Details for Exterior Brick Masonry Veneer Supported by Metal Plate Connected Wood Trusses

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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. In particular, this type of construction is used 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 ability to act as an approved weather covering.

Typical residential brick veneer wall systems consist of an exterior brick masonry veneer wall and an interior wood frame wall (backup framing), separated by an air cavity and metal ties connecting the brick veneer cladding to the backup framing. The cavity between the brick veneer and backup wood frame provides drainage and acts as a thermal barrier. The brick veneer provides weather resistance. Together, this is known as a "simple rain screen" wall construction. No significant structural problems have been reported: (1) where brick veneer cladding was capable of supporting its own weight all the way down to the foundation, or (2) where it was supported by properly sized steel lintel angles and/or wood structural components at commonly sized window and door openings. However, supporting brick veneer cladding above larger openings, such as a two-car garage door, a large bay window and/or patio doors, represents more challenging conditions.

In a typical brick veneer wall system, the wood framing is designed to carry all lateral and gravity loads, except for the self weight of the brick masonry. However, in reality, brick veneer cladding does carry a portion of lateral load due to its higher stiffness compared to the wood backup structure. These lateral loads from exterior masonry walls are transferred through the tie connections. 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 is not covered by the prescriptive methods of either the *International Residential Code* (*IRC*) or the design methods of the *International Building Code* (*IBC*). However, the code-compliant use of metal plate connected wood trusses to support brick veneer can be accomplished by both individual design and by adhering to the recommendations that follow. This *Tech Note* focuses on a common use of brick veneer with metal plate connected wood trusses. This involves a gable end at the transition from a wider section of a building to a narrower section. In this case, the truss typically bears on an exterior wall for part of the span and then clear spans the remaining distance. The brick veneer is supported by the exterior bearing for part of the span, but it requires some other support where the brick veneer extends past this bearing. Using the truss to provide this support may be necessary (see **Figure 1**). The concepts provided surrounding these brick veneer application issues can be applied to many different situations utilizing metal plate connected wood trusses.

