Research Report

Exterior Brick Masonry Veneer supported by Metal Plate Connected Wood Trusses

SRR No. 1605-04

Structural Building Components Association (SBCA)

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This research report is based on practical scientific research (literature review, testing, analysis, etc.), with the goal of supporting strategic needs for code and standards development and market expansion. This research report complies with the following sections of the building code:

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

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Introduction:

Wood frame structures with attached brick masonry veneer cladding are a common form of residential construction throughout the United States, particularly in central and southeastern regions with moderate seismic and/or high wind activity. Brick veneer cladding is appreciated for its pleasant appearance, excellent thermal performance and its ability to prevent water penetration.

Residential brick veneer wall systems characteristically consist of brick masonry veneer at the exterior side of the wall which is attached to a wood frame wall. The wood framing and the brick veneer are connected with metal ties which hold the brick veneer out from the wood framing, creating an air cavity between the brick veneer and the wood framing. The cavity between the brick veneer and backup wood frame provides drainage, a thermal barrier and weather resistance. This is known as “simple rain screen” wall construction. No significant structural problems have been reported where brick veneer cladding was capable of supporting its own weight all the way down to the foundation, or where it was supported by properly sized steel lintel angles and/or wood structural components at conventionally sized window and door openings. However, supporting brick veneer cladding above larger openings such as a two-car garage door or large bay and/or patio door represent more difficult conditions.

In a typical brick veneer wall system, the wood framing is designed to carry all lateral and gravity loads, except for self-weight of the brick masonry. Nonetheless, brick veneer cladding does carry a portion of lateral load due to its higher stiffness than that of the wood backup structure. These lateral loads from exterior masonry walls are transferred through the tie connection, therefore the properties of these connections play a key role in the overall behavior and performance of residential brick veneer wall construction.

Issue:

The use of brick veneer supported by Metal Plate Connected Wood Trusses (MPCWT) is not covered by the prescriptive methods of either the *IBC* or the *IRC*. Even so, code compliant use of MPCWT to support brick veneer can be accomplished by both individual designs and by adhering to the recommendations that follow. This discussion mostly focuses on a common use of MPCWT’s; the gable end at the transition from a wider section of a building to a narrower section. However, the concepts shown can be applied to many different situations utilizing MPCWT’s.

Historically, considerable damage has been reported to residential brick veneer exterior cladding, including cracking, relative displacement, and the collapse of veneer brick masonry under out-of-plane loading resulting from strong wind and/or moderate earthquakes. Although most of the reported failures were caused due to out-of-plane lateral loads, several failures including cracking and/or wall arching were reported to be caused by inadequate anchorage of the steel lintels supporting the brick masonry, excessive deflections due to inadequate section of steel lintel, improper use of veneer material, and poor workmanship specifically as it relates to installation of veneer ties.

Key issues include:

- The out-of-plane wall damage occurs as brick veneer moves away from roof gable ends and walls resulting from wind suction and/or seismic loading. This loading places a high demand on the displacement capacity of the ties.
- Tie fastener pull-out, failure of workers to embed ties into the mortar, poor bonding between ties and mortar, poor quality of mortar and tie corrosion.
- Improper installation of ties including placement above or below the mortar joints due to ties being installed before the brick laying process begin. When misaligned, the ties have to be bent up or down in order for ties to be embedded into the mortar joints. Misalignment not only reduces embedment depth but also reduces the effectiveness of the ties because the wind direction is not acting parallel to the ties.
- Inadequate attachment of steel shelf angle to the roof gable end trusses and walls.
- Inadequately sized steel lintel.

Background:

Prescriptive installation requirements for supporting brick veneer with wood frame are specified in the 2009, 2012 & 2015 International Residential Codes (*IRC*) with limitations. Supporting brick veneer can include steel angles bolted to wall framing or steel angles supported by beefed-up rafters. A movement joint is required to be installed between veneers supported by foundation and veneers supported by wood or steel. Additionally, prescriptive installation requirements are specified in The Masonry Society (TMS) 402/602, the Brick Industry Association (BIA) Technical Notes 18A, 28, 31B, and 44B, and FEMA Technical Fact Sheet No. 5.4 Attachment of Brick Veneer in High-Wind Regions

According to the *IRC* brick veneer masonry can be supported by wood framing when observing the stated limitations:

IRC 2015 **R703.8.2 Exterior veneer support** (IRC 2009 & 2012 R703.7.2)

Except in Seismic Design Categories D_0, D_1 and D_2, exterior masonry veneers having an installed weight of 40 pounds per square foot (195 kg/m²) or less shall be permitted to be supported on wood or cold-formed steel construction. Where masonry veneer supported by wood or cold-formed steel construction adjoins masonry veneer supported by the foundation, there shall be a movement joint between the veneer supported by the wood or cold-formed steel construction and the veneer supported by the foundation. The wood or cold-formed steel construction supporting the masonry veneer shall be designed to limit the deflection to 1/600 of the span for the supporting members. The design of the wood or cold-formed steel construction shall consider the weight of the veneer and any other loads.

IRC 2015 **R703.8.2.1 Support by steel angle (IRC 2009 & 2012 R703.7.2.1)**

A minimum 6-inch by 4-inch by 5/16-inch (152 mm by 102 mm by 8 mm) steel angle, with the long leg placed vertically, shall be anchored to double 2-inch by 4-inch (51 mm by 102 mm) wood studs or double 350S162 cold-formed steel studs at a maximum on-center spacing of 16 inches (406 mm). Anchorage of the steel angle at every double stud spacing shall be not less than two 7/16-inch-diameter (11 mm) by 4-inch (102 mm) lag screws for wood construction or two 7/16-inch (11.1 mm) bolts with washers for cold-formed steel construction. The steel angle shall have a minimum clearance to underlying construction of 1/16 inch (1.6 mm). Not less than two-thirds the width of the masonry veneer thickness shall bear on the steel angle. Flashing and weep holes shall be located in the masonry veneer in accordance with Figure R703.8.2.1. The maximum height of masonry veneer above the steel angle support shall be 12 feet 8 inches (3861 mm). The airspace separating the masonry veneer from the wood backing shall be in accordance with Sections R703.8.4 and R703.8.4.2. The method of support for the masonry veneer on wood construction shall be constructed in accordance with Figure R703.8.2.1

The maximum slope of the roof construction without stops shall be 7:12. Roof construction with slopes greater than 7:12 but not more than 12:12 shall have stops of a minimum 3-inch by 3-inch by 1/4-inch (76 mm by 76 mm by 6.4 mm) steel plate welded to the angle at 24 inches (610 mm) on center along the angle or as approved by the building official.

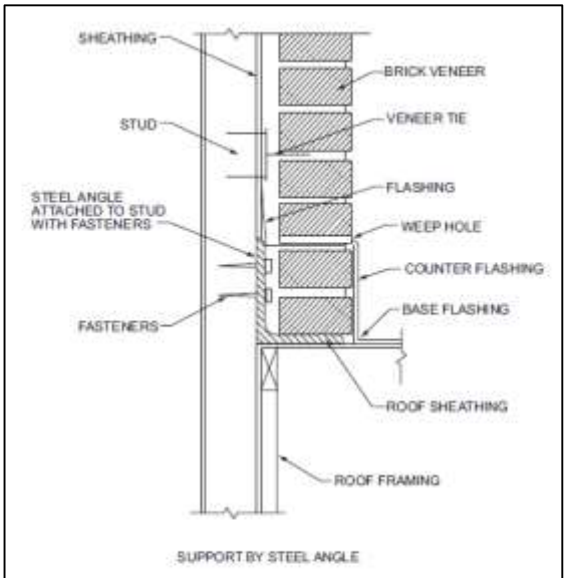

FIGURE R703.8.2.1
EXTERIOR MASONRY VENEER SUPPORT BY STEEL ANGLES

IRC 2015 **R703.8.2.2 Support by roof construction (IRC 2009 & 2012 R703.7.2.2)**

A steel angle shall be placed directly on top of the roof construction. The roof supporting construction for the steel angle shall consist of not fewer than three 2-inch by 6-inch (51mm by 152 mm) wood members for wood construction or three 550S162 cold-formed steel members for cold formed steel light frame construction. A wood member abutting the vertical wall stud construction shall be anchored with not fewer than three 5/8-inch (15.9 mm) diameter by 5-inch (127 mm) lag screws to every wood stud spacing. Each additional wood roof member shall be anchored by the use of two 10d nails at every wood stud spacing. A cold-formed steel member abutting the vertical wall stud shall be anchored with not fewer than nine No. 8 screws to every cold-formed steel stud. Each additional cold-formed steel roof member shall be anchored to the adjoining roof member using two No. 8 screws at every stud spacing. Not less than two-thirds the width of the masonry veneer thickness shall bear on the steel angle. Flashing and weep holes shall be located in the masonry veneer wythe in accordance with Figure R703.8.2.2. The maximum height of the masonry veneer above the steel angle support shall be 12 feet 8 inches (38.61 mm). The airspace separating the masonry veneer from the wood backing shall be in accordance with Sections R703.8.4 and R703.8.4.2. The support for the masonry veneer shall be constructed in accordance with Figure R703.8.2.2.

