Attachment of Brick Veneer in High-Wind Regions

Purpose: *To recommend practices for installing brick veneer that will enhance wind resistance in high-wind regions (i.e., greater than 90-miles per hour [mph] basic [gust design] wind speed).*[1]

Key Issues

- When not adequately attached, brick veneer is frequently blown off walls of residential and non-residential buildings during hurricanes (Figure 1). When brick veneer fails, wind-driven water can enter and damage buildings, and building occupants can be vulnerable to injury from windborne debris (particularly if walls are sheathed with plastic foam insulation or wood fiberboard instead of wood panels). Pedestrians in the vicinity of damaged walls can also be vulnerable to injury from falling veneer (Figure 2).
- Common failure modes include tie (anchor) corrosion (Figure 3), tie fastener pull-out (Figure 4), failure of masons to embed ties into the mortar (Figure 5), and poor bonding between ties and mortar and mortar of poor quality (Figure 6).
- Ties are often installed before brick laying begins. When this is done, ties are often improperly placed above or below the mortar joints. When misaligned, the ties must be angled up or down in order for the ties to be embedded into the mortar joints (Figure 7). Misalignment not only reduces embedment depth, but also reduces the effectiveness of the ties because wind forces do not act parallel to the ties themselves.
- Corrugated ties typically used in residential veneer construction provide little resistance to compressive loads. Use of compression struts would likely be beneficial, but off-the-shelf devices do not currently exist. Two-piece adjustable ties (Figure 8) provide significantly greater compressive strength than corrugated ties and are, therefore, recommended. However, if corrugated ties are used, it is recommended that they be installed as shown in Figures 9 and 10 in order to enhance their wind performance.

1 The 90 mph speed is based on ASCE 7-05. If ASCE 7-10 is being used, the equivalent wind speed trigger is 115 mph for Risk Category II buildings.

Figure 1. Failed brick veneer over plywood. Many of the ties are still attached to the substrate, but several of the tie fasteners pulled out of the substrate and the ties are embedded in the collapsed veneer. Estimated wind speed: 107 miles per hour (peak gust, Exposure C, at 33 feet).

Figure 2. The upper portion of the brick veneer at this apartment building collapsed. Pedestrian and vehicular traffic in the vicinity of the damaged wall are vulnerable to injury and damage if remaining portions of the wall were to collapse during subsequent storms.

Figure 3. Significant tie corrosion caused the brick at a fire station to fail, even though the building is not near the coast. Note that metal is missing for half of the width of the tie at two locations (red arrows). The left end of the tie was still embedded into a concrete masonry unit back-up wall. The right end is where the tie failed in tension, thus leaving a portion of the tie embedded in the collapsed brick.

Figure 4. This tie remained embedded in the mortar joint while the smooth-shank nail pulled out from the stud.

Figure 5. These four ties were never embedded into the mortar joint.

- Buildings that experience veneer damage typically do not comply with current building codes. Building code requirements for brick veneer have changed over the years. Model codes prior to 1995 permitted brick veneer in any location, with no wind speed restrictions. Also, some older model codes allowed brick veneers to be anchored with fewer ties than what is required by today's standards.

The Masonry Society's (TMS) 402/American Concrete Institute 530/American Society of Civil Engineers (ASCE) 5 *Building Code Requirements and Specifications for Masonry Structures* (TMS 402) is the current masonry standard referenced by model building codes. The 2009 International Residential Code (IRC) and the 2009 International Building Code (IBC) references the 2008 edition of TMS 402, which is the latest edition.

TMS 402 addresses brick veneer in two manners: rational design and a prescriptive approach. Nearly all brick veneer in residential and low-rise construction follows the prescriptive approach. The first edition of TMS 402 limited the use of prescriptive design to areas with a basic wind speed of 110 mph or less. The 2008 edition of TMS 402 extended the prescriptive requirements to include a basic wind speed of 130 mph, but limits the veneer wall area per tie that can be anchored with veneer ties to 70 percent of that allowed in lower wind speed regions. The 2008 edition requires rational design approaches in locations where the basic wind speeds exceed 130 mph.

Some noteworthy distinctions exist in the requirements for anchored brick veneer between the 2005 and the 2008 editions of TMS 402. For lower wind speed regions (110 mph and below), TMS 402-05 limited the vertical spacing of ties to 18 inches; the 2008 edition allows vertical ties to be spaced up to 25 inches, provided the wall area of veneer anchored per tie does not exceed 2.67 square feet. In TMS's high-wind regions (over 110 mph and up to 130 mph), both editions of the code limit vertical spacing to 18 inches. TMS 402-08 also limits the space between veneer anchored with corrugated ties and the wall sheathing to 1 inch. This is to avoid compression failures in the corrugated ties when they are exposed to positive pressures.

