SBC ASSOCIATION

Research Report

Heel Blocking Requirements and Capacity Analysis

SRR No. 1506-07

Structural Building Components Association (SBCA)

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Introduction:

Both the International Residential Code (*IRC*) and the International Building Code (*IBC*) require that the top plates of exterior braced wall panels be attached to the rafters or roof trusses above. Note that this connection is only required for designated exterior braced wall panels, not all exterior walls. The *IRC* provides requirements and options based primarily on Seismic Design Category and height from top of wall to the top of the roof framing. The *IBC* requirements are less complicated.

This report will discuss the code requirements and provide alternate engineered designs and capacities, including heel/bird blocking, partial height blocking and blocking panels.

Heel blocking is a commonly used method to transfer in-plane lateral loads from the braced wall panel to the roof diaphragm. Structural engineers may have questions regarding the prescriptive code requirements or the capacity of commonly used heel blocking to achieve a desired load transfer. In addition there may be questions as to who is responsible for the determining the required strength.

Key Definitions:

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 Panel: A full-height section of wall constructed to resist in-plane shear loads through interaction of framing members, sheathing material and anchors. The panel's length meets the requirements of its particular bracing method and contributes toward the total amount of bracing required along its braced wall line.

Building Designer: Owner of the building or the person that contracts with the Owner for the design of the Framing Structural System and/or who is responsible for the preparation of the Construction Documents. When mandated by the Legal Requirements, the Building Designer shall be a Registered Design Professional.

Cross-grain Bending: When a wood member is loaded such that it tends to bend in a direction against or across the grain, it is said to be in cross-grain bending. Wood is weak in bending about this axis.

DIAPHRAGM: A horizontal or nearly horizontal system acting to transmit lateral forces to the vertical resisting elements. Where the term "diaphragm" is used, it includes horizontal bracing systems.

Heel Block/ Bird Block/ E Block: Is a term used for the block installed between roof truss heels at the top of the exterior wall.

Partial Height Blocking: When a heel block in not provided throughout the combined height of the raised heel and the bottom chord member, it is called Partial Height Blocking. The shear transfer capacity of this kind of blocking is less than that of full height blocking, but it provides room for insulation ducts, etc.

Perimeter Blocking: Blocking along the perimeter of the roof diaphragm that has the ability to transfer loads into the side walls or shear walls.

Truss Designer: Person responsible for the preparation of the Truss Design Drawings.

Weak-axis Bending: When a structural member is loaded such that it tends to bend about the axis of lower moment of inertia, it is said to be in weak-axis bending. The member is weak in bending about this axis.

Background:

In order to discuss heel blocking issues, one must understand the function of roof diaphragms and shear walls. Structures can be designed to take a considerable amount of lateral load from wind or earthquake loading. In simple terms, lateral loads in the roof system are transferred through the roof diaphragm, which is the structural plane created by the roof sheathing. To design the roof diaphragm, building designers determine the thickness and grade of the roof sheathing, the nail size and frequency, the size of the supporting framing members and the amount of blocking required. The perimeter of the diaphragm then must have the ability to transfer loads into the side walls, or shear walls. Shear walls act like a roof diaphragm, only installed vertically. Blocking between truss heels can function as this perimeter blocking of the roof diaphragm and becomes one of the connections from the roof diaphragm to the shear wall.

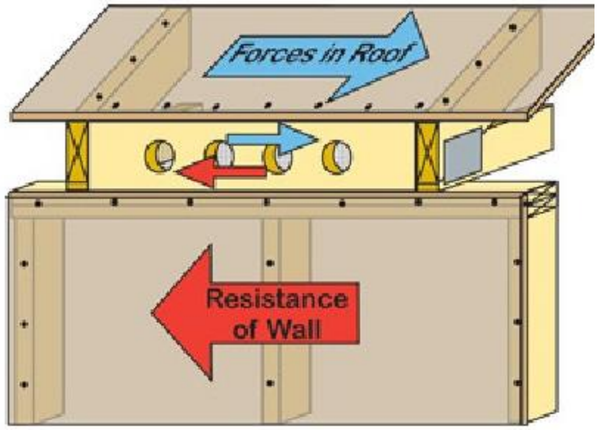

Figure 1: Shear forces acting on heel block

The Building Designer may not assume that prescriptive heel blocking will perform adequately as perimeter blocking for the roof diaphragm, especially if unsure of the blocking material or how it is being installed. The blocking will be subject to two opposing horizontal forces like those shown as red and blue arrows in Figure 1.

Who is responsible for the strength, capacity and adequacy of Heel Blocking?

The Truss Designer assumes that the truss will be installed plumb and in-plane and will carry only in-plane loads. The Building Designer is responsible for designing the system to resist any loads and forces not in-plane with the truss, which would include the means to resist rotation and lateral displacement.

The *IRC* requires blocking at the truss heels where there is a greater expectation of lateral loads causing rotation and displacement (Figure 2). Blocking is not typically installed in most interior parts of the country because the truss-to-bearing connections and the relatively close roof sheathing attachment is assumed to be sufficient to prevent any movement. Note that the block may not have to go the full height of the truss heel to effectively block it and keep it from rotating, nor is a block always required in every space between trusses. In addition, ventilation requirements may need more area than a partial height block can supply.

