

**Exterior Brick Masonry Veneer
Supported by Metal Plate Connected
Wood Trusses (MPCWT)**

Overview

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SBCA

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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



Introduction

- Brick veneer cladding is appreciated for its pleasant appearance, excellent thermal performance and its ability to prevent water penetration



Introduction

- “Simple rain screen” construction, shown at right is a common assembly.
- It consists of:
 - Brick masonry veneer at the exterior side of the wall
 - A wood frame wall at the interior
 - Metal ties (vener anchors) attaching the brick and wood

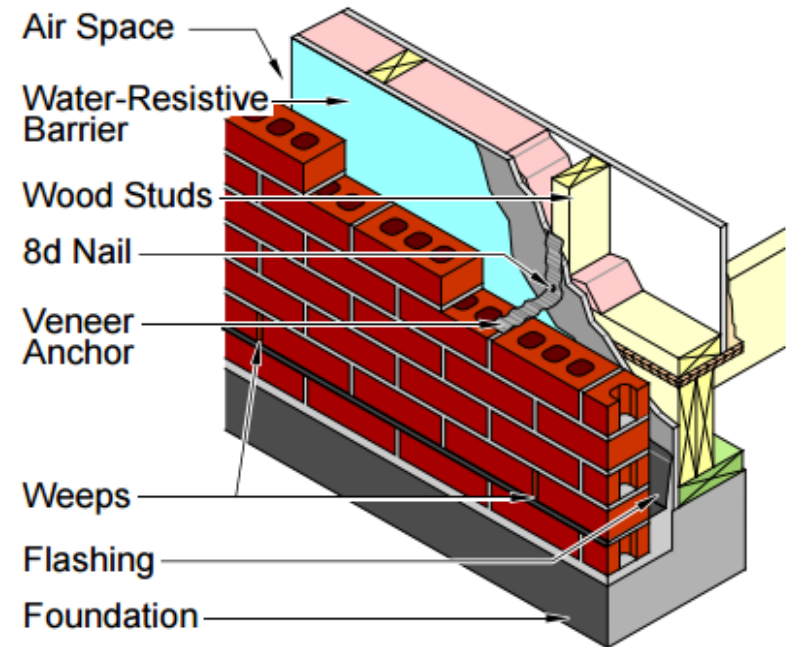


Photo: gobrick.com

Introduction

- The metal ties hold the brick veneer away from the wood framing creating an air space between the two
- This air space serves multiple role:
 - Drainage
 - Thermal barrier
 - Weather resistance

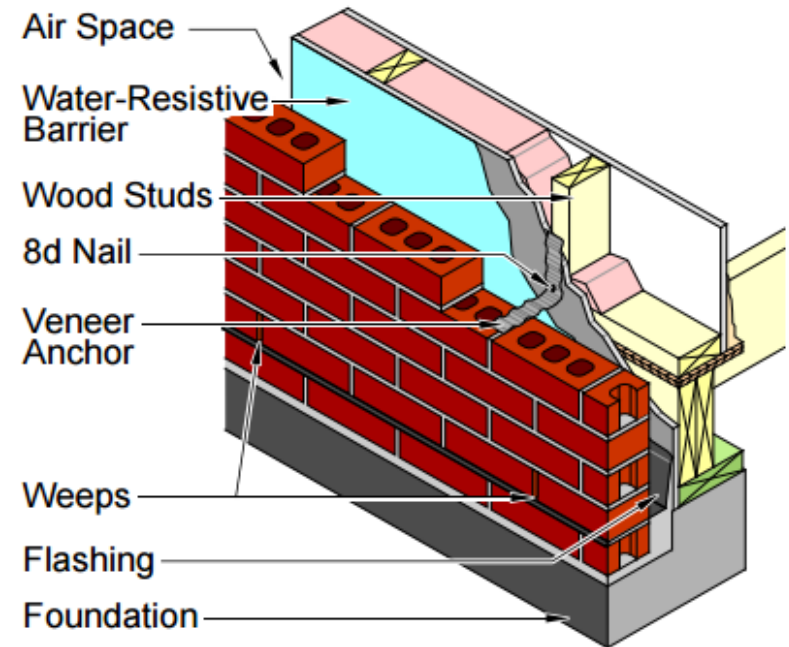


Photo: gobrick.com

Introduction

- Additionally, from a structural perspective the tie connection is important in transferring lateral loads between the brick veneer and wood framing

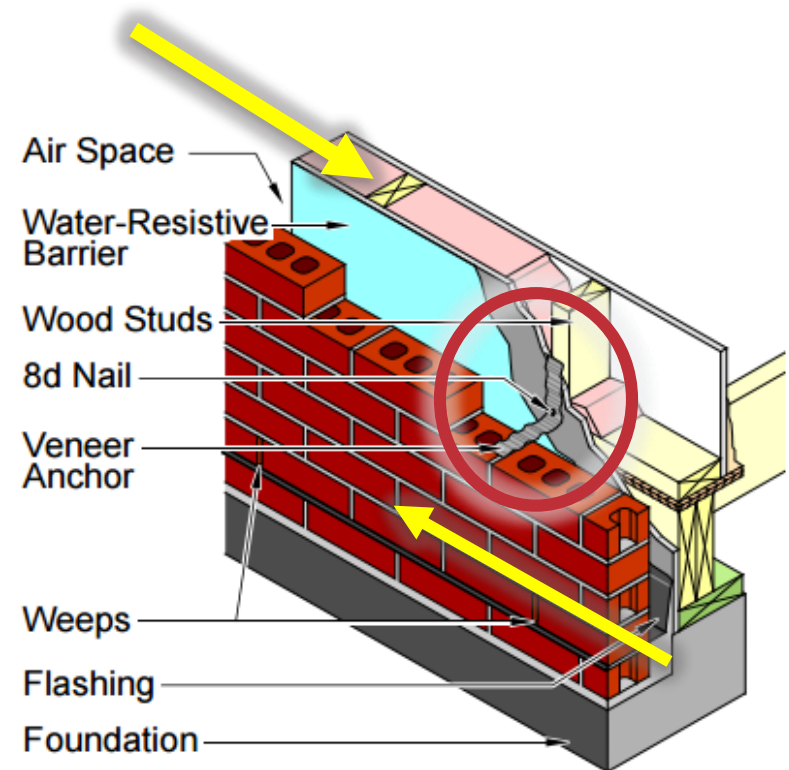


Photo: gobrick.com

Introduction

- Typically, the wood framing is designed to carry all lateral and gravity loads except for self-weight of the brick
- However, the brick does carry a portion of lateral load due to having higher stiffness than the wood framing