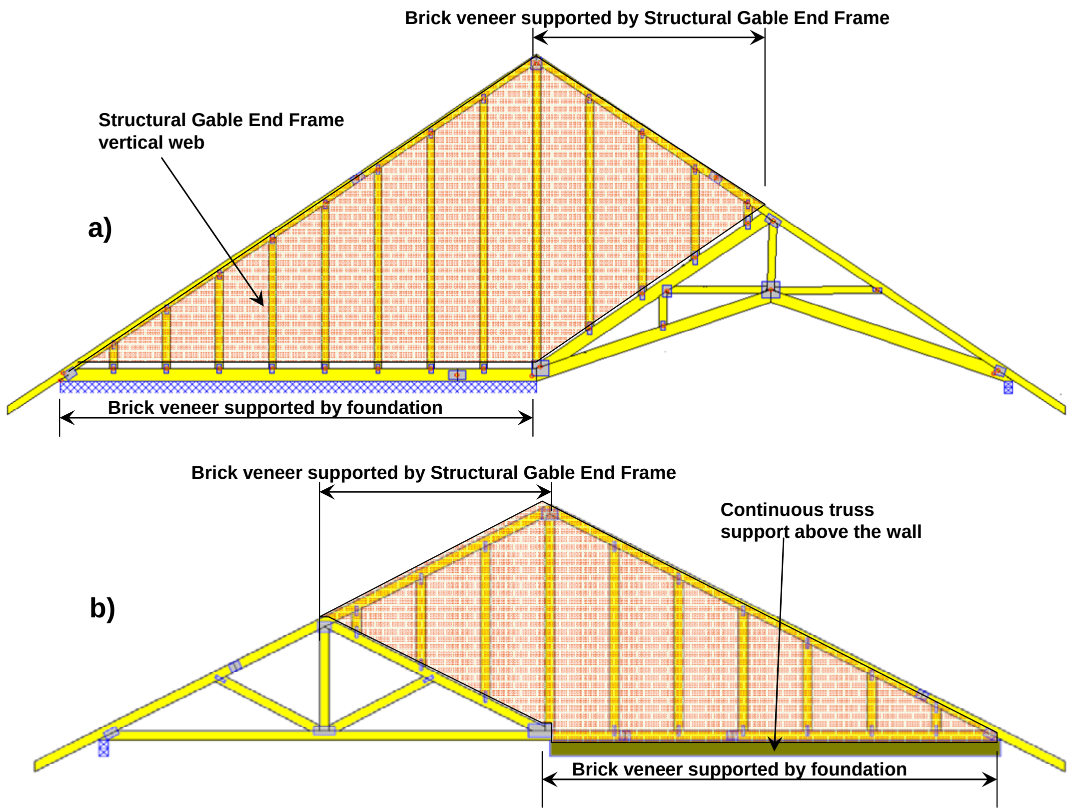


Illustration of brick veneer supported with metal plate connected wood trusses
FIGURE 1

Historically, considerable damage has been reported to residential brick veneer exterior cladding, including cracking, relative displacement and collapse of veneer brick masonry under out-of-plane loading. This often results from strong wind and/or moderate earthquakes. Most of the reported failures were caused by out-of-plane lateral loads. However, 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 design of the steel lintel, poor mortar quality, tie corrosion and poor installation of the veneer tie.

Key issues include:

Out-of-plane wall damage occurs as brick veneer moves away from gable end frames and the wall below due to wind suction and/or seismic loading. This loading places a high demand on the attachment capacity of the ties.

