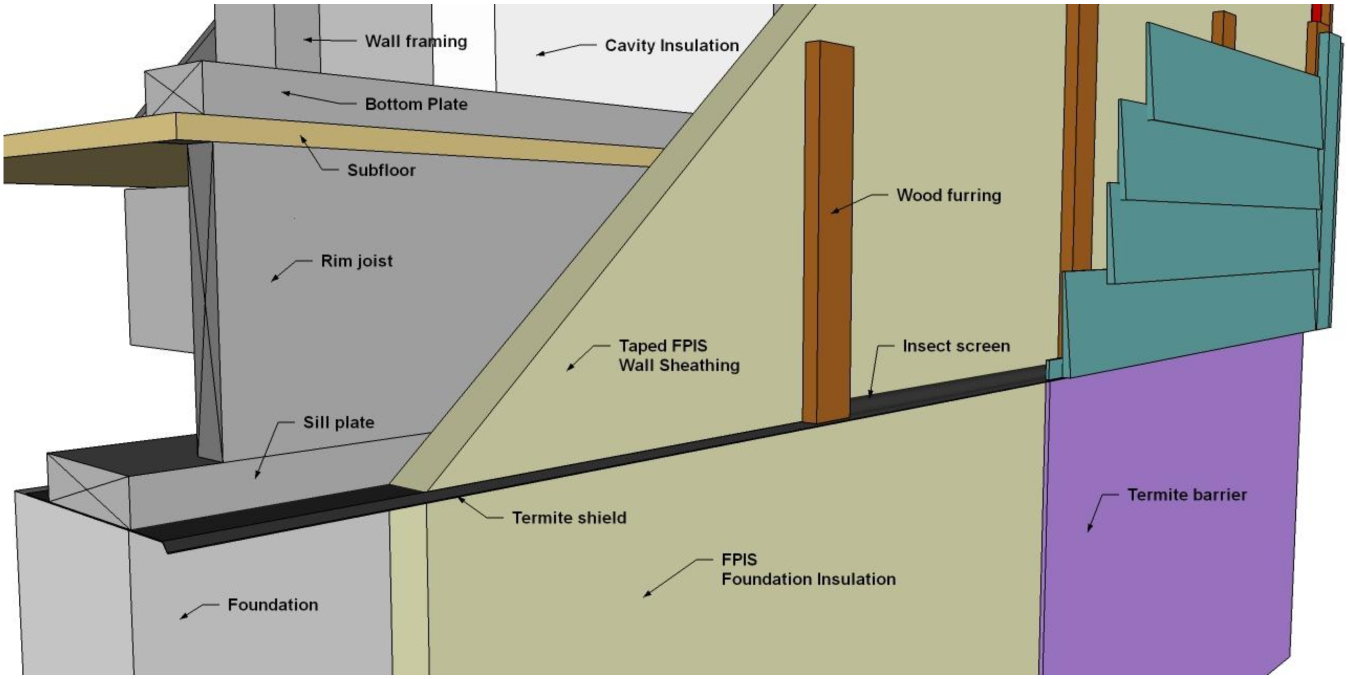

Figure 5c: FPIS Extending over Foundation with Termite Shield & Approved Termite Barrier

6.6. Top of wall – Gable (unconditioned attic space illustrating non-FPIS sheathing at gable)

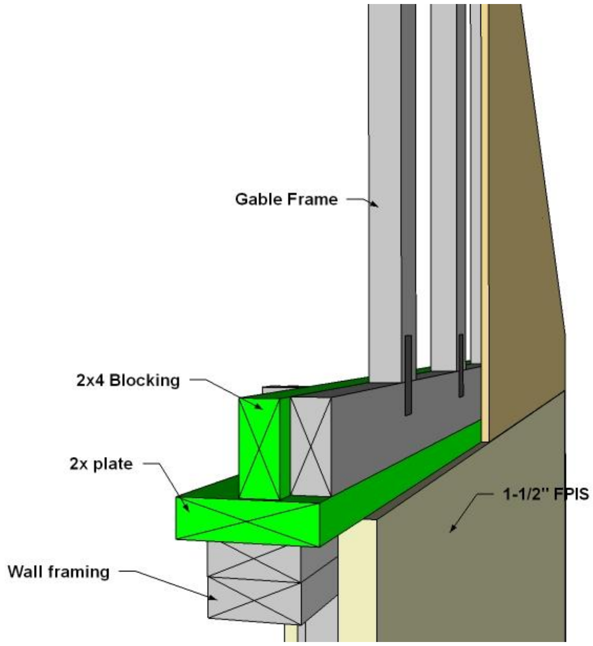

Figure 6a: Top of Wall at Gable End with Gable End Frame Sheathed with WSP & Supported over FPIS with 2x, Which Also Extends to Inside of Wall to Supply Attachment for Ceiling Finish
Note: Bracing is not shown.

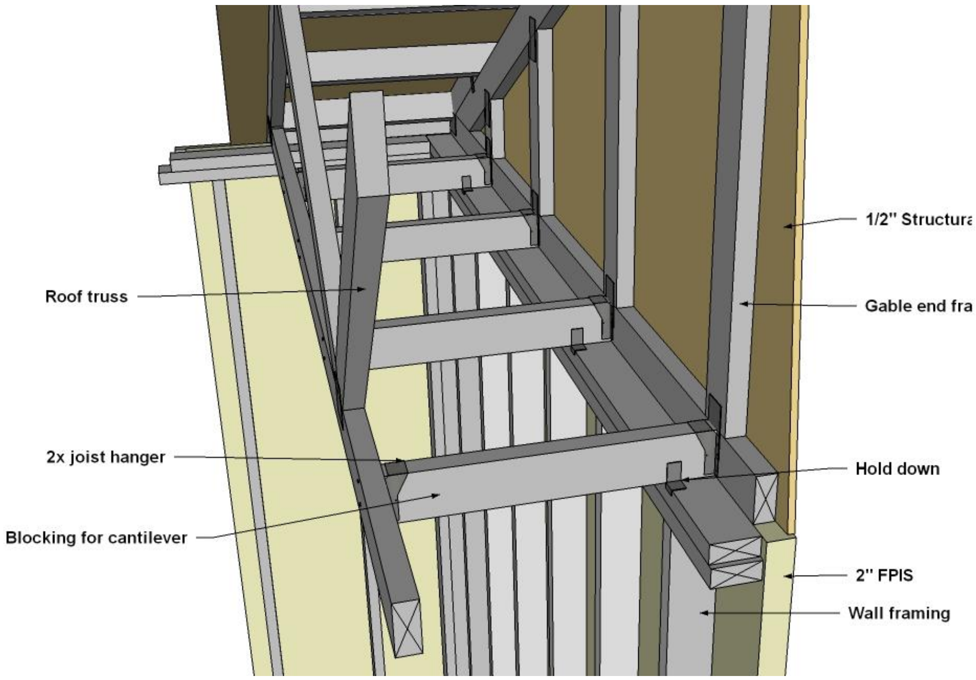

Figure 6b: Top of Wall at Gable End with Gable End Frame Sheathed with WSP & Cantilevered over Wall
Note: Gable bracing is not shown. Contact component manufacturer for load specific details.

6.7. Top of wall – Gable (conditioned attic space illustrating FPIS sheathing at gable)

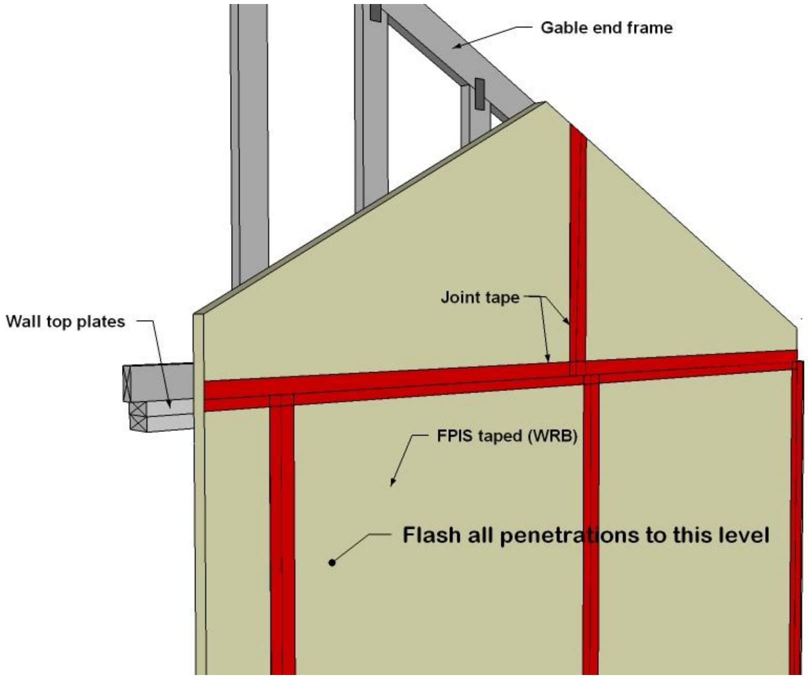

Figure 7: Top of Wall at Gable End with Gable End Frame Sheathed with FPIS Continuous from Wall Below
Note: Bracing is not shown.

6.8. Top of wall – Eave – rafter, standard truss heel, high truss heel, & cantilevered truss

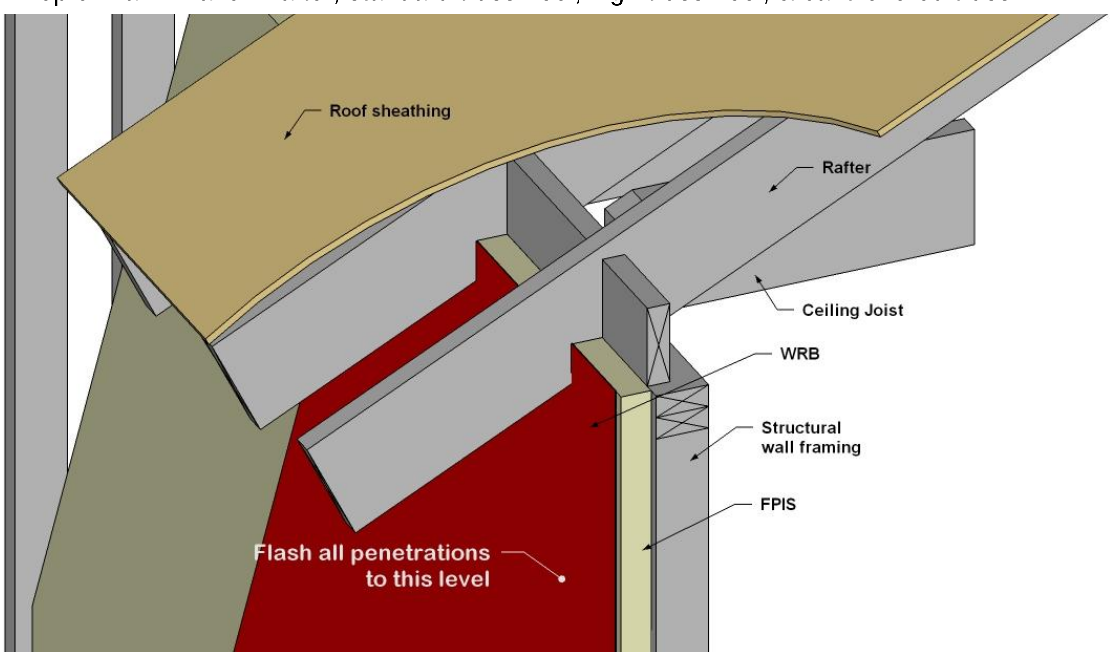

Figure 8a: Top of Wall at Eave with Rafter Construction

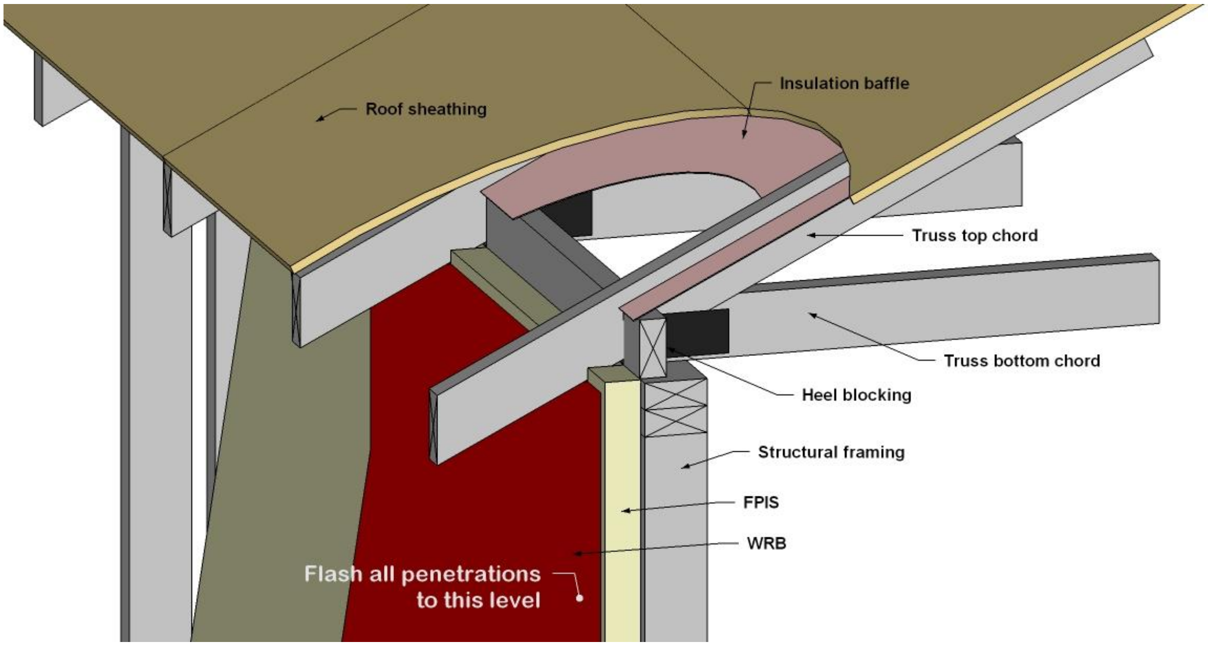

Figure 8b: Top of Wall at Eave with Standard Heel Truss

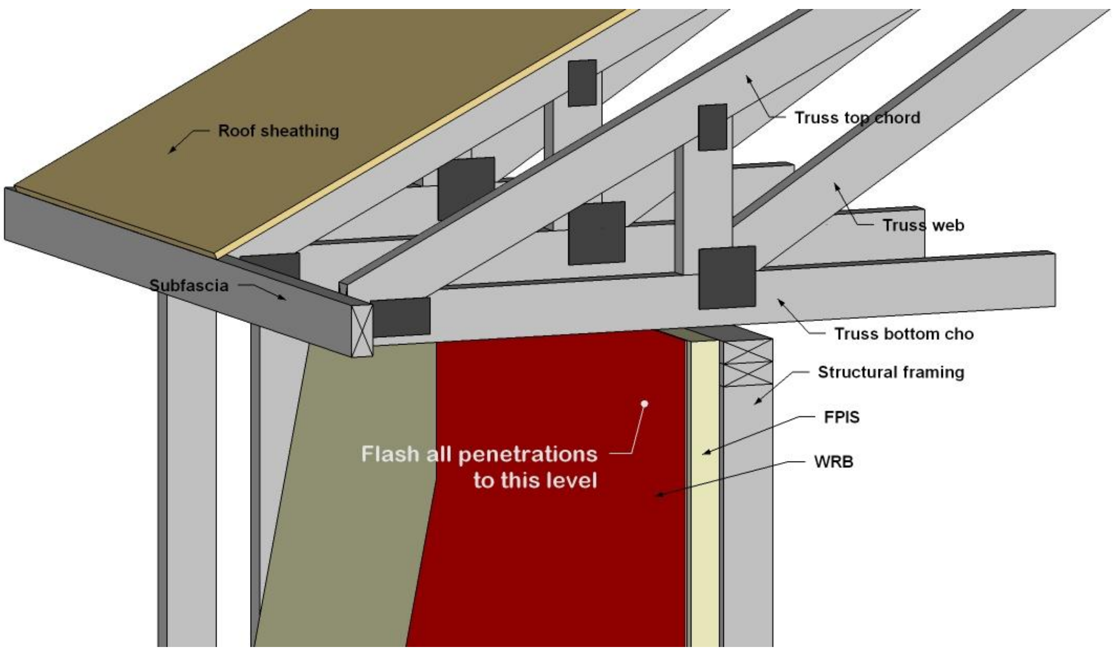

Figure 8c: Top of Wall at Eave with Energy Heel Truss

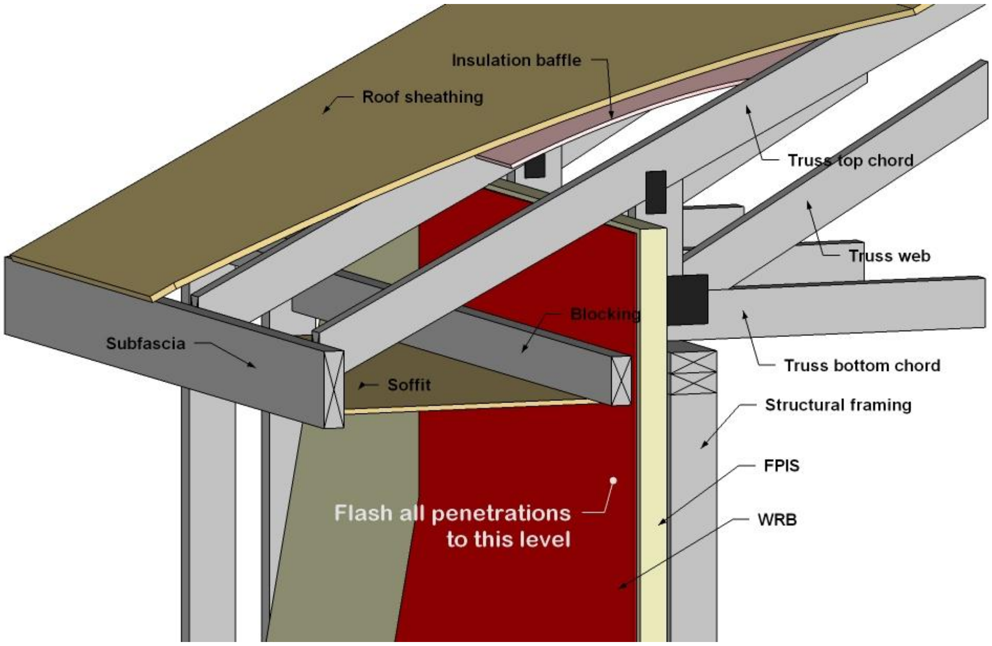

Figure 8d: Top of Wall at Cantilever Truss

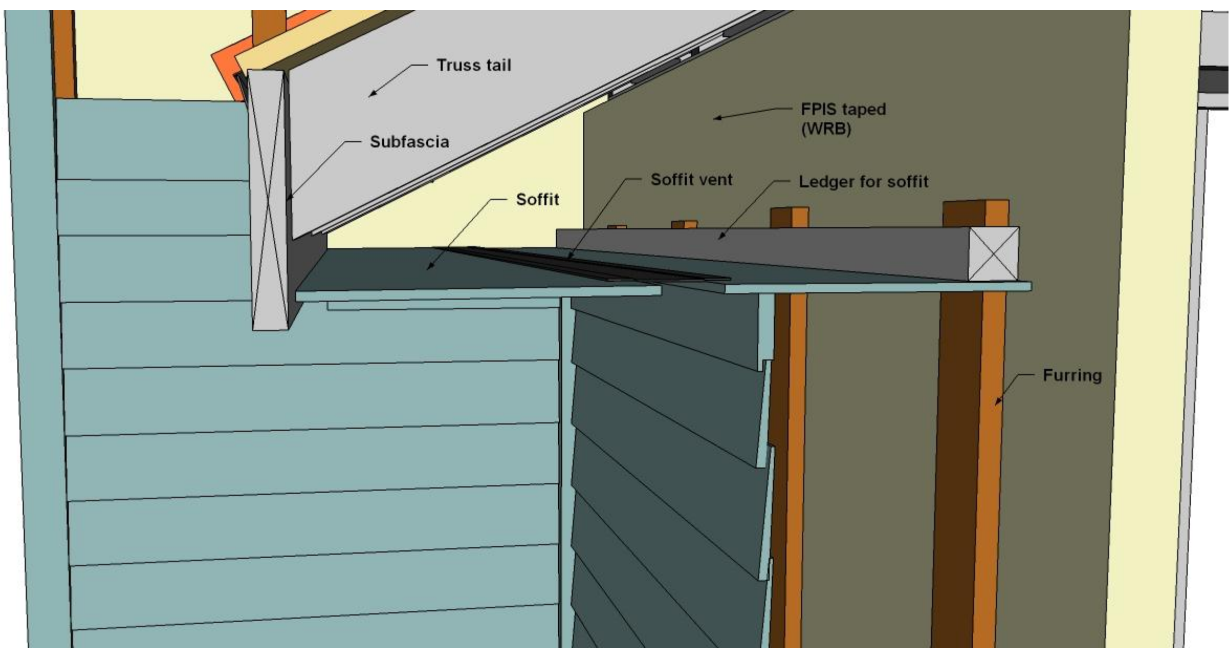

Figure 8e: Top of Wall Standard Truss Eave Detail with Eave Ledger Attached to Structural Framing through FPIS