The maximum slope of the roof construction without stops shall be 7:12. Roof construction with slopes greater than 7:12 but not more than 12:12 shall have stops of a minimum 3-inch by 3-inch by 1/4-inch (76 mm by 76 mm by 6.4 mm) steel plate welded to the angle at 24 inches (610 mm) on center along the angle or as approved by the building official.

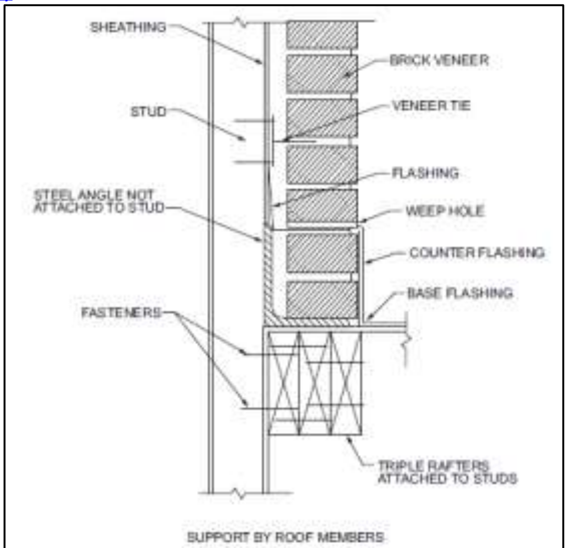

FIGURE R703.8.2.2
EXTERIOR MASONRY VENEER SUPPORT BY ROOF MEMBERS

IRC 2015 Veneer ties

R703.8.4 Anchorage. Masonry veneer shall be anchored to the supporting wall studs with corrosion-resistant metal ties embedded in mortar or grout and extending into the veneer a minimum of 1-1/2 inches (38 mm), with not less than 5/8-inch (15.9 mm) mortar or grout cover to outside face. Masonry veneer shall conform to Table R703.8.4.

R703.8.4.1 Size and spacing. Veneer ties, if strand wire, shall be not less in thickness than No. 9 U.S. gage [(0.148 inch) (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 inch) (0.76 mm)] 7/8 inch (22 mm) corrugated. Each tie shall support not more than 2.67 square feet (0.25 m^2) of wall area and shall be spaced not more than 32 inches (813 mm) on center horizontally and 24 inches (610 mm) on center vertically.

> **Exception:** In Seismic Design Category D_0, D_1 or D_2 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 (0.19 m^2) of wall area.

R703.8.4.1.1 Veneer ties around wall openings. Additional metal ties shall be provided around wall openings greater than 16 inches (406 mm) in either dimension. Metal ties around the perimeter of openings shall be spaced not more than 3 feet (914 mm) on center and placed within 12 inches (305 mm) of the wall opening.

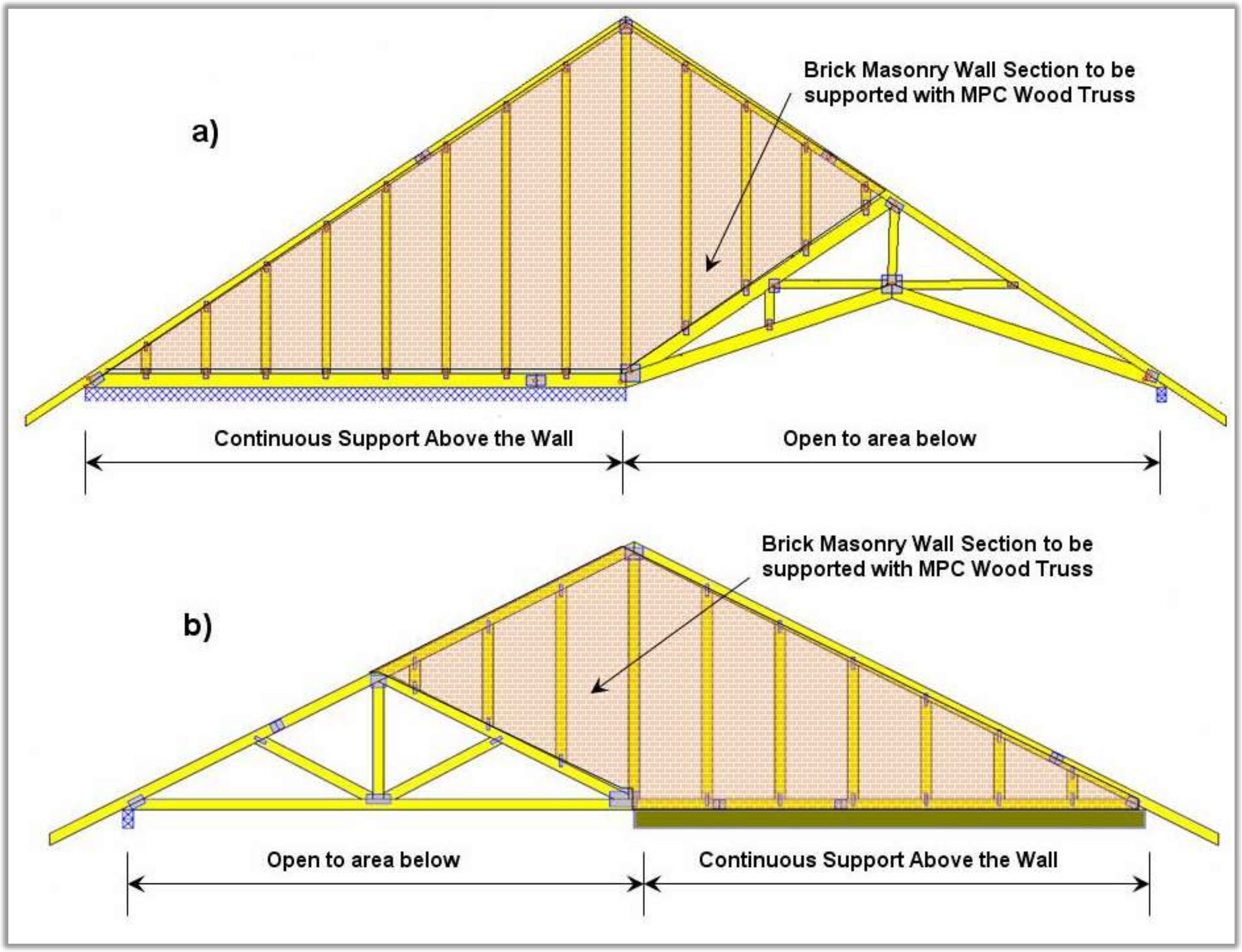

Figure 1. Supporting brick veneer with MPCWT

***IRC* requirements and limitations to MPCWT:**

The *IRC* provides two details for attaching a steel angle to wood framing (Figure R703.8.2.1 and R703.8.2.2). In both details, there is an adjacent wood framed backup wall. The *IRC* does not address MPCWTs supporting brick veneer masonry at all. Examples of supporting brick veneer with MPCWT utilizing a steel lintel are given in Figure 1.
For buildings with conventional construction that contain structural elements exceeding the limits in *IRC* Section R301 Design Criteria or otherwise not conforming to this code, the *IRC* has provisions regarding designing these elements in accordance with accepted engineering practice.