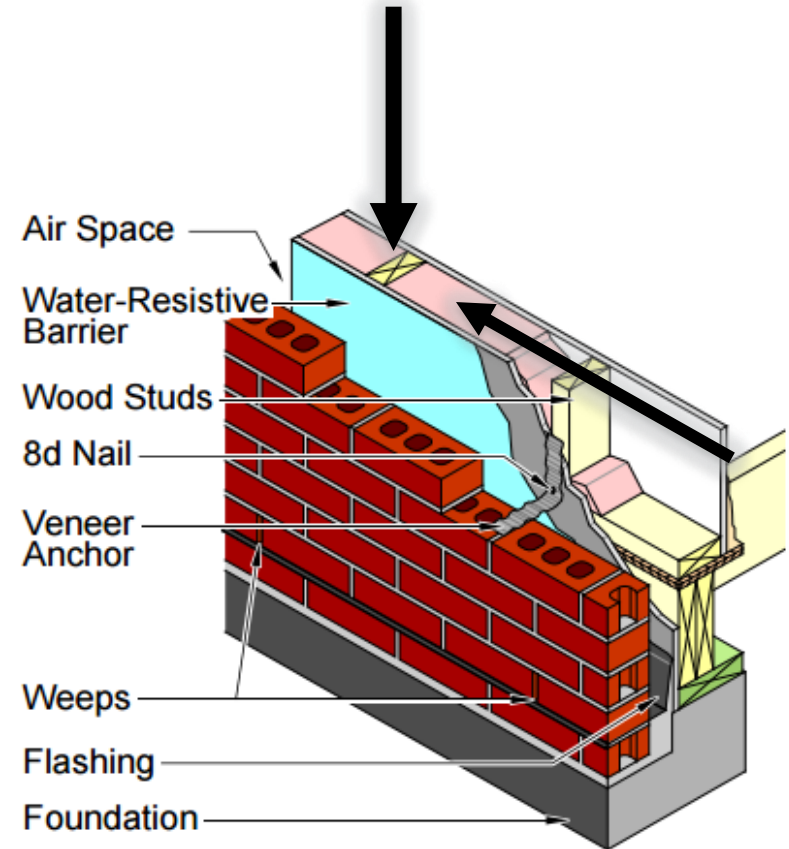


Photo: gobrick.com

Introduction

- No significant structural problems have been reported with brick veneer under typical scenarios:
 - The cladding is capable of supporting its own weight all the way down to the foundation
 - The cladding is supported by properly sized steel lintel angles and/or wood structural components over conventionally sized window and door openings



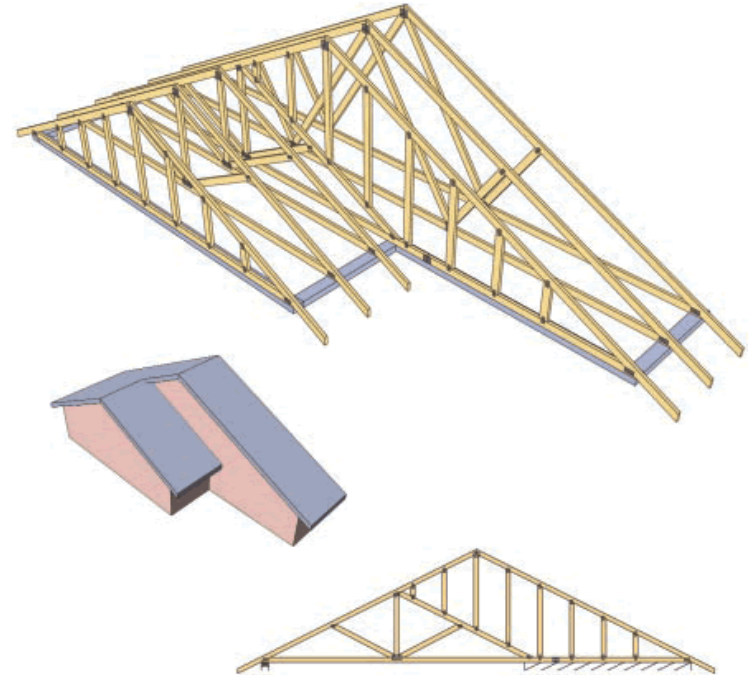
Introduction

- Supporting brick veneer cladding above larger openings such as a two-car garage door or large patio door can be more difficult
- The use of brick veneer supported by MPCWT is not covered by the prescriptive methods in the codes
- However, code compliance can be accomplished by both individual designs and by adhering to the recommendations that follow



Issue

- This presentation focuses on the gable end at the transition from a wider section of a building to a narrower section
- The concepts shown can be applied to many different situations utilizing MPCWT's



Background

- Per IRC 2015, brick veneer masonry can be supported by wood framing when observing the stated 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
- [R703.8.2 Exterior veneer support](#)
- [R703.8.2.1 Support by steel angle](#)
- [R703.8.2.2 Support by roof construction](#)

Background

- Additional, prescriptive installation requirements are specified in
 - The Masonry Society (TMS) 402/602
 - The Brick Industry Association (BIA) Technical Notes 18A, 28, 31B, and 44B



Background

- The *IRC* provides two details for attaching a steel angle to wood framing, Figures [R703.8.2.1](#) (right) and [R703.8.2.2](#) (following slide)