Errors during installation can affect long-term performance. This includes tie fastener pullout, failure of workers to embed ties into the mortar, poor bonding between ties and mortar, poor quality of mortar, and tie corrosion.

Ties are installed improperly. This can include placement above or below the mortar joints due to the ties being installed before the brick laying process begins.

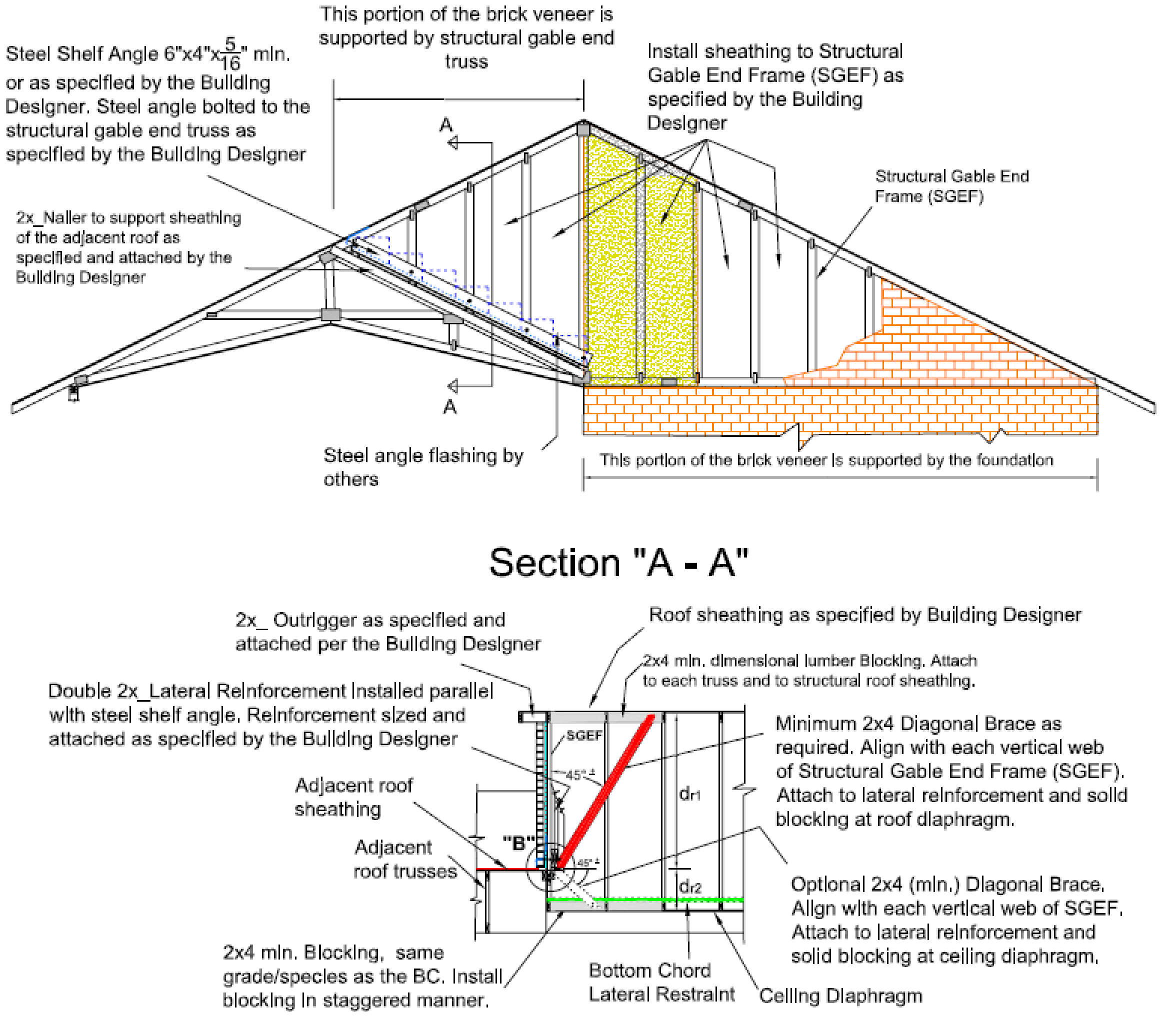
- When misaligned, the ties have to be bent up or down in order to be embedded into the mortar joints.
- Misalignment not only reduces embedment depth, but also reduces the effectiveness of the ties. This reduction is due to the wind suction force not acting parallel with the ties.