R301.1.3. Engineered design

> Where a building of otherwise conventional construction contains structural elements exceeding the limits of Section R301 or otherwise not conforming to this code, these elements shall be designed in accordance with accepted engineering practice. The extent of such design need only demonstrate compliance of nonconventional elements with other applicable provisions and shall be compatible with the performance of the conventional framed system. Engineered design in accordance with the International Building Code is permitted for buildings and structures, and parts thereof, included in the scope of this code.

Furthermore, similar conceptual provision for structural components and/or assembly exceeding the limitation of conventional construction is addressed in Section 2308.1.1 of the 2009, 2012 & *2015 International Building Code (IBC).*

> **2308.1.1 Portions exceeding limitations of conventional light-frame construction**
> When portions of a building of otherwise conventional light-frame construction exceed the limits of Section 2308.2, those portions and the supporting load path shall be designed in accordance with accepted engineering practice and the provisions of this code. For the purposes of this section, the term "portions" shall mean parts of buildings containing volume and area such as a room or a series of rooms. The extent of such design need only demonstrate compliance of the nonconventional light-framed elements with other applicable provisions of this code and shall be compatible with the performance of the conventional light-framed system.

Analysis:

For the MPCWT carrying the brick/masonry wall, the following guidance and recommendations are provided based on 2009, 2012 & 2015 IRC and IBC sections described above, wind loads specified in ASCE 7-10 "Design Loads for Buildings and Other Structures," fastener strengths specified in the American Forest and Paper Association's (AF&PA's) National Design Specification for Wood Construction, Masonry Structures standards contained in TMS 402/602, general guidance given in Brick Industry Association's Technical Notes 18A, 28, 28B, 31B and 44B , FEMA Technical Fact Sheet No. 5.4 Attachment of Brick Veneer in High-Wind Regions and our professional judgment.

- The MPCWT must be designed for the additional loading from the brick in locations where there is not bearing directly below the brick.
- If the angle iron is being supported by bolts attached directly to the MPCWT, then the MPCWT must be designed with the holes for the bolts taken into account.
- Truss total load deflection is limited to L/600.
- Load Duration factor for the brick veneer is C_D=0.9.
- Creep factor for long-term deflection calculation shall be 1.5 for dry lumber and 2.0 for unseasoned lumber. Creep is defined as time-dependent deformation of a structural member under constant load. In this case brick dead load is a constant and/or sustained load (see ANSI/TPI 1-2014).
- Maximum weight of brick masonry veneer is 40 psf.
- Maximum height of brick masonry is 12'8" per the IRC.
- Sheathing must be covered with a water-resistant membrane, unless the sheathing is water resistant and the joints are sealed.
- Attachment of steel lintel to MPCWT should be based on the recommended details per Figures 2 & 3. A minimum 6 inches x 4 inches x 5/16 inch (152 mm x 102 mm x 8 mm) steel angle, with the long leg placed vertically, shall be anchored to MPCWT using bolts installed per recommendations in Tables 1 or 2.

  The maximum slope of the roof construction without stops welded to the steel angle shall be 7:12. Supporting the brick veneer with trusses with slopes greater than 7:12 but not more than 12:12 shall have stops, with a minimum size of 3 inch x 3 inch x ¼ inch (76 mm x76 mm x 6 mm) steel plates, welded to the angle at a maximum spacing of 24 inches (610 mm) on center along the angle or as approved by the building official.

- The lateral support of brick veneer carried with MPCWT is provided by the ties and backing system, including lateral restraint of the trusses to resist the transferred loads. The ties must be capable of resisting tension and compression resulting from forces acting perpendicular to truss plane. Stainless steel ties specified under ASTM A 240 or A 580 or corrosion protected ties such as zinc coated corrugated steel ties, minimum 22 U.S. gauge thick (0.0299") by 7/8-inch wide and 6-inch long (0.76mm x 22 mm x 152 mm) complying with ASTM A 653 and A 153 class B2 shall be used. Veneer ties shall be spaced at maximum 32" o.c. (813 mm) horizontally and 24" o.c. (610 mm) vertically and shall support no more than 2.67 ft^2 (0.25 m^2) of brick veneer wall area; however, it is suggested that for newer construction wall studs be spaced at 16" o.c., so that ties can be anchored at this spacing. Strand wire ties are less susceptible to corrosion than corrugated steel sheet ties. Minimum strand wire size diameter shall be 9 U.S. gauge [(0.148") (4 mm)] and be spaced same as corrugated steel ties and shall have a hook embedded in the mortar joint.

  Tables 4 & 5 provide recommendations for maximum vertical tie spacing for high wind areas when structural gable truss vertical members or studs in a wall are spaced at 24", 16" and 12" on center. In the areas that are susceptible to both high wind and seismic loads, the masonry brick veneer system should be evaluated by a Registered Design Professional to ensure that brick veneer cladding can resist both seismic and wind design loads.

- Design of the Lateral Restraint/Bracing of the truss is the responsibility of the building designer (see ANSI/TPI 1-2014). Reference the Architect's/Design Engineer's details and BCSI for additional gable end/truss bracing details.

- Flashing and weep holes shall be located in the brick veneer wythe above the steel angle per the building codes. Flashing should consist of normal base flashing, step flashing and counter flashing installed directly on the adjacent (i.e., lower) roof sheathing. Weep holes shall be at a maximum spacing of 33" (838 mm) o.c. and shall be not less than 3/16" (5 mm) in diameter.

- Create vertical expansion joints at a maximum spacing of 25' (7.6 m). The actual location of vertical expansion joints in a structure depends on the structural configuration as well as the expected amount of horizontal movement. The expansion joint in residential construction is typically sized to be similar in width to a mortar joint, usually between 3/8" (10 mm) and ½" (13 mm). In addition, vertical expansion joints should be considered at or near corners, offsets and setbacks, wall intersections, changes in the wall height, where wall backing system changes, where support of brick veneer changes and where wall function or climatic exposure changes. (See Figure 6).

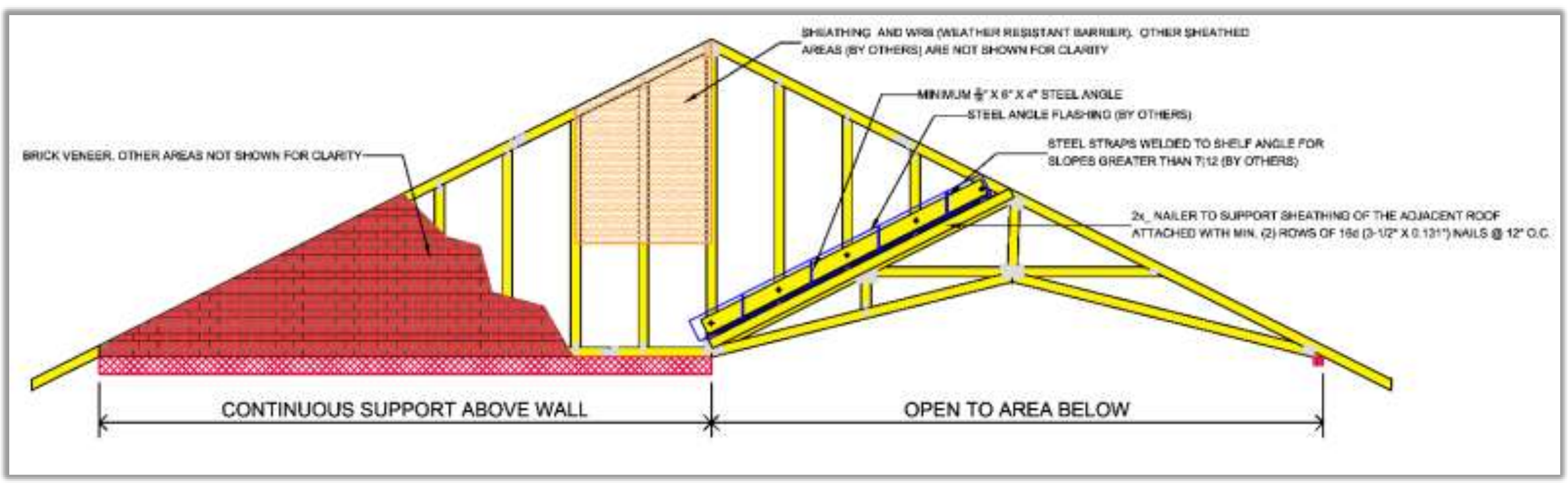

Figure 2. Recommended detail for attaching steel lintel to MPCWT supporting brick masonry veneer