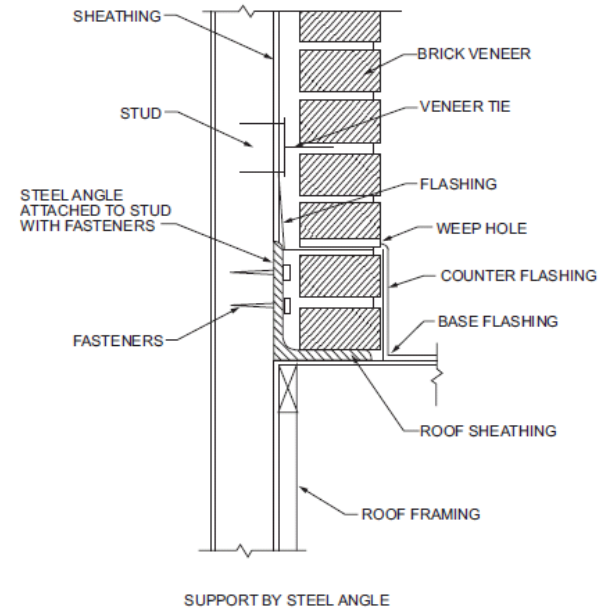


FIGURE R703.8.2.1
EXTERIOR MASONRY VENEER SUPPORT BY STEEL ANGLES

Background

- In both details, there is an adjacent wood framed backup wall

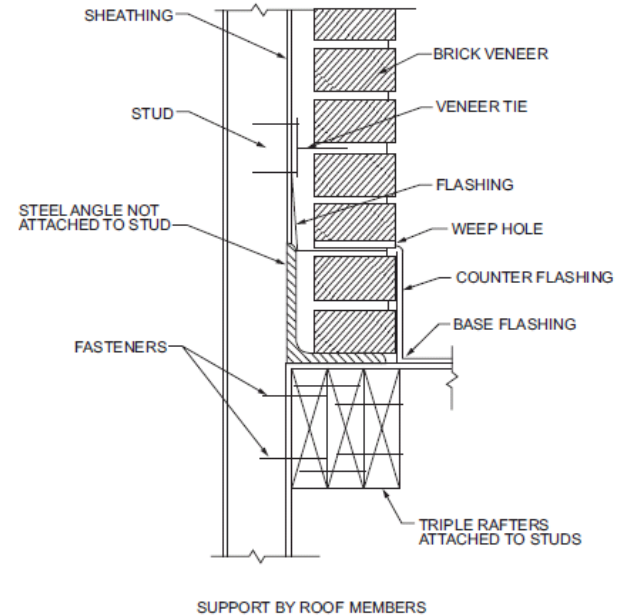
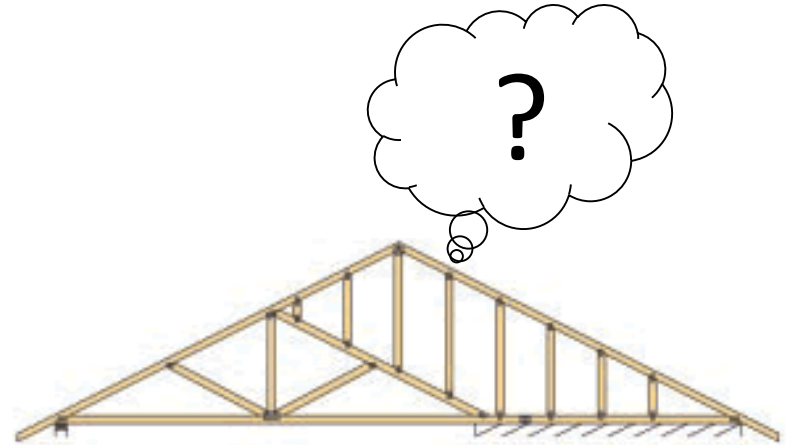


FIGURE R703.8.2.2
EXTERIOR MASONRY VENEER SUPPORT BY ROOF MEMBERS

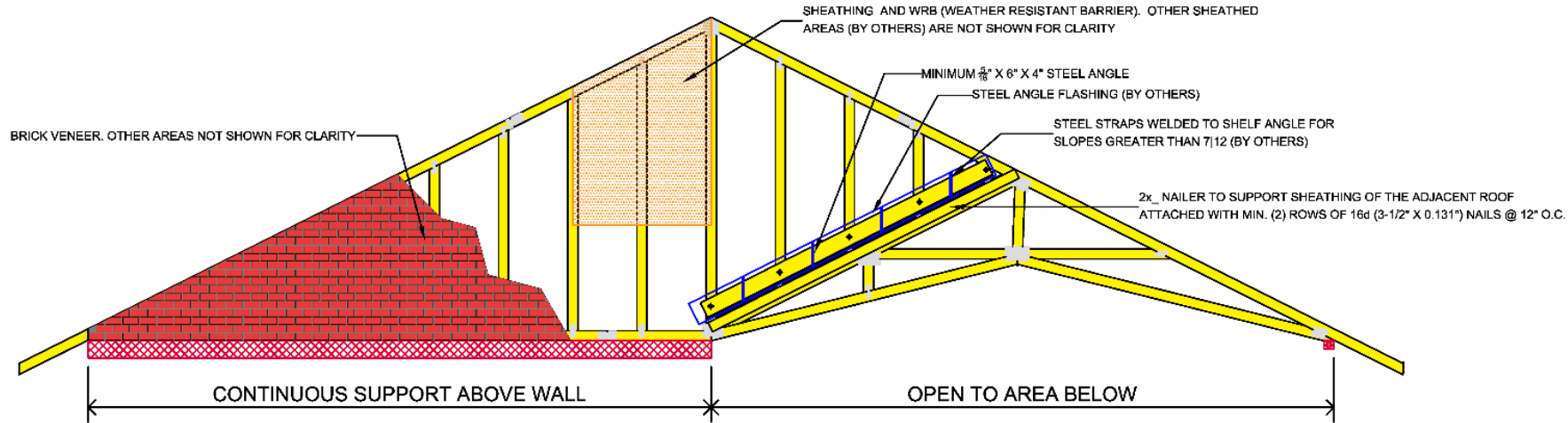
Background

- However, the *IRC 2015* includes no prescriptive provisions to specifically address an exterior brick veneer wall supported directly by MPCWT



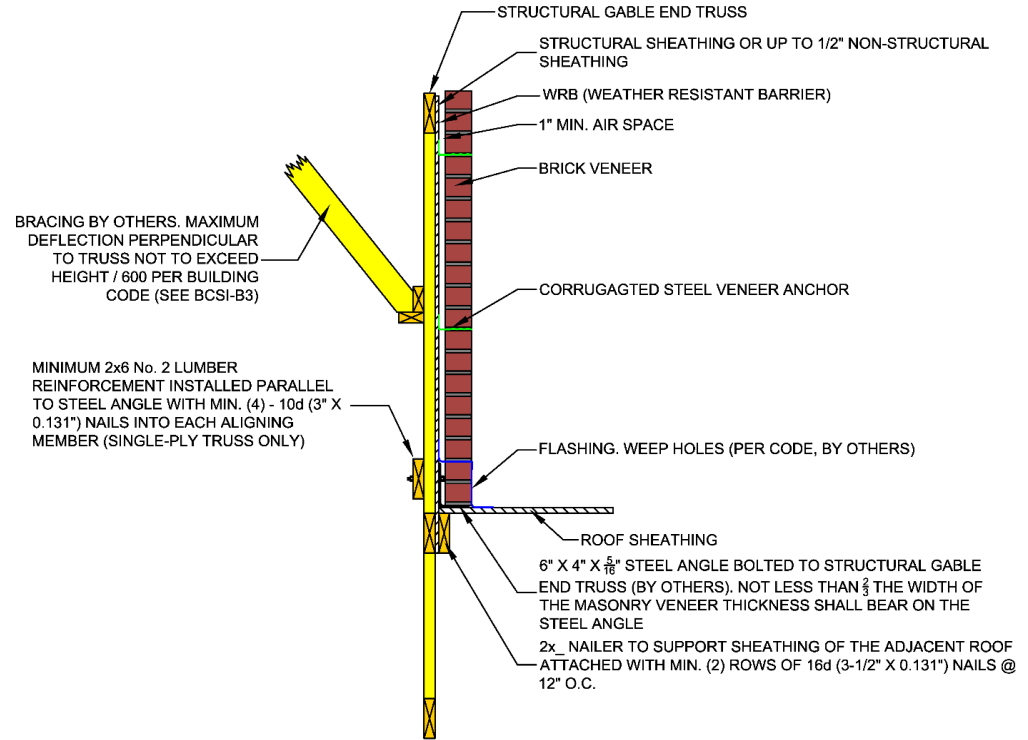
Background

- The detail below may be referred to by the building designer to achieve a code-conforming steel lintel connection



Background

- Section view of previous slide



Background

- The lateral support of brick veneer should be provided by the ties and wood backing system, including proper restraint of the MPCWT to resist the lateral loads imposed
- The ties must be capable of resisting tension and compression resulting from forces acting perpendicular to the truss plane