Roof gable end trusses and wall attachment/connection details are inadequate for the steel shelf angle.

Recommendations:

Metal plate connected wood trusses can effectively support brick masonry veneer walls as long as brick veneer is supported by a steel lintel angle that is properly designed, detailed and attached to the truss members. The steel lintel must be bolted to the structural gable truss vertical members as recommended in **Figures 2** and **3**. This detail may be used by the building designer as a template to achieve a code-conforming steel lintel connection.

In addition, the lateral support of brick veneer should be provided by the ties and wood backing system, including proper restraint of the metal plate connected wood truss, to resist the lateral loads imposed on them (see **Figures 2**, **3** and **4**).



Note 1: For larger spans, the vertical members of the Structural Gable End Frame (SGEF) might need to be reinforced with strongbacks to improve rotational stiffnes of the backup system. Reinforcement sized and attached as specified by the Building Designer

Note 2: Depending on the heights of "dr1" and "dr2", the attachment of the diagonal brace to the solid blocking may occur at several truss spacings in from the Structural Gable End Frame (SGEF)

Illustration of brick veneer supported with metal plate connected wood trusses
FIGURE 2

Detail "B"

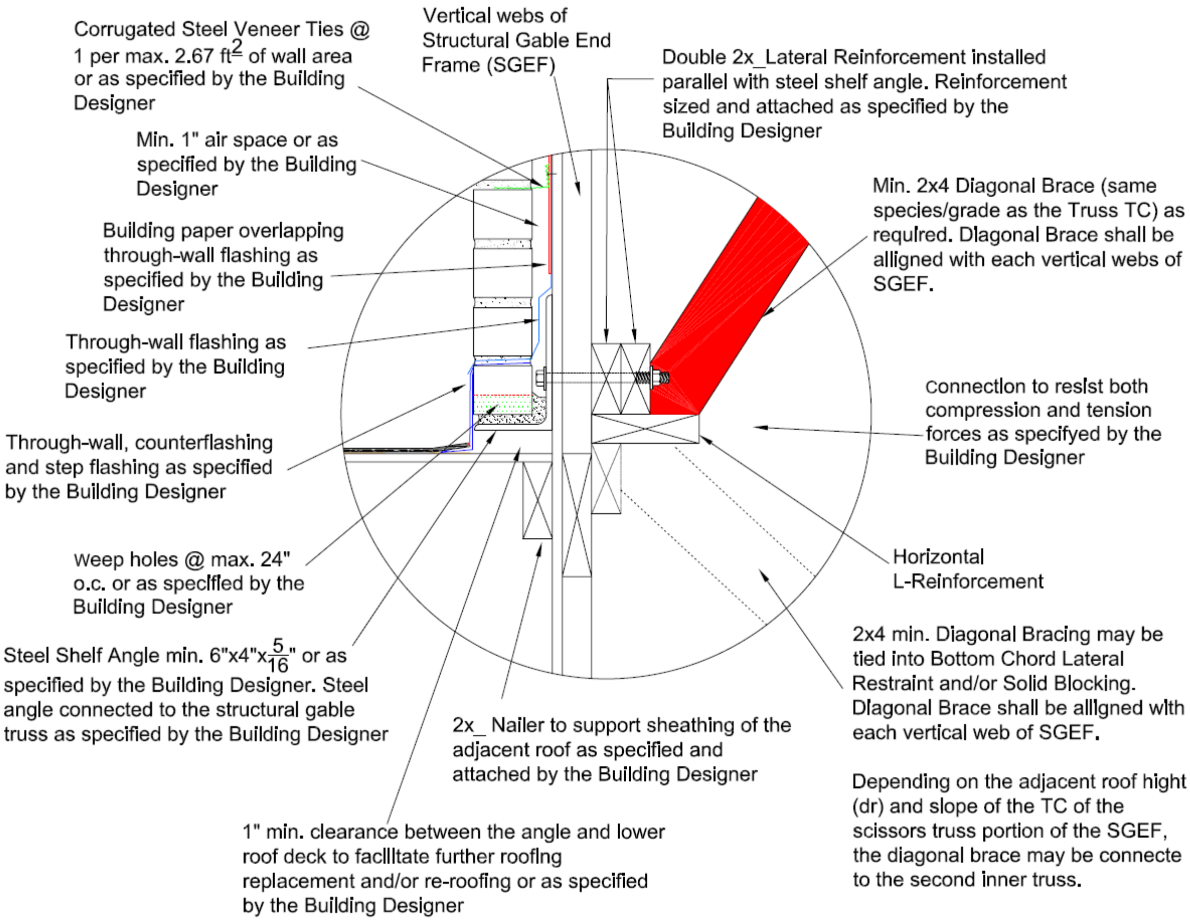
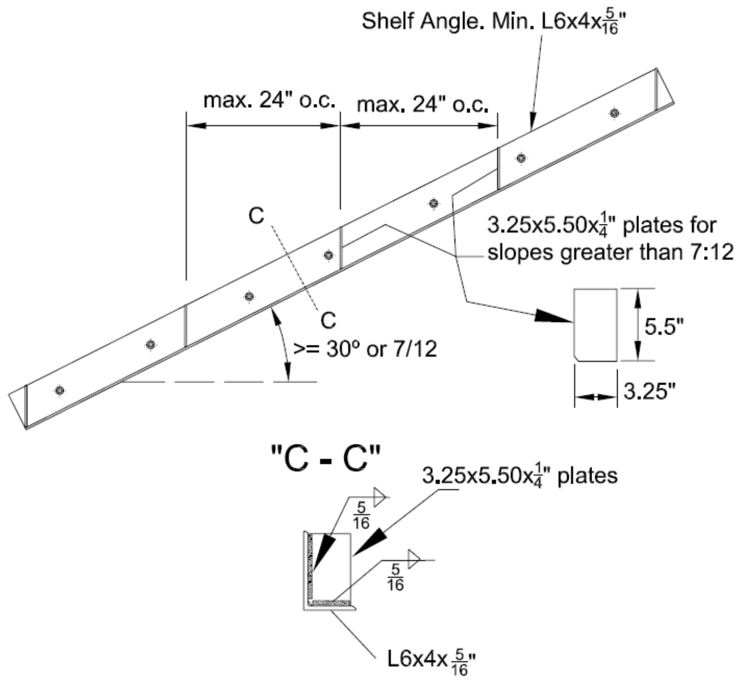