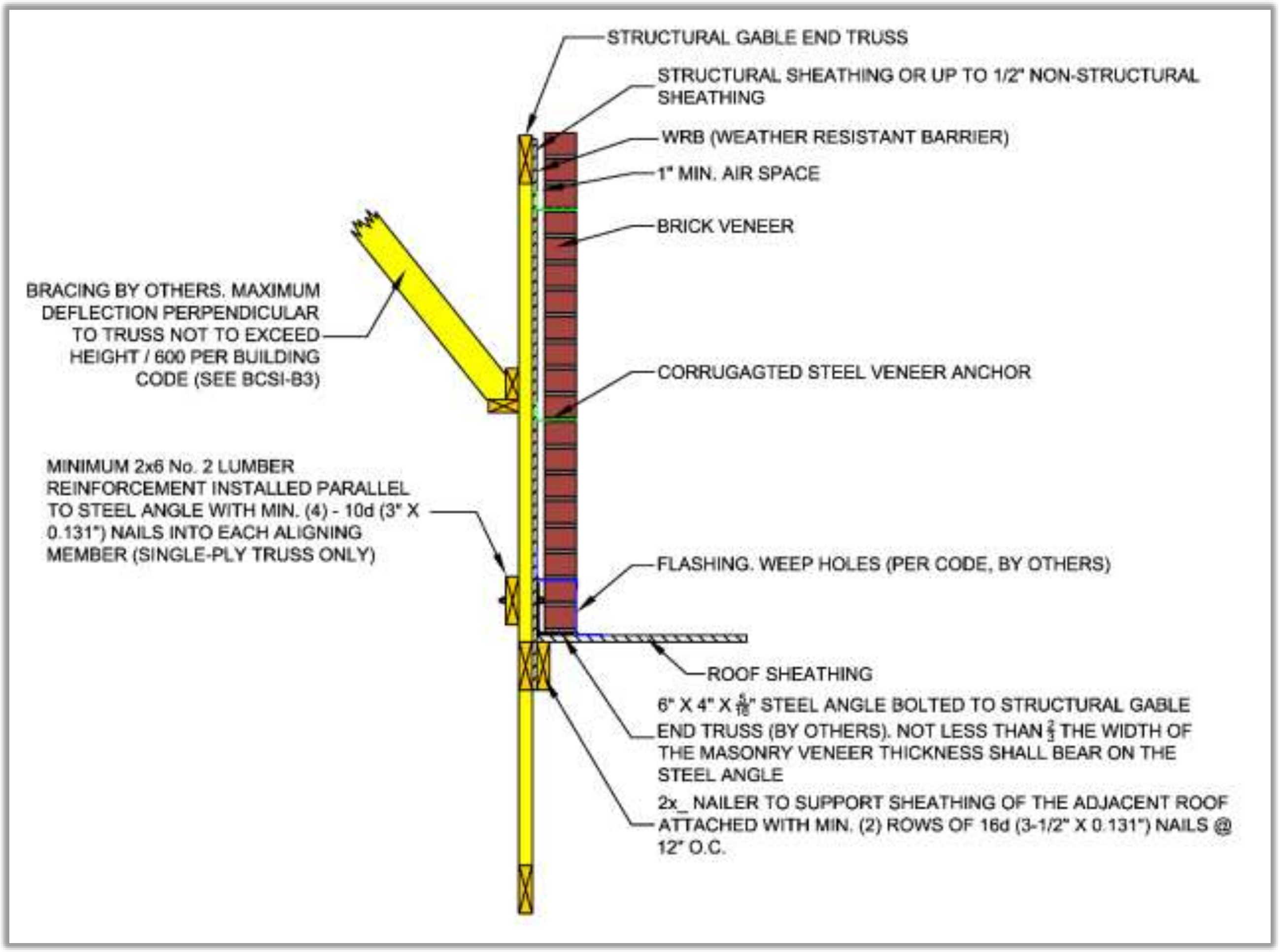

Figure 3. Recommended detail for attaching steel lintel to MPCWT supporting brick masonry veneer with the use of bolts see Tables 1 & 2

Bolt Spacing (Truss Vertical Member Spacing)	Bolt Diameter [1,b] With Structural Sheathing (OSB, Plywood)			
	3/8-inch bolt diam.	1/2-inch bolt diam.	5/8-inch bolt diam.	3/4-inch bolt diam. [2]
24 inches o.c.[c]	Max. 4'-6" brick height	Max. 6'-1" brick height	Max. 7'-9" brick height	Max. 9'-5" brick height
16 inches o.c.[c]	Max. 6'-11" brick height	Max. 9'-5" brick height	Max. 11'-10" brick height	Max. 14'-3" [a] brick height
12 inches o.c.[c]	Max. 9'-4" brick height	Max. 12'-8" brick height	Max. 15'-11" [a] brick height	Max. 19'-2" [a] brick height

[1] Bolt shear capacity is calculated based on 2015 NDS for Wood Construction for lumber with Specific Gravity G=0.42 (Spruce-Pine-Fir) with moisture content less than 19% and the following adjustment factors: C_D=0.9, C_t and C_M =1.0.
[2] Use only with minimum 2x4 vertical truss members. F_{em}=4700 psi, F_{es}=87000 psi, 5/16" Steel, no gap, Bolt F_{yb}=45000 psi
Brick weight up to 40 PSF.
[a] The maximum height of brick masonry veneer above the steel angle support using prescriptive requirements of 2015 IRC shall be 12'-8". Weight of brick shall be included in truss design.
[b] Pre-drill oval holes in the shelf angle for easier field installation adjustment.
[c] It must be noted that the design of the truss only accounts for the gravitational loads in the plane of the truss. The building designer needs to adequately account for loads normal to the face of the truss and the bracing/restraint of the roof and wall system.

Table 1: Shelf angle bolt sizing based on the supported height of brick masonry and truss vertical member spacing with structural sheathing attached to the truss.

Bolt Spacing (Truss Vertical Member Spacing)	Bolt Diameter[1,b] With up to ½" of Non-Structural Sheathing (Weather Resistant Barrier, Insulation, etc.)			
	3/8-inch bolt diam.	1/2-inch bolt diam.	5/8-inch bolt diam.	3/4-inch bolt diam. [2]
24 inches o.c.[c]	Max. 3'-1" brick height	Max. 4'-4" brick height	Max. 5'-6" brick height	Max. 6'-8" brick height
16 inches o.c.[c]	Max. 4'-9" brick height	Max. 6'-8" brick height	Max. 8'-5" brick height	Max. 10'-3" brick height
12 inches o.c.[c]	Max. 6'-6" brick height	Max. 9'-0" brick height	Max. 11'-5" brick height	Max. 13'-9" [a] brick height

[1] Bolt shear capacity is calculated based on 2015 NDS for Wood Construction for lumber with Specific Gravity G=0.42 (Spruce-Pine-Fir) with moisture content less than 19% and the following adjustment factors: C_D=0.9, C_t and C_M =1.0.
[2] Use only with minimum 2x4 vertical truss members. F_{em}=4700 psi, F_{es}=87000 psi, 5/16" Steel with ½" gap between steel and truss, Bolt F_{yb}=45000 psi, Brick weight up to 40 PSF.
[a] The maximum height of brick masonry veneer above the steel angle support using prescriptive requirements of 2015 IRC shall be 12'-8". Weight of brick shall be included in truss design.
[b] Pre-drill oval holes in the shelf angle for easier field installation adjustment.
[c] It must be noted that the design of the truss only accounts for the gravitational loads in the plane of the truss. The building designer needs to adequately account for loads normal to the face of the truss and the bracing/restraint of the roof and wall system.

Table 2: Shelf angle bolt sizing based on the supported height of brick masonry and truss vertical member spacing with non-structural sheathing attached to the truss.

