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

Design Guide

Revised 11/17/2016

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Introduction

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

- Code compliance can be accomplished by both individual designs and by adhering to the guidance in this presentation
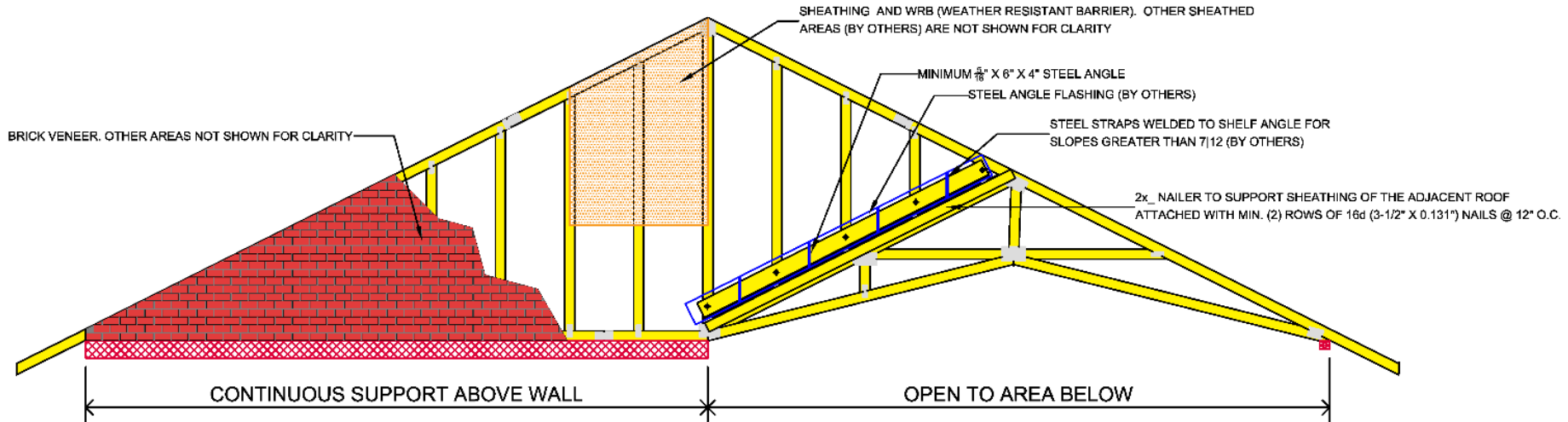

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Introduction

- This presentation specifically focuses on 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 trusses, such as supporting brick veneer at dormer locations.
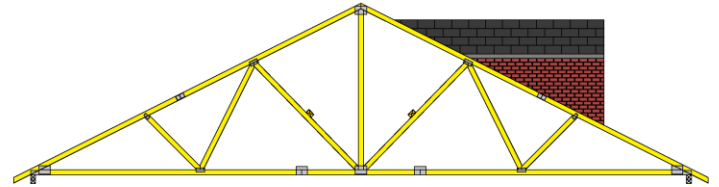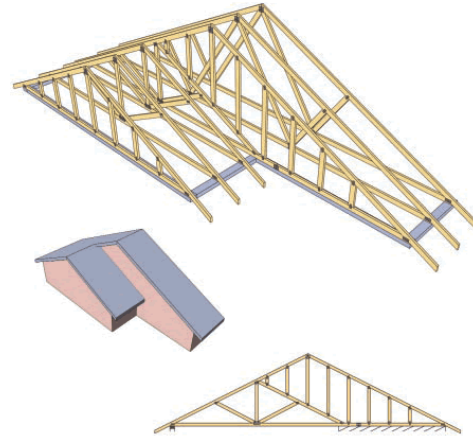
Step 1: Review Detail

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

SHEATHING AND WRB (WEATHER RESISTANT BARRIER). OTHER SHEATHED AREAS (BY OTHERS) ARE NOT SHOWN FOR CLARITY

MINIMUM 5/16" X 6" X 4" STEEL ANGLE

STEEL ANGLE FLASHING (BY OTHERS)

STEEL STRAPS WELDED TO SHELF ANGLE FOR SLOPES GREATER THAN 7|12 (BY OTHERS)

BRICK VENEER. OTHER AREAS NOT SHOWN FOR CLARITY

2x_ NAILER TO SUPPORT SHEATHING OF THE ADJACENT ROOF ATTACHED WITH MIN. (2) ROWS OF 16d (3-1/2" X 0.131") NAILS @ 12" O.C.