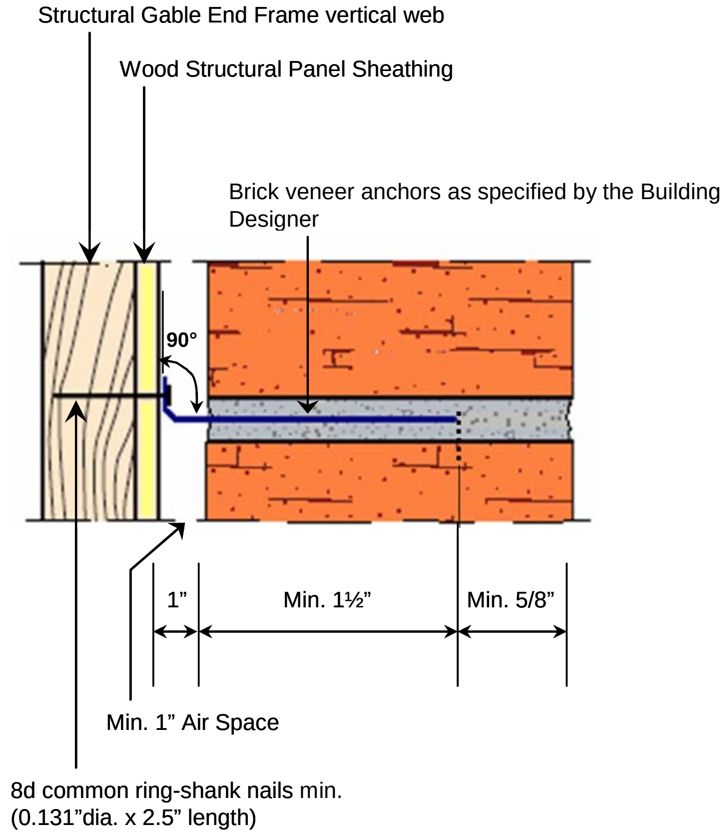
Illustration of brick veneer supported with metal plate connected wood trusses utilizing a steel angle lintel: steel shelf angle connection detail