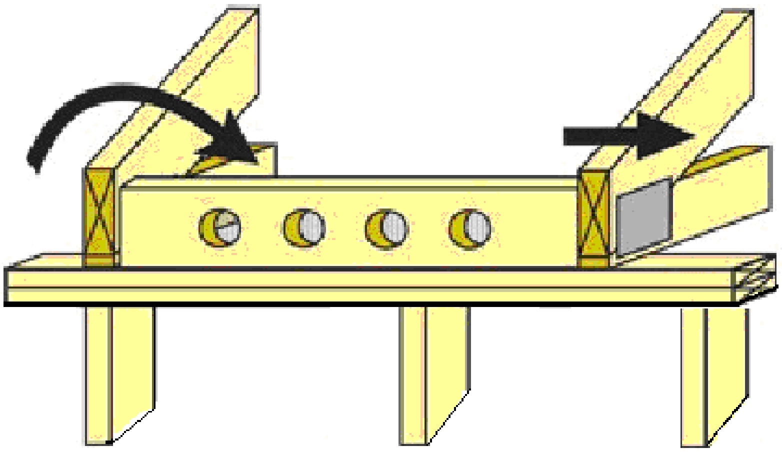

Figure 2: Blocking prevents rotation and lateral displacement

The strength, capacity and adequacy of heel blocking should be determined as being required or not by the Building Designer and if required, the Building Designer is responsible for the design.

After presenting the *IRC* and *IBC* 2015 code requirements, three engineered blocking solutions will be discussed:

- Heel/bird blocking
- Partial Height blocking
- Engineered Blocking Panels

Building Code Requirements:

International Residential Code (*IRC*) [1]

General code requirements for bracing (lateral support) of roof trusses is located in *IRC* 2015 Section R802.10.3. The language for floor trusses is located at Section R502.11.2 and is the same. This requirement is specifically to resist rotation and does not address the transfer of wind or seismic forces.

> **R802.10.3 Bracing.** Trusses shall be braced to prevent rotation and provide lateral stability in accordance with the requirements specified in the construction documents for the building and on the individual truss design drawings. In the absence of specific bracing requirements, trusses shall be braced in accordance with accepted industry practice such as the SBCA Building Component Safety Information (BCSI) Guide to Good Practice for Handling, Installing & Bracing of Metal Plate Connected Wood Trusses.

The *IRC* 2015 provides prescriptive guidance for the connection of the roof diaphragm to the supporting shear walls discussed in this report. Section R602.10.8.2 describes this connection requirements which are primarily determined by the project seismic zone and distance from the roof sheathing to the top of the braced wall panel plate.

> **R602.10.8.2 Connections to roof framing.** Top plates of exterior braced wall panels shall be attached to rafters or roof trusses above in accordance with Table R602.3(1) and this section. Where required by this section, blocking between rafters or roof trusses shall be attached to top plates of braced wall panels and to rafters and roof trusses in accordance with Table R602.3(1). A continuous band, rim or header joist or roof truss parallel to the braced wall panels shall be permitted to replace the blocking required by this section. Blocking shall not be required over openings in continuously sheathed braced wall lines. In addition to the requirements of this section, lateral support shall be provided for rafters and ceiling joists in accordance with Section R802.8 and for trusses in accordance with Section R802.10.3. Roof ventilation shall be provided in accordance with Section R806.1.
>
> 1. For Seismic Design Categories A, B and C where the distance from the top of the braced wall panel to the top of the rafters or roof trusses above is 9 1/4 inches (235 mm) or less, blocking between rafters or roof trusses shall not be required. Where the distance from the top of the braced wall panel to the top of the rafters or roof trusses above is between 9 1/4 inches (235 mm) and 15 1/4 inches (387 mm), blocking between rafters or roof trusses shall be provided above the braced wall panel in accordance with Figure R602.10.8.2(1).
>
>   **Exception:** Where the outside edge of truss vertical web members aligns with the outside face of the wall studs below, wood structural panel sheathing extending above the top plate as shown in Figure R602.10.8.2(3) shall be permitted to be fastened to each truss web with three-8d nails (2 1/2 inches x 0.131 inch) and blocking between the trusses shall not be required.
> 2. For Seismic Design Categories D_0, D_1 and, where the distance from the top of the braced wall panel to the top of the rafters or roof trusses is 15 1/4 inches (387 mm) or less, blocking between rafters or roof trusses shall be provided above the braced wall panel in accordance with Figure R602.10.8.2(1).
> 3. Where the distance from the top of the braced wall panel to the top of rafters or roof trusses exceeds 15 1/4 inches (387 mm), the top plates of the braced wall panel shall be connected to perpendicular rafters or roof trusses above in accordance with one or more of the following methods:
>   - 3.1. Soffit blocking panels constructed in accordance with Figure R602.10.8.2(2).
>   - 3.2. Vertical blocking panels constructed in accordance with Figure R602.10.8.2(3).
>   - 3.3. Blocking panels provided by the roof truss manufacturer and designed in accordance with Section R802.
>   - 3.4. Blocking, blocking panels or other methods of lateral load transfer designed in accordance with the AWC WFCM or accepted engineering practice.