CONTINUOUS SUPPORT ABOVE WALL

OPEN TO AREA BELOW

Step 1: Review Detail

- Section view of previous slide

- Note that sheathing must be covered with a water-resistant membrane, unless the sheathing is water resistant and the joints are sealed.
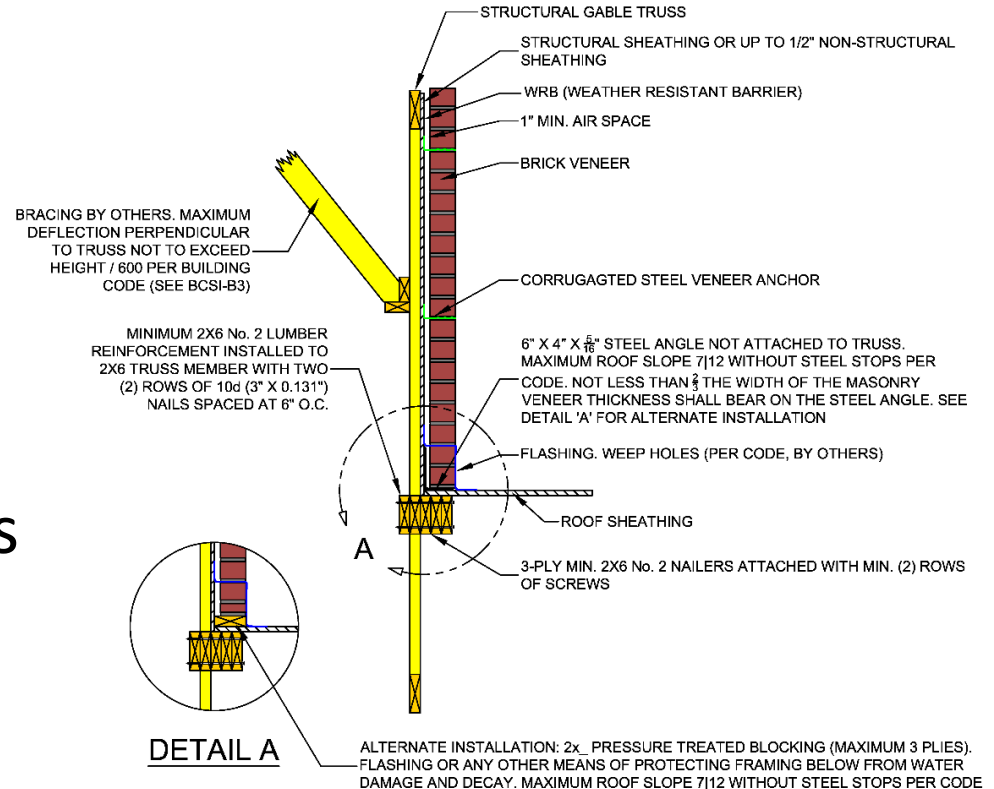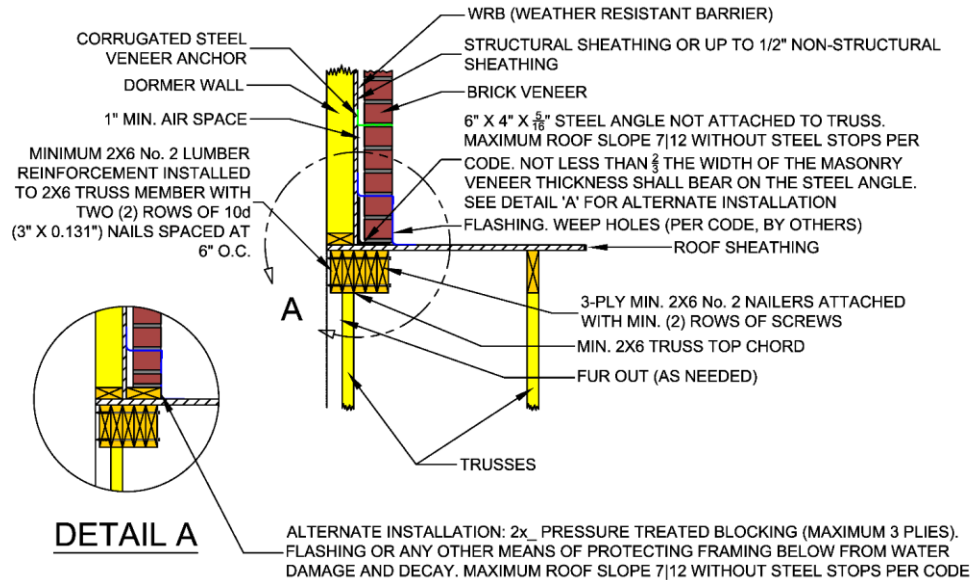