FIGURE 3



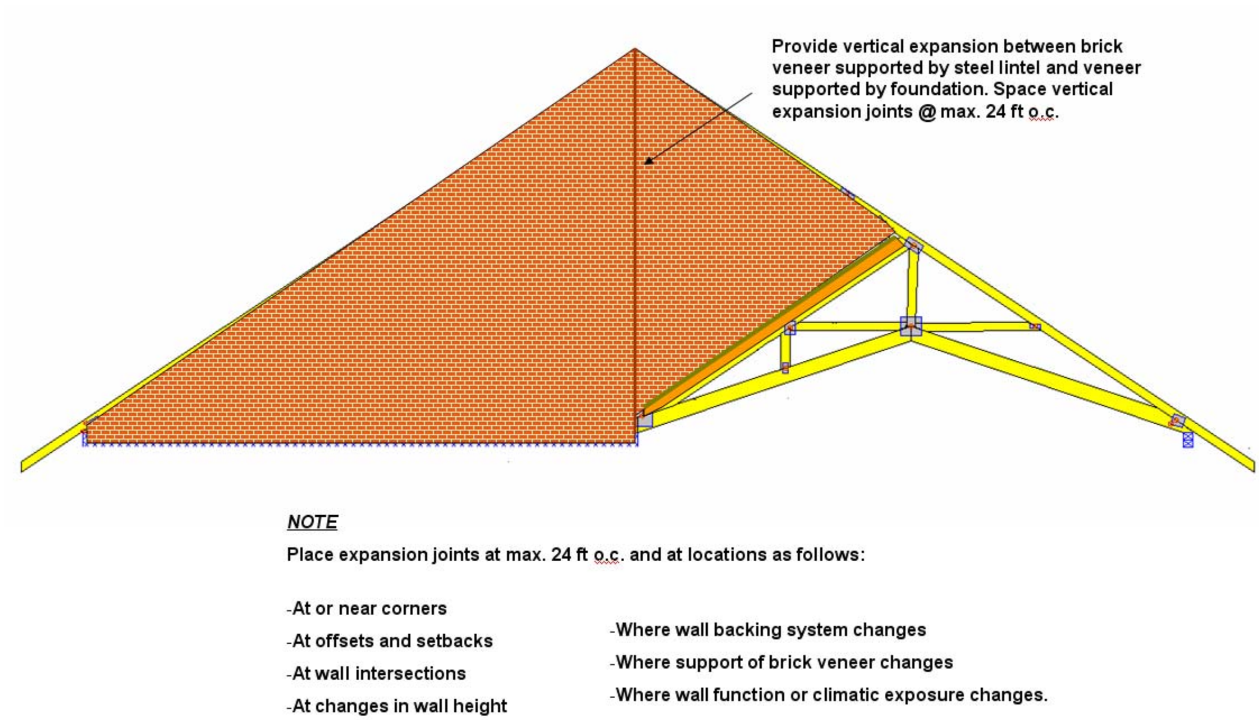
Steel shelf angle with vertical stops welded in the crook of the shelf angle for roof slopes exceeding 7/12
FIGURE 4

The ties must be capable of resisting tension and compression resulting from forces acting perpendicular to the truss plane (see **Figure 5**).



Recommended detail for masonry brick veneer corrugated steel tie embedment
FIGURE 5

Brick veneer masonry should be designed and installed with vertical expansion joints spaced at a maximum of 24 feet on-center. The actual location of the vertical expansion joints in a structure depends on structural configuration, as well as the expected amount of horizontal movement. The expansion joint in residential construction is typically sized to be of a similar width as a mortar joint, usually between $^{3}/_{8}$ inch (10 mm) and ½ inch (13 mm). In addition, vertical expansion joints should be considered at corners, offsets, openings, wall intersections and changes in wall height (see **Figure 6**).



Recommended expansion joint location for brick veneer cladding supported with metal plate connected wood trusses through a steel lintel

FIGURE 6

The truss manufacturer shall obtain the truss design criteria, connection details and related requirements (including information about brick veneer masonry) from the construction documents. All information shall be communicated to the truss designer. Since the design of metal plate connected wood trusses accounts only for gravity and environmental loads in the plane of the truss, lateral loads (i.e., wind and seismic) acting perpendicular to the face of a truss must be addressed by the building designer or Registered Design Professional. The building designer or Registered Design Professional, who understands the intended flow of loads for the entire building system, is responsible for accounting for those loads, designing the building stability bracing (including the entire truss roof system lateral restraint and diagonal bracing), and safely transferring those loads through the building and into the ground.

Appendix
Background & Analysis

Prescriptive installation requirements for supporting brick veneer with wood frame structures are specified in the *2006 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. Additional prescriptive installation requirements are specified in the *2005 Masonry Standards Joint Committee Code* (MSJC) and the *2005 Brick Industry Association* (BIA) *Technical Notes* 28, 31B, 18A, and 44B.