6.9. Roof intersecting with wall (two views of same application)

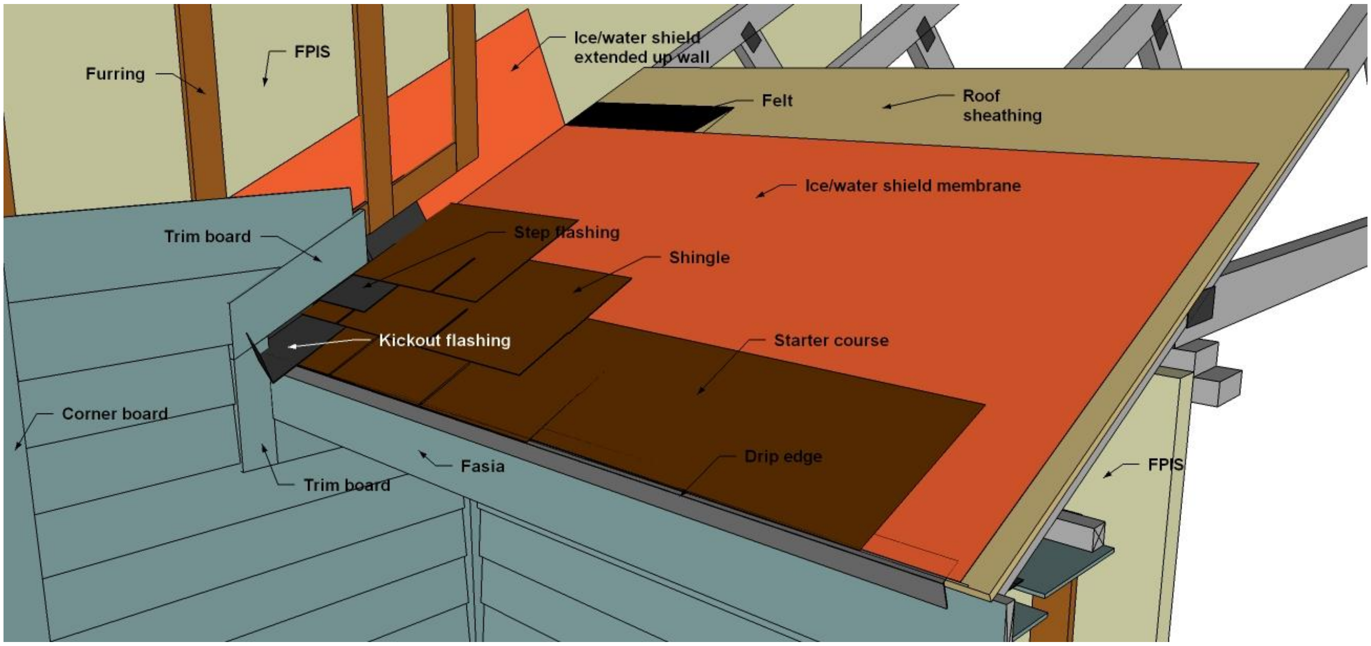

Figure 9a: Roof Intersecting with Wall

Figure 9b: Roof Intersecting with Wall (from inside) – Blocking

6.10. Deck Ledger – 2" FPIS CI at patio door opening (two views of same application) with 1" FPIS behind ledger[7]

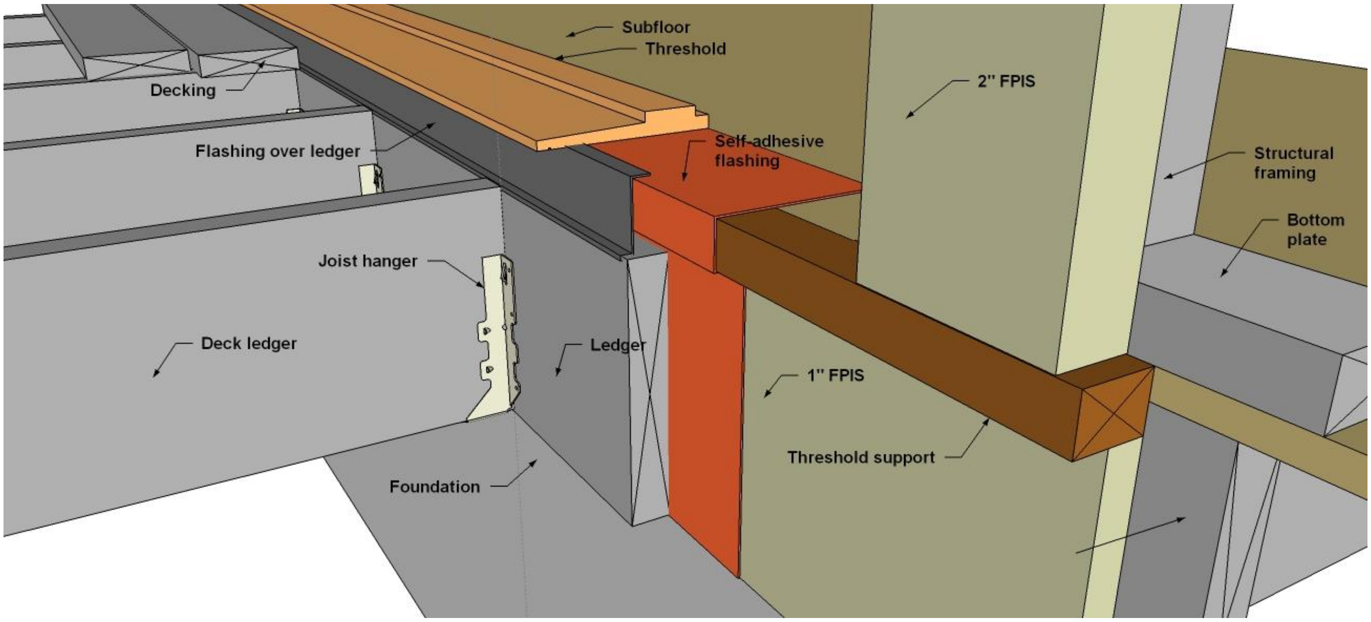

Figure 10a: Deck ledger – 2" FPIS Wall Sheathing, 1" FPIS behind Ledger at Patio Door Opening

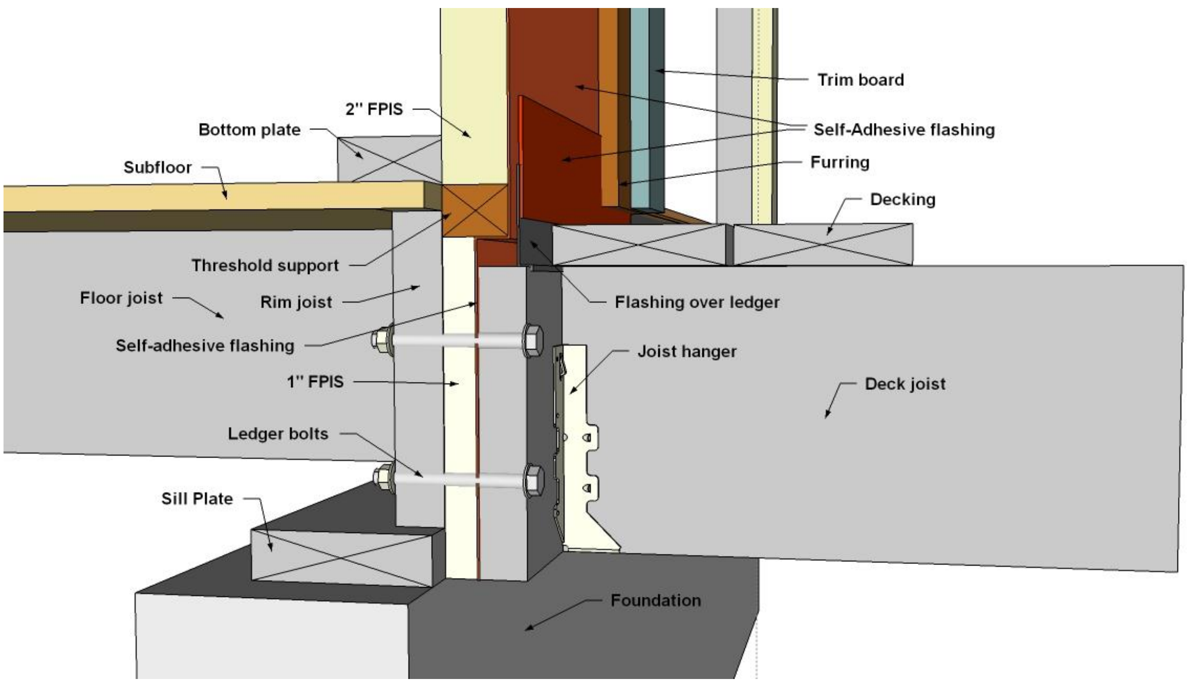

Figure 10b: Deck Ledger – 2" FPIS Wall Sheathing, 1" FPIS behind Ledger at Rim

[7] An alternative is to specify a separately supported deck. For additional information, see *IBC* Section 1604.8.3, *IRC* Section R507 and AWC TR12.

6.11. Penetration Details

6.11.1. Window/door penetrations (flush behind siding layer) – 2" or less CI

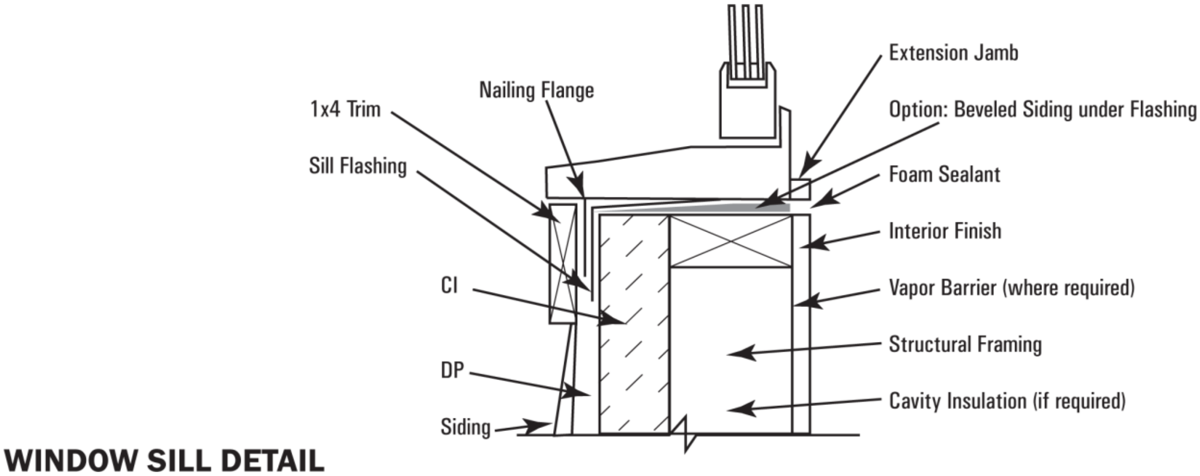

Figure 11a: Sill Detail – Window over CI

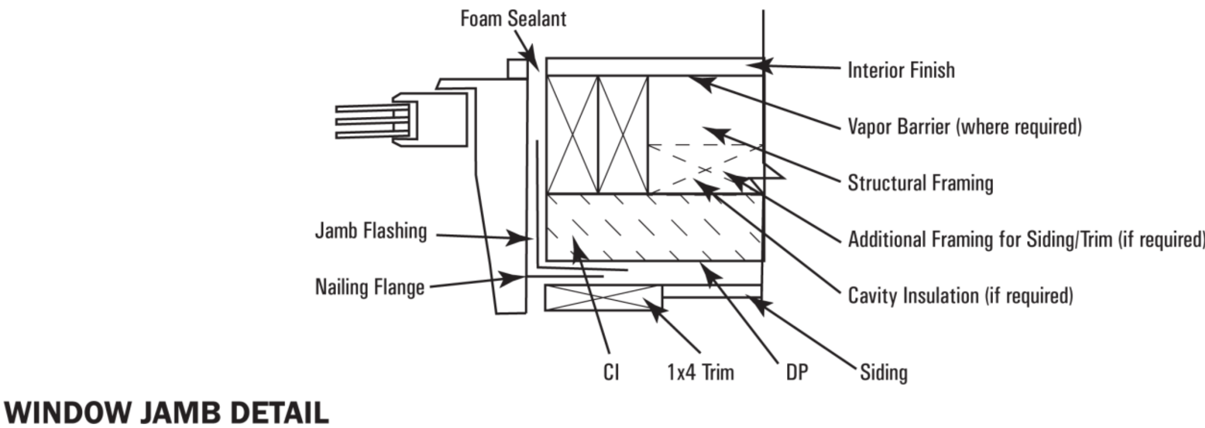

Figure 11b: Jamb Detail – Window over CI

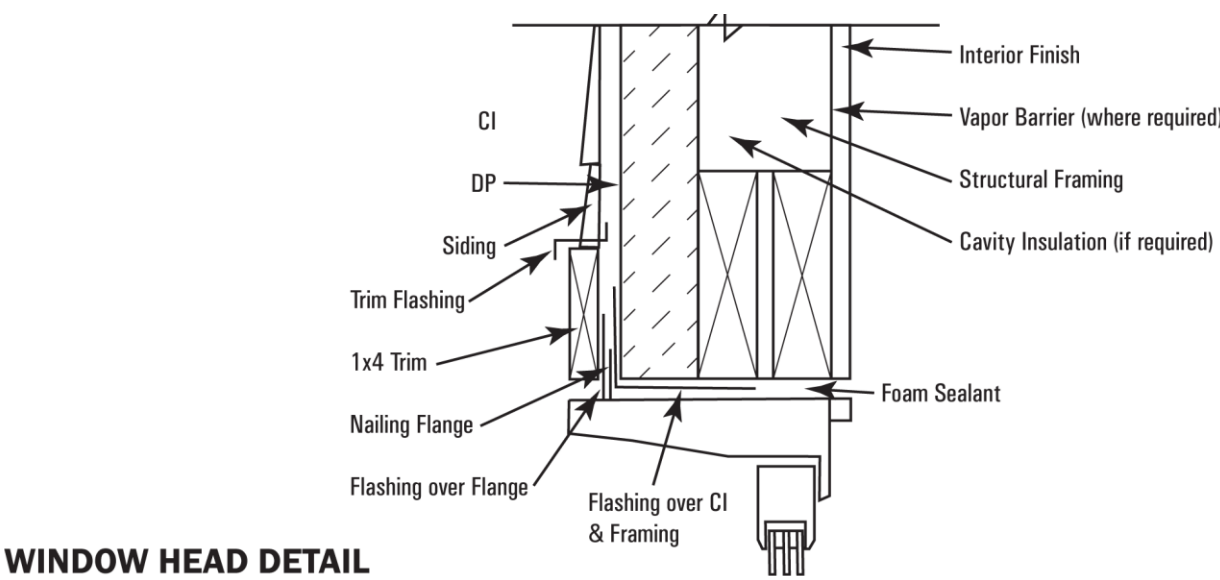

Figure 9c:

Figure 11c: Head detail – Window over CI – 2" or Less CI

6.11.2. Window/door penetrations (flush behind siding layer) – 2" or more CI (maximum 4") using wood buck

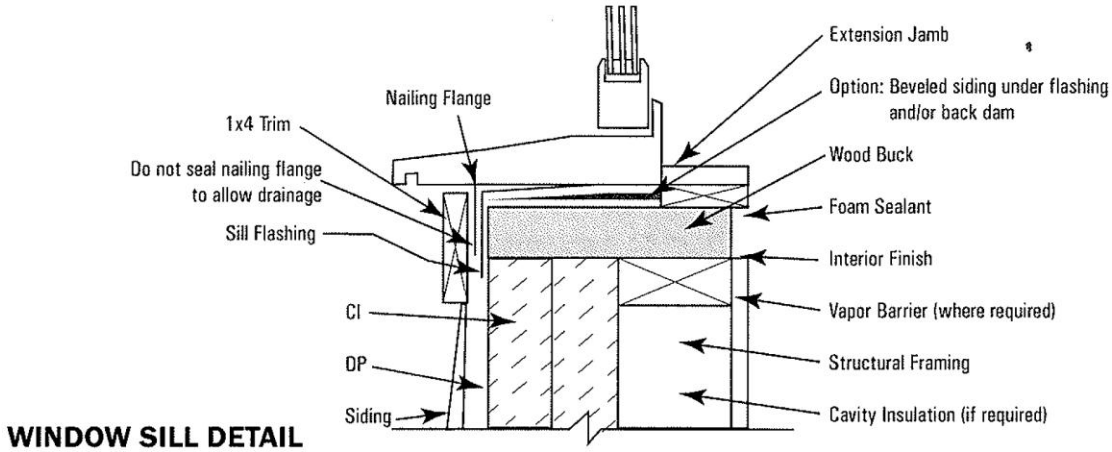

Figure 11d: Sill Detail – Window over CI – 2" or More CI

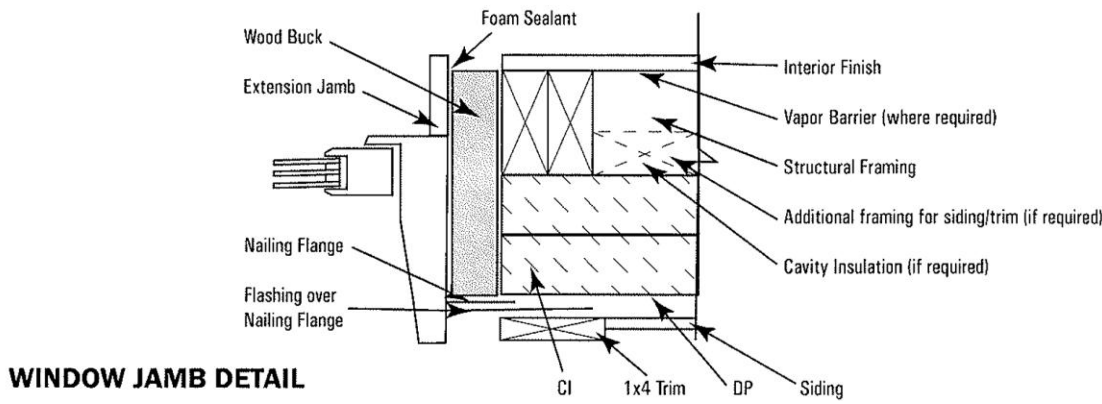

Figure 11e: Jamb Detail – Window over CI – 2" or More CI

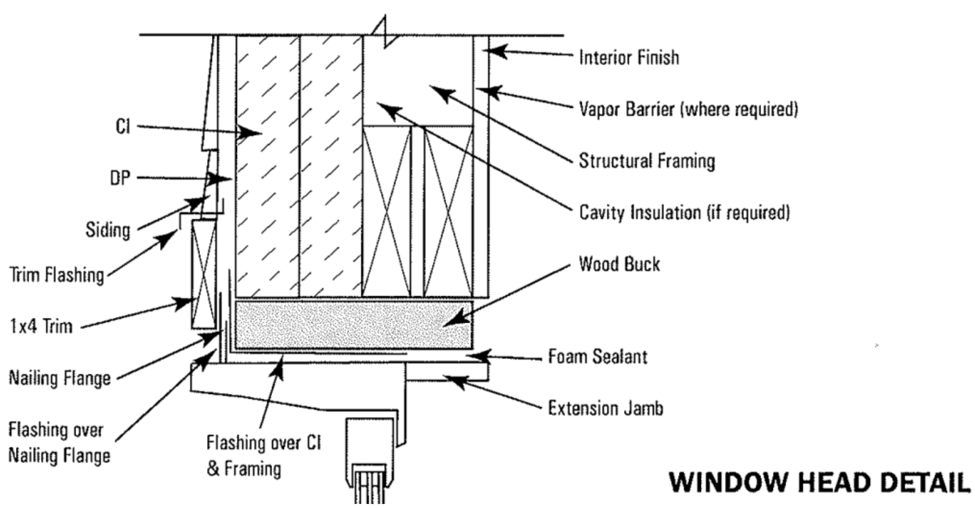

Figure 11f: Head Detail – Window over CI – 2" or More CI

6.11.3. Window/door penetrations (flush to interior finish layer – "Innie") – 2" or more CI (maximum 4") using wood buck

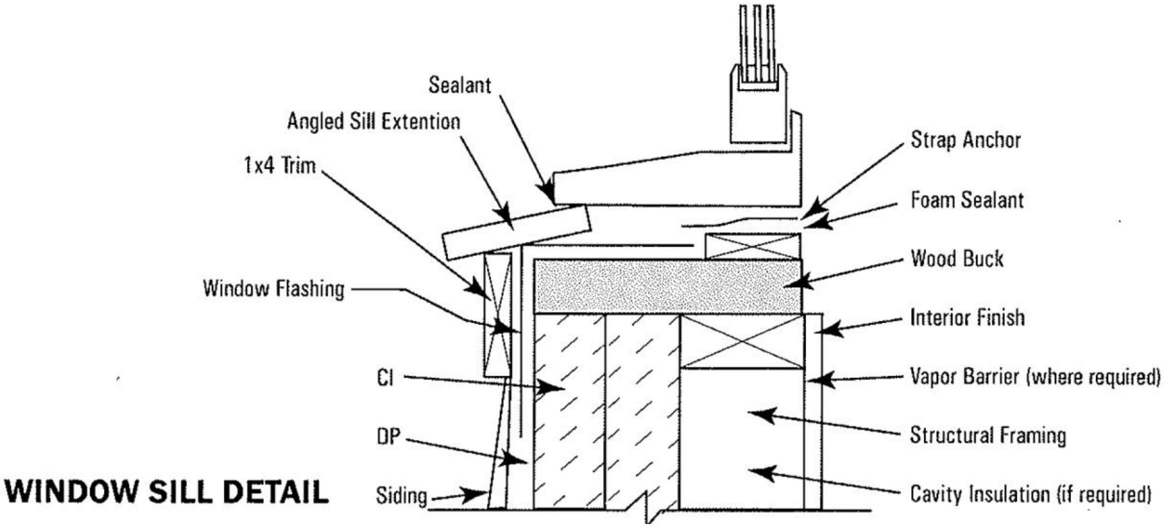

Figure 11g: Sill Detail – "Innie" Window over CI – 2" or more CI

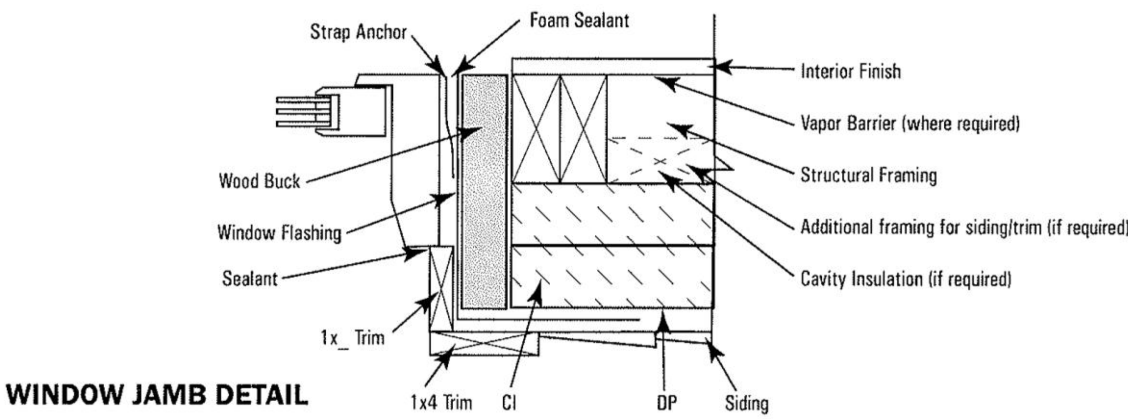

Figure 11h: Jamb Detail – "Innie" Window over CI – 2" or More CI

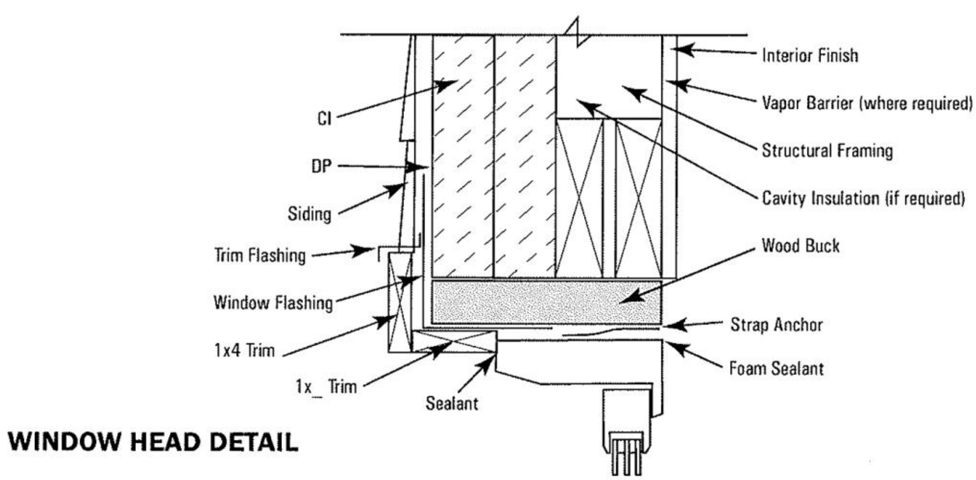

Figure 11i: Head Detail – "Innie" Window over CI – 2" or More CI

6.12. Other penetrations

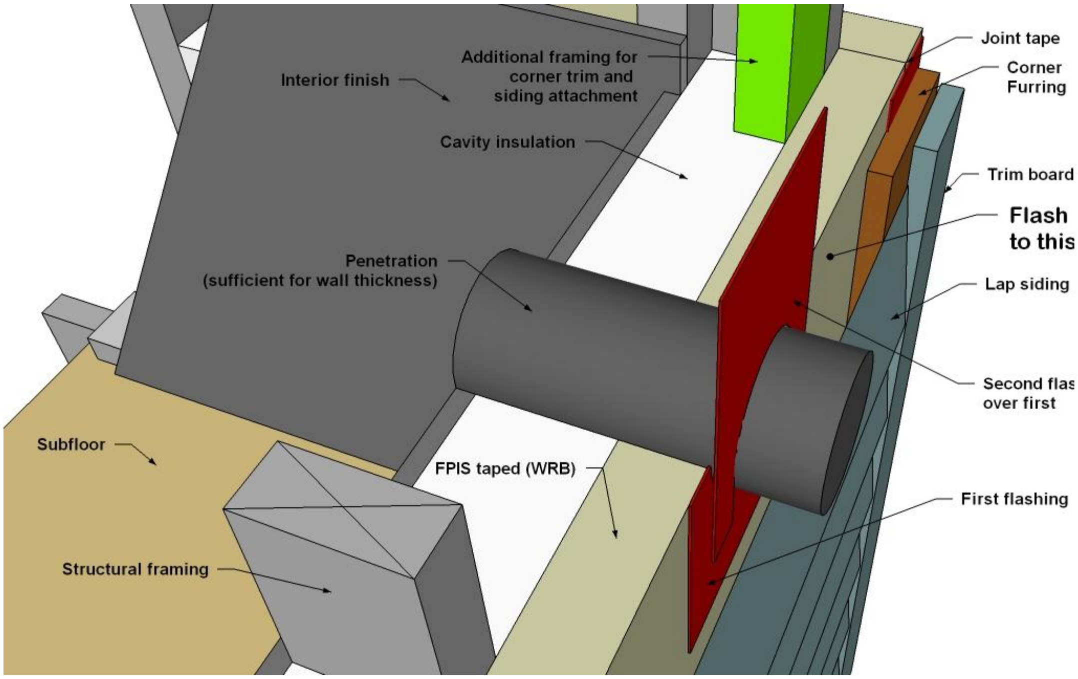

Figure 12: Penetration – 2" FPIS Taped Joints, Furring, Lap Siding

7. Conditions of Use:

7.2. The insulated sheathing products listed in Section 1 of this report comply with, or are suitable alternatives to, the applicable sections of the *2006*, *2009* and *2012 IBC* and the *2006*, *2009* and the *2012 IRC* and are subject to the following conditions.

7.2.1. These products shall be installed in compliance with:

7.2.1.1. The manufacturer's installation instructions

7.2.1.2. The applicable building code sections

7.2.1.2.1. Structural requirements

7.2.1.2.2. Fire requirements

7.2.1.2.3. Wind pressure requirements

7.2.1.2.4. Exterior wall covering requirements

7.2.1.2.5. Flashing requirements

7.2.1.2.6. Moisture barrier requirements

7.2.1.3. This TER

8. Identification:

8.2. All FPIS products shall be marked in accordance the ASTM C578 or ASTM C1289 as applicable to the type of material and bear the label of an approved agency on the packaging or individual FPIS panels.

8.3. Additional technical information and related TERs can be found from the SBC Research Institute (www.sbcri.info).

9. References:

9.2. TER 1006-01: *Prescriptive Wind Pressure Performance of Foam Plastic Insulation Used as Insulating Sheathing in Exterior Wall Covering Assemblies* (available at www.foamsheathing.org)

9.3. Guide to Attaching Exterior Wall Coverings through Foam Sheathing to Wood or Steel Wall Framing, FSC *Tech Matters*, (available at www.foamsheathing.org)

9.4. Additional technical information and related manufacturer's instructions can be found at each of the manufacturer's websites:

9.4.1. Atlas Roofing Corporation – www.atlasroofing.com

9.4.2. Dow Chemical Company – www.building.dow.com

9.4.3. Johns Manville – www.jm.com

9.4.4. Owens Corning – www.owenscorning.com

9.4.5. Rmax Operating, LLC – www.rmax.com

10. Review Schedule:

10.2. This TER is subject to periodic review and revision.

10.3. For information on the current status of this report, contact SBCRI.

Technical Evaluation Report

TO ASSIST WITH CODE COMPLIANCE

Attachment of Windows with Integral Flanges through Foam Plastic Insulating Sheathing to Wood Framing **TER No. 1304-01**

Issue Date: August 29, 2013
Updated: October 18, 2013

Foam Sheathing Committee (FSC) Members

Atlas Roofing Corporation – atlasroofing.com
Dow Chemical Company – dow.com
Johns Manville – jm.com
Owens Corning – owenscorning.com
Rmax Operating, LLC – rmax.com

Division: 06 00 00 – WOOD, PLASTICS, AND COMPOSITES
Section: 06 16 00 – Sheathing

Division: 07 00 00 – THERMAL AND MOISTURE PROTECTION
Section: 07 21 00 – Building Insulation

1. Code Compliance Process Evaluated:

1.1. The practice of installing windows with the integral flanges placed over code-compliant foam plastic insulating sheathing (FPIS).

1.1.1. Fasteners are attached through the pre-punched nail slots or holes in the window flanges, through the FPIS and into the framing behind the window.

1.1.2. Installing windows using this method is a common practice, and this Technical Evaluation Report (TER) is intended to supplement this practice and the window manufacturer's installation instructions.

1.1.3. Where the window manufacturer's installation instructions provide additional or conflicting information, the more stringent requirements shall apply.

1.2. For the most recent version of this report, visit drjengineering.org.

2. Applicable Codes and Standards:[1]

2.1. *2006,2009 and 2012 International Building Code* (*IBC*)

2.2. *2006, 2009 and 2012 International Residential Code* (*IRC*)

2.3. *AAMA 2400-02 – Standard Practice for Installation of Windows with a Mounting Flange in Stud Frame Construction*

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[1] Unless otherwise noted, code references are from the 2012 versions of the codes.

2.4. *2008 and 2012 National Design Specification for Wood Construction* (*NDS*)

2.5. *American Wood Council – Technical Report 12, General Dowel Equations for Calculating Lateral Connection Values*

2.6. *ANSI FS100-12 – Standard Requirements for Wind Pressure Resistance of Foam Plastic Insulating Sheathing Used in Exterior Wall Covering Assemblies*

2.7. *ASTM C578* – Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation

2.8. *ASTM C1289 – Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board*

2.9. *ASTM E330-02 (2010) – Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference*

2.10. *AAMA A440-05 – Standard/Specification for Windows, Doors and Unit Skylights*

3. Evaluation Scope:

3.1. The testing that serves as the basis of this evaluation is limited to one manufacturer, model, and size of window.

3.1.1. As such, this evaluation is intended as a proof of concept only and is not intended to be used as the sole means of approving a specific product for this application.

3.2. The intent of this TER is to provide proof of concept information regarding the ability of FPIS to serve as the sheathing layer installed directly behind window flanges. Due to the vast array of window manufacturers, window types, weights, attachment methods, etc., the manufacturer must decide whether this method of installation can be used for their respective products.

3.3. This TER examines the following structural aspects of the tested assemblies:

3.3.1. Ability of the window flanges to support the weight of the window itself.

3.3.2. Ability of the fasteners to support the weight of the window.

3.3.3. Ability to limit deflection of the fasteners (cantilevered through foam and into the framing) to 0.015"[2].

3.3.4. Ability of the windows to resist transverse wind loading when installed over foam sheathing per *ASTM E330*.

3.3.5. The following items related to window performance are outside the scope of this TER; however, many of these attributes are addressed in other testing and documentation. See individual manufacturer data for these attributes:

3.3.5.1. Protection from wind-borne debris in accordance with *IRC* Section R612.6.

3.3.5.2. Performance of glazing installed within the window and door assemblies.

3.3.5.3. Air infiltration.

3.3.5.4. Water penetration and flashing details.

3.3.5.5. Quality control inspection of FSC member manufacturing facilities and certification to *ASTM C1289* or *ASTM C578.*

4. Product Description and Materials:

4.1. The window selected for this study was a Crestline, Select 200 series, single hung window.

4.1.1. This is a vinyl window with integral flanges.

4.1.2. The actual window dimensions are 29½" wide x 41½" tall, fitting a rough opening of 30" wide x 42" tall.

4.1.3. The flange width is 1.98"

4.1.4. The flange thickness is 0.06".

4.1.5. The total window weight is 27.2 lbs.

[2] This 0.015" deflection limit is based on the assumed limit used to develop the *NDS* dowel equations.

4.2. Members of the American Chemistry Council's Foam Sheathing Committee (FSC) and the trade names of their products that meet the minimum requirements for the FPIS in this TER for use in this application are listed below.[3]

4.2.1. Polyisocyanurate Products (Polyiso) – Type I[4], ASTM C1289

4.2.1.1. Atlas Roofing Corporation – "Energy Shield®", "EnergyShield PRO" and "EnergyShield PRO 2" and "Rboard[5]"
8240Byron Center SW
Byron Center, MI 49315
616-583-1347

4.2.1.2. Dow Chemical Company – "Super TUFF-R™" and " THERMAX™"
200 Larkin Center
1605 Joseph Drive
Midland, MI 48674
989-638-8655

4.2.1.3. Rmax Operating, LLC – "R-Matte® Plus-3", "Thermasheath®-3", "Durasheath-3", "TSX8500", "TSX8510" and "Thermasheath-SI".
13524 Welch Road
Dallas, TX 75244
972-387-4500

4.2.2. Expanded Polystyrene (EPS) – Type II, ASTM C578

4.2.2.1. Atlas Roofing Corporation – " ThermalStar®"
2000 River Edge Parkway, Suite 800
Atlanta, GA 30328
800-388-6134

4.2.3. Extruded Polystyrene (XPS) – Type X, ASTM C578

4.2.3.1. Dow Chemical Company – "STYROFOAM™"
1605 Joseph Drive
Midland, MI 48674
989-638-8655

4.2.3.2. Owens Corning – "FOAMULAR®"
One Owens Corning Pkwy.
Toledo, OH 43659
419-248-8315

5. Applications:

5.1. The pertinent code sections related to this application are replicated as follows.

5.1.1. *IRC* code sections:

> **R612.1 General.** This section prescribes performance and construction requirements for exterior window and door installed in wall. Windows and doors shall be installed and flashed in accordance with the fenestration manufacturer's written installation instructions. Window and door openings shall be flashed in accordance with Section R703.8. Written installation instructions shall be provided by the fenestration manufacturer for each window or door.
>
> **R612.2 Performance.** Exterior windows and doors shall be designed to resist the design wind loads specified in Table R301.2(2) adjusted for height and exposure in accordance with Table R301.2(3).

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[3] FPIS Types listed in this TER are minimums having a compressive strength of at least 15 psi. Substitution of products with equal or greater performance shall be permitted in accordance with Section 6.2.

[4] As defined in *ASTM C1289*, Type 1 products are those that are faced with aluminum foil on both major surfaces of the core foam. These products also have a minimum compressive strength of 16 psi.

[5] Atlas Rboard is a Type 2, Class 2, Grade 1 Polyisocyanurate FPIS having a minimum compressive strength of 16 psi in accordance with *ASTM C1289*.

R612.3 Testing and labeling. Exterior windows and sliding doors shall be tested by an *approved* independent laboratory, and bear a *label* identifying manufacturer, performance characteristics and *approved* inspection agency to indicate compliance with AAMA\WDMA\CSA 101/I.S.2/A440. Exterior side-hinged doors shall be tested and *labeled* as conforming to AAMA\WDMA\CSA 101/I.S.2/A440 or comply with Section R612.5.

R612.5 Other exterior window and door assemblies. Exterior windows and door assemblies not included within the scope of Section R612.3 or Section R612.4[6] shall be tested in accordance with ASTM E 330. Glass in assemblies covered by this exception shall comply with Section R308.5.

R612.7.1 Anchoring requirements. Window and glass door assemblies shall be anchored in accordance with the published manufacturer's recommendations to achieve the design pressure specified. **Substitute anchoring systems used for substrates not specified by the fenestration manufacturer shall provide equal or greater anchoring performance as demonstrated by accepted engineering practice [emphasis added].**

5.1.2. *IBC* code sections:

1405.13 Exterior windows and doors. Windows and doors installed in exterior walls shall conform to the testing and performance requirements of Section 1710.5. Windows and doors that are part of the exterior building envelope are to be tested for wind-load resistance in accordance with the methods specified in Section 1710.5.2 (see commentary, Section 1710.5.2).