To summarize:
Fastening of blocking to the top plate is to be in accordance with Table R602.3(1) [item 1] (see Figure 3)

ITEM	DESCRIPTION OF BUILDING ELEMENTS	NUMBER AND TYPE OF FASTENER[a, b, c]	SPACING AND LOCATION
		Roof	
1	Blocking between ceiling joists or rafters to top plate	4-8d box (2 1/2″ × 0.113″) or 3-8d common (2 1/2″ × 0.131″); or 3-10d box (3″ × 0.128″); or 3-3″ × 0.131″ nails	Toe nail

Figure 3: Table R602.3(1)

[1] *IRC* 2015, *International Residential Code*, International Code Council, Inc., Washington, DC

For Seismic Design Categories A, B, and C:

- Where the distance from the top of the braced wall panel to the top of the rafters or roof trusses above is $9^1/_4$ inches or less, blocking between rafters or roof trusses is not required.
- Where this distance is greater than $9^1/_4$ inches and less than $15^1/_4$ inches blocking according to Figure 4 is required.
- An exception allows wood structural panels to extend above the top plate where the outside edge of the truss aligns with the outside face of the wall[2].

For Seismic Design Categories D_0, D_1 where the distance from the top of the braced wall panel to the top of the rafters or roof trusses above is $15^1/_4$ inches or less blocking according to Figure 4 is required.

For all Seismic Design Categories, where the distance from the top of the braced wall panel to the top of the rafters or roof trusses above is greater than $15^1/_4$ inches blocking according to Figure 5 or Figure 6 is required or one of the other listed options.

See Table 1 for a summary of these requirements.

Seismic Design Category	Braced Wall to Roof Truss Distance			Engineered Design Allowed
	≤ $9^1/_4$"	> $9^1/_4$" & ≤ $15^1/_4$"	> $15^1/_4$"	
A, B, C	None	Figure 4	Figure 5 or 6	Yes
D_0, D_1	Figure 4	Figure 4	Figure 5 or 6	Yes

Table 1: Summary *IRC* Blocking Provisions

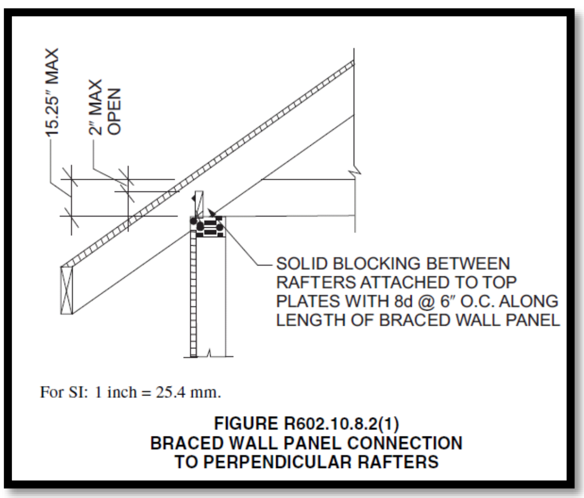

Figure 4: R602.10.8.2(1)

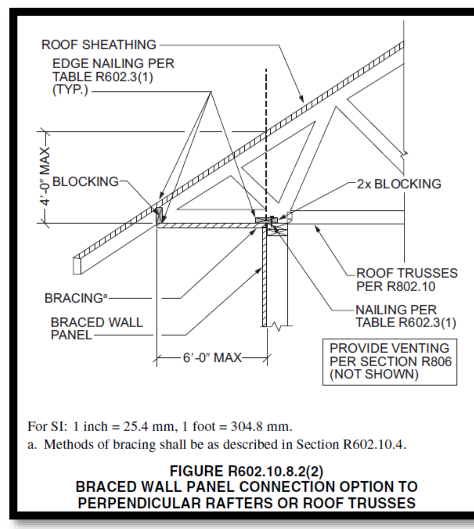

Figure 5: R602.10.8.2(2)

[2] APA 2014, "*Use of Wood Structural Panels for Energy-Heel Trusses*", SR-103A, APA, The Engineered Wood Association, Tacoma, WA. OR US Department of Agriculture 2013, "*Evaluation of the High-Heel Roof-to-Wall Connection with Extended OSB Wall Sheathing*", General Technical Report FPL-GTR-222, Forest Products Laboratory, Madison, WI. OR NAHB Research Center 2012, "High Heel Roof-to-Wall Connection Testing", HAHB Research Center, Upper Marlboro, MD.

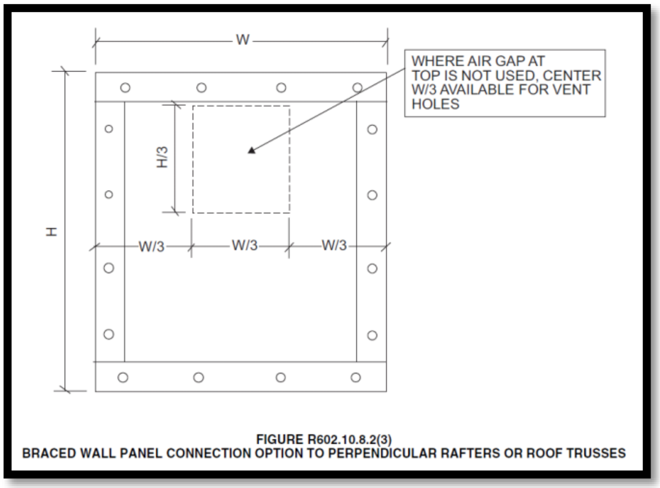

Figure 6: R602.10.8.2(3)

International Building Code (*IBC*)[3]

General code requirements for bracing (lateral support) of roof trusses in the *IBC*-2015 are located in Section 2303.4.4

> **2303.4.4 Anchorage.** The design for the transfer of loads and anchorage of each truss to the supporting structure is the responsibility of the registered design professional.