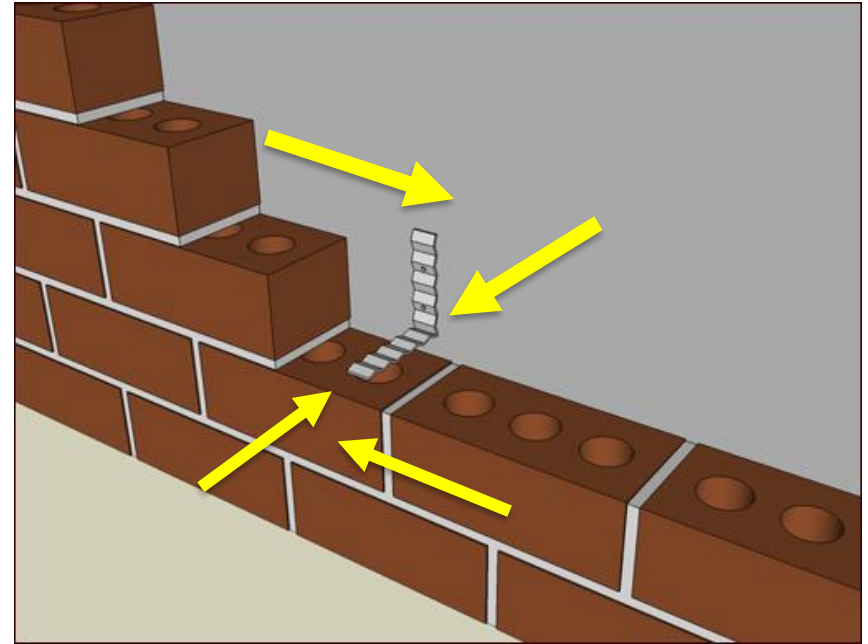
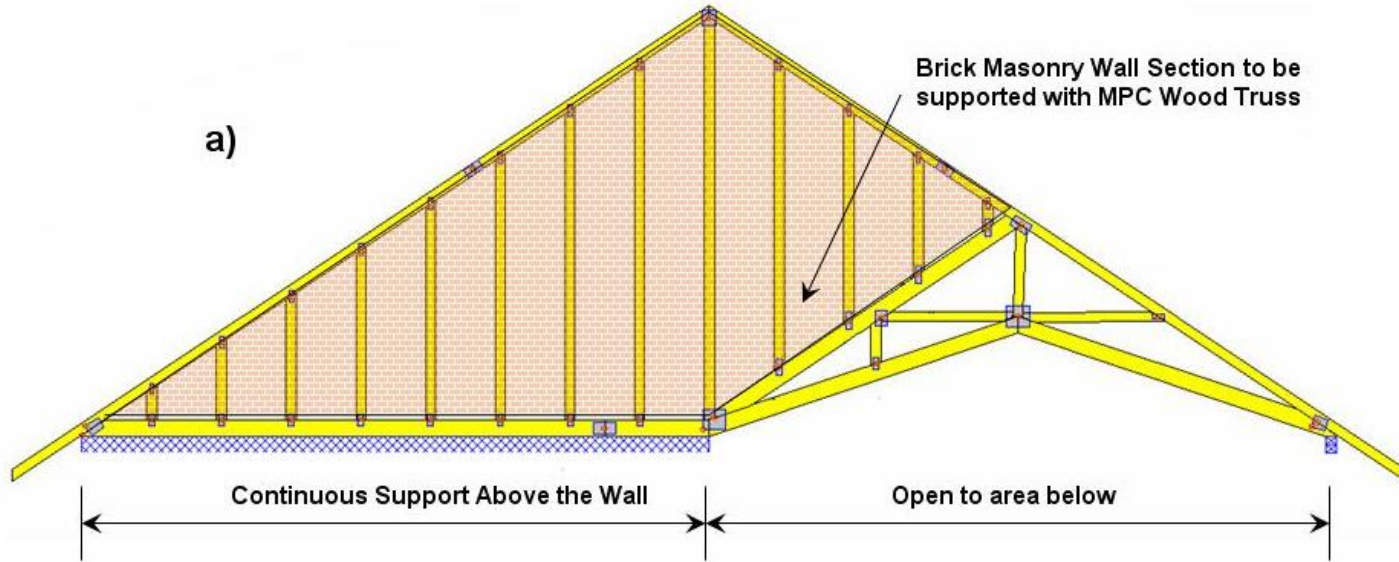


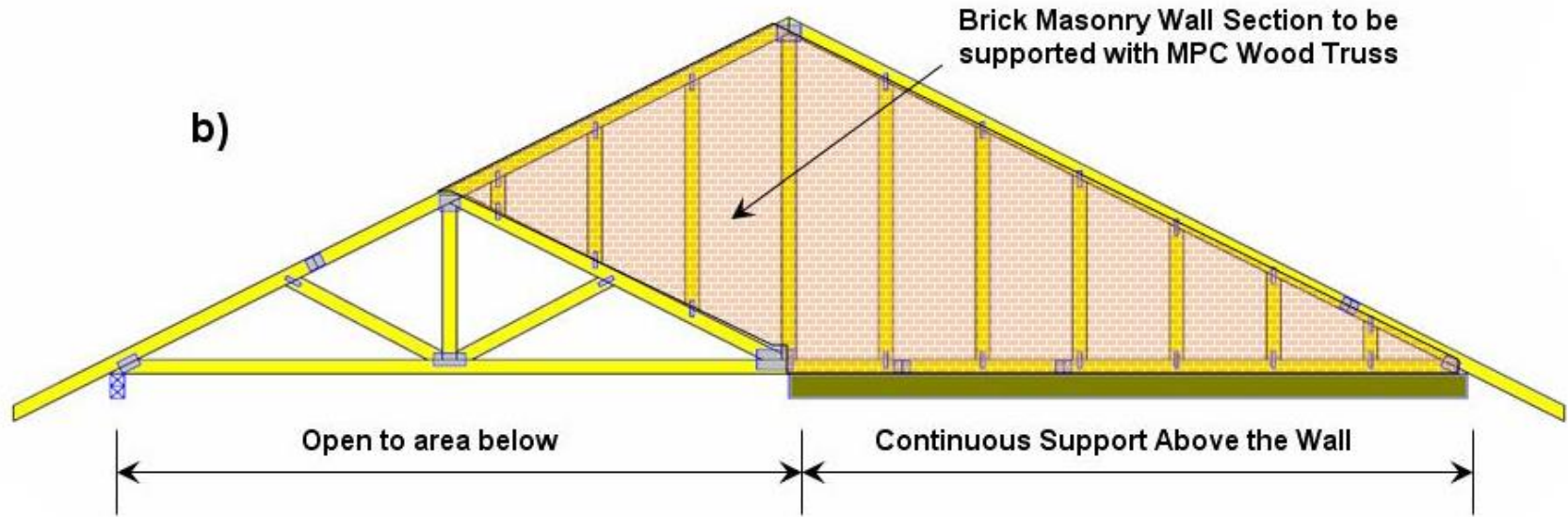
Photo: masonrymagazine.com

Background

- Examples of supporting brick veneer with MPCWT utilizing a steel lintel are given in the following examples (a) and (b)



Background



Background

- 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](#)