1405.13.1 Installation. Windows and doors shall be installed in accordance with approved manufacturer's instructions. Fastener size and spacing shall be provided in such instructions and shall be calculated based on maximum loads and spacing used in the tests.

1710.5 Exterior window and door assemblies. The design pressure rating of exterior windows and doors in buildings shall be determined in accordance with Section 1710.5.1 or 1710.5.2.

1710.5.1 Exterior windows and doors. Exterior windows and sliding doors shall be tested and labeled as conforming to AAMA/WDMA/CSA101/I.S.2/A440. The *label* shall state the name of the manufacturer, the *approved* labeling agency and the product designation as specified in AAMA/WDMA/CSA101/I.S.2/A440. Exterior side-hinged doors shall be tested and *labeled* as conforming to AAMA/WDMA/CSA101/I.S.2/A440 or comply with Section 1710.5.2. Products tested and labeled as conforming to AAMA/WDMA/CSA101/I.S.2/A440 shall not be subject to the requirements of Sections 2403.2 and 2403.3.

1710.5.2 Exterior windows and door assemblies not provided for in Section 1710.5.1. Exterior window and door assemblies shall be tested in accordance with ASTM E 330.Structural performance of garage doors and rolling doors shall be determined in accordance with either ASTM E 330 or ANSI/DASMA 108, and shall meet the acceptance criteria of ANSI/DASMA 108. Exterior window and door assemblies containing glass shall comply with Section 2403. The design pressure for testing shall be calculated in accordance with Chapter 16. Each assembly shall be tested for 10 seconds at a load equal to 1 ½ times the design pressure.

5.2. Testing window assemblies for gravity loads is not specifically required by the building codes.

5.2.1. Most manufacturer installation instructions require that the window be fully supported at the sill.

5.2.2. As a result, the manufacturer's installation instructions and the building codes are mainly concerned with transverse wind loading and the ability of the assemblies to maintain the integrity of the building envelope in resisting penetration by wind-driven rain.

5.3. Depending on a number of factors (including the wall framing, wall cladding, window type, flange type, method of attachment, etc.), when installed over a layer of FPIS, it may be difficult or impractical to provide full support for gravity loads of the window assembly by means of a sill directly supporting the assembly (see Figure 1).

5.3.1. In this application, the window would be cantilevered outside the framing with support of the assembly provided only by the fasteners extending through the window flange and FPIS into the framing.

[6] *IRC* Section R612.4 addresses garage doors, which are outside the scope of this TER.

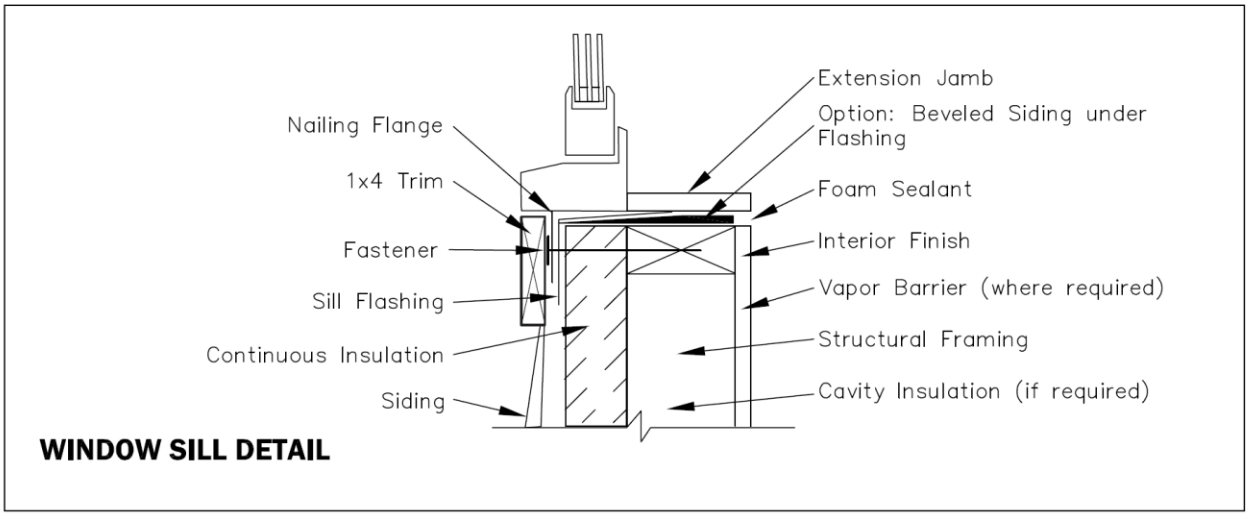

Figure 1: Window Sill Detail

5.4. As a result, FSC commissioned exploratory testing to gain an understanding of the performance of one window type and size used in this application.

5.4.1. Three series of tests were undertaken.

5.4.1.1. Series 1: Measurement of the long-term vertical deflection of a typical integral-flanged window with respect to the wall framing (see Photo 1)

Photo 1: Long-Term Deflection under Self-Weight Testing

5.4.1.2. Series 2: Proof tests to verify that the calculations used to specify fasteners and to limit deflection to 0.015" are accurate (see Photo 2)

Photo 2: Structural Loading – Fastener/Flange Capacity

5.4.1.3. Series 3: *ASTM E330* wind pressure testing to confirm resistance to wind loads of a typical integral-flanged window installed over FPIS with those installed directly to framing (see Photo 3)

Photo 3: Wind Pressure Loading Test Setup

5.5. Series 1: SBCRI testing to measure resistance to long-term deflection under self-weight

5.5.1. Three identical window frames were constructed. Windows were purchased locally and attached as follows:

5.5.1.1. All assemblies were constructed in accordance with the fastening requirements of *IRC* Table R602.3(1).

5.5.1.2. The sill of the rough opening was not installed so that no support was provided for the window other than through the fastening of the window side and top flanges. Also, no shims or supplemental anchoring devices were installed.

5.5.1.3. String pots were installed to measure the deflection at the lower corners of the window in relation to the base of the assembly.

5.5.1.4. Assembly 1: Window was attached directly to the rough opening.

5.5.1.5. Assembly 2: Layer of 1" FPIS was installed over the framing, and the window was installed with the fasteners extending through the FPIS and into the wood framing.

5.5.1.6. Assembly 3: Layer of 2" FPIS was installed over the framing, and the window was installed with the fasteners extending through the FPIS and into the wood framing.

5.5.2. The assemblies are shown in Photo 1.Test results:

5.5.2.1. After two weeks – No significant movement in any of the three assemblies.

5.6. Series 2: Proof tests to verify that the calculations used to specify fasteners and to limit deflection to 0.015" are accurate

5.6.1. Test frames, similar to those in the Series 1 tests, were constructed. As in the earlier tests, one had the window attached through 1" of FPIS, and one had the window attached through 2" of FPIS. An example is shown in Photo 2.

5.6.2. All testing was conducted using mechanical fasteners only; no sealant/adhesive was used in flange joints, as is normally required.

5.6.3. In each case, load was applied directly to the head of the window until failure of the window flange or fasteners occurred.

5.6.4. Test results:

5.6.4.1. Figure 2 shows the load deflection plots of the tests through failure. The plots show the average deflection taken from the lower left and lower right corners of the windows during the tests. Both tests reached failure with a load in the range of 3,300-3,600 lbs, showing that the window flanges and fasteners have an ultimate capacity that greatly exceeds the weight of the window and can be designed to support the weight of the windows alone. Further, there is a lot of resiliency in the connections up through $1^1/_2$" of window movement, providing a tough, strong and resilient connection.

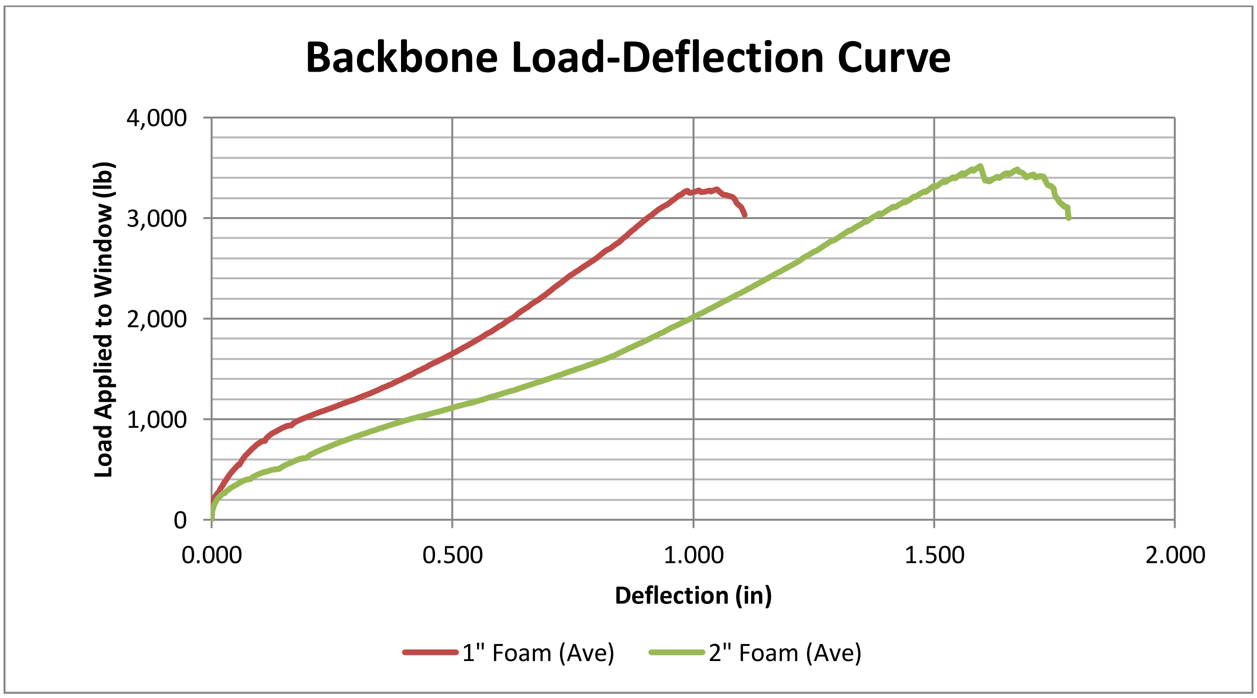

Figure 2: Backbone Load-Deflection Plot

5.6.4.2. Figure 3 shows the loads applied to the test windows through a deflection of 0.016" and the average deflection as measured at the bottom corners of the window.

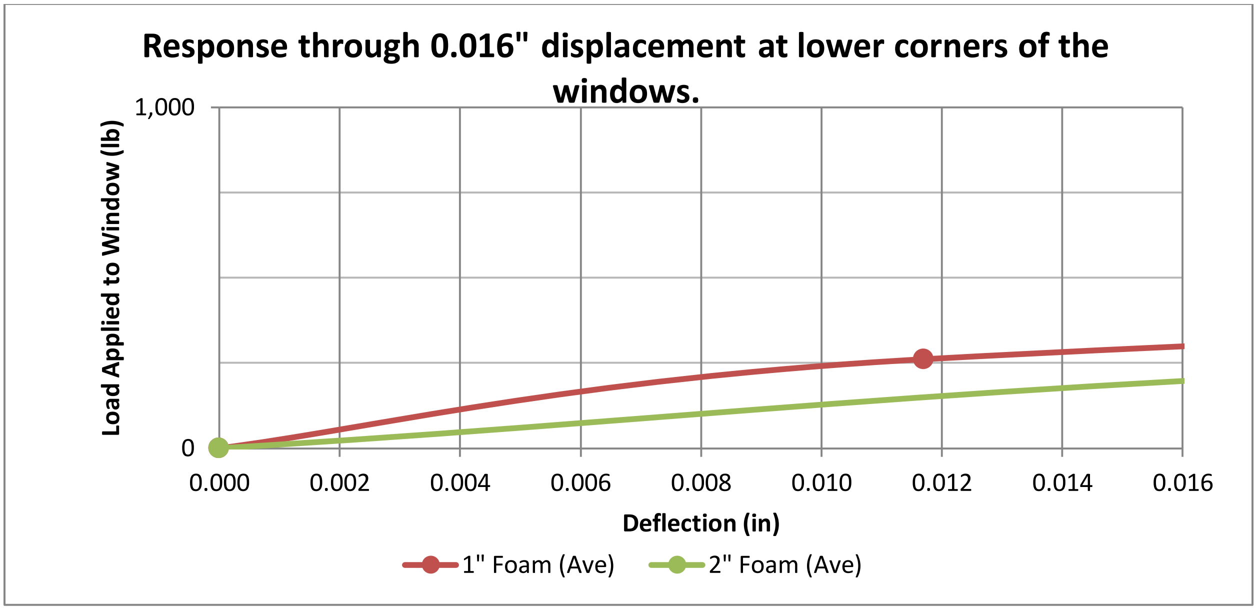

Figure 3: Response to Applied Load through 0.016" Displacement at Lower Corners of the Windows

5.6.4.3. Table 1 summarizes the structural loading required to achieve 0.015" of deflection and the corresponding load that was applied to each fastener to achieve that deflection.

5.6.4.4. Table 1 also shows the calculated load in accordance with AWC's *Technical Report 12* (*TR12*), Table 1, General Dowel Equations.

5.6.4.4.1. This calculation allows a designer to calculate the lateral resistance of fasteners where a gap exists between the side member load on the fastener and the main framing member.

5.6.4.4.2. In this application, the FPIS is installed in the gap between the side member load on the fastener and the main framing member.

5.6.4.5. This confirms that the calculations in *NDS*/*TR12* conservatively estimate the deflection and can be used to limit deflection to 0.015" in this application.

FPIS Thickness	Applied Load	Tested Load per Fastener (lbs)	Load per Fastener Calculated per *NDS*/*TR12* (lbs)[1]
2"	158	6	5
1"	280	10.7	9
1. The allowable load for these fasteners was calculated using a reduction factor of 3, versus the reduction factor of 2.2 as allowed by *NDS/TR12*, providing a higher factor of safety.			

Table 1: Test Results Comparing Tested Load per Fastener with the Calculated Load to Limit Deflection to 0.015"

5.7. Series 3: *ASTM E330* wind pressure testing to compare the resistance to wind loads of windows installed over FPIS

5.7.1. An assembly with a window unit was built to the requirements of *ASTM E330* and tested with 2" of FPIS applied. The test setup is shown in Photo 3.

5.7.1.1. Table 2 summarizes the maximum wind pressure experienced by the wall.

Wall Type	Minimum Structural Pressure Rating (STP)	Failure Load (psf)
2" Foam Sheathing	37.5	118

Table 2: Summary of Wind Pressure Test Results

5.7.1.2. The windows used in this test had a minimum design pressure (DP) rating of +/- 25 psf and a minimum structural pressure (STP) of +/-37.5 psf.

5.7.1.3. The 2" FPIS test showed significant excess capacity with respect to the code-compliant wind pressure rating for the window unit.

5.7.1.4. In addition, the tests were conducted without shims applied to jambs at the location of cross rails or any other support than the fastening of the flange through foam sheathing to the jamb studs.

6. Installation:

6.1. Proposed General Installation Requirements for Window Flange Fasteners

6.1.1. Attach to the wall framing in accordance with the window manufacturer's installation instructions.

6.1.2. Minimum penetration of the fastener into wood framing shall be 1¼".

6.1.3. Minimum lumber shall have a specific gravity (SG) of 0.42 (SPF).

6.1.4. In no case shall fasteners be spaced greater than 16" o.c., per *AAMA 2400*.

6.1.5. Fastener head shall be driven flush with the surface of the window flange for a flush and smooth fit against the foam sheathing.

6.1.6. Care shall be taken to avoid overdriving the fasteners.

6.2. General Requirements for FPIS

6.2.1. Minimum compressive strength – 15 psi

6.2.2. Maximum foam thickness – 2"

6.2.3. Compliant with *ASTM C578* or *ASTM C1289*, as applicable

6.2.4. Table 3 provides the minimum fastener size and maximum spacing for attachment of windows through FPIS and into the framing.

Minimum Fastener (or equal)	Thickness of Foam Sheathing (in)	Maximum Fastener Spacing in Flanges per Width of Window Unit	
		≤ 3'	> 3'
0.120"-Diameter Roofing Nail	½"	16" o.c.	9" o.c.
	1"	10" o.c.	5" o.c.
	1½"	7" o.c.	3.5" o.c.
	2"	6" o.c.	3" o.c.

1. Values assume integral flanges with fasteners that support 100% of window unit weight even when sill shims are installed per the manufacturer's installation instructions.
2. Table is based on a window unit weight of 7 pounds per square foot. For different weights, multiply fastener spacing by 7/w, where w is the actual weight in pounds per square foot.
3. The fastener spacing provided in this table are the maximum allowed based on support of the window unit's weight.
4. For wind load resistance, a lesser fastener spacing may be specified in the window manufacturer's installation instructions.
5. The window manufacturer's installation instructions, where more stringent, shall be followed in the event of any conflict.
6. Spacing calculations in table assume that vertical flanges support 100% of the gravity load.

Table 3: Minimum Fastener Size & Maximum Spacing along Window Flanges for Attachment to Wood Framing through FPIS

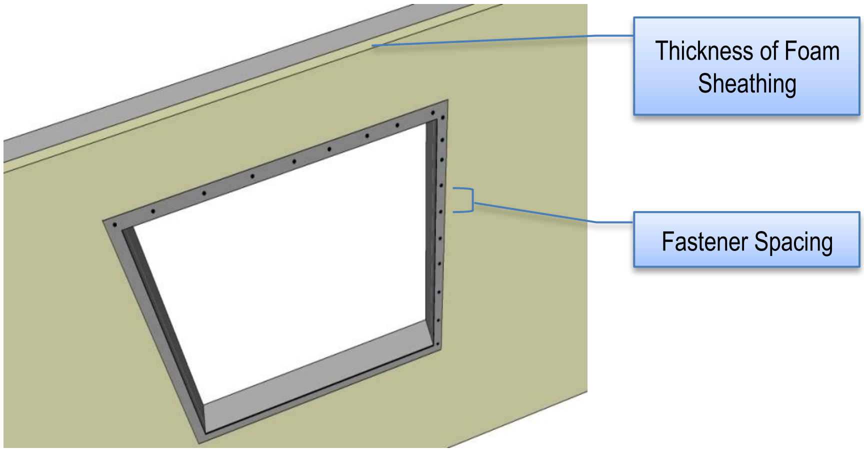

Figure 4: Window Installation over FPIS

7. Test and Engineering Substantiating Data:

7.1. FSC TER 1202-05: *Construction Details for the Use of Foam Plastic Insulating sheathing (FPIS) in Light-Frame Construction.*

7.2. FSC Tech Matters, Guide *to Attaching Exterior Wall Coverings through Foam Sheathing to Wood or Steel Wall Framing*.

7.3. Test report evaluating the wind pressure resistance of windows installed over FPIS by SBCRI.

7.4. Test report evaluating the resistance of fasteners in windows installed over FPIS and OSB by SBCRI.

7.5. Test report evaluating creep of fasteners installed into windows over FPIS and OSB by SBCRI

7.6. *Fastening Systems for Continuous Insulation*, New York State Energy Research and Development Authority (NYSERDA), April 2010.

7.7. *ASHRAE Journal*, "Installation Requirement for Attachment of Integral Flange-Mounted Window Units Over Foam Plastic Insulating Sheathing", Feb 2013.

7.8. Some information contained herein is the result of testing and/or data analysis by other sources, which DrJ relies on to be accurate as it undertakes its engineering analysis.

7.8.1. DrJ does not assume responsibility for the accuracy of data provided by testing facilities, but relies on each testing agency's accuracy and accepted engineering procedures, experience, and good technical judgment.