For allowable stress design (ASD) for wood construction the *IBC* directs one to AWC SDPWS (Section 2306.2). For conventional light-frame construction the *IBC* includes different requirements than in the *IRC* (see Figure 7).

> **2308.6.7 Connections of braced wall panels.** Braced wall panel joints shall occur over studs or blocking. Braced wall panels shall be fastened to studs, top and bottom plates and at panel edges. Braced wall panels shall be applied to nominal 2-inch-wide [actual 1$^1/_2$-inch (38 mm)] or larger stud framing.
>
> **2308.6.7.2 Top plate connection.** . . . Where roof trusses are used and are installed perpendicular to an exterior braced wall line, lateral forces shall be transferred from the roof diaphragm to the braced wall over the full length of the braced wall line by blocking of the ends of the trusses or by other approved methods providing equivalent lateral force transfer. Blocking shall be not less than 2 inches (51 mm) in nominal thickness and equal to the depth of the truss at the wall line and shall be fastened to the braced wall line top plate as specified in Table 2304.10.1. Notching or drilling of holes in blocking in accordance with the requirements of Section 2308.4.2.4 or 2308.7.4 shall be permitted.
>
> **Exception:** Where the roof sheathing is greater than 9$^1/_4$ inches (235 mm) above the top plate, solid blocking is not required where the framing members are connected using one of the following methods:
> 1. In accordance with Figure 2308.6.7.2(1).
> 2. In accordance with Figure 2308.6.7.2(2).
> 3. Full-height engineered blocking panels designed for values listed in AWC WFCM.
> 4. A design in accordance with accepted engineering methods.

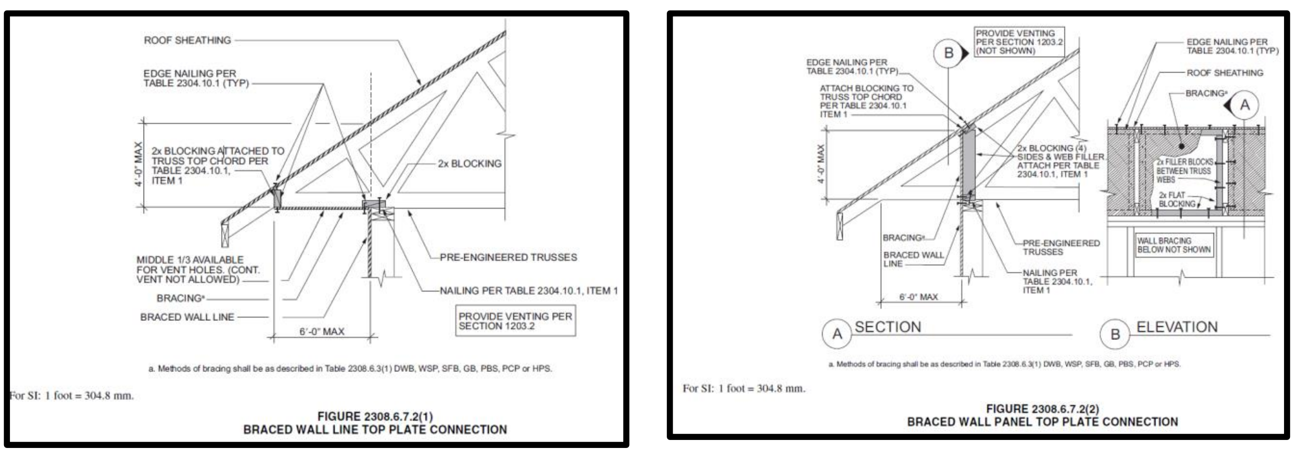

Figure 7: *IBC* Truss-to-Wall Connection Details

[3] *IBC* 2015, *International Building Code*, International Code Council, Inc., Washington, DC.

Engineered Design

Heel or Bird Blocks

In the case of heel/bird blocking, the ability of the blocking to resist these transferred forces depends on the adjusted shear design value parallel to grain (horizontal shear) of the lumber grade and species as well as the amount of material removed to create the ventilation holes

A Bird/Heel/E Block is installed between roof truss heels at the top of the exterior wall to carry and transfer lateral forces from the roof diaphragm to the braced wall. In cases where these blocks have ventilation holes drilled in them, they typically have a piece of wire mesh attached on one side to prevent birds or other animals from traveling through the holes into the attic space.

Analyzing the Capacity of a Heel Block

Let us consider, for instance, that the truss manufacturer uses 2"x6" beveled blocks in vented roof with a letterbox type ventilation hole that is two inches high by ten inches long as shown in Figure 8. Note that the energy/ventilation requirements in *IRC* R806.2 and R806.3 need to be met as well. In addition, attics or roofs can be designed and constructed to be either vented or un-vented in any hygro-thermal zone (IECC[4] Figure R301). The choice of venting or not venting is a design and construction choice and not a requirement determined by the physics or by the building codes.