STRUCTURAL GABLE END TRUSS

STRUCTURAL SHEATHING OR UP TO 1/2" NON-STRUCTURAL SHEATHING

WRB (WEATHER RESISTANT BARRIER)

1" MIN. AIR SPACE

BRICK VENEER

CORRUGAGTED STEEL VENEER ANCHOR

BRACING BY OTHERS. MAXIMUM DEFLECTION PERPENDICULAR TO TRUSS NOT TO EXCEED HEIGHT / 600 PER BUILDING CODE (SEE BCSI-B3)

MINIMUM 2x6 No. 2 LUMBER REINFORCEMENT INSTALLED PARALLEL TO STEEL ANGLE WITH MIN. (4) - 10d (3" X 0.131") NAILS INTO EACH ALIGNING MEMBER (SINGLE-PLY TRUSS ONLY)

FLASHING. WEEP HOLES (PER CODE, BY OTHERS)

ROOF SHEATHING

6" X 4" X 5/16" STEEL ANGLE BOLTED TO STRUCTURAL GABLE END TRUSS (BY OTHERS). NOT LESS THAN 2/3 THE WIDTH OF THE MASONRY VENEER THICKNESS SHALL BEAR ON THE STEEL ANGLE

2x_ NAILER TO SUPPORT SHEATHING OF THE ADJACENT ROOF ATTACHED WITH MIN. (2) ROWS OF 16d (3-1/2" X 0.131") NAILS @ 12" O.C.

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Step 1: Review Detail

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

STRUCTURAL GABLE TRUSS

STRUCTURAL SHEATHING OR UP TO 1/2" NON-STRUCTURAL SHEATHING

WRB (WEATHER RESISTANT BARRIER)

1" MIN. AIR SPACE

BRICK VENEER

BRACING BY OTHERS. MAXIMUM DEFLECTION PERPENDICULAR TO TRUSS NOT TO EXCEED HEIGHT / 600 PER BUILDING CODE (SEE BCSI-B3)

CORRUGAGTED STEEL VENEER ANCHOR

MINIMUM 2X6 No. 2 LUMBER REINFORCEMENT INSTALLED TO 2X6 TRUSS MEMBER WITH TWO (2) ROWS OF 10d (3" X 0.131") NAILS SPACED AT 6" O.C.