According to *2006 IRC*, brick veneer masonry can be supported by wood framing when observing these stated limitations:

> R703.7.2 Exterior veneer support. Except in Seismic Design Categories D0, D1 and D2, 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. When 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.
>
> R703.7.2.1 Support by steel angle. A minimum 6 inches by 4 inches 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 inches by 4 inches (51 mm by 102 mm) wood studs at a maximum on-center spacing of 16 inches (406 mm). Anchorage of the steel angle at every double stud spacing shall be a minimum of two 7/16 inch (11 mm) diameter by 4 inch (102 mm) lag screws. The steel angle shall have a minimum clearance to underlying construction of 1/16 inch (2 mm). A minimum of 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 R703.7.2.1. The maximum height of masonry veneer above the steel angle support shall be 12 feet, 8 inches (3861 mm). The air space separating the masonry veneer from the wood backing shall be in accordance with Sections R703.7.4 and R703.7.4.2. The method of support for the masonry veneer on wood construction shall be constructed in accordance with Figure R703.7.2.1.
>
> 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 x 3 inch x 1/4 inch (76 mm x 76 mm x 6 mm) steel plate welded to the angle at 24 inches (610 mm) on center along the angle or as approved by the building official.
>
> R703.7.2.2 Support by roof construction. A steel angle shall be placed directly on top of the roof construction. The roof supporting construction for the steel angle shall consist of a minimum of three 2-inch by 6-inch (51mm by 152 mm) wood members. The wood member abutting the vertical wall stud construction shall be anchored with a minimum of three 5/8-inch (16 mm) diameter by 5-inch (127 mm) lag screws to every wood stud spacing. Each additional roof member shall be anchored by the use of two 10d nails at every wood stud spacing. A minimum of 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 R703.7.2.2. The maximum height of the masonry veneer above the steel angle support shall be 12 feet, 8 inches (3861 mm). The air space separating the masonry veneer from the wood backing shall be in accordance with Sections R703.7.4 and R703.7.4.2. The support for the masonry veneer on wood construction shall be constructed in accordance with Figure R703.7.2.2.
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x 76 mm x 6 mm) steel plate welded to the angle at 24 inches (610 mm) on center along the angle or as approved by the building official.

However, the *2006 IRC* includes no prescriptive provisions to specifically address an exterior brick veneer wall supported by metal plate connected wood trusses.

IRC Requirements and Limitations Regarding Metal Plate Connected Wood Trusses:

The *IRC* provides two details for attaching a steel angle to wood framing (Figures R703.7.2.1 and R703.7.2.2). In both details, there is an adjacent wood framed backup wall. The *IRC* does not address metal plate connected wood trusses supporting brick veneer masonry at all.

For buildings with conventional construction that contain structural elements exceeding the limits in Section R301, 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. When 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 to demonstrate compliance of non-conventional elements with other applicable provisions and shall be compatible with the performance of the conventional framed systems.
>
> Engineered design in accordance with the International Building Code is permitted for all buildings and structures, and pars thereof, included in the scope of this code.

Furthermore, a similar conceptual provision for structural components and/or assembly exceeding the limitation of conventional construction is addressed in Section 2308.1.1 of the *2006 IBC*.

> 2308.1.1 Portions exceeding limitations of conventional construction. When portions of a building or otherwise conventional construction exceed the limits of Section 2308.2, these portions and the supporting load path shall be designed in accordance with accepted engineering practice and the provisions of this code. For the purpose of this section, the term “portions” shall mean parts of building containing volume and area such as room or a series of rooms.

References:

[1] American Forest & Paper Association (AF&PA). 2005 National Design Specification (NDS) for Wood Construction. AF&PA, 1111 19th Street, NW, Suite 800, Washington, DC 20036
[2] Masonry Standard Joint Committee (MSJC), Building Code requirements for Masonry Structures (ACI 530-05/ASCE 5-05/TMS 402-05) and Specifications for Masonry Structures (ACI 530.1-05/ASCE 6-05/TMS 602-05)
[3] IRC. *International Residential Code* (2000/2003/2006 editions). International Code Council, Inc., Washington, DC
[4] IBC. *International Building Code* (2000/2003/2006 editions). International Code Council, Inc., Washington, DC
[5] ASCE, 2005. *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-05), American Society of Civil Engineers, Reston, VA
[6] Masonry Advisory council. Supporting Exterior brick veneer on Wood Construction
[7] The Brick Industry Association. Technical Notes on Brick Construction 18A, 28 and 28A

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