Background

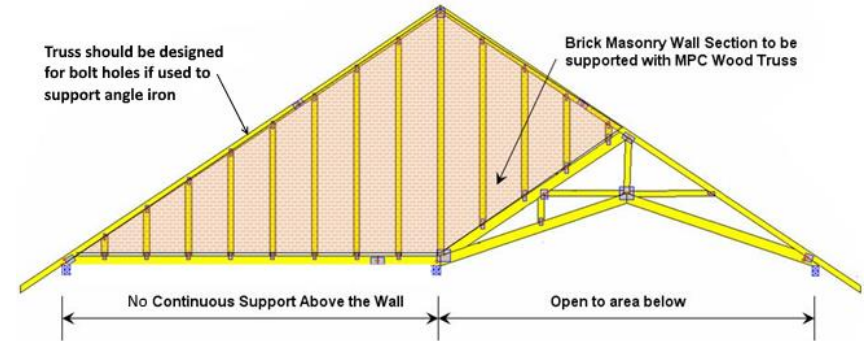
- Furthermore, similar conceptual provision for structural components and/or assembly exceeding the limitation of conventional construction is addressed in Section 2308.1.1 of the *2012 International Building Code (IBC)*
- 2308.1.1 Portions exceeding limitations of conventional light-frame construction

Analysis

- For the individual truss carrying the brick/masonry wall through a steel lintel attached to the truss, the guidance and recommendations on the following slides are provided based on our professional judgment and the following sources:
 - 2015 IRC and 2015 IBC
 - Wind loads specified in [ASCE 7-10](#)
 - Fastener strengths specified in the NDS
 - Masonry Structures standards contained in [TMS 402/602](#).
 - General guidance given in [Brick Industry Association's Technical Notes 18A, 28, 28B and 44B](#)

Analysis

- The MPCWT must be designed for the additional loading from the brick where bearing is not 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.

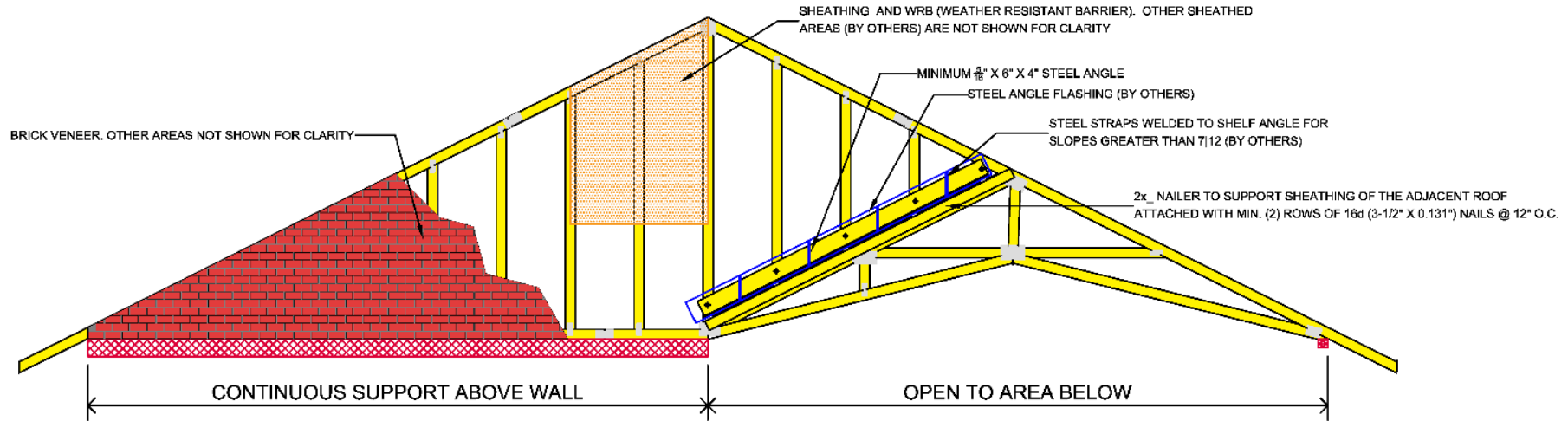


Analysis

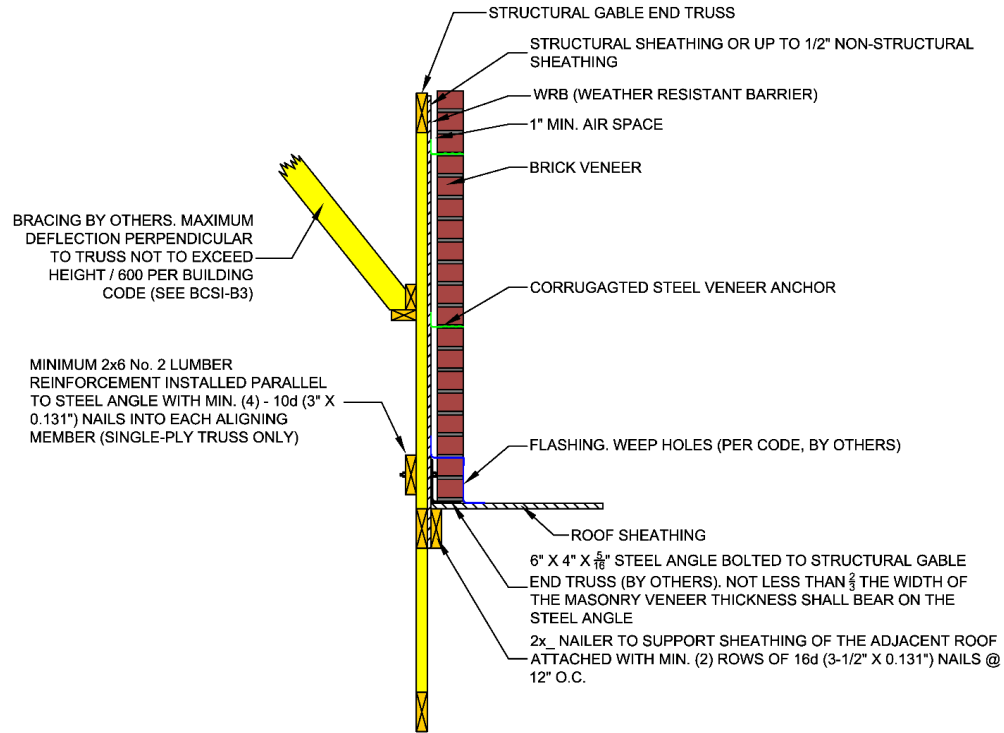
- Truss total load deflection is limited to $L/600$
- Load Duration factor is $C_D=0.9$
- Creep factor for long-term deflection calculation shall be 1.5 for dry lumber and 2.0 for unseasoned lumber
 - Creep is defined as time-dependent deformation of a structural member under constant load. In this case brick dead load is a constant and/or sustained load (see ANSI/TPI 1-2002, 2007)
- 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.

Analysis

- Steel lintel attachment to MPCWT should be **per the following details:**



Analysis



Analysis

- A minimum 6" x 4" x 5/16" (152 mm by 102 mm by 8 mm) steel angle, with the long leg placed vertically, shall be anchored to MPCWT using bolts per the following tables
- For assemblies with Structural Sheathing:

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.

Analysis

- For assemblies with Non-Structural Sheathing:

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.