6" X 4" X $\frac{5}{16}$" STEEL ANGLE NOT ATTACHED TO TRUSS. MAXIMUM ROOF SLOPE 7|12 WITHOUT STEEL STOPS PER CODE. NOT LESS THAN $\frac{2}{3}$ THE WIDTH OF THE MASONRY VENEER THICKNESS SHALL BEAR ON THE STEEL ANGLE. SEE DETAIL 'A' FOR ALTERNATE INSTALLATION

FLASHING. WEEP HOLES (PER CODE, BY OTHERS)

A

ROOF SHEATHING

3-PLY MIN. 2X6 No. 2 NAILERS ATTACHED WITH MIN. (2) ROWS OF SCREWS

DETAIL A

ALTERNATE INSTALLATION: 2x_ PRESSURE TREATED BLOCKING (MAXIMUM 3 PLIES). FLASHING OR ANY OTHER MEANS OF PROTECTING FRAMING BELOW FROM WATER DAMAGE AND DECAY. MAXIMUM ROOF SLOPE 7|12 WITHOUT STEEL STOPS PER CODE
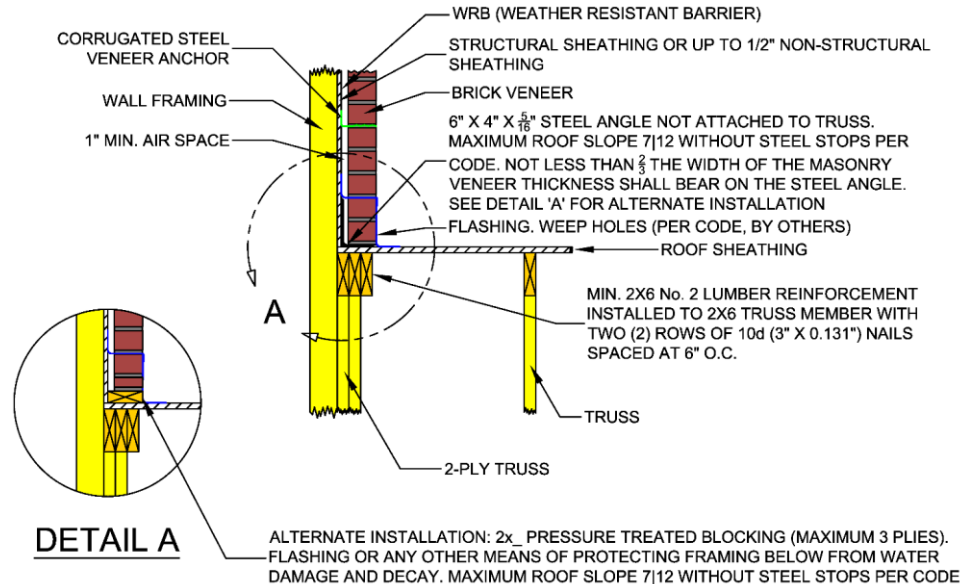
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Step 1: Review Detail

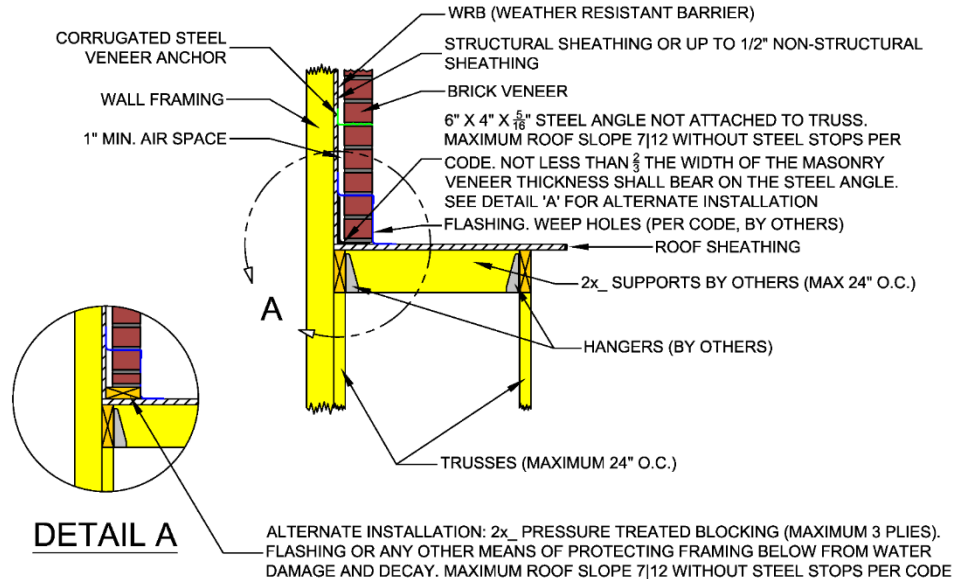- Another alternative connection using (3) 2x6's to support the brick masonry veneer:

Step 1: Review Detail

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

Step 1: Review Detail

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

CORRUGATED STEEL VENEER ANCHOR

WALL FRAMING

1" MIN. AIR SPACE

WRB (WEATHER RESISTANT BARRIER)

STRUCTURAL SHEATHING OR UP TO 1/2" NON-STRUCTURAL SHEATHING

BRICK VENEER

6" X 4" X $\frac{5}{16}$" STEEL ANGLE NOT ATTACHED TO TRUSS. MAXIMUM ROOF SLOPE 7|12 WITHOUT STEEL STOPS PER CODE. NOT LESS THAN $\frac{2}{3}$ THE WIDTH OF THE MASONRY VENEER THICKNESS SHALL BEAR ON THE STEEL ANGLE. SEE DETAIL 'A' FOR ALTERNATE INSTALLATION

FLASHING. WEEP HOLES (PER CODE, BY OTHERS)

ROOF SHEATHING

2x_ SUPPORTS BY OTHERS (MAX 24" O.C.)

HANGERS (BY OTHERS)

TRUSSES (MAXIMUM 24" O.C.)

A

DETAIL A

ALTERNATE INSTALLATION: 2x_ PRESSURE TREATED BLOCKING (MAXIMUM 3 PLIES). FLASHING OR ANY OTHER MEANS OF PROTECTING FRAMING BELOW FROM WATER DAMAGE AND DECAY. MAXIMUM ROOF SLOPE 7|12 WITHOUT STEEL STOPS PER CODE

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Step 2: Verify Design Values

- 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

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Step 3: Select Lintel

- 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.

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Step 3: Select Lintel

- 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.

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Step 4: Determine if Stops are Needed

- The maximum slope of the roof construction without stops welded to the steel angle shall be 7:12

- Trusses supporting veneer with slopes between 7:12 and 12:12 shall have stops of a minimum 3" x 3" x ¼" (76 mm x76 mm x 6 mm) steel plates welded to the angle at max. 24" (610 mm) o.c. along the angle or as approved by the building official

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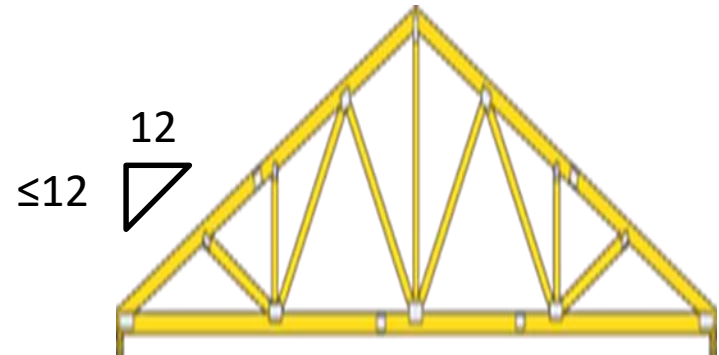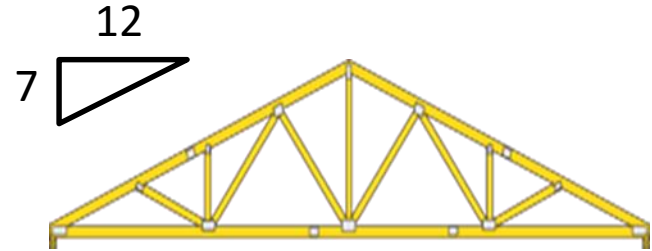
Step 5: Select Ties