7.9. Where appropriate, DrJ relies on the derivation of design values, which have been codified into law through the codes and standards listed in Section 2, to undertake the review of test data that is comparative or shows equivalency to an intended end use application. DrJ undertakes its engineering evaluation based on code-adopted design values, code-adopted installation details and all code-based and new product test data and analysis provided.

7.9.1. DrJ does not assume responsibility for the accuracy of any code-adopted design values but relies upon their accuracy for engineering evaluation.

7.9.2. DrJ relies upon the fact that the manufacturers of code-adopted products stand behind these legally established design values that are generated by the manufacturer of those products or the members of the associations that publish those design values.

7.10. DrJ evaluates all equivalency testing and related analysis using this engineering foundation.

8. Findings:

8.1. *IBC* Section 104.11 and *IRC* Section R104.11 specifically state that:

> The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code.

8.2. When connected in accordance with this TER, fastening is sufficient to limit long-term deflection due to the self-weight of the window assembly.

8.3. Proof testing of integral-flanged window assemblies described in this TER confirm the use of Table 3 (based on *NDS*/*TR12* calculations) for the attachment of windows though FPIS.

8.4. Wind pressure tests indicate that integral-flanged windows can be installed over up to 2" of FPIS, even in the absence of shims or special anchors. However, where shims or special anchors are required by the window manufacturer, the window manufacturer's installation instructions shall be followed.

9. Conditions of Use:

9.1. The insulated sheathing products listed in Section 4 of this report comply with, or are suitable alternatives to, the applicable sections of the *IRC and IBC* (see Section 5.1) and are subject to the following conditions.

9.1.1. These products shall be installed in compliance with the manufacturer's instructions, applicable building code(s) and this TER.

10. Identification:

10.1. The foam sheathing described in this TER is identified by a label on the board or packaging material bearing the manufacturer's name, product name, label of the third-party inspection agency, and other information to confirm code compliance.

11. Review Schedule:

11.1. This TER is subject to periodic review and revision. For the most recent version of this report, visit drjengineering.org.

11.2. For information on the current status of this report, contact DrJ.

Appendix A:
TERs Are Comparable to, Compatible with, and Equivalent to the Purpose of an ICC-ES ESR

1. Technical Evaluation Reports (TERs), drafted and maintained by DrJ (professional engineering firm and ISO Guide 65 applicant through ANSI/ACLASS), assess how specific products comply with the provisions of the building code. DrJ is a code-defined "approved source," and DrJ employs professional engineers and follows state professional engineering rules and regulations.
2. TERs are comparable to, compatible with, and equivalent to the purpose of an ICC Evaluation Service (ICC-ES) Evaluation Service Reports (ESRs).[7]
   - **2.1.** ICC Evaluation Service does not provide an engineer's seal on any of its ESRs.
   - **2.2.** Furthermore, the ICC-ES Evaluation Report Purpose is defined as follows[8]:

ICC EVALUATION SERVICE

www.icc-es.org | (800) 423-6587 | (562) 699-0543 *A Subsidiary of the International Code Council®*

ICC EVALUATION SERVICE, LLC,
RULES OF PROCEDURE FOR EVALUATION REPORTS

1.0 PURPOSE

These rules set forth procedures governing ICC Evaluation Service, LLC (ICC-ES), issuance and maintenance of evaluation reports on building materials and products, methods of construction, prefabricated building components, and prefabricated buildings.

ICC-ES evaluation reports assist those enforcing model codes in determining whether a given subject complies with those codes. An evaluation report is not to be construed as representing a judgment about aesthetics or any other attributes not specifically addressed in the report, nor as an endorsement or recommendation for use of the subject of the report. Approval for use is the prerogative and responsibility of the Code Official; ICC-ES does not intend to assume, nor can ICC-ES assume, that prerogative and responsibility.

   - **2.3.** ICC ESR Disclaimer[9]:

ICC-ES Evaluation Reports are not to be construed as representing aesthetics or any other attributes not specifically addressed, nor are they to be construed as an endorsement of the subject of the report or a recommendation for its use. There is no warranty by ICC Evaluation Service, LLC, express or implied, as to any finding or other matter in this report, or as to any product covered by the report.

ANSI Accredited Program PRODUCT CERTIFICATION 1000

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8 See the "ICC-ES Rules of Procedure" at www.icc-es.org/pdf/rules_evalrpts.pdf.
9 Page 1 footer of each ICC-ES report that can be found at www.icc-es.org/reports/index.cfm.

3. DrJ Sealed Engineering

3.1. DrJ engineers have undertaken the rigorous engineering and analysis work to determine the subject of this report's compliance with the codes and standards referenced in Section 2.

3.2. DrJ work:

3.2.1. Complies with accepted engineering procedures, experience and good technical judgment.

3.2.2. Is the work of an independent person, firm or corporation who is competent and experienced in the application of engineering principles to materials, methods or systems analyses.

3.3. A Technical Evaluation Report generated by DrJ is in all "code-compliance-evaluation-processing" respects equivalent to an ICC-ES ESR, as ICC-ES defines its approach, with one material difference.

3.3.1. DrJ will seal all TERs, as needed, so that responsibility for the work is well-defined.

3.3.2. The DrJ responsibility statement is identical to that provided in ICC-ES ESRs.

DrJ (drjengineering.org) research reports are not to be construed as representing aesthetics or any other attributes not specifically addressed, nor are they to be construed as an endorsement of the subject of the report or a recommendation for its use. There is no warranty by DrJ express or implied as to any finding or other matter in this report or as to any product covered by this report.

Appendix B: Legal Aspects of Product Approval

1. Product Approval

1.1. In general, the model and local codes provide for the use of alternative materials, designs and methods of construction by having a legal provision that states something similar to:

> The provisions of this code/law are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code/law, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the compliance official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code/law, and that the material, design, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code/law.

1.2. In concert with preserving "free and unfettered competition as the rule of trade", should this alternative material, design or method of construction not be approved, the building official shall respond in writing, stating the specific reasons for non-code-compliance and/or for non-professional engineering regulation compliance.

> Congress passed the first antitrust law, the Sherman Act, in 1890 as a "comprehensive charter of economic liberty aimed at preserving free and unfettered competition as the rule of trade." In 1914, Congress passed two additional antitrust laws: the Federal Trade Commission Act, which created the FTC, and the Clayton Act. With some revisions, these are the three core federal antitrust laws still in effect today.
>
> …Yet for over 100 years, the antitrust laws have had the same basic objective: to protect the process of competition for the benefit of consumers, making sure there are strong incentives for businesses to operate efficiently, keep prices down, and keep quality up….
>
> The Sherman Act outlaws "every contract, combination, or conspiracy in restraint of trade," and any "monopolization, attempted monopolization, or conspiracy or combination to monopolize." For instance, in some sense, an agreement between two individuals to form a partnership restrains trade, but may not do so unreasonably, and thus may be lawful under the antitrust laws. On the other hand, certain acts are considered so harmful to competition that they are almost always illegal.
>
> The penalties for violating the Sherman Act can be severe. Although most enforcement actions are civil, the Sherman Act is also a criminal law, and individuals and businesses that violate it may be prosecuted by the Department of Justice.[10]

2. Legal Validity of this TER

2.1. This TER is a code-defined (e.g., *2009 IBC* and *IRC* Section 104.11.1 and *2009 IBC* Section 1703.4.2) "research report" that provides supporting data to assist in the approval of materials, designs or assemblies not specifically provided for in this code.

2.2. Therefore, this TER is a valid research report from a professional engineering company that complies with the code definition of "approved source." If required by the authority having jurisdiction, this TER can also be sealed to comply with professional engineering laws and regulations.

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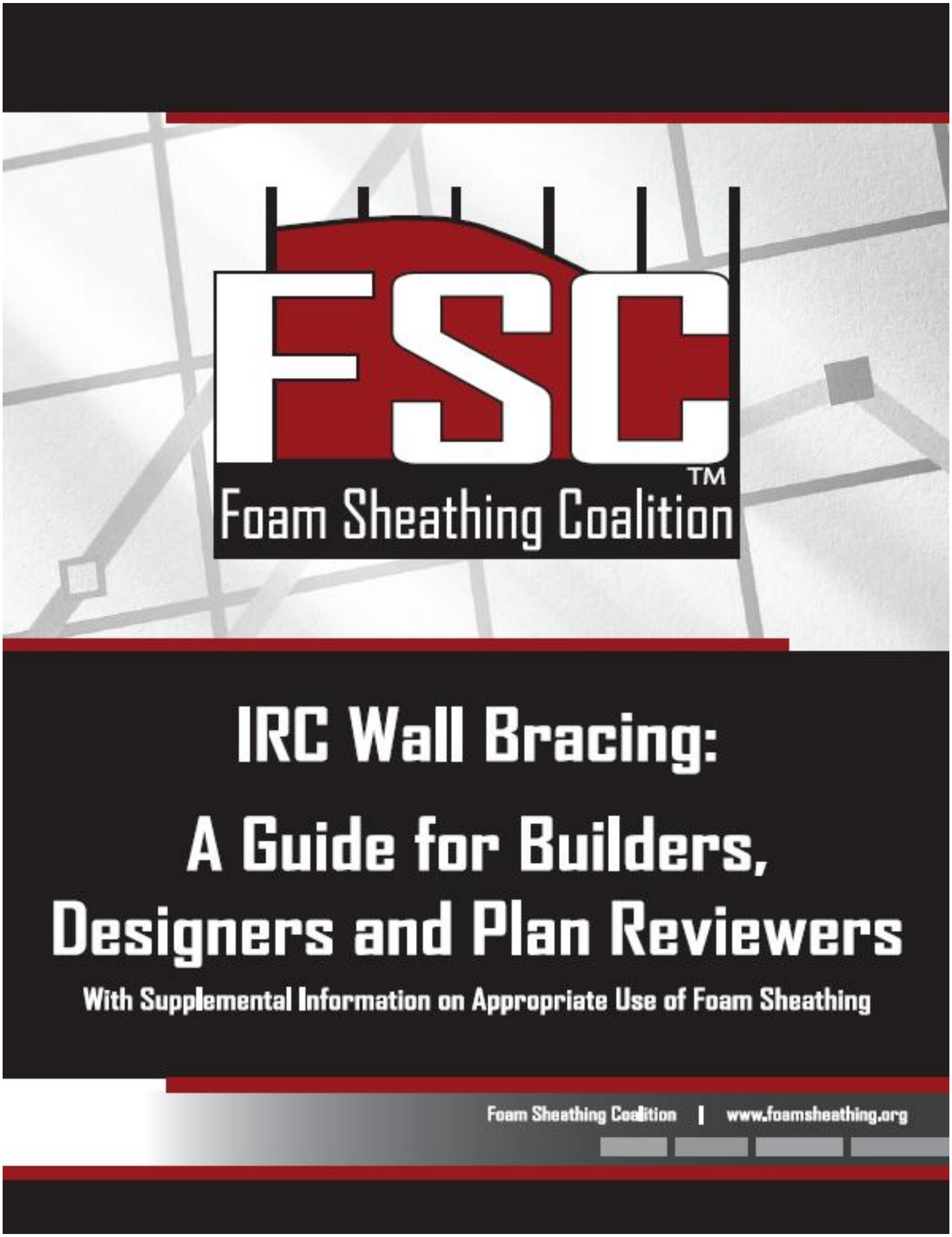
[10] http://www.ftc.gov/bc/antitrust/antitrust_laws.shtm

Version 2.1 – IBS 2010 Special Resource Edition



FSC™ Foam Sheathing Coalition

IRC Wall Bracing:

A Guide for Builders, Designers and Plan Reviewers

With Supplemental Information on Appropriate Use of Foam Sheathing

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Table of Contents

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

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

Introduction

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

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

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

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

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

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

List of Figures/Tables

Section 1: Basic Concepts for Code-Compliant Wall Bracing

1.1 Why is Wall Bracing Needed?

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

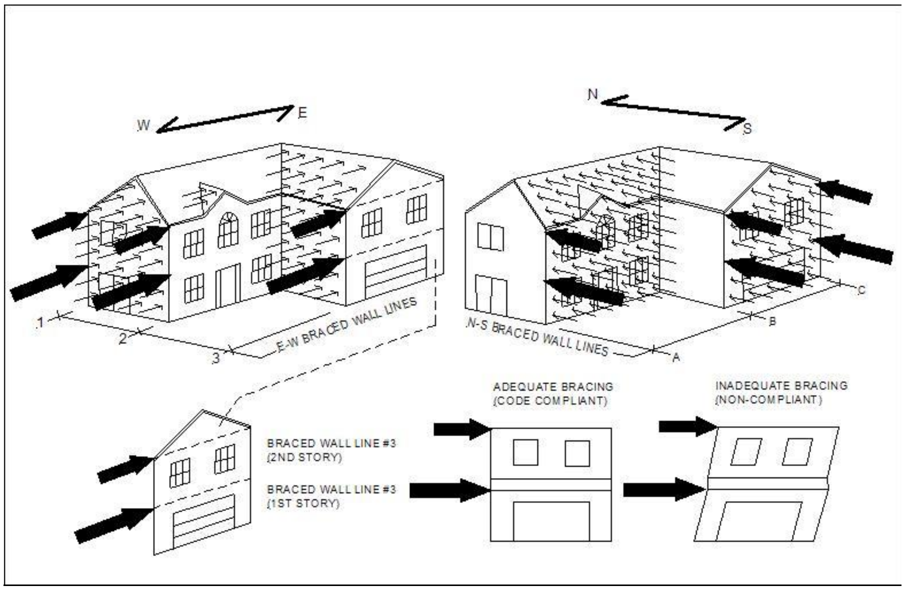


Figure 1***: Wall Bracing and Racking Forces***

1.2 How does Wall Bracing Work?

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

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

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

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

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

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

1.3 When Should I Consider Wall Bracing?

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

> **R106.1.1 Information on construction documents. …**Where required by the *building official*, all braced wall lines, shall be identified on the *construction documents* and all pertinent information including, but not limited to, bracing methods, location and length of braced wall panels, foundation requirements of braced wall panels at top and bottom shall be provided.

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

1.4 Scope Limitations

This guide is limited to the following use conditions:

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

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

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

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

1.5 Definitions

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

> **BRACED WALL LINE.** A straight line through the building plan that represents the location of the lateral resistance provided by the wall bracing.
>
> **BRACED WALL LINE, CONTINUOUSLY SHEATHED.** A *braced wall line* with structural sheathing applied to all sheathable surfaces including the areas above and below openings.
>
> **BRACED WALL LINE, INTERMITTENT BRACING.** A *braced wall line* with discrete structural sheathing panels or braces provided only at specified locations and not requiring continuous structural sheathing on other portions of a wall.
>
> **BRACED WALL PANEL.** A full-height section of wall constructed in compliance with an approved bracing method to resist in-plane shear loads through interaction of framing members, bracing materials, connections and anchors.

1.6 Key Concepts and Rules

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

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

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

> ***BWL Offset Rule*** *(R602.10.1.4)* **-** Figure 2 illustrates limitations on the permissible off-set of braced wall panels in off-set portions of a designated braced wall line.
>
> ***BWL End Rule*** *(R602.10.1)* – The end of a braced wall line can be determined in two ways as shown in Figure 2. The end may occur at the intersection of a perpendicular exterior wall (actual wall line) or projection thereof or with the intersection of a perpendicular braced wall line (dashed line representing the bracing effect of actual walls). The case resulting in the maximum BWL length must be used.

These above rules have important implications for flexible and efficient bracing designs. They also are important to consider when locating BWPs along or near the ends of a BWL as addressed later. While not addressed in the scope of this guide, the ends of a BWL must be known to be able to determine its length which is used to determine the amount of seismic bracing required in high-hazard earthquake areas. Wind bracing amounts in the IRC are not dependent on BWL length and the BWL only needs to provide sufficient space for the length of wind bracing required.

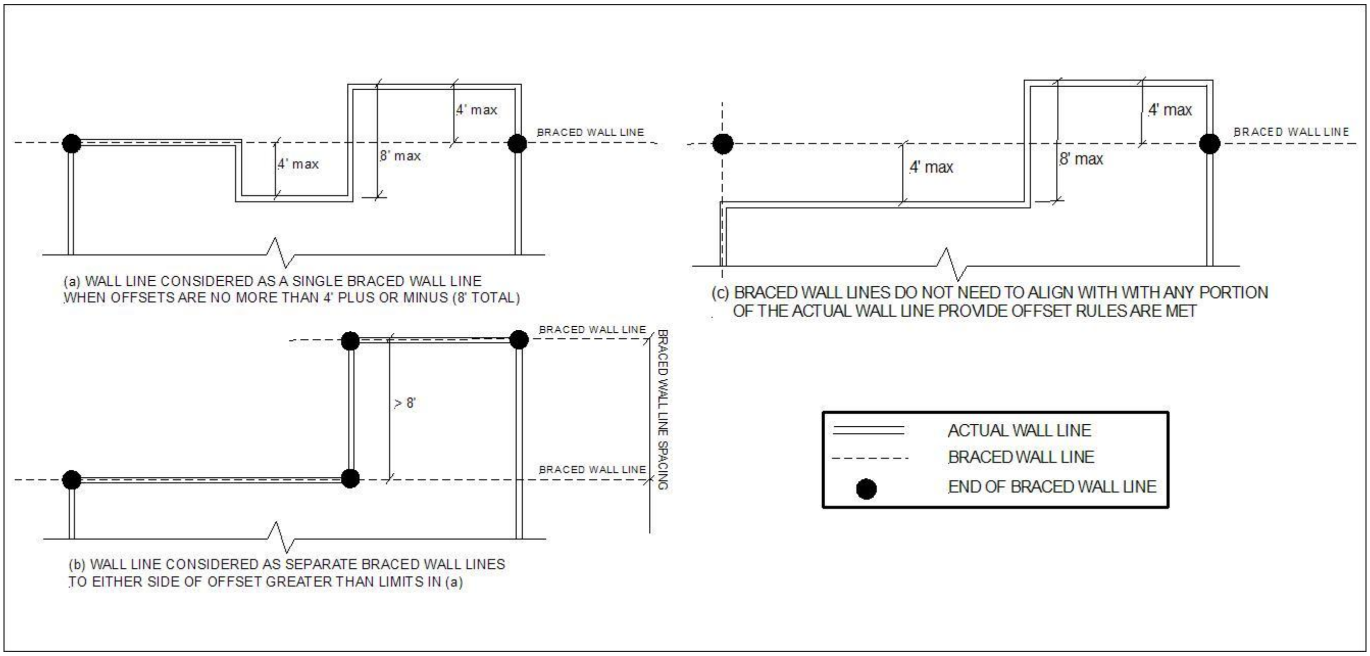


Figure 2: ***Braced Wall Line Layout Rules (Offsets and Ends)***

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

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

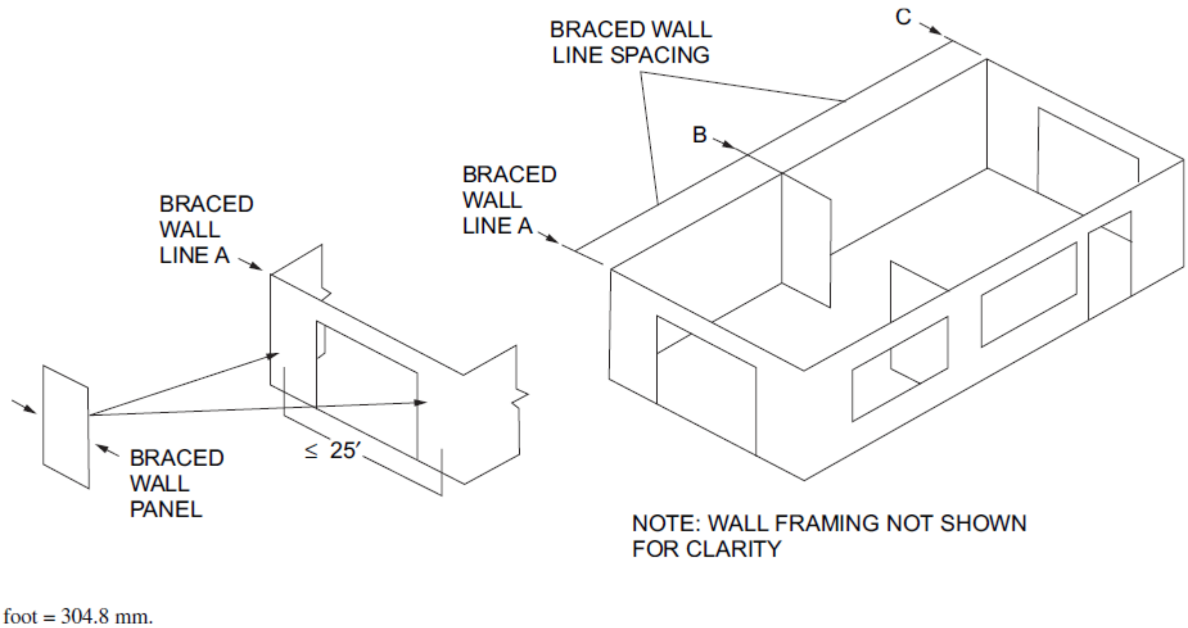


Figure 3: Braced Wall Panels and Braced Wall Lines
(IRC Figure R602.10.1.4(1))

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

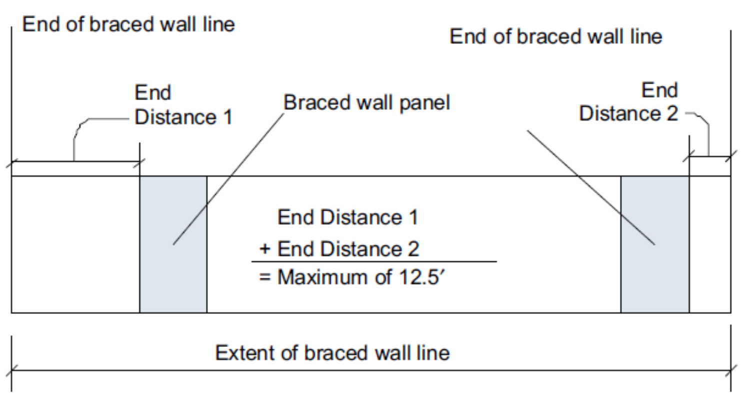
Braced Wall Panel (R602.10.1.1) – Also shown in Figure 3, a braced wall panel (BWP) is a section of a braced wall line that is specifically braced with a code-compliant bracing method (e.g., let-in brace, a wood structural panel, or other bracing methods). The various braced wall panel construction methods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

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

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

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

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



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

For SI: 1 foot = 304.8 mm.