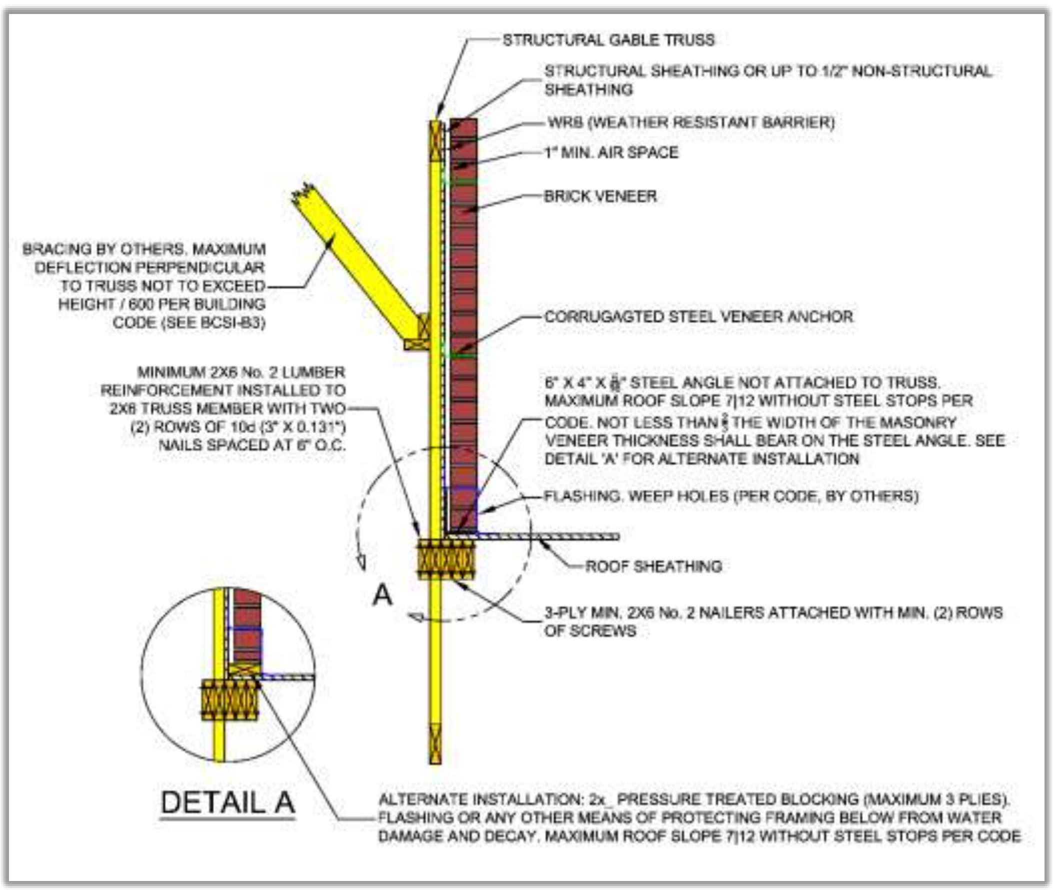

Figure 4 Detail for attaching (3) Minimum 2x6's to MPCWT supporting brick masonry veneer, directly above the 2x6's, using shelf tapping wood screws, see Table 3

	Fasten Master TLOK08/LOG008 or Simpson SDS25800 or USP WS8 Screws [1] 8" minimum screw length	
	SP/DFL SG=0.50	HF/SPF SG=0.42
2 Staggered Rows of Screws @ 8" o.c.[b,c]	Max. 15'-3" [a] brick height	Max. 12'-11" [a] brick height
2 Staggered Rows of Screws @ 12" o.c.[b,c]	Max. 10'-1" brick height	Max. 8'-6" brick height
2 Staggered Rows of Screws @ 16" o.c.[b,c]	Max. 7'-6" brick height	Max. 6'-4" brick height
2 Staggered Rows of Screws @ 24" o.c.[b,c]	Max. 4'-11" brick height	Max. 4'-1" brick height

[1] Screw shear capacity is calculated based on 2015 NDS for Wood Construction for lumber with Specific Gravity G=0.42 (Spruce-Pine-Fir) and Specific Gravity G=0.50 (Douglas Fir-Larch) with moisture content less than 19% and the following adjustment factors: C_D=0.9, C_t and C_M =1.0. 3" main member, 4-1/2" side member
Use only with minimum 2x6 members.
[a] The maximum height of brick masonry veneer above the steel angle support using prescriptive requirements of 2015 IRC shall be 12'-8".
[b] Screws to be staggered half the o.c. spacing with a minimum 1-3/4" edge distance and 6" end distance. Weight of brick shall be included in truss design.
[c] It must be noted that the design of the truss only accounts for the gravitational loads in the plane of the truss. The building designer needs to adequately account for loads normal to the face of the truss and the bracing/restraint of the roof and wall system.

Table 3: Maximum height of brick masonry based on shelf tapping wood screw spacing

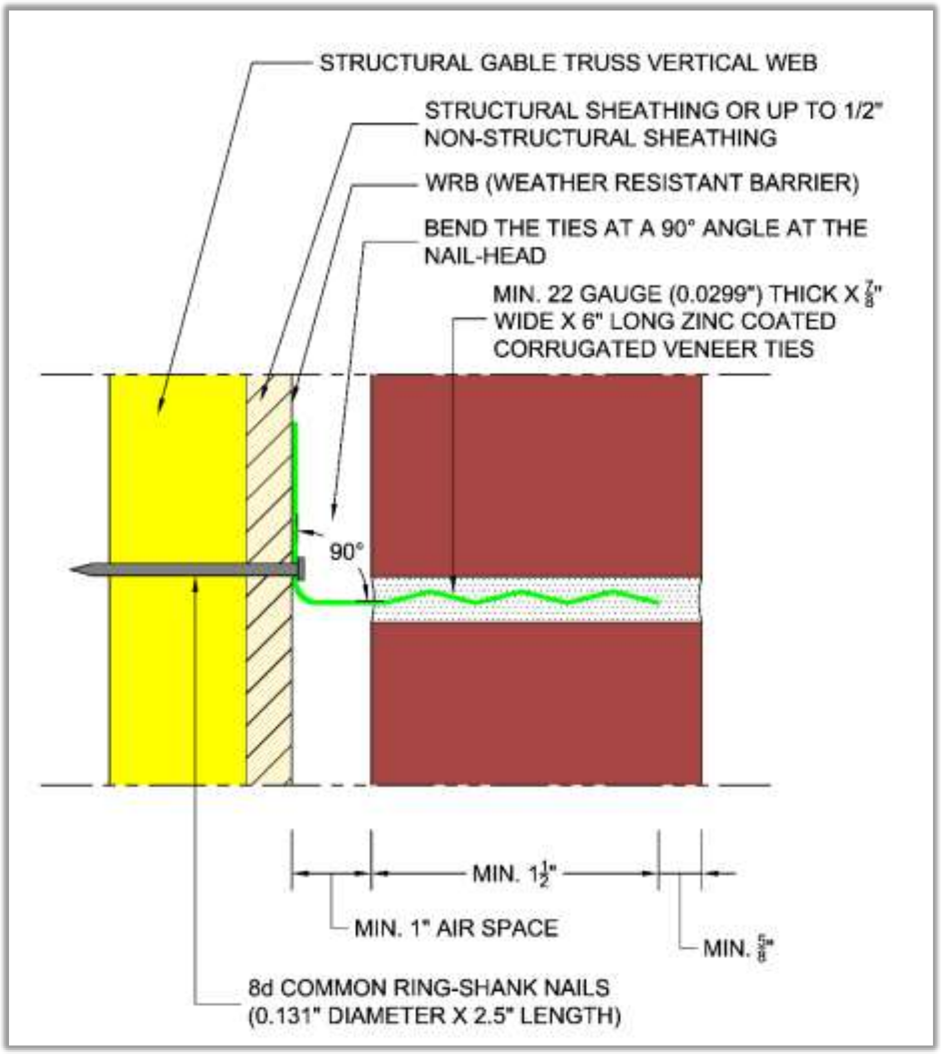

Figure 5. Recommended detail for masonry brick veneer corrugated steel tie embedment, See Tables 4 & 5