- 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
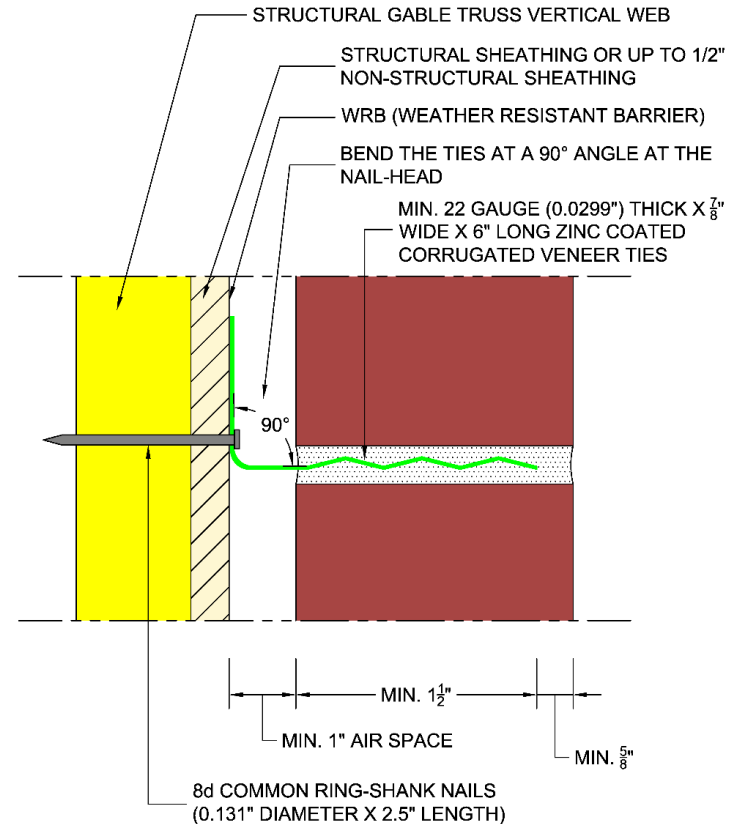
Step 5: Select Ties

- 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

Step 6: Select Tie Spacing

- Veneer ties shall be spaced at maximum 32" o.c. (610 mm) horizontally and 24" o.c. vertically and shall support max 2.67 ft^2 (0.25 m^2) 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

STRUCTURAL GABLE TRUSS VERTICAL WEB

STRUCTURAL SHEATHING OR UP TO 1/2" NON-STRUCTURAL SHEATHING

WRB (WEATHER RESISTANT BARRIER)

BEND THE TIES AT A 90° ANGLE AT THE NAIL-HEAD

MIN. 22 GAUGE (0.0299") THICK X $\frac{7}{8}$" WIDE X 6" LONG ZINC COATED CORRUGATED VENEER TIES

90°

MIN. 1$\frac{1}{2}$"

MIN. 1" AIR SPACE

MIN. $\frac{5}{8}$"

8d COMMON RING-SHANK NAILS (0.131" DIAMETER X 2.5" LENGTH)

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Step 6: Select Tie Spacing

- The following tables provides 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

Step 6: Select Tie Spacing

- 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_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.