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

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

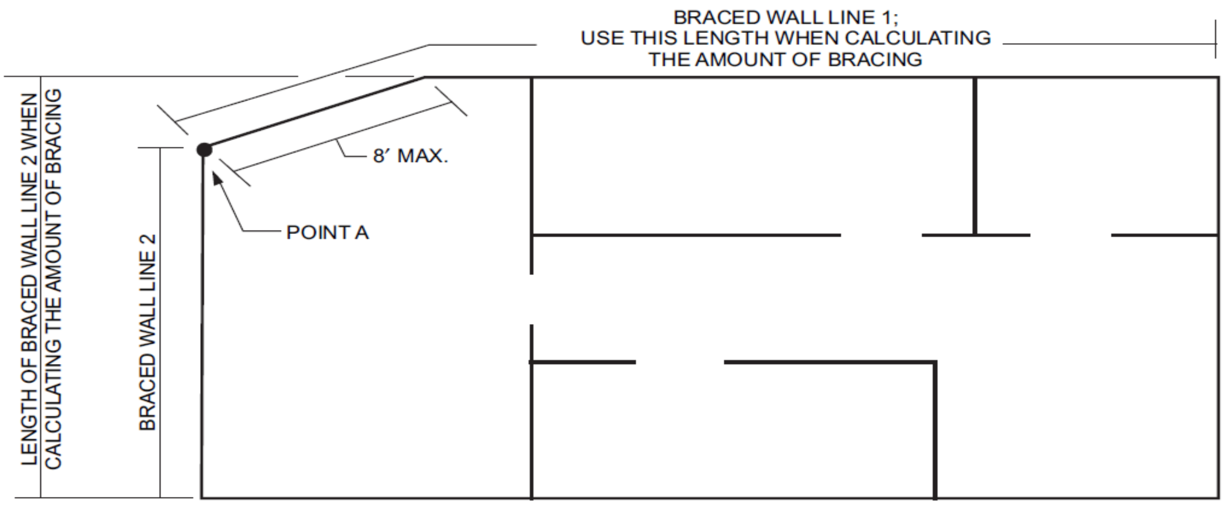
> ✍: An expected change for the 2012 IRC includes a reduction of the *BWP end distance to 10' together with the elimination of the cumulative 12.5' end distance requirement discussed above. In addition, the spacing of BWPs is changed from 25'oc to 20' edge-to-edge. Further, braced wall lines 16' or less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

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

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

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

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



For SI: 1 foot = 304.8 mm.

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

Section 2: IRC Wall Bracing Methods

2.1 Overview

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

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

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

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

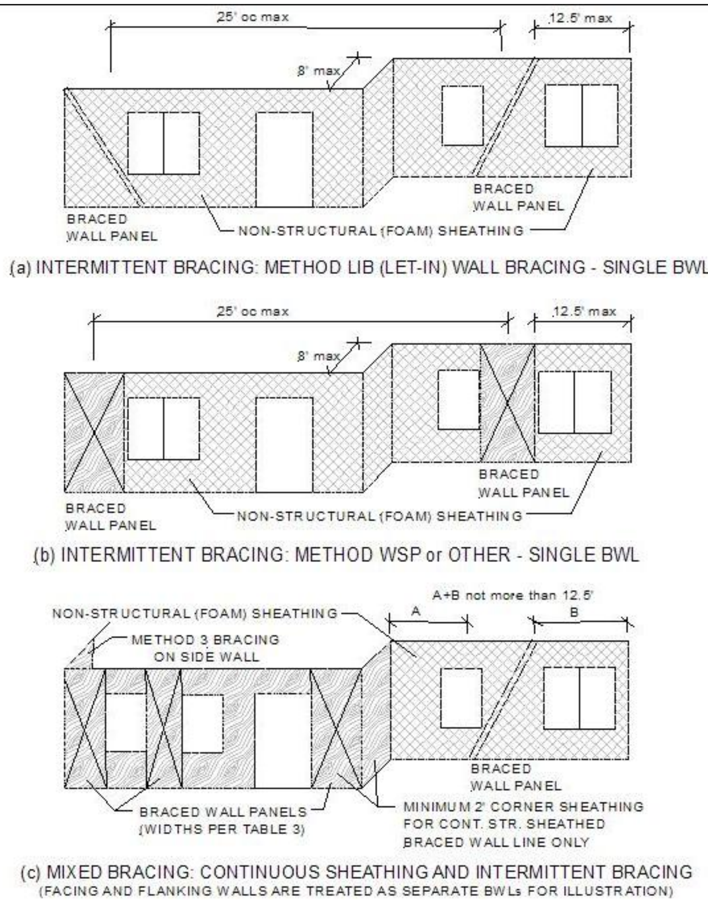


Figure 6: Illustration of intermittent, continuous, and mixed bracing methods.

2.2 Intermittent Braced Wall Panel Construction Methods

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

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

Table 1: Intermittent Bracing Methods and Requirements

(Based on IRC Section R602.10.2)

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

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

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

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

(Based on IRC Table R602.10.3.1)

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

NP = Not permitted

a. Linear interpolation shall be permitted.

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

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

"Partial Credit" Allowance for Select Intermittent Bracing Methods

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

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

(Based on IRC Table R602.10.3)

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

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

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

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

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

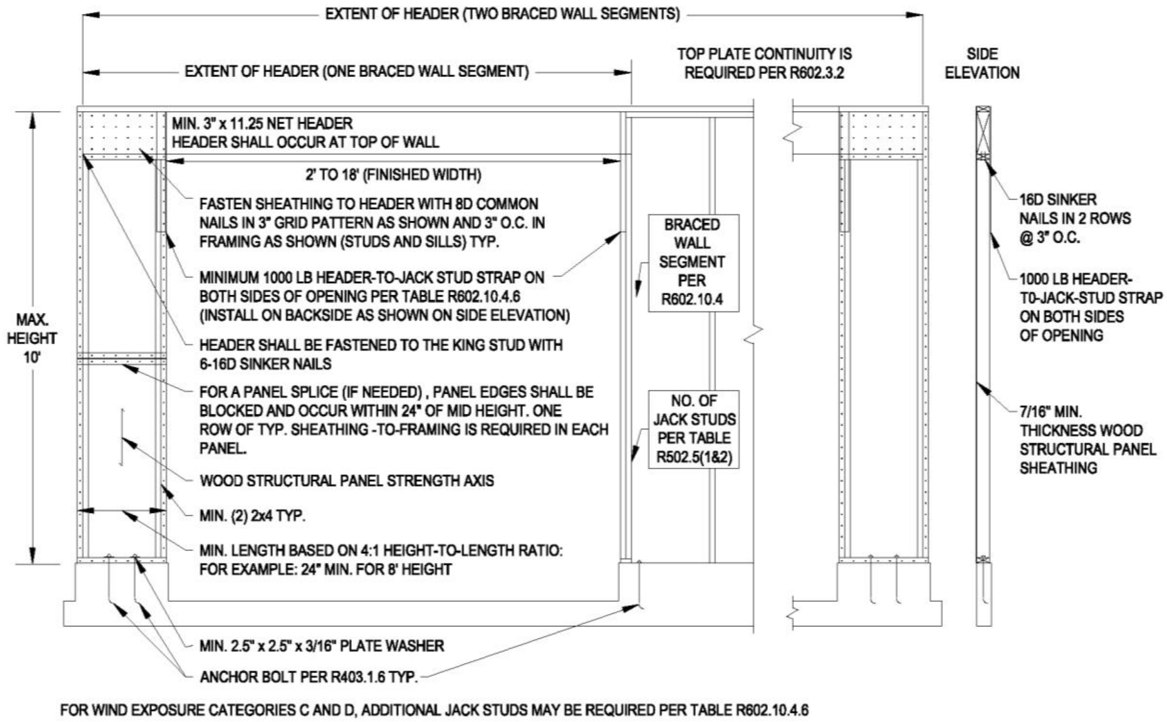
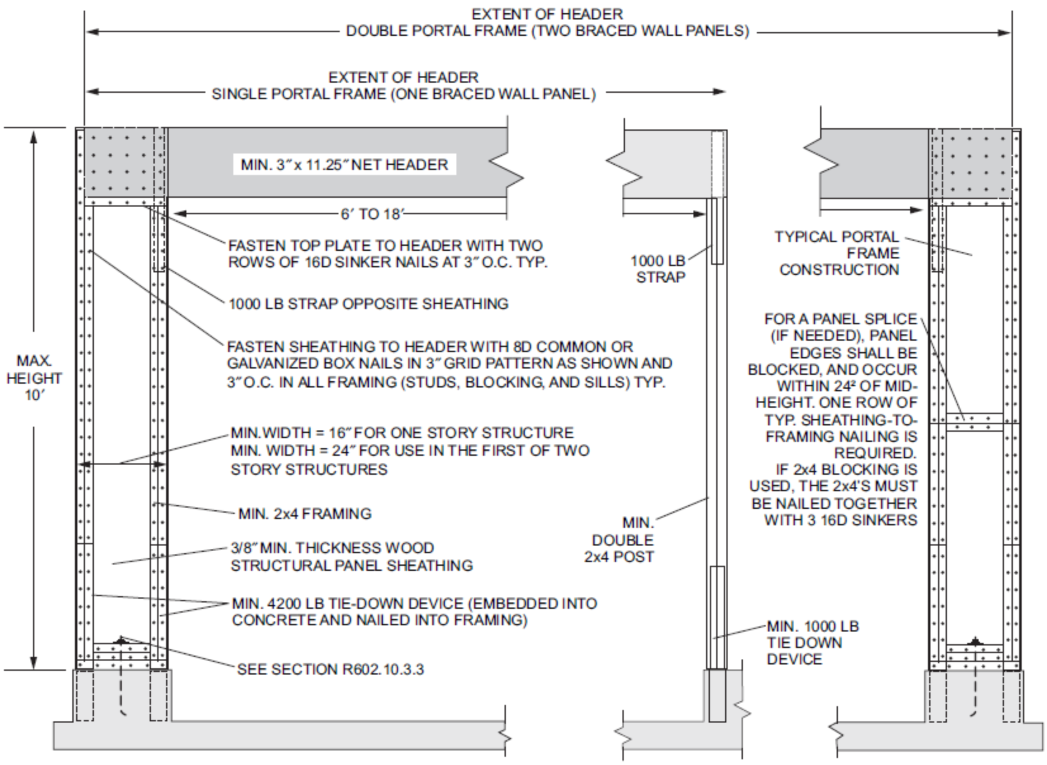


Figure 7: Method PFG Portal Frame at Garage Door Openings
(Similar to 2009 IRC Figure R602.10.3.4)

Method PFH (Portal Frame with Hold-down Brackets)

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



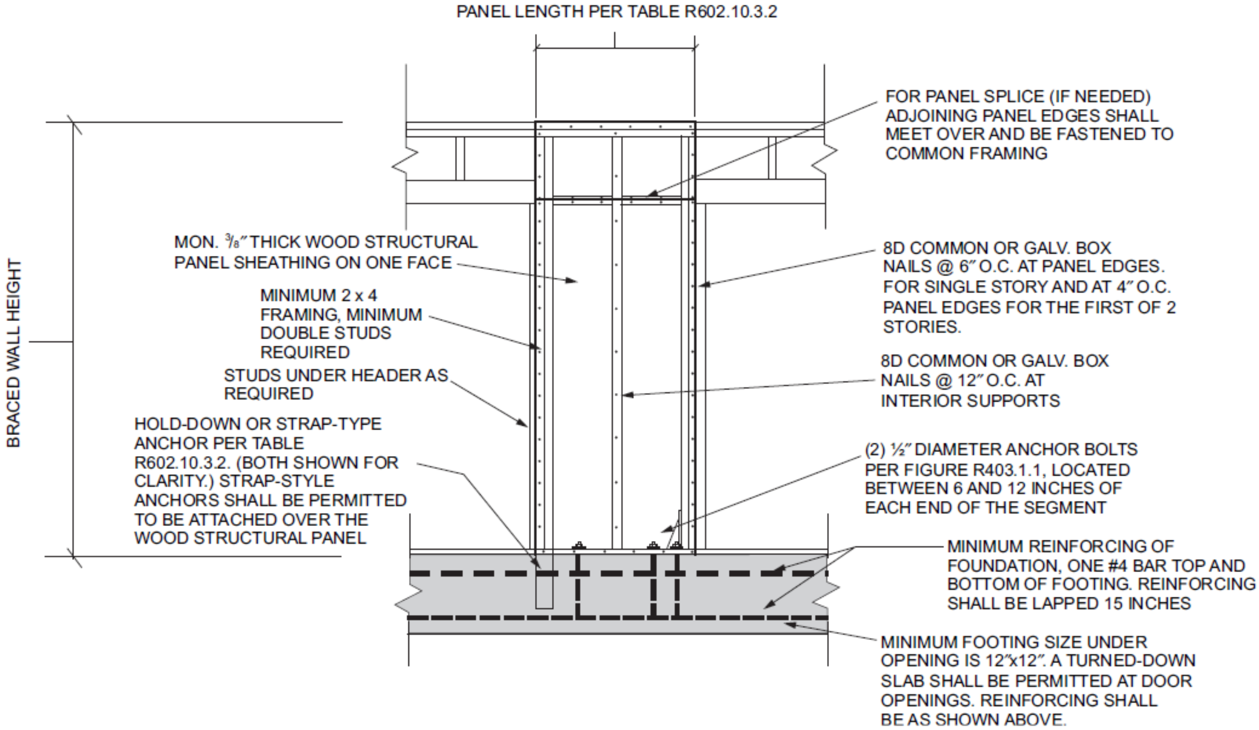
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound force = 4.448 N.

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

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

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

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



For SI: 1 inch = 25.4 mm.

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

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

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

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

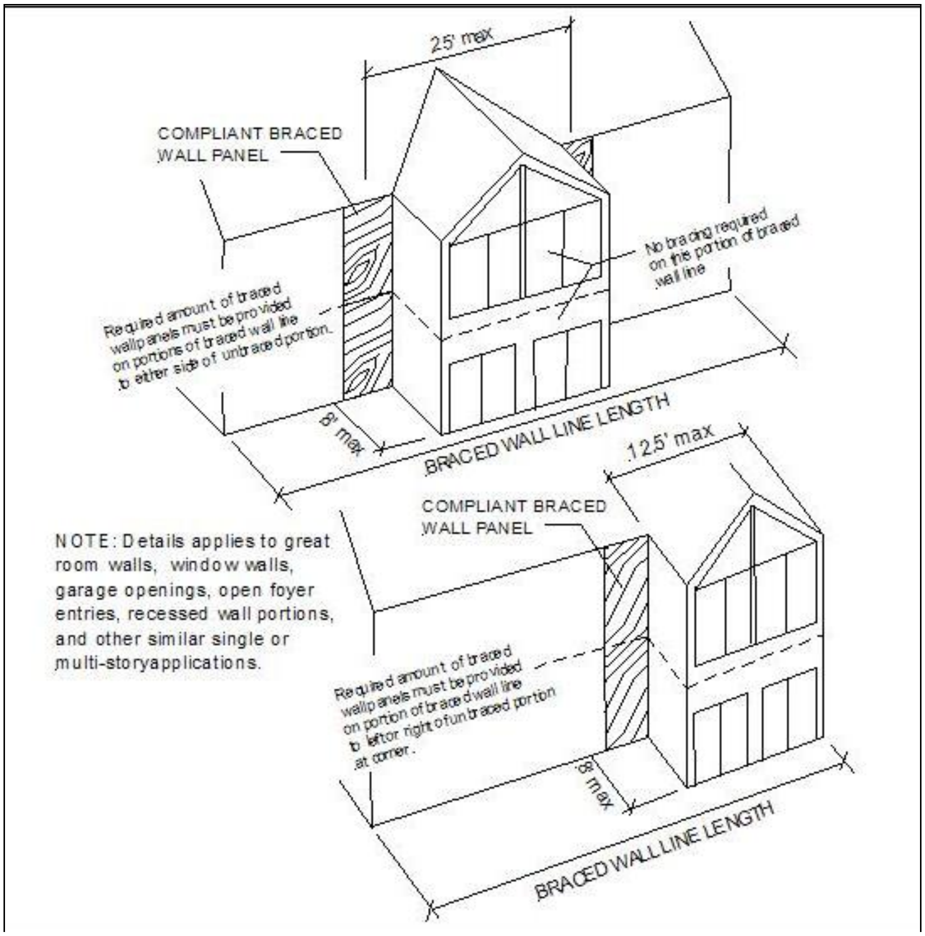


Figure 10: Limits for Large Openings in Braced Wall Lines with Intermittent Bracing

2.3 Continuously Sheathed Methods

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

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

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

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

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

Continuous Sheathing Method General Provisions

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

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

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

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

(Based on IRC Table R602.10.4.2 and Table R602.10.5.2)

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

NP = Not permitted

a. Linear interpolation shall be permitted.