Wind Speed (3-sec Peak Gust)	Wind[1,2,9] Pressure (psf)	Maximum Vertical spacing for Ties in inches[1,2,3,4,8] 8d (0.131" x 2.5") Ring-Shank Nails With Non-Structural Sheathing (Weather Resistant Barrier, Insulation, etc.) and 1-1/2" of Nail penetration in truss member.					
		Truss members @ 24" o.c.		Truss members @ 16" o.c.		Truss members @ 12" o.c.	
		SPF	SYP	SPF	SYP	SPF	SYP
115 mph	19.1	15	16[5]	23	24[5]	24[5]	24[5]
120 mph	20.8	14	16[5]	21	24[5]	24[5]	24[5]
130 mph	24.4	12	16[5]	18	24[5]	24[5]	24[5]
140 mph	28.3	10	16[5]	15	24[5]	21	24[5]
150 mph	32.5	9	12[6]	13	18[6]	18	24[5]
160 mph	37.0	8	12[6]	12	18[6]	16	24[5]
180 mph	46.8	NA[7]	NA[7]	9	16	12	18[7]

[1] The vertical tie spacing is based on wind loads derived from ASCE 7-10 Components and Cladding – Method 1 (simplified – Figure 30.5-1, Zone 5, Effective wind area = 10 sf), located in Exposure category B, h = 30 ft., importance factor (*I=1*) and no topographic influence ($K_{zt}=1.0$). For other heights, exposure, importance factor and topographic influence, an engineered design is recommended. Table based on a tie in every vertical.
[2] Net Design Wind Pressures from ASCE 7-10 Figure 30.5-1 have been multiplied by 0.6 for Allowable Stress Design.
[3] Nail withdrawal strength is for truss lumber with Specific Gravity G=0.42 (Spruce-Pine-Fir (SPF)) and G=0.55 (Southern Yellow Pine (SYP)) with moisture content less than 19% and the following adjustment factors: C_D=1.0, C_t=0.8, C_M, C_{eg}, and C_{tn}=1.0. See FEMA Technical Fact Sheet No. 5.4 Attachment of Brick Veneer in High-Wind Regions.
$W = 1800G^2D$ x 1.6 SPF NV = 49.9 SYP NV = 85.6
[4] Nail embedment depth of 1-1/2" was assumed for 8d common ring-shank nails (0.131"-diameter x 2 ½"-long).
[5] The maximum vertical spacing allowed by the Brick Industry Association's Technical Notes 28 is 24" & requires an anchor for every 2.67 sq. ft. of wall area.
[6] Where the wind pressure exceeds 30 psf, reduce wall area supported by each anchor to max. 2 SF per the IRC R703.8.4.1 & the Brick Industry Association's Technical Note 28
[7] Where wind pressure exceeds 40 psf do not space anchors more than 18" vertically & horizontally per the Brick Industry Association's Technical Note 28
[8] Additional anchors required around openings larger than 16" in either dimension. See the IRC or IBC for these requirements.
[9] It must be noted that the design of the truss only accounts for the gravitational loads in the plane of the truss. The building designer needs to adequately account for loads normal to the face of the truss and the bracing/restraint of the roof and wall system.

Table 4: Suggested Maximum vertical spacing for brick veneer ties for truss members spaced at 24", 16" and 12" centers With non-structural sheathing attached to the MPCWT

Wind Speed (3-sec Peak Gust)	Wind[1,2,9] Pressure (psf)	Maximum Vertical spacing for Ties in inches[1,2,3,4,8] 8d (0.131" x 2.5") Ring-Shank Nails With ½" Structural Sheathing (OSB, or Plywood) and 2" of Nail penetration[4]					
		Truss members @ 24" o.c.		Truss members @ 16" o.c.		Truss members @ 12" o.c.	
		SPF	SYP	SPF	SYP	SPF	SYP
115 mph	19.1	16[5]	16[5]	24[5]	24[5]	24[5]	24[5]
120 mph	20.8	16[5]	16[5]	24[5]	24[5]	24[5]	24[5]
130 mph	24.4	16	16[5]	24[5]	24[5]	24[5]	24[5]
140 mph	28.3	14	16[5]	21	24[5]	24[5]	24[5]
150 mph	32.5	12	12[6]	18	18[6]	24[5]	24[5]
160 mph	37.0	10	12[6]	16	18[6]	21	24[5]
180 mph	46.8	NA[7]	NA[7]	12	18[6, 7]	17	18[7]

[1] The vertical tie spacing is based on wind loads derived from ASCE 7-10 Components and Cladding – Method 1 (simplified – Figure 30.5-1, Zone 5, Effective wind area = 10 sf), located in Exposure category B, h = 30 ft., importance factor (*I=1*) and no topographic influence ($K_{zt}=1.0$). For other heights, exposure, importance factor and topographic influence, an engineered design is recommended. Table based on a tie in every vertical.
[2] Net Design Wind Pressures from ASCE 7-10 Figure 30.5-1 have been multiplied by 0.6 for Allowable Stress Design.
[3] Nail withdrawal strength is for truss lumber with Specific Gravity G=0.42 (Spruce-Pine-Fir (SPF)) and G=0.55 (Southern Yellow Pine (SYP)) with moisture content less than 19% and the following adjustment factors: C_D=1.0, C_t=0.8, C_M, C_{eg}, and C_{tn}=1.0. See FEMA Technical Fact Sheet No. 5.4 Attachment of Brick Veneer in High-Wind Regions.
$W = 1800G^2D$ x 1.6 SPF NV = 66.55 SYP NV = 114.12
[4] Nail embedment depth of 2" was assumed for 8d common ring-shank nails (0.131"-diameter x 2 ½"-long) (1-1/2" truss plus ½" structural sheathing). A minimum of 3 (0.131" x 2") nails required attaching the sheathing to the truss for every tie.
[5] The maximum vertical spacing allowed by the Brick Industry Association's Technical Notes 28 is 24" & requires an anchor for every 2.67 sq. ft. of wall area.
[6] Where the wind pressure exceeds 30 psf, reduce wall area supported by each anchor to max. 2 SF per the IRC R703.8.4.1 & the Brick Industry Association's Technical Note 28
[7] Where wind pressure exceeds 40 psf do not space anchors more than 18" vertically & horizontally per the Brick Industry Association's Technical Note 28
[8] Additional anchors required around openings larger than 16" in either dimension. See the IRC or IBC for these requirements.
[9] It must be noted that the design of the truss only accounts for the gravitational loads in the plane of the truss. The building designer needs to adequately account for loads normal to the face of the truss and the bracing/restraint of the roof and wall system.

Table 5: Suggested Maximum vertical spacing for brick veneer ties for truss members spaced at 24", 16" and 12" centers with structural sheathing attached directly to the MPCWT

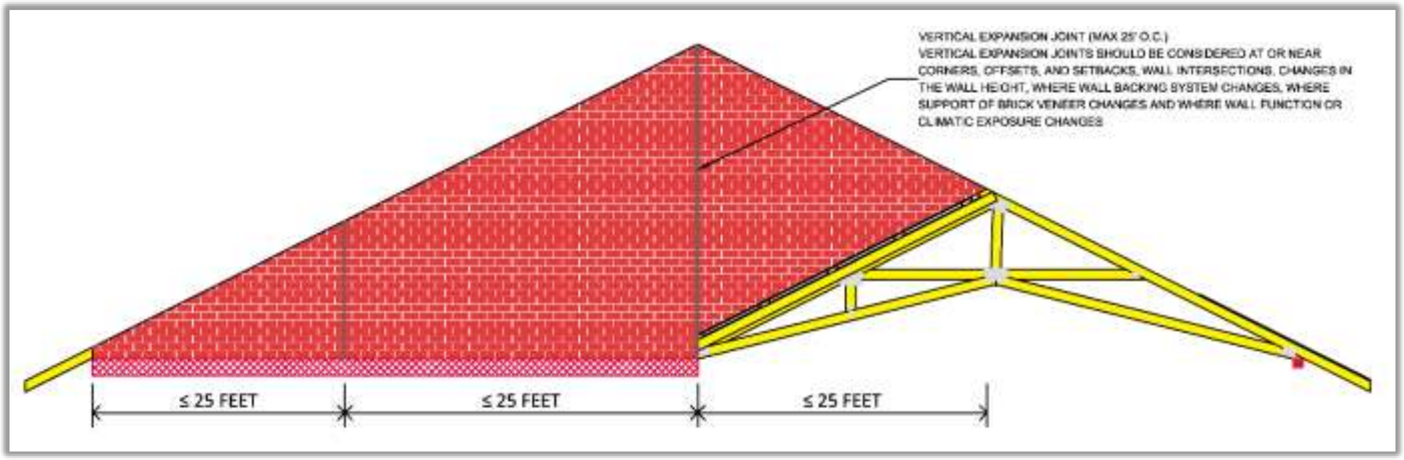

Figure 6. Expansion joint location for brick veneer cladding supported with MPCWT (see IRC for code requirements)

MPCWT Supporting Brick Veneer at Dormers:

Metal Plate Connected Wood Trusses (MPCWT) may also be used to support brick veneer at dormer locations (Figure 7). The same requirements as listed under the Analysis would also apply in this situation when applicable. Note depending on where the dormer is placed on the truss, the truss may need to be designed with an additional point load from a header carrying the front of the dormer brick veneer loading.