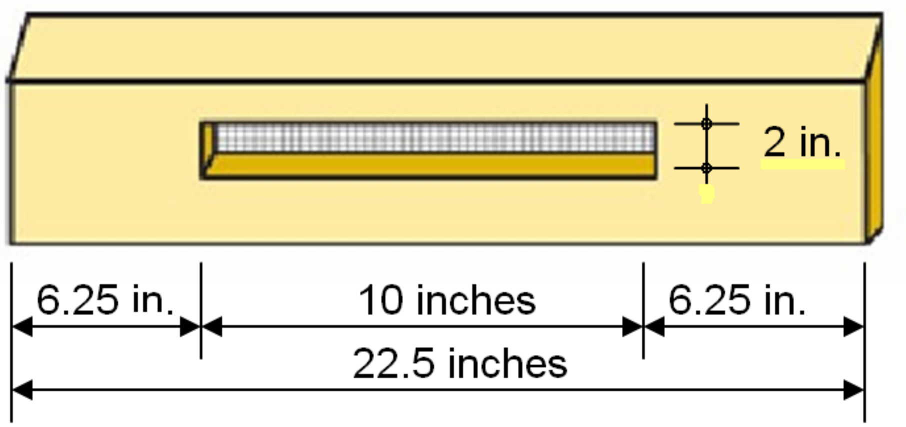

Figure 8: A letterbox type ventilation block

Imagine a horizontal plane cutting through the block at the location of the least material, see Figure 9.

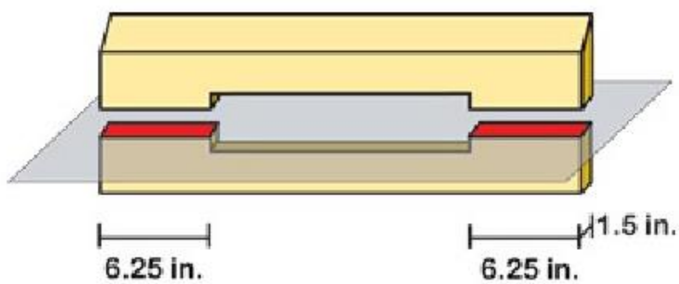

Figure 9: Area of block that resists shear

This is the area of block left to resist the shear forces being transferred from the roof diaphragm to the wall below. In this case it's a total of 18.75 square inches. To be conservative, we will use the referenced value of horizontal shear F_v = 110 psi, which is for "Northern Species" according to the AWC *National Design Specification® (NDS®) for Wood Construction*[5], Supplement, *Design Values for Wood Construction*. The only adjustment factor to consider is load duration factor (Table 2.3.2 of the *NDS*). We will use the 1.6 factor since these forces are either caused by wind or seismic events:

[4] *IBC* 2015, *International Energy Conservation Code*, International Code Council, Inc., Washington, DC.
[5] AWC 2015, *National Design Specification for Wood Construction, Design Values for Wood Construction (NDS)"*, American Wood Council (AWC), Washington, DC.

Shear Capacity of Block = F_v' x Area
Shear Capacity of Block = (110 psi x 1.6) x 18.75 sq.in. = 3300 pounds

Shear loads are expressed in terms of pounds per lineal foot (plf), so a 22.5 inch block with 3300 pounds of shear capacity would convert to 1760 plf (1650 pounds divided by 1.875 ft. [22.5 inches]).

Is that enough? Yes. This is well above the magnitude of lateral loads that are expected to be generated in light frame wood construction. The APA Engineered Wood Association publishes a booklet called *Introduction to Lateral Design*[6] with charts for designing diaphragms and shear walls. In it, the highest recommended load listed is 820 plf for roof diaphragms and 870 plf for shear walls. Therefore, even a low grade "bird block" with a large horizontal ventilation opening will more than suffice as perimeter blocking provided the building designer properly details the roof-to-block and the block-to-wall connections.

Similarly, to calculate the capacity of heel block with holes drilled in it, the effective area that should be used would be given by

Area = L x B – n x d x B

where:
L = Length of block
B = Breadth of the block
d = Diameter of the hole
n = Number of holes

The effective area in this case would be more than that in the case of a rectangular slot in the heel block analyzed above; implying that the shear transfer capacity will be higher.

Partial Height Blocking - Analysis

Partial height blocking is illustrated in the *IRC* (see Figure 4).

In some instances Partial Height Blocking may be used to leave room for insulation baffles. Per *IRC* R806.3, a minimum of 1" space must be provided between insulation and the roof sheathing at the location of the vent. The use of Partial Height Blocking relies on both weak-axis bending and cross-grain bending of the top chord member of trusses to transfer lateral forces from the roof diaphragm to the wall below. Section 3.8.2 of the *NDS*[7] recommends avoiding "designs that induce stress perpendicular to grain". However, it also recognizes that such conditions may be unavoidable and require special consideration. This condition exists with a number of connections in conventional light-frame wood construction[8]. The *NDS* refers to the USDA-FPL *Wood Handbook*[9] for guidance on mechanical reinforcement when tension perpendicular to grain cannot be avoided. The *Wood Handbook* indicates that the stress property limit for cross-grain bending stress ($F_{b,cg}$) is approximately $^1/_{20}$th of the parallel-to-grain bending stress property (F_b). In a study of cross-grain bending stresses in bottom plates of shear walls toward the development of a design checking procedure, testing indicated that use of a ratio of about $^1/_{30}$ ($F_{b,cg}$: F_b) can be used to prevent cross-grain bending (tension) failure from occurring prior to other more favorable (ductile) failure modes such as diaphragm shear failure[6]. However, an analysis model (free-body diagram) is necessary to determine the level of cross-grain bending stresses relative to other design stresses induced on a system of members and connections. This model is not a trivial matter and requires assumptions regarding the amount of cross-grain bending force attributed to a unit length of a member experiencing such a force. This assumption involves judgments regarding relative stiffness, post-yield behavior of connections, and resulting force distribution through a diaphragm and framing system. Thus, the design check is only as good as the assumptions in this regard. Therefore, a more reliable approach is to base the design on relevant test data, which is addressed in the following paragraph.