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

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

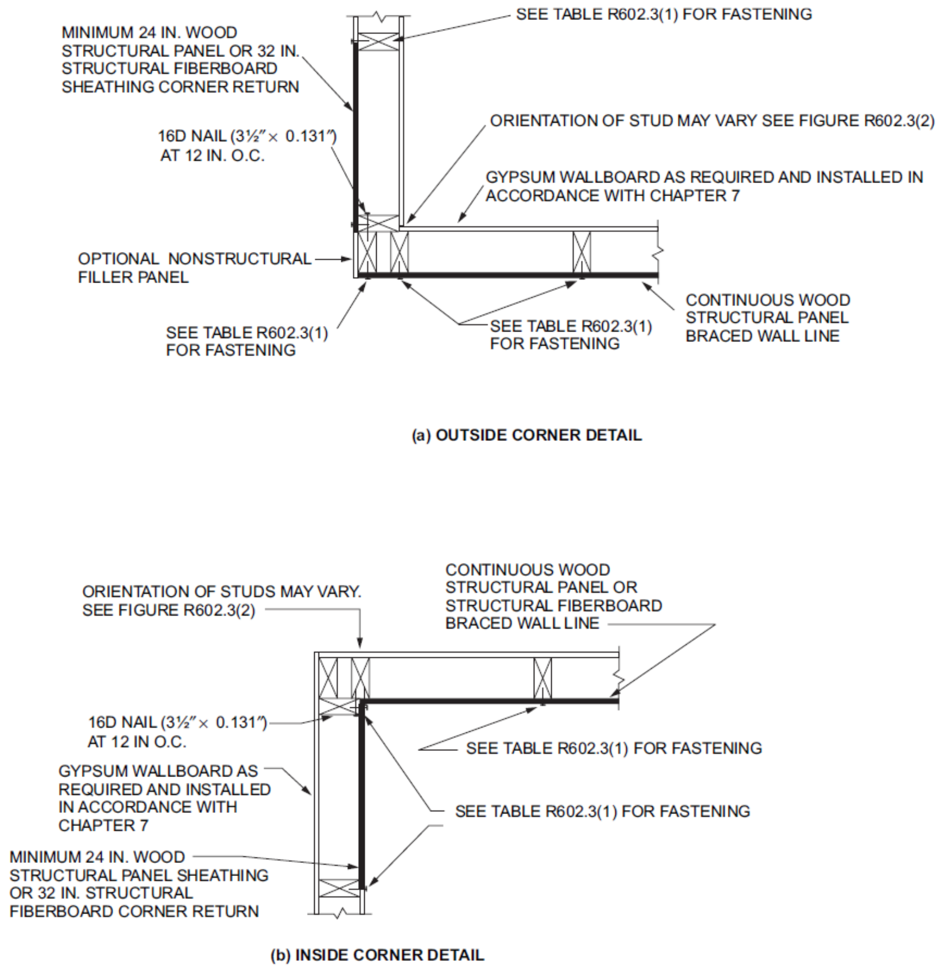
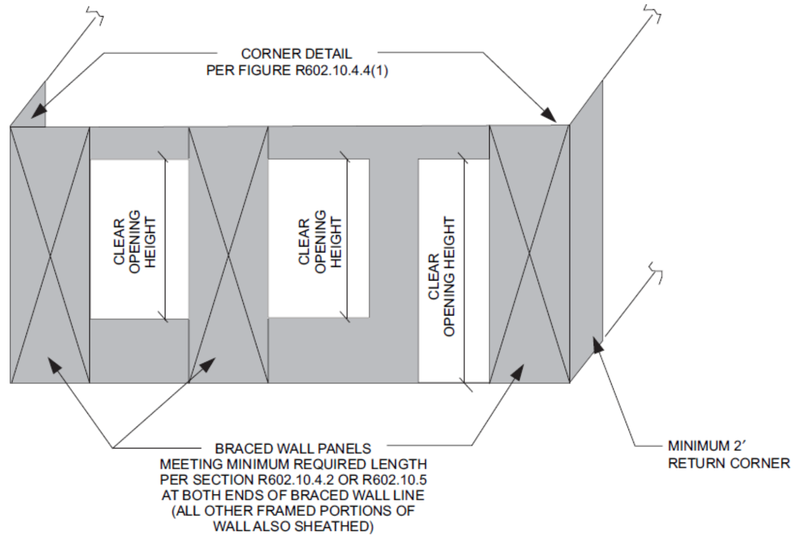


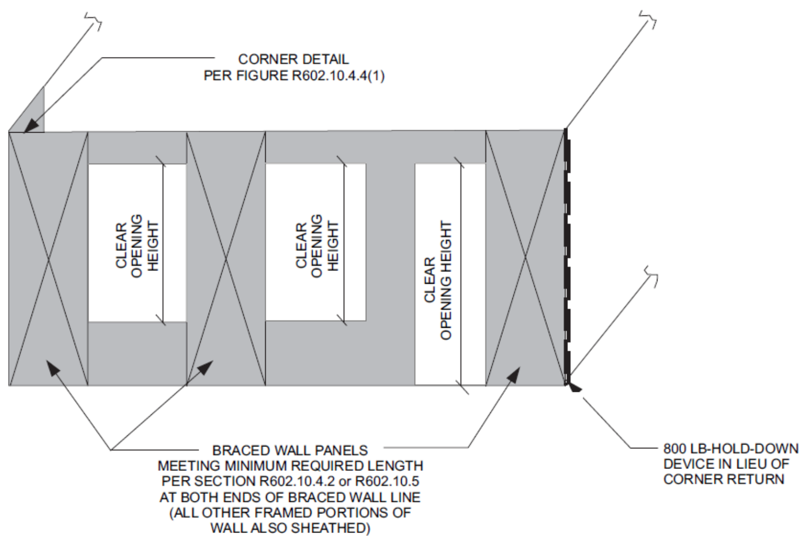
Figure 11*: Corner Framing for Continuous Structural Sheathing*
(IRC Figure R602.10.4.4(1))



For SI: 1 foot = 304.8 mm.

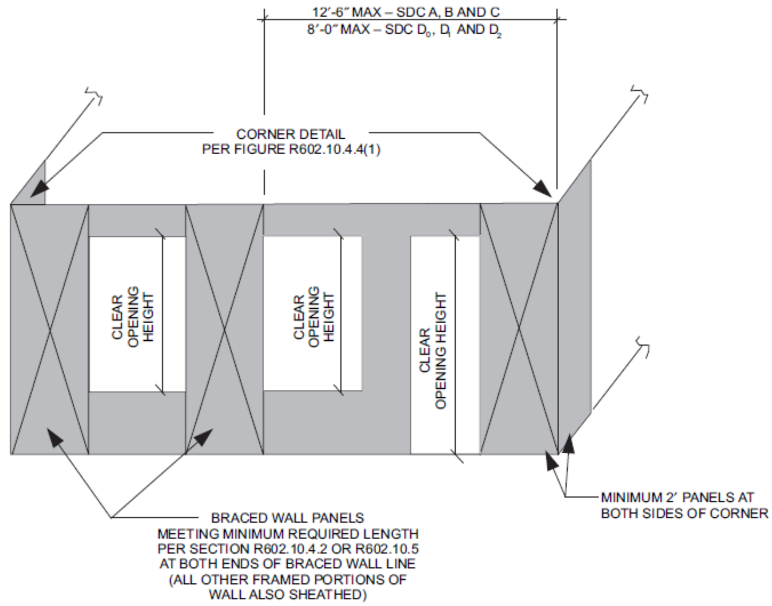
Figure 12*: Corner Return Detail for Braced Wall Line with Continuous Sheathing*
(IRC Figure R602.10.4.4(2))

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



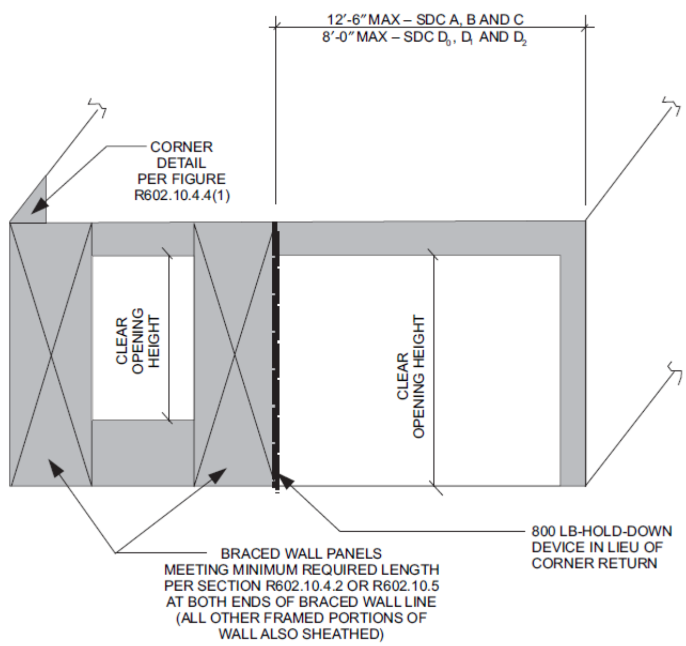
For SI: 1 inch = 25.4 mm, 1 pound = 4.448 N.

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



For SI: 1 inch = 25.4 mm.

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



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

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

Narrow Panel Bracing for Use with Continuous Wood Structural Panel Sheathing

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

Method CS-G

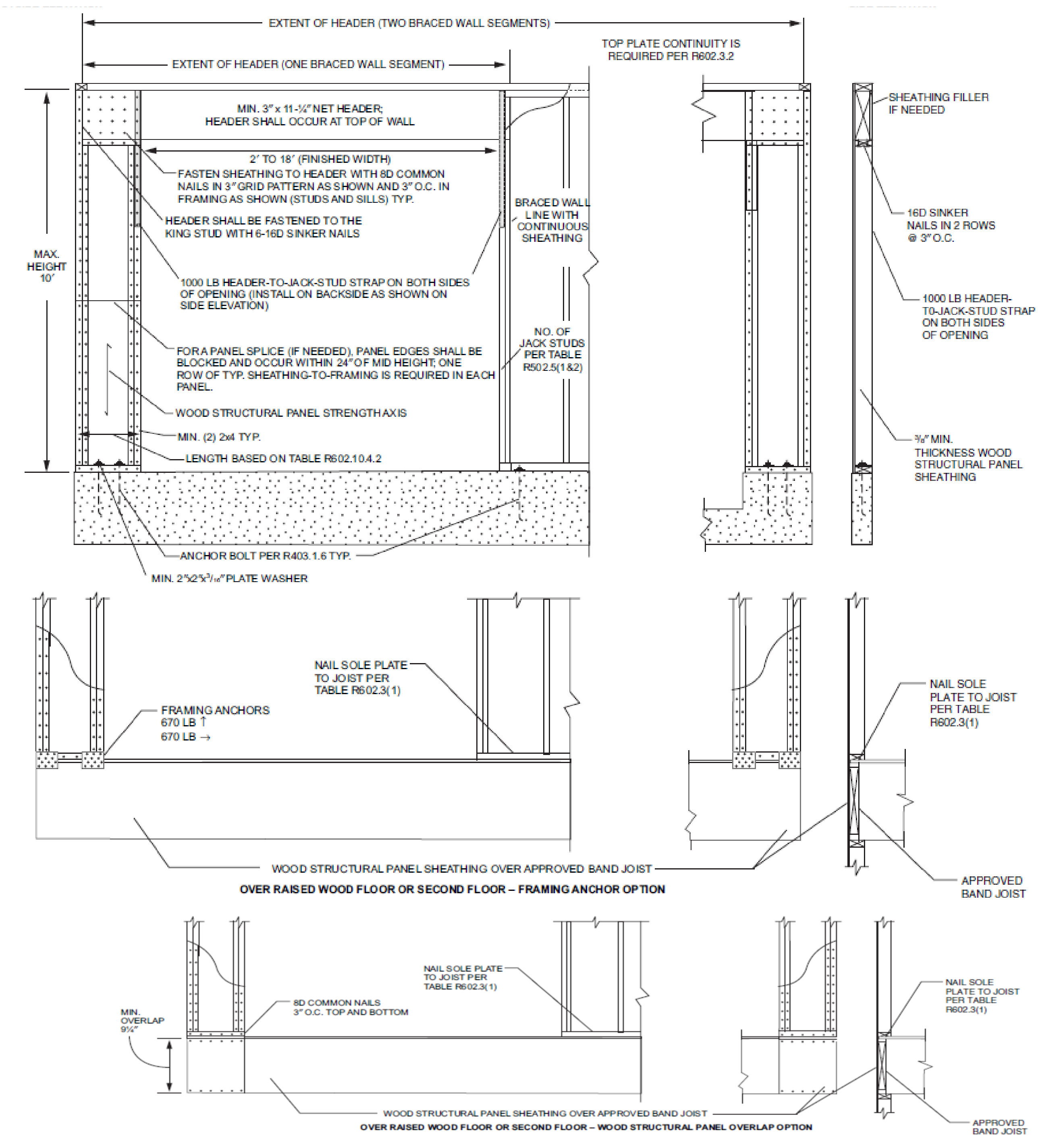
A special exception to Table 6 provides for CS-WSP braced wall panel widths as narrow as 2 feet for limited use in a garage opening wall per Table 6. Restrictions include:

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

Method CS-PF

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

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



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

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

2.4 Important Construction Requirements for Wall Bracing

Basic Connection Requirements for Braced Wall Panels

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

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

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

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

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

Braced Wall Panel Wind Uplift Connections

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

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

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

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

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

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

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

Braced Wall Panel Support

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

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

Section 3: Applying the Code

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

3.1 Overview

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

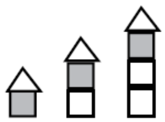
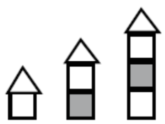
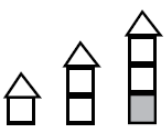
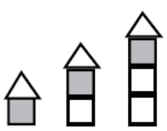
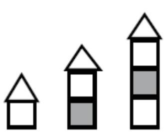
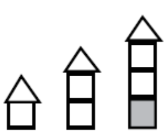
1. provides a comprehensive step-by-step procedure for applying the code (Section 3.2),
2. demonstrates how to calculate the required length of bracing using Table 7 and its many footnoted adjustment factors or multipliers (Section 3.3), and
3. shows how to determine the length of bracing provided by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

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

Table 7*: Length of Bracing Requirements*

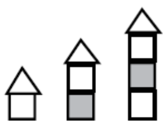
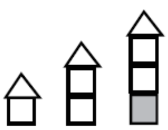
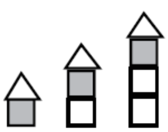
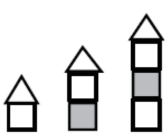
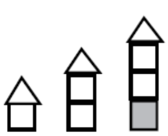
(IRC Table R602.10.1.2(1))

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

EXPOSURE CATEGORY B, 30 FT MEAN ROOF HEIGHT, 10 FT EAVE TO RIDGE HEIGHT, 10 FT WALL HEIGHT, 2 BRACED WALL LINES			MINIMUM TOTAL LENGTH (feet) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE			
Basic Wind Speed (mph)	Story Location	Braced Wall Line Spacing (feet)	Method LIB[f, h]	Method GB (double sided)[g]	Methods DWB, WSP, SFB, PCP, HPS[f, i]	Continuous Sheathing
≤ 85 (mph)		10	3.5	3.5	2.0	1.5
		20	6.0	6.0	3.5	3.0
		30	8.5	8.5	5.0	4.5
		40	11.5	11.5	6.5	5.5
		50	14.0	14.0	8.0	7.0
		60	16.5	16.5	9.5	8.0
		10	6.5	6.5	3.5	3.0
		20	11.5	11.5	6.5	5.5
		30	16.5	16.5	9.5	8.0
		40	21.5	21.5	12.5	10.5
		50	26.5	26.5	15.0	13.0
		60	31.5	31.5	18.0	15.5
		10	NP	9.0	5.5	4.5
		20	NP	17.0	10.0	8.5
		30	NP	24.5	14.0	12.0
		40	NP	32.0	18.0	15.5
		50	NP	39.0	22.5	19.0
		60	NP	46.5	26.5	22.5
≤ 90 (mph)		10	3.5	3.5	2.0	2.0
		20	7.0	7.0	4.0	3.5
		30	9.5	9.5	5.5	5.0
		40	12.5	12.5	7.5	6.0
		50	15.5	15.5	9.0	7.5
		60	18.5	18.5	10.5	9.0
		10	7.0	7.0	4.0	3.5
		20	13.0	13.0	7.5	6.5
		30	18.5	18.5	10.5	9.0
		40	24.0	24.0	14.0	12.0
		50	29.5	29.5	17.0	14.5
		60	35.0	35.0	20.0	17.0
		10	NP	10.5	6.0	5.0
		20	NP	19.0	11.0	9.5
		30	NP	27.5	15.5	13.5
		40	NP	35.5	20.5	17.5
		50	NP	44.0	25.0	21.5
		60	NP	52.0	30.0	25.5

(continued)

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

EXPOSURE CATEGORY B, 30 FT MEAN ROOF HEIGHT, 10 FT EAVE TO RIDGE HEIGHT, 10 FT WALL HEIGHT, 2 BRACED WALL LINES			MINIMUM TOTAL LENGTH (feet) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE			
Basic Wind Speed (mph)	**Story Location**	**Braced wall Line Spacing (feet)**	**Method LIB[f, h]**	**Method GB (doubled sided)[g]**	**Method DWB, WSP, SFB, PCP, HPS[f, i]**	**Continuous Sheathing**
≤ 100 (mph)		10	4.5	4.5	2.5	2.5
		20	8.5	8.5	5.0	4.0
		30	12.0	12.0	7.0	6.0
		40	15.5	15.5	9.0	7.5
		50	19.0	19.0	11.0	9.5
		60	22.5	22.5	13.0	11.0
		10	8.5	8.5	5.0	4.5
		20	16.0	16.0	9.0	8.0
		30	23.0	23.0	13.0	11.0
		40	29.5	29.5	17.0	14.5
		50	36.5	36.5	21.0	18.0
		60	43.5	43.5	25.0	21.0
		10	NP	12.5	7.5	6.0
		20	NP	23.5	13.5	11.5
		30	NP	34.0	19.5	16.5
		40	NP	44.0	25.0	21.5
		50	NP	54.0	31.0	26.5
		60	NP	64.0	36.5	31.0
≤ 110 (mph)		10	5.5	5.5	3.0	3.0
		20	10.0	10.0	6.0	5.0
		30	14.5	14.5	8.5	7.0
		40	18.5	18.5	11.0	9.0
		50	23.0	23.0	13.0	11.5
		60	27.5	27.5	15.5	13.5
		10	10.5	10.5	6.0	5.0
		20	19.0	19.0	11.0	9.5
		30	27.5	27.5	16.0	13.5
		40	36.0	36.0	20.5	17.5
		50	44.0	44.0	25.5	21.5
		60	52.5	52.5	30.0	25.5
		10	NP	15.5	9.0	7.5
		20	NP	28.5	16.5	14.0
		30	NP	41.0	23.5	20.0
		40	NP	53.0	30.5	26.0
		50	NP	65.5	37.5	32.0
		60	NP	77.5	44.5	37.5

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

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

NOTES:

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

3.2 Applying the Code: Step by Step

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

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

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

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

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

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

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

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

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

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

3.3 Calculating the Required Length of Bracing

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

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

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

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

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

OR

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

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

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

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

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

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

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

14.26 feet = 14 feet + ? inches

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

14.26 feet = 14 feet – 3 inches

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

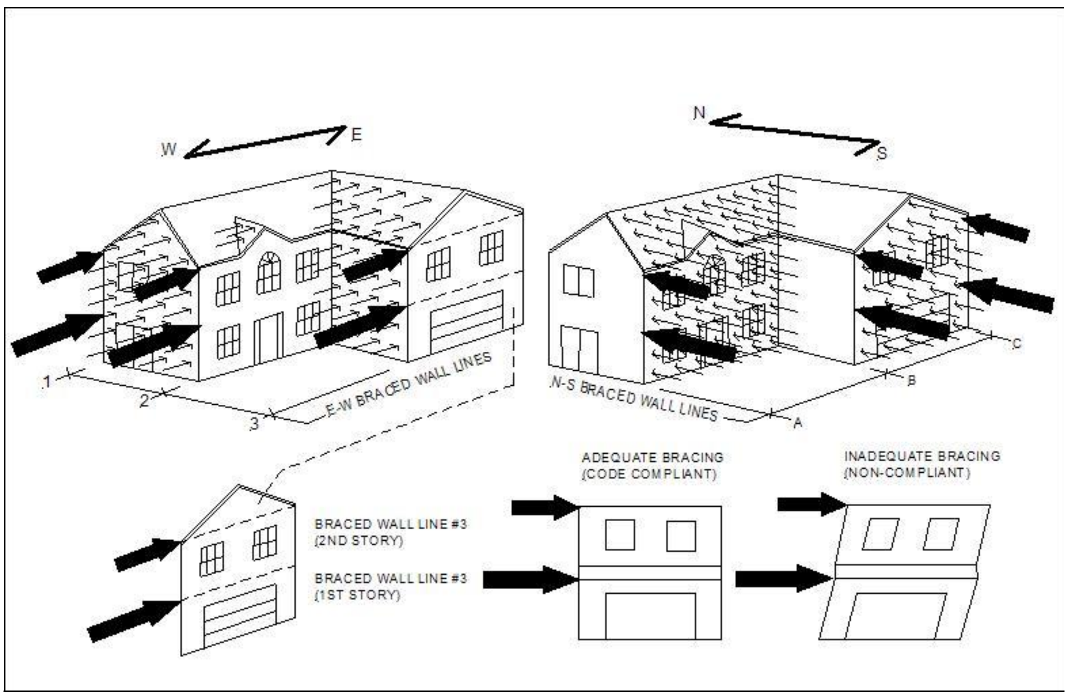


Figure 17: **Example house plan for bracing length calculation**

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

3.4 Verifying the Provided Length of Bracing

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

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

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

Section 4: 'Beyond Code' Bracing Solutions

4.1 Overview

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

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

4.2 Custom Engineered Solutions

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

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

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

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

As an alternative to the above described method, it is also possible to apply the IRC bracing provision in a manner consistent with engineering principles. An example design showing a fairly efficient solution for a reasonably complex house plan is included in ***Appendix B – Engineered Design Example Using IRC Bracing Provisions***. The design example was developed by the author of this guide as a result of the ICC Ad Hoc Wall Bracing Committee's interest in exploring various ways to configure and implement the IRC's wall bracing provision.