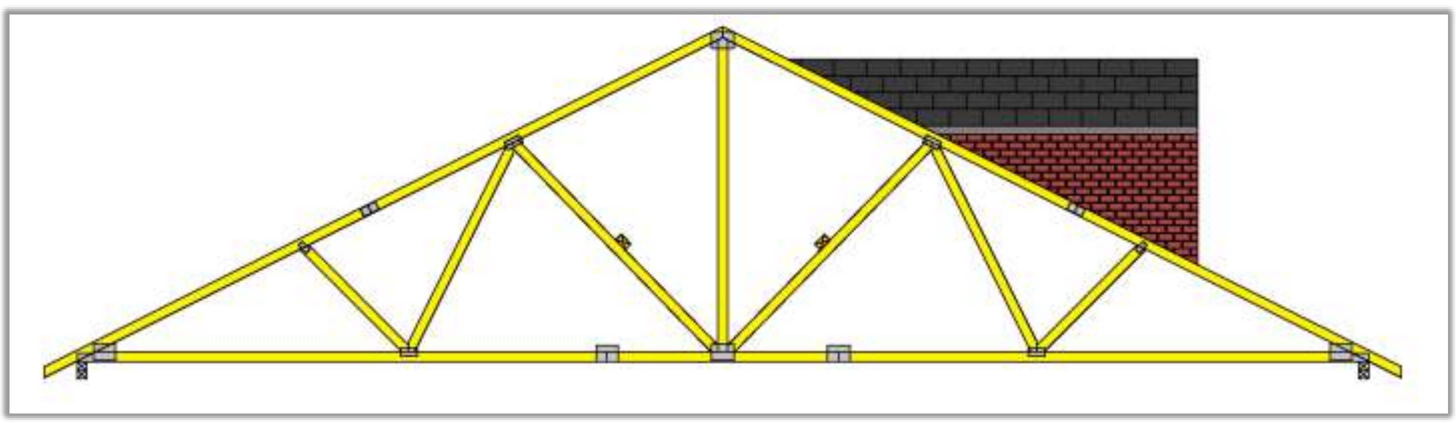

Figure 7. MPCWT supporting a dormer with Brick Veneer

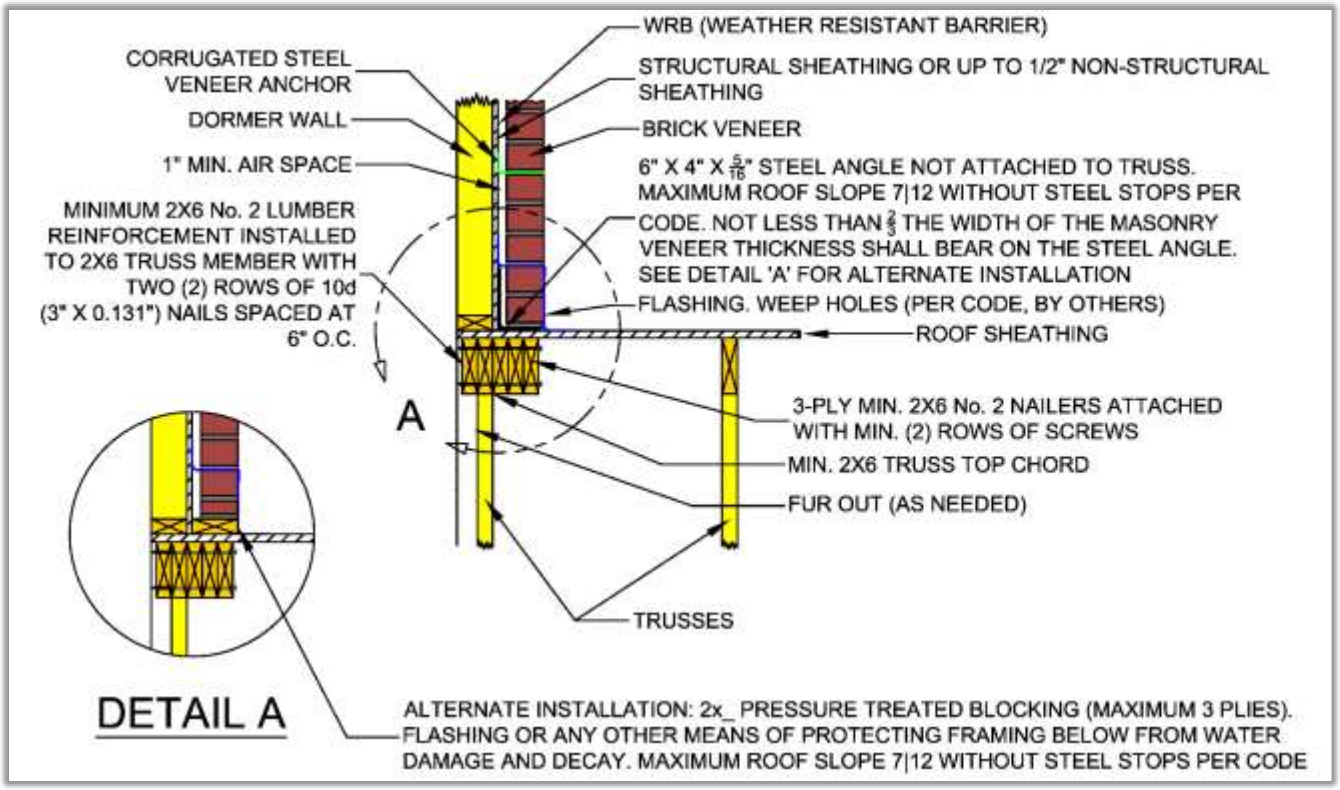

Figure 8. Detail for attaching (3) Minimum 2x6's to MPCWT supporting brick masonry veneer using shelf tapping wood screws, see Table 3