Fortunately, relevant testing of lateral force transfer from a conventional wood-frame roof diaphragm system to braced walls has been conducted (HUD)[10]. The 2002 tests used no blocking and thus produced a greater cross-grain bending moment on the top chord of the trusses than would be experienced in the raised-heel truss condition with Partial Height Blocking (refer to Figure 10). Therefore, the HUD test results represent a conservative estimate of lateral force transfer capability of

[6] 2003, "*Introduction to Lateral Design*", APA, The Engineered Wood Association, Tacoma, WA.
[7] AWC 2015, *National Design Specification for Wood Construction, Design Values for Wood Construction (NDS)"*, American Wood Council (AWC), Washington, DC.
[8] Crandell, J..H. and Kochkin, V., 2003, "Common Engineering Issues in Conventional Construction", *Wood Design Focus,* Vol.13, No.3, Forest Products Society, Madison, WI.
[9] U.S. Department of Agriculture, 2010, "*Wood Handbook, Wood as Engineering Material",* General Technical Report FPL-GTR-190, Forest Products Laboratory, Madison, WI.
[10] HUD, 2002, "*Roof Framing Connections in Conventional Residential Construction"*, U.S. Department of Housing and Urban Development, Washington, DC.

a "partial-height blocking only" detail. From the testing, a maximum lateral force transfer of about 550 to 590 lbs/truss was documented with the absence of failure of the top chord due to cross-grain bending, indicating yielding and ductile overall response. Some toe-nails experienced edge tear-out failure, but the overall roof-to-wall connection system failed in a ductile manner due to yielding of toe-nails, yielding of the truss clips and/or yielding of truss plate connections. Similar results were reported without creating any failure in the wall-to-roof connection on a whole building test where the maximum roof diaphragm shear transfer into the wall reached 407 or 756 lbs/truss joint (Paevere[11]; Kasal, at al.[12]; HUD[13]). A cyclic loading protocol was applied to the building allowing forces to transfer cyclically into the walls through the roof diaphragm. The average value of 570 lbs/truss will be used hereafter to ensure a conservative solution.

For additional information, see the more current Forest Products Laboratory testing (FPL)[14] which is related to the requirements in the 2012 *IRC*.

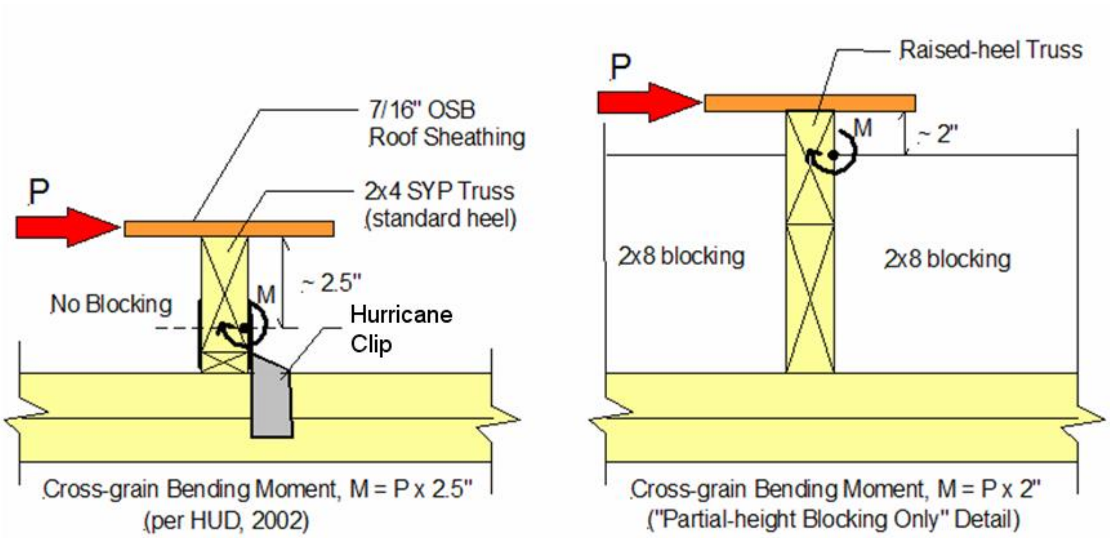

Figure 10: Cross grain bending moment in top chord of a standard-heel truss without blocking (per HUD, 2002) relative to a raise-heel truss with a "partial-height blocking only" detail.

With the bottom edge of Partial Height Blocking adequately fastened to the top plate or wall sheathing, an ultimate in-plane force transfer of at least 570 lbs per truss can be achieved without cross-grain bending failure of the truss top chord member. Applying a safety factor of 2.5 results in a 228 lbs/truss design value for in-plane shear transfer for the "Partial Height Blocking only" detail. With trusses spaced at 24" o.c., this design value relates to a design unit shear in the roof diaphragm of 114 plf. For a normal weight roof-ceiling system (e.g., 15 psf) and assuming an S_{DS} of 1.17g (Seismic Design Category D_2 per the *IRC* or S_s = 1.75g and Site Class D per the *IBC*), a span limit for roof diaphragm systems with partial-height blocking only is determined as follows (per *IBC* Simplified Method / ASCE 7-10[15] Section 12.14 Simplified Method):

$V = 1.2\ (S_{DS}/R)\ W \times 1/1.4 \times \Omega_0$

where:

V = shear force per unit length at the roof diaphragm connection to the wall

W = ½ x (Roof Span) x (1-ft unit length along wall) x (D_r of 15 psf dead load of roof-ceiling assembly) = D_r x (Roof Span)

For Light-frame bearing wall systems sheathed with wood structural panels rated for shear resistance:

R = seismic response modifier = 6.5 and Ω_o = over-strength factor = 3.0

S_{DS} = 1.17g (*IRC* Seismic Design Category D_2, S_s = 1.75, Soil Site Class D)

1/1.4 = factor to convert from strength design force to ASD design force level.