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Step 6: Select Tie Spacing

- 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_{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_{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.
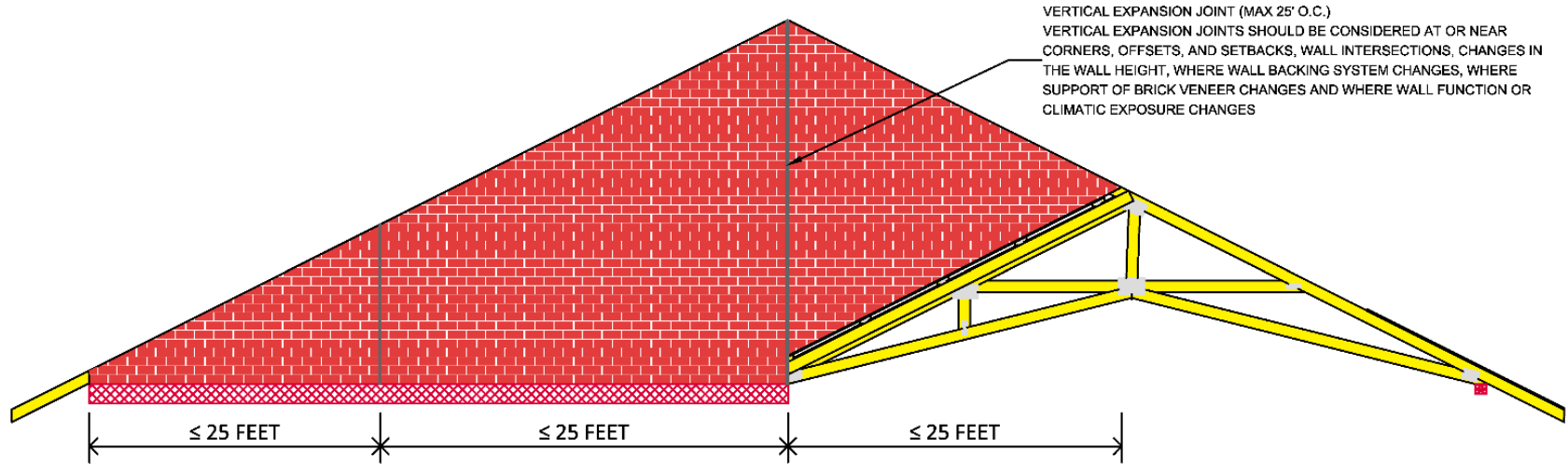
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Step 7: Flashing and Weep Holes

- **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.

FLASHING. WEEP HOLES (PER CODE, BY OTHERS)

ROOF SHEATHING
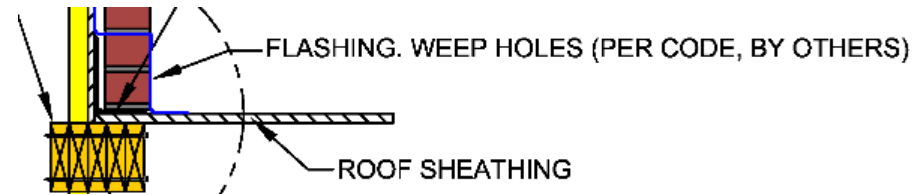
Step 8: Vertical Expansion Joints

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

VERTICAL EXPANSION JOINT (MAX 25' O.C.)
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

≤ 25 FEET   ≤ 25 FEET   ≤ 25 FEET

Step 8: Vertical Expansion Joints

- 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 3/8" (10 mm) and ½" (13 mm)

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Step 8: Vertical Expansion Joints

- 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

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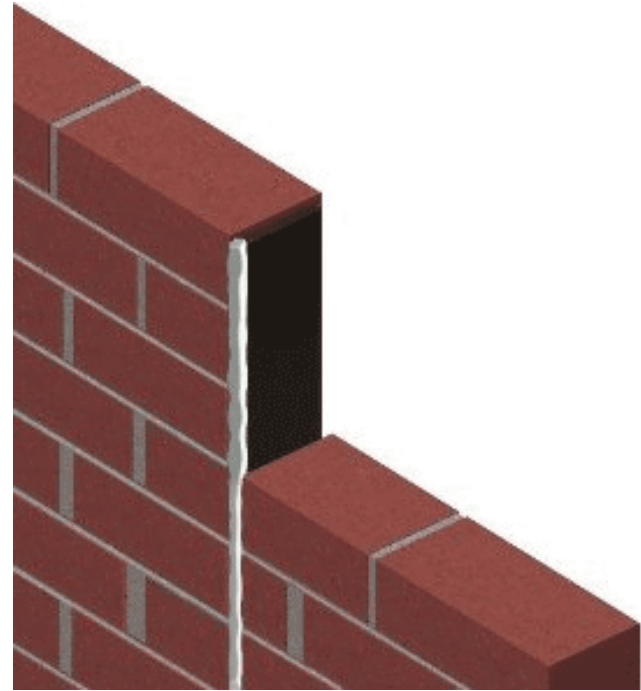
References

- 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