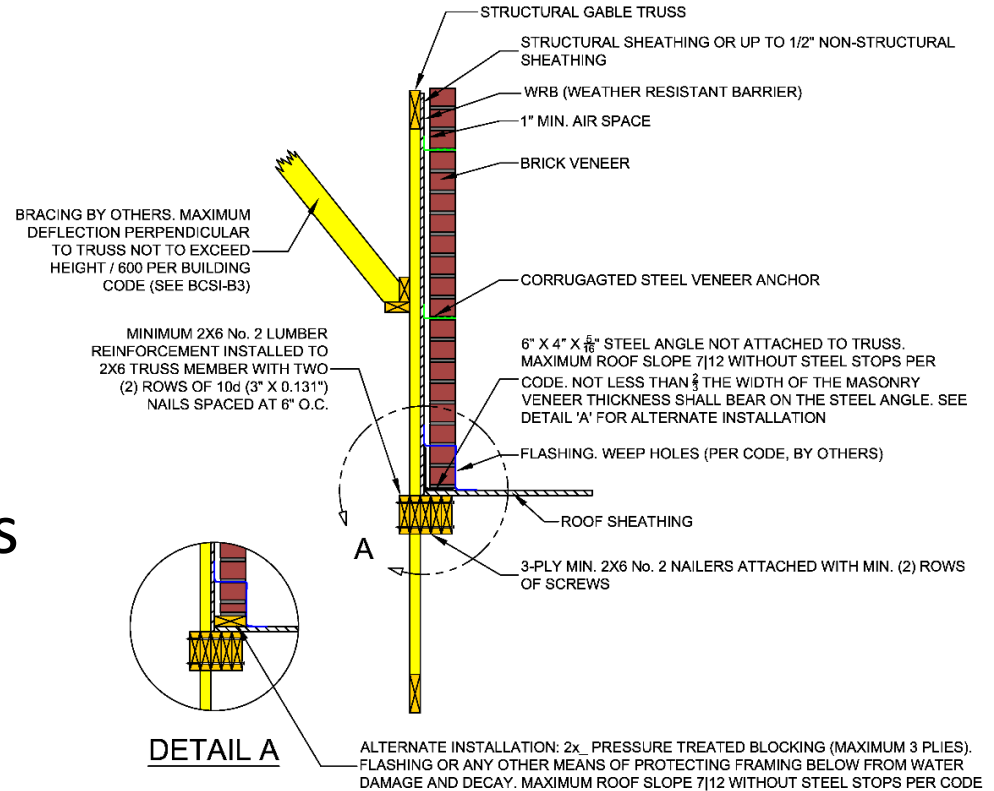
^a The maximum height of brick masonry veneer above the steel angle support using prescriptive requirements of 2015 IRC shall be 12'-8". Weight of brick shall be included in truss design.

^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.

Analysis

- An alternative connection using (3) 2x6's to support the brick masonry veneer directly above the 2x6's



Analysis

- Screw spacing and maximum brick height details for the (3) 2x6 masonry support system are found in the following table:

	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.

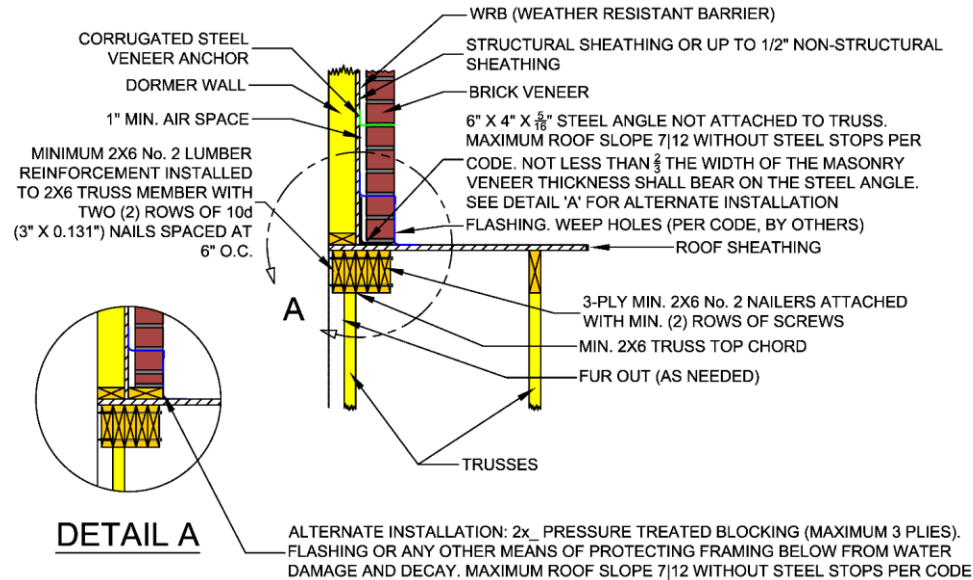
^a The maximum height of brick masonry veneer above the steel angle support using prescriptive requirements of 2015 IRC shall be 12'-8".

^b Screws to be staggered half the oc 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.

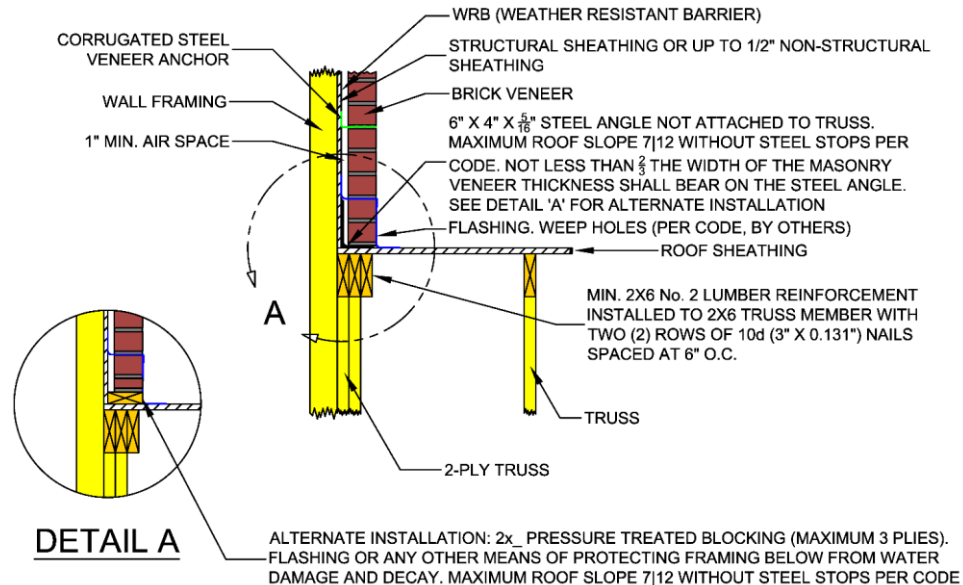
Analysis

- Another alternative connection using (3) 2x6's to support the brick masonry veneer:



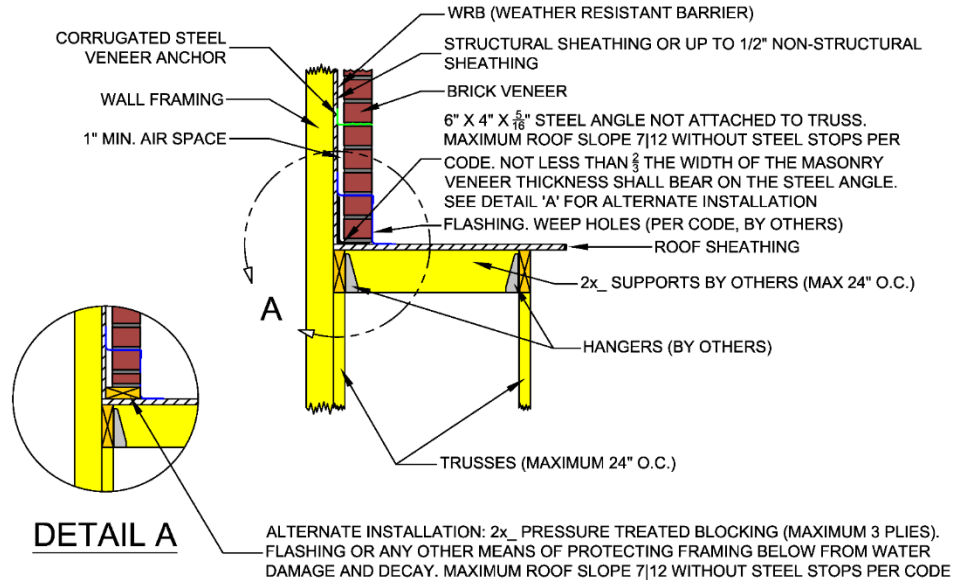
Analysis

- An alternative connection using 2-ply MPCWT directly below to support the brick masonry veneer:



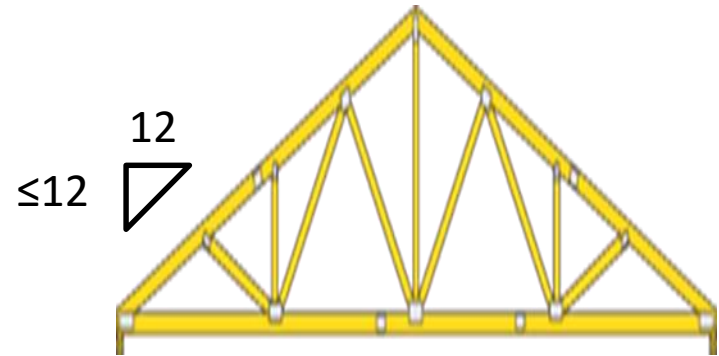
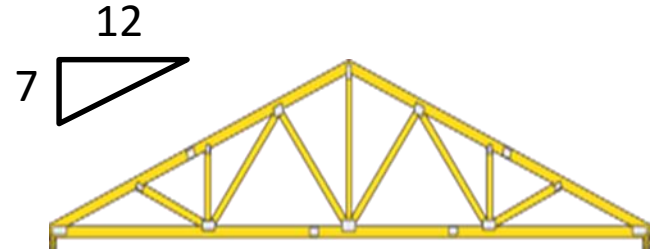
Analysis

- An alternative connection using 2x_ material between MPCWT to support the brick masonry veneer:



Analysis

- 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 from 7:12 up to 12:12 shall have stops, with a minimum size of 3"x3"x 1/4" (76 mm x 76 mm x 6 mm) steel plates, welded to the angle at a maximum spacing of 24" (610 mm) o.c. along the angle or as approved by the building official.



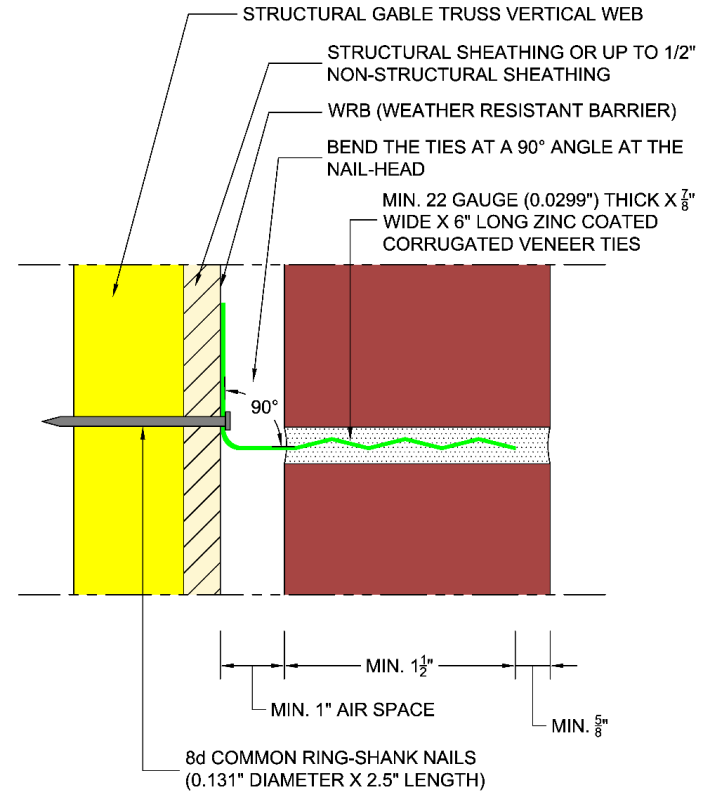
Analysis

- Lateral support is provided by the ties and backing system.
- 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](#)
- Corrosion protected ties such as zinc coated corrugated steel ties, minimum 22 U.S. gauge thick (0.0299"), 7/8" x 6" (0.76mm x 22 mm x 152 mm) complying with [ASTM A 653](#) and [A 153](#) class B2



Analysis

- Veneer ties shall be spaced at maximum 32" o.c. (610 mm) horizontally and 24" o.c. vertically and shall support max 2.67 ft² (0.25 m²) of brick veneer wall area
- For new construction, wall stud spacing of 16" o.c. is recommended so that ties can be anchored at this spacing



Analysis

- 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") or (4 mm)] and be spaced same as corrugated steel ties and shall have a hook embedded in the mortar joint



Analysis

- The following tables provide recommendations for maximum vertical tie spacing for high wind areas when structural gable truss vertical members are spaced at 24", 16" and 12" on center spacing
- In the areas that are susceptible to both high wind and seismic loads, masonry brick veneer system should be evaluated by an RDP to ensure that brick veneer cladding can resist both seismic and wind design loads

Analysis

- Maximum vertical tie spacing for assemblies with structural sheathing

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: $C_D=1.0$, $C_L=0.8$, C_M , C_{eg} , and $C_{in}=1.0$. See [FEMA Technical Fact Sheet No. 5.4 Attachment of Brick Veneer in High-Wind Regions](#).

$W = 1800G^2D \times 1.6$ 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.

Analysis

- Maximum vertical tie spacing for assemblies with **non-structural sheathing**

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_t=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_p=1.0, C_t=0.8, C_{Nr}, C_{eg}, and C_{in}=1.0. See [FEMA Technical Fact Sheet No. 5.4 Attachment of Brick Veneer in High-Wind Regions](#).

W = 1800G²D 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 1/2"-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](#).

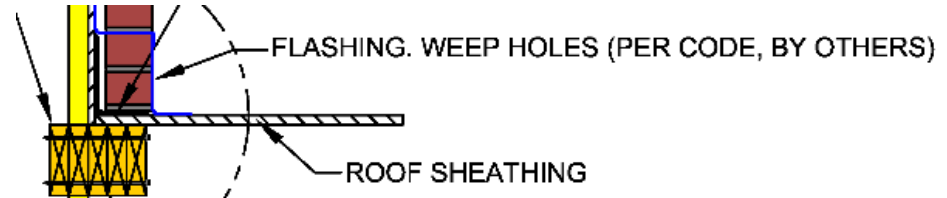
⁷ Where wind pressure exceeds 40 psf do not space anchors more than 18" vertically & horizontally per the [Brick Industry Association's Technical Note 28](#).