[11] Paevere, P.J., 2002, *"Full Scale testing, modeling and analysis of light frame structures under lateral loading."* Ph.D. Thesis, Dept. of Civil and Environmental Engineering, The University of Melbourne, Parkville, Victoria, Australia.

[12] Kasal, B., Collins, M.S., Paevere, P., and Foliente, G.C., 2004, *"Design models of light frame wood buildings under lateral loads"*, J. Struct Eng, 130(8), 1263-1271.

[13] HUD, 2001. *Wood Shear Walls with Corners.* U.S. Department of Housing and Urban Development, Washington, DC.

[14] U.S. Department of Agriculture, 2012, "Evaluation of the Lateral Performance of Roof Truss-to-Wall Connections in Light-Frame Wood Systems", General Technical Report FPL-GTR-214, Forest Products Laboratory, Madison, WI.

[15] ASCE/SEI 7, 2010, *Minimum Design Loads for Buildings and Other Structures*", American Society of Civil Engineers, Reston, VA.

In this case the over-strength factor Ω_o is used for design load path from roof-to-wall when partial height-blocking is used; it prevents potential occurrence of brittle failure mode due to cross-grain bending by preventing this potential failure and/or response from being the "weak link" in the lateral force resisting system.

Making the above substitutions and solving for "Roof Span," the following limit equation is determined for the "partial-height blocking only" detail in Seismic Design Category D_2 (S_{DS} = 1.17g):

$$\text{Roof Span} = 2 \times 1.4 \times V \times R / [(1.2 \times S_{DS} \times D_r) \times \Omega_o]$$

Substituting V = 114 plf (design unit shear for Partial Height Blocking), R = 6.5, S_{DS} = 1.17g and D_r = 15 psf, the following roof span limit is determined:

Roof Span = 2 x 1.4 x (114 plf) x 6.5 / [(1.2 x 1.17 x 15 psf) x 3.0] = **33 feet**

Thus, for the stated design conditions, the "partial-height blocking only" detail provides adequate seismic shear force transfer from the roof diaphragm system to walls at the perimeter of the roof for roof clear spans up to **33 feet**. For heavier or lighter roof systems or greater or lesser seismic design ground motions, an applicable span limit can be similarly determined. Note that the above equation includes a seismic over-strength factor (Omega) and that this practice is not necessarily required by ASCE 7-10, *IBC*, and AWC SDPWS[16]. It is used here to alleviate any reasonable concern with the partial-height blocking force transfer mechanism that does not necessarily prevent a brittle failure mode (cross-grain bending), even though this was not observed in available full-scale testing data for the resistance values used in the above analysis. Using the over-strength factor further ensures that the partial-height blocking force transfer mechanism will not result in a "weak link" in the lateral force load path.

Also, a similar equation can be developed for transfer of shear forces due to wind acting on the gable end of a roof. Such analysis indicates that for a 120 mph Exposure B condition, the roof clear span should be limited to 28 feet for 12:12 gable roof pitch or 52 feet for a 6:12 gable roof pitch or less. For hipped roofs, the span limits for wind should not control over seismic. For gable roof pitches in between 12:12 and 6:12, the roof span limit can be scaled by interpolation (e.g., span limit of 40 feet for 9:12 gable roof pitch). This analysis is based on ASCE 7-10 wind loads with the assumption that the length of the roof (along ridge) is at least equal to the span of the roof with a gable end tributary area equal to one-half the story height of 8 feet plus one-half the gable end area above the supporting end walls.

For special conditions requiring an even greater amount of force transfer than can be provided by the "partial-height blocking only" detail, the following options should be considered:

1. Provide the additional full-height blocking in the eave overhang (6 in. from the Partial Height Blocking). The force transfer mechanism described above for the Partial Height Blocking exists with or without the additional full-height blocking between the fascia board and the partial-height blocking at the wall line. However, the presence of the full-height blocking in the roof eave may cause more of the force from the roof diaphragm to transfer to the partial-height blocking by weak-axis bending of the top chord rather than cross-grain bending of the top chord. The actual distribution of forces through these two interactive load pathways involves system effects that are difficult to analyze without relying on judgment.
2. Use approved proprietary connection hardware in place of or in addition to Partial Height Blocking.

In addition, where and/or if possible, the following additional options are recommended as well:

1. Conduct the roof system shear transfer tests similar to that described above (HUD, 2002), but conduct the tests using a raised heel truss with the "partial-height blocking only" detail. This should result in a greater force transfer than estimated above from existing tests of standard heel trusses without any blocking.
2. Conduct roof system shear transfer tests as indicated in #2, but with the additional full-height blocking per #1. This should give modestly greater shear capacity than determined above (short of placing the full-height blocking at the wall plate) and demonstrate that the force transfer capacity is greater than that limited by assuming that Weak Axis Bending of the top chord alone controls the force transfer (i.e., there are other force transfer mechanisms besides just Weak Axis Bending at play including the systems effect that should demonstrate that the analysis is overly-conservative).