4.3 Useful Engineering Concepts

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

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

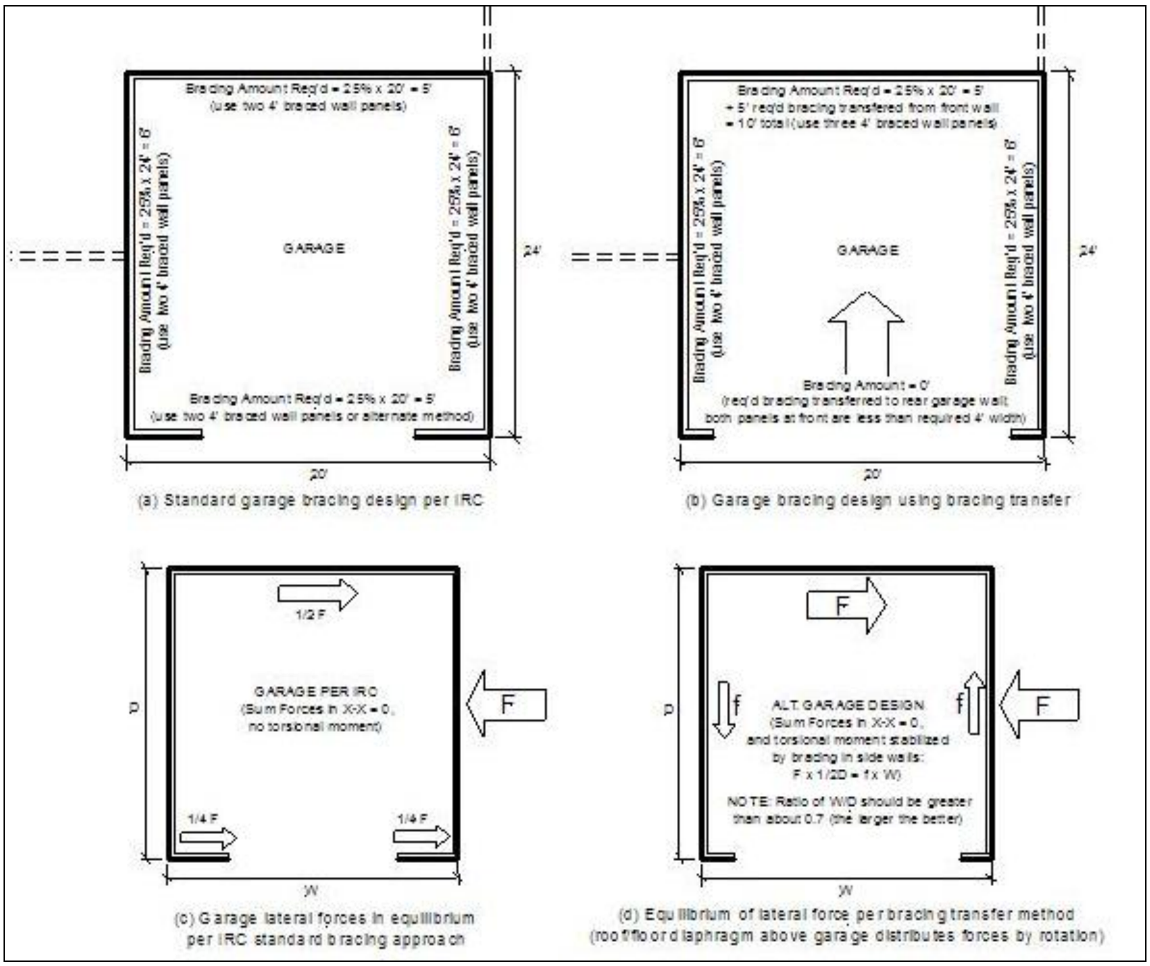
Interior Partition Walls as a Bracing Method – Because standard interior partition walls are constructed in much the same manner as Method GB wall bracing (except for the fastening schedule), these types of interior walls can be considered for their contribution to the bracing of a residential building.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

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

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

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

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



(a) Standard garage bracing design per IRC

(b) Garage bracing design using bracing transfer

(c) Garage lateral forces in equilibrium per IRC standard bracing approach

(d) Equilibrium of lateral force per bracing transfer method (roof/floor diaphragm above garage distributes forces by rotation)

Figure 18: Bracing Transfer

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

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

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

4.4 Proprietary Bracing Products

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

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

Contact the proprietary brace manufacturer for additional guidance and requirements.

Section 5: Wall Bracing Options for Foam-Sheathed Walls

5.1 Wall System Design – Bracing and Beyond

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

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

5.2 Why Use Foam Sheathing?

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

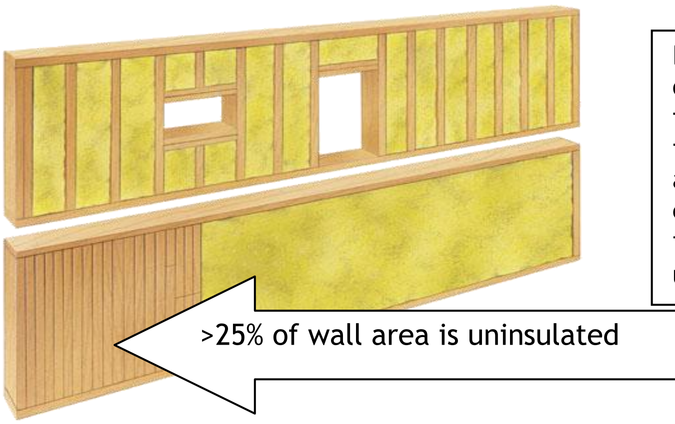
Although foam sheathing is NOT an acceptable wall bracing material on its own, the additional benefits – especially for energy efficiency and moisture resistance – and the range of available of compatible bracing techniques – makes it a preferred choice in many wall configurations.

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

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

** from Hutcheon*

[3] *In accordance with IRC 2009.*



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

Figure 19: Cavity Insulation and Wall Framing

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

5. 3 Meeting Energy Code Requirements

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

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

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

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

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

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

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

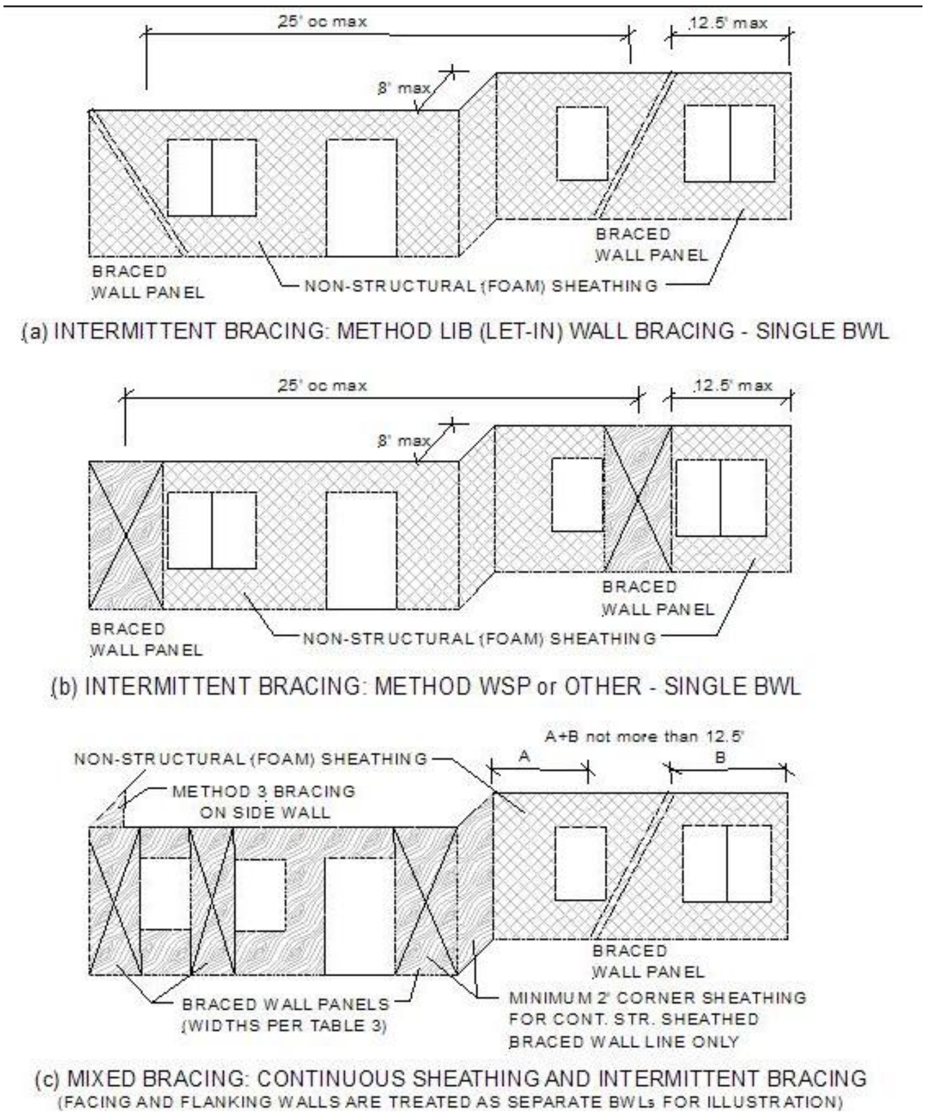


Figure 20: Illustration of Bracing Methods with Foam Sheathing

5.5 Examples

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

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

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

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

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

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

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

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

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

5.6 Interfaces between Materials

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

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

Section 6: Resources and References

Wall Bracing Design Resources:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The Story Behind IRC Wall Bracing Provisions - Wood Design Focus

Proprietary Bracing Products:

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

Appendix A: Wall Bracing Design and Plan Check Worksheet

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

APPENDIX B: Engineered Design Example Using IRC Bracing Provisions

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

Objectives

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

Given

- Typical large production house plan 2-1/2 story with basement and integral/attached garage (see Figure B1)
- Wind Speed – 90 mph (Exposure B)
- Seismic Design Category – SDC A/B (exempt)
- Special wind bracing amount adjustment factors (Table 7 footnotes):

  <u>Main Building Portion</u>
  - Wind Exposure B & 3 story – 1.0 (based on rear elevation)
  - Roof eave-to-ridge height, 13 ft – 1.1 factor
  - 9' Wall height: 0.95 (main building)

  <u>Wings (Conservatory and Suite)</u>
  - Wind Exposure B & 2 story – 1.0 (based on rear elevation)
  - Roof eave-to-ridge height, 10 ft – 1.0 factor
  - 10' Wall height: 1.0 (conservatory and 1st floor suite)

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

Figure B1: Elevation Views of Example House

Bracing Analysis

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

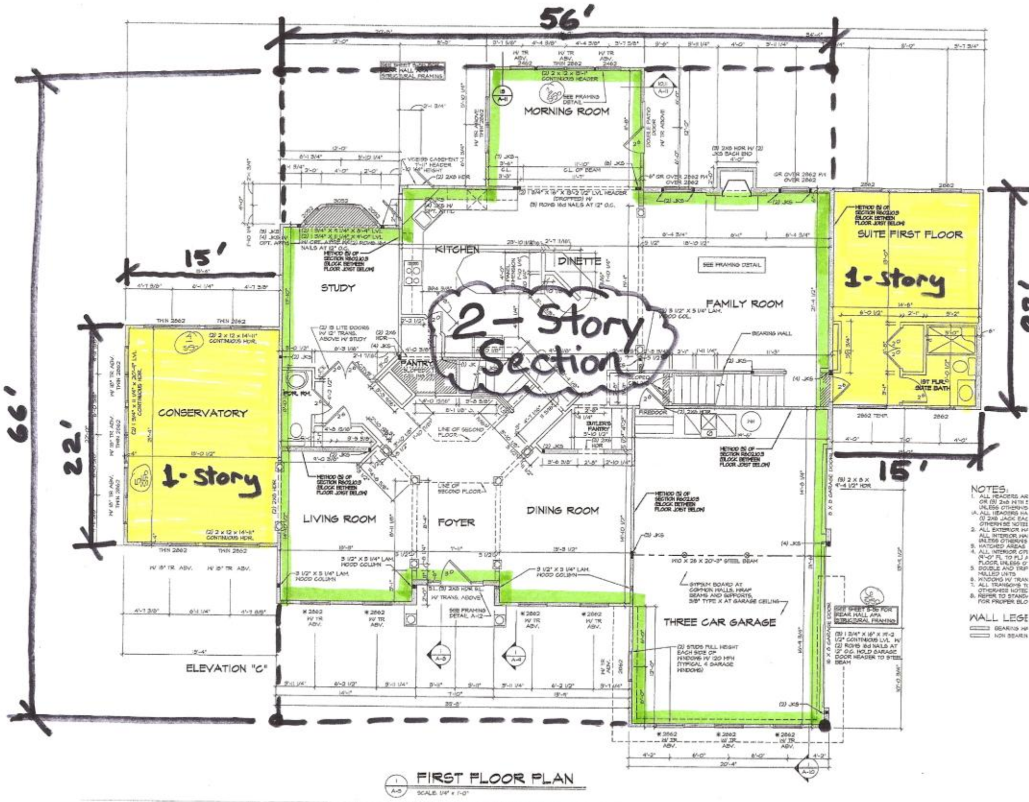


Figure B2: Plan View of Example House Plan

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

<u>Main Building (2-story Portion, 56' x 66')</u>

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)

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

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.

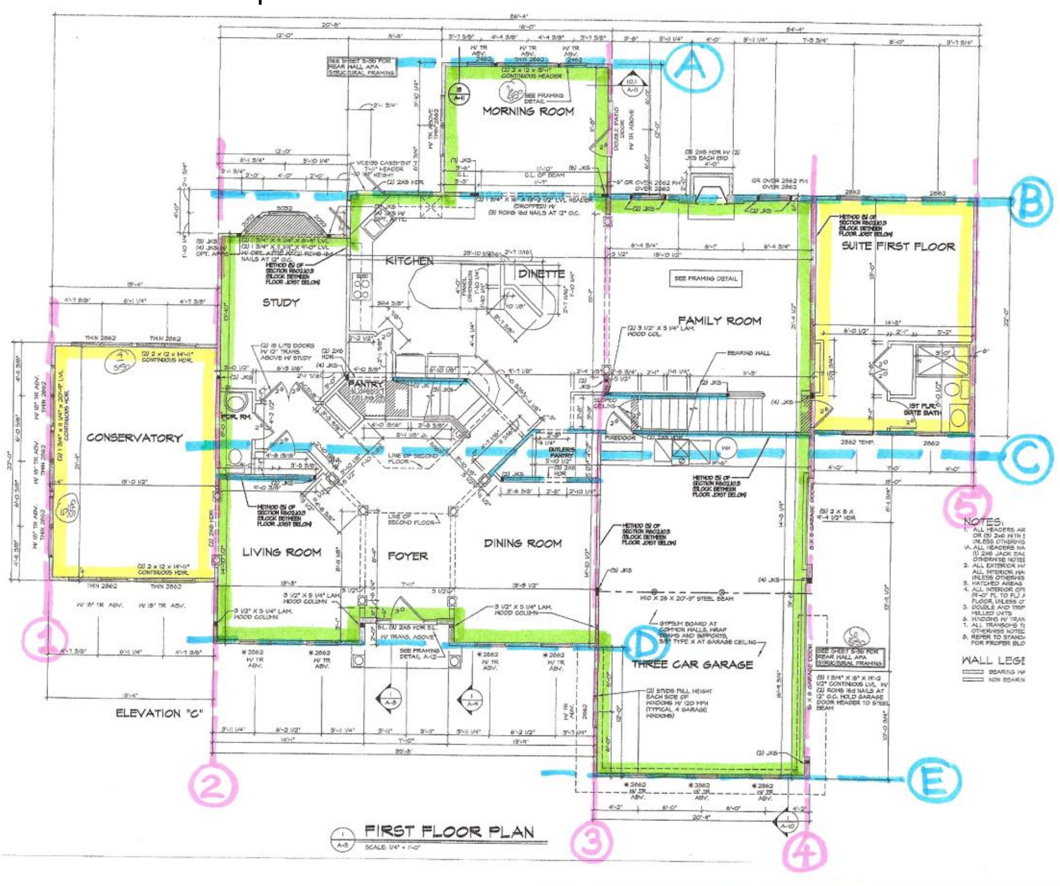


Figure B3: Plan View with Braced Wall Lines

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

<u>Front-to-Back Wall Lines</u>

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.***

<u>Left-to-Right Wall Lines</u>

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
<u>Wall Line E: 8% x 46'WSP = 3.7 feet WSP</u>
100% x 46' WSP = 46' WSP

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

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

Wall Line A: 3.7 feet of WSP required.

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

Wall Line B: 7.8 feet of WSP required.

- ➔ **OK.** ~16' of WSP provided.

Wall Line C: 23 feet of WSP required.

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

Wall Line D: 7.8 feet of bracing required.

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

Wall Line E: 3.7 feet of bracing required.

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

APPENDIX C: Technical Guidance for Appropriate Use of Foam Sheathing

Overview

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

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

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

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

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

FS156-09/10 (IRC)

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

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

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

Revise as follows:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Revise existing Section R703.4 as follows:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Revise existing Section R703.5.1 as follows:

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

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

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

Revise existing Section R703.6.1 as follows:

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

Revise existing Section R703.7.4.1 as follows:

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

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

Revise existing Section R703.11.2 as follows:

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

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

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

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

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

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

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