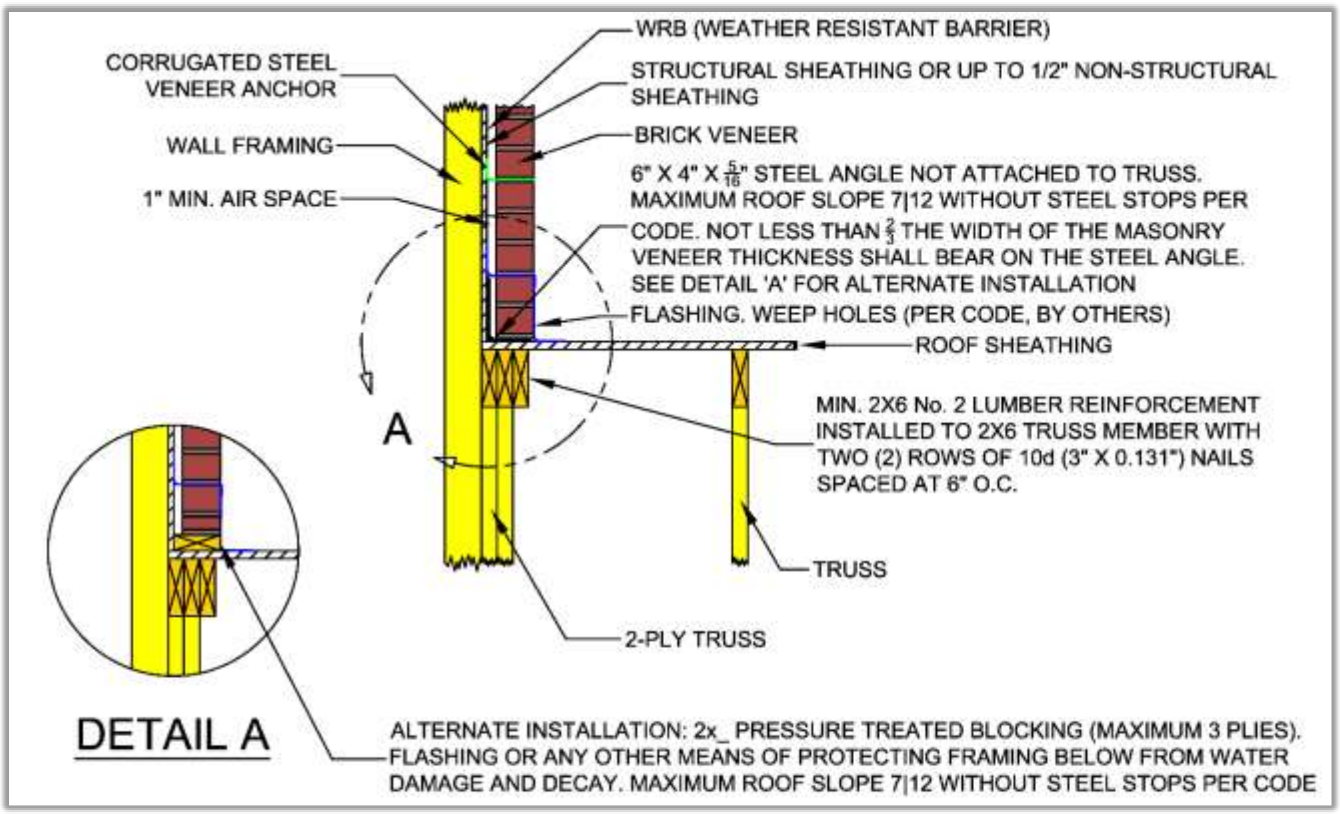

Figure 9. Detail for supporting brick masonry veneer using 2-Ply MPCWT directly under the veneer.

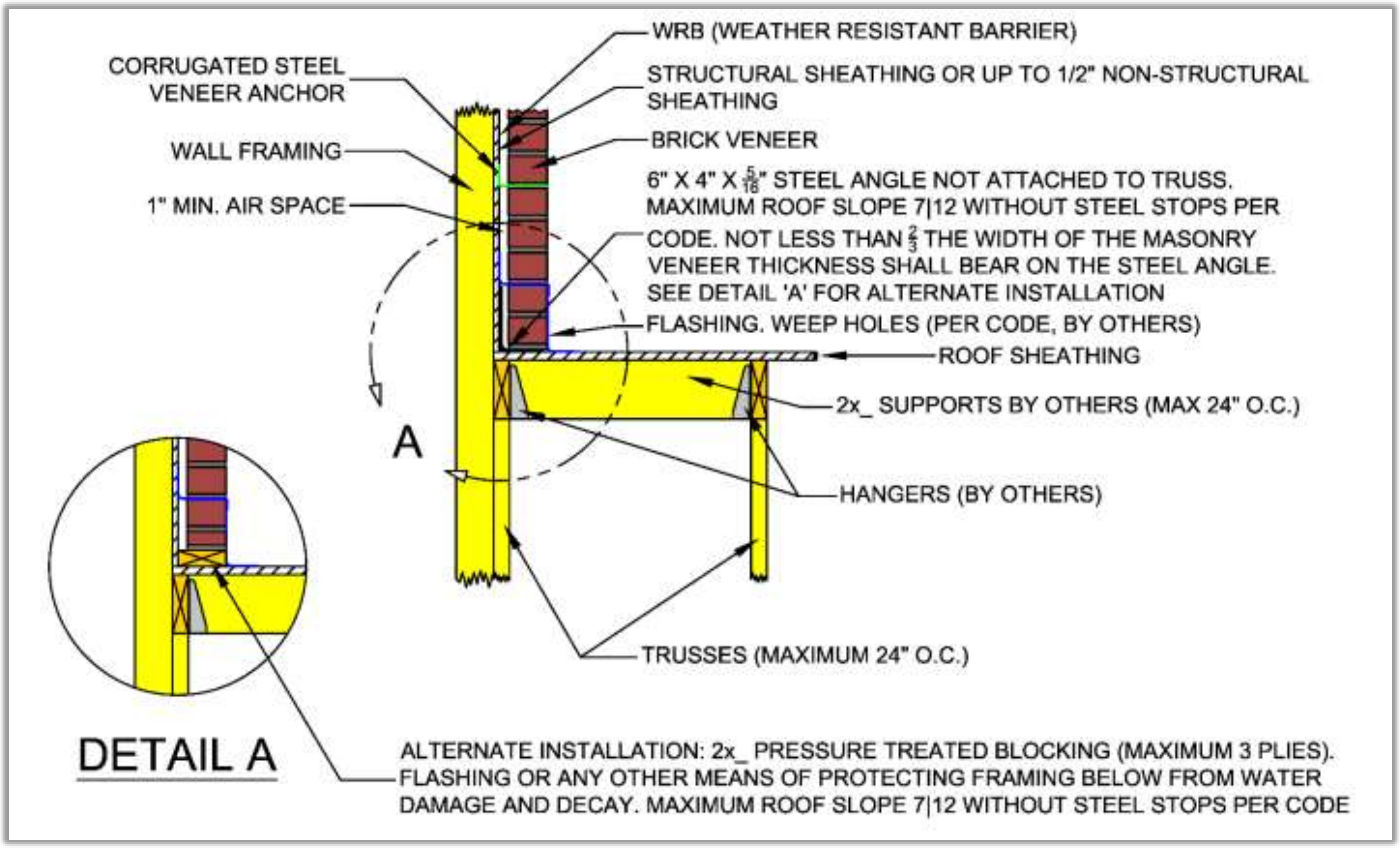

Figure 10. Brick veneer supported with 2x_ material between MPCWT.

Conditions of Use:

Metal plate connected wood trusses can effectively support brick masonry veneer when properly designed to do so. Code compliant use of MPCWT to support brick veneer may be accomplished by both individual designs and by adhering to the recommendations in this report. The concepts shown can be applied to many different situations utilizing MPCWT's.

The details shown in this report are presented only as a guide for use by a qualified Building Designer and/or Contractor. It is not intended that these recommendations be interpreted as superior to the Building Designer's designs.

Disclaimer: It must be noted that the design of the truss only accounts for the gravitational loads in the plane of the truss. The building designer needs to adequately account for loads normal to the face of the truss and the bracing/restraint of the roof and wall system.

References:

[1] American Forest & Paper Association (AF&PA). 2015 National Design Specification® (NDS®) for Wood Construction. AF&PA, 1111 19th Street, NW, Suite 800, Washington, DC 20036. http://www.awc.org/

[2] American Concrete Institute, Masonry Standard Joint Committee (MSJC), Building Code requirements for Masonry Structures (ACI 530-11/ASCE 5-11/TMS 402-11) and Specifications for Masonry Structures (ACI 530.1-11/ASCE 6-11/TMS 602-11). http://www.asce.org/Product.aspx?ID=2147487569&ProductID=197024187

[3] IRC. *International Residential Code* (2015 edition). International Code Council, Inc., Washington, DC. http://publicecodes.cyberregs.com/icod/irc/2015/index.htm

[4] IBC. *International Building Code* (2015 edition). International Code Council, Inc., Washington, DC. http://publicecodes.cyberregs.com/icod/ibc/2015/index.htm

[5] ASCE, 2010. *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-10), American Society of Civil Engineers, Reston, VA. http://www.asce.org/Product.aspx?id=25769807967&productid=154164477

[6] Masonry Advisory Council. Supporting Exterior Brick Veneer on Wood Construction
http://www.maconline.org/tech/construction/bwood/bwood4/bwood4.html

[7] The Brick Industry Association. Technical Notes on Brick Construction 18A, 28, 28A and 44B.
http://www.gobrick.com/Technical-Notes

[8] FEMA Technical Fact Sheet No. 5.4 Attachment of Brick Veneer in High-Wind Regions

This research report is subject to periodic review and revision. For the most recent version of this report, visit sbcindustry.com. For information on the current status of this report, contact SBCA.