Thus, partial blocking can be used as long as the shear force does not exceed 114 plf along the wall. If it is not, any of the above measures can be employed to ensure sufficient heel block capacity.

[16] 2015, "*Special Design Provisions for Wind & Seismic (SDPWS)*", American Forest & Paper Association, Washington, DC.

Engineered Panel Blocking

Examples of Panel Blocking are illustrated in *IRC* Figure 6 or *IBC* Figure 7 and Figure 11.

Another option Building Designers may specify for high heel or flat truss applications is a blocking panel (Figure 11). Truss manufacturers can provide these as long as they have enough information to complete the design (the shear load). The lateral loads are easily resisted by panel blocks and the component manufacturer gets to supply another structural component that has solid design values while also using up what otherwise may be waste material.

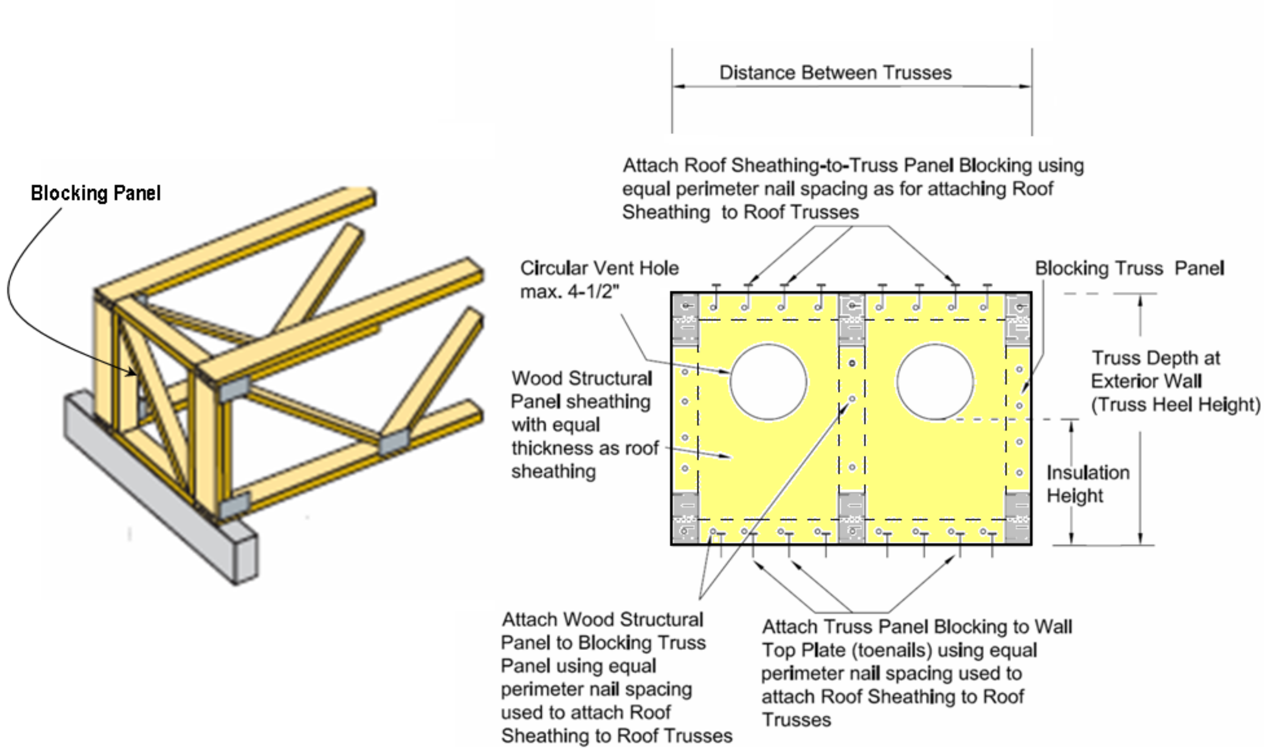

Figure 11: Use of blocking panel for parallel chord (flat) truss or a raised heel pitched truss

Conclusion:

In closing, a heel block or "bird block" with a large horizontal ventilation opening can more than suffice as perimeter blocking, provided the building designer properly details the roof-to-block and the block-to-wall connections. However, the Building Designer should always make sure that the blocking can provide sufficient capacity, especially before using Partial Height Blocking. Partial Height Blocking can be used as long as it is able to achieve sufficient shear transfer. If it is not, either full height blocking at the wall or full height blocking in the eave overhang should be considered. Alternatively, approved proprietary connection hardware in place of or in addition to Partial Height Blocking should be used.

The Building Designer should also be aware that it is his responsibility to account for the capacity of the Heel Blocking (or any other method he chooses to use) to transfer the lateral forces from the roof diaphragm to the shear walls; the Truss Designer has to account only for the in-plane strength of the truss. The Building Designer must be aware that the lateral load capacity will also be limited by the capacity of the roof sheathing (diaphragm). Lateral load capacity of the roof sheathing will be reduced due to insufficient perimeter nailing caused by the absence of blocking as a nailing surface.

Heel Blocking has become an important part of the structural load path of the roof to the foundation. Therefore, it is important to understand how the load transfer actually occurs in order to make a decision about whether the type of blocking being provided is sufficient without compromising energy/ventilation requirements.