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.

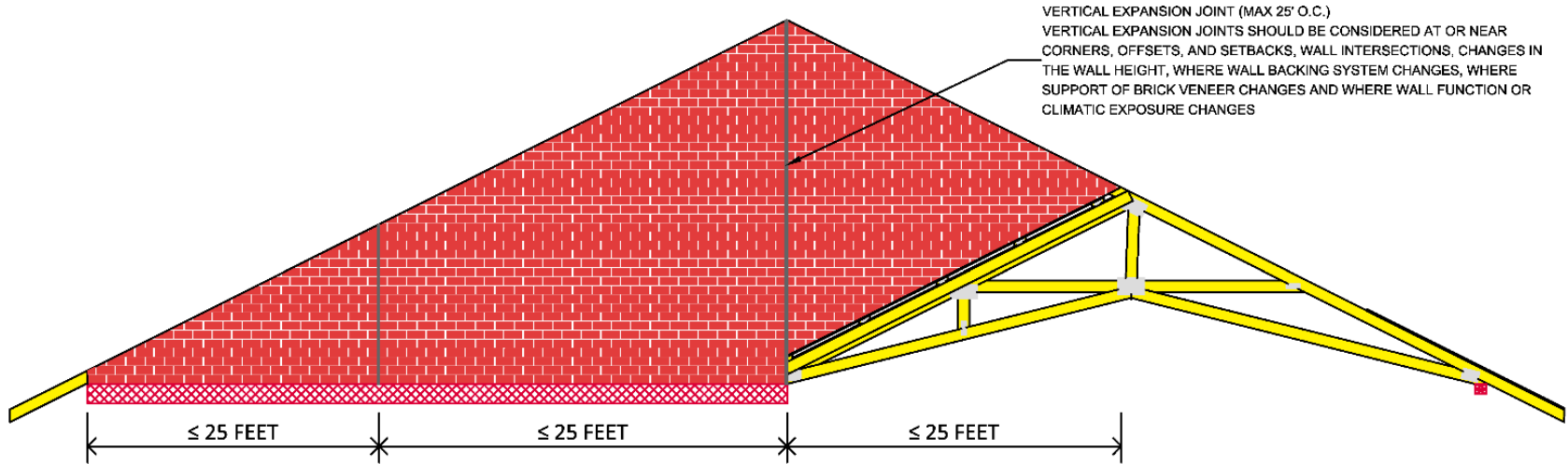
Analysis

- **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.



Analysis

- Create vertical expansion joints @ a maximum 25' (7.6 m) o.c.



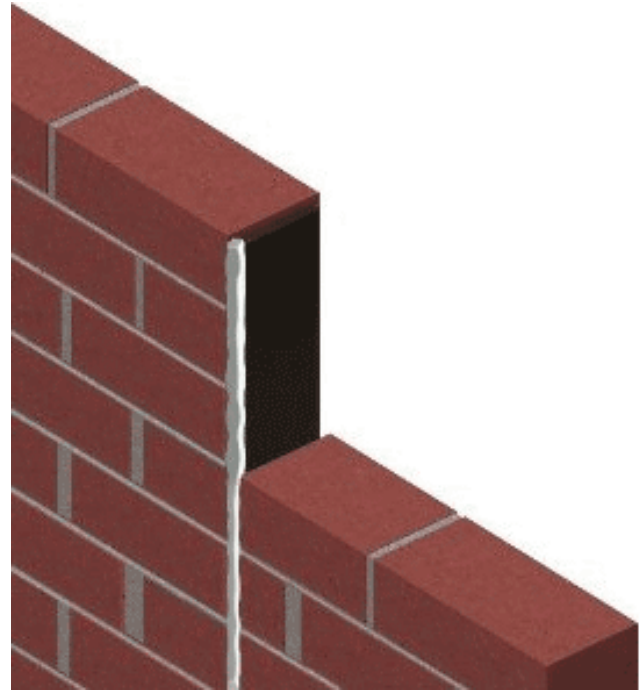
Analysis

- The actual location of vertical expansion joints in a structure depends on the structural configuration as well as the expected amount of horizontal movement
- Expansion joints are typically sized similar to a mortar joint, usually between $\frac{3}{8}$ " (10 mm) and $\frac{1}{2}$ " (13 mm)



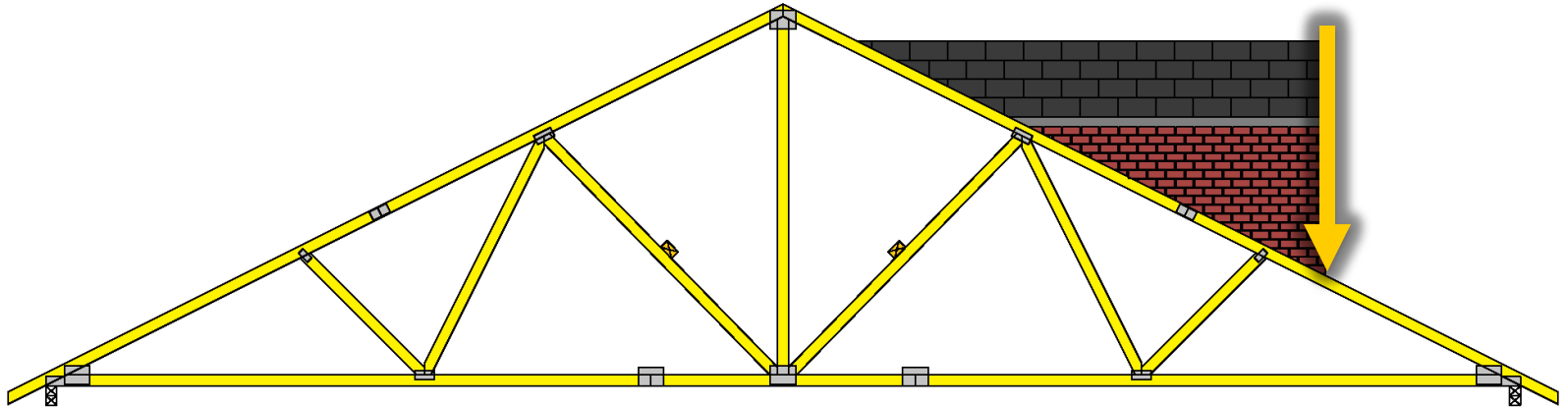
Analysis

- Vertical expansion joints should also be considered with:
 - Corners
 - Offsets
 - Setbacks
 - Wall intersections
 - Changes in the wall height
 - Wall backing system changes
 - Brick veneer support changes
 - Wall function or climatic exposure changes



Analysis

- MPCWT may also be used to support brick veneer at dormer locations.
- Depending on where the dormer is placed, the truss may need to be designed with an additional point load from a header carrying the front of the dormer brick veneer loading.



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 shown here.
- The concepts shown can be applied to many different situations utilizing MPCWT's and are presented only as a guide for use by a qualified Building Designer and/or Contractor.

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