- The following Brick Industry Association (BIA) Technical Notes provide guidance on brick veneer: Technical Notes 28 – Anchored Brick Veneer, Wood Frame Construction; Technical Notes 28B – Brick Veneer/Steel Stud Walls; and Technical Notes 44B – Wall Ties. Although these Technical Notes provide attachment recommendations, the recommendations are inadequate because they are not specific for high-wind regions.

Construction Guidance

The brick veneer wall system is complex in its behavior. There are limited test data on which to draw. The following guidance is based on professional judgment, wind loads specified in ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures,* fastener strengths specified in the American Forest and Paper Association's (AF&PA's) National Design Specification (NDS) for Wood Construction, and brick veneer standards contained in TMS 402-08. In addition to the general guidance given in BIA Technical Notes 28 and 28B, the following guidelines are recommended:

Tie Spacing: The ability for Brick Ties and Tie Fasteners to function properly is highly dependent on horizontal and vertical spacing of ties. Horizontal spacing of ties will often coincide with stud spacing of either 16-inch or 24-inch on center (see Table 1) because tie fasteners are required to be installed directly into framing. Spacing of ties horizontally and vertically must not exceed a) spacings which will overload the tie or tie fastener based on a tributary area of wind pressure on the brick veneer, or b) prescriptive limits on spacing of ties. More information on horizontal and vertical tie spacing is available in Table 1.

Tie Fasteners: 8d (0.131" diameter) ring-shank nails are recommended instead of smooth-shank nails. A minimum embedment of 2 inches into framing is suggested.

Ties: For use with wood studs, two-piece adjustable ties are recommended. However, where corrugated steel ties are used, use 22-gauge minimum, 7/8 by 6 inches, complying with American Society for Testing and Materials (ASTM) A 366 with a zinc coating complying with ASTM A 153 Class B2. For ties for use with steel studs, see BIA Technical Notes 28B – Brick Veneer/Steel Stud Walls. Stainless steel ties should be used in areas within 3,000 feet of the coast.

Note: In areas that are also susceptible to high seismic loads, brick veneer should be evaluated by an engineer to ensure that it can resist seismic and wind design loads.

Figure 6. This tie was embedded in the mortar, but the bond was poor.

Sustainability

Brick veneer can offer a very long service life, provided the ties are not weakened by corrosion. To help ensure that brick veneer achieves its long life potential, in addition to properly designing and installing the ties, stainless steel ties are recommended.

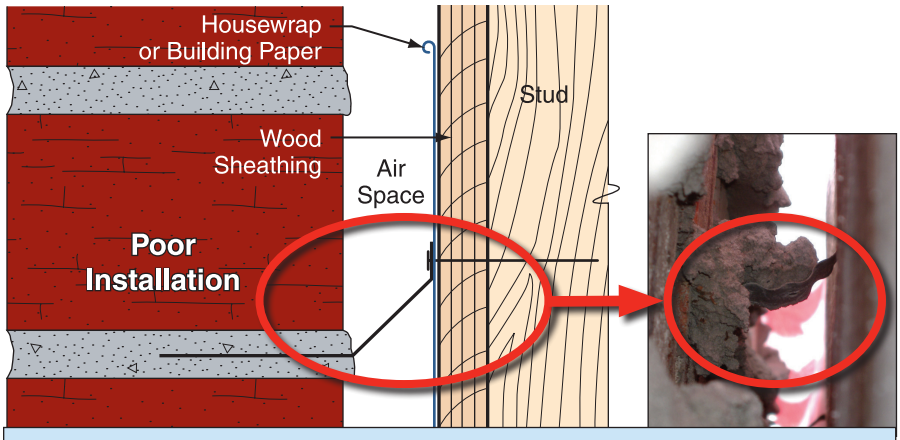

Figure 7. Misalignment of the tie reduces the embedment and promotes veneer failure.

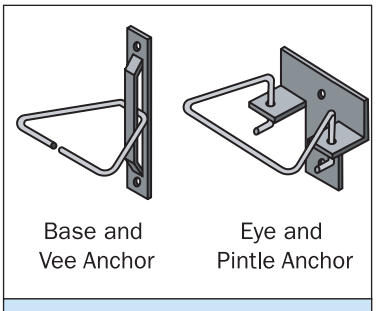

Figure 8. Examples of two-piece adjustable ties.

Tie Installation

- Install ties as the brick is laid so that the ties are properly aligned with the brick coursing. Alternatively, instead of installing ties as the brick is laid, measure the locations of the brick coursing, snap chalk lines, and install ties so that they are properly aligned with the coursing, and then install the brick.
- Install brick ties spaced based on the appropriate wind speed and stud spacing shown in Table 1. In areas where the 2006 Edition of the IBC or IRC are adopted, install brick veneer ties as noted in Table 1 but with a maximum vertical spacing of no more than 18 inches to satisfy the requirements of TMS 402-05.
- Locate ties within 8 inches of door and window openings and within 12 inches of the top of veneer sections.
- Bend the ties at a 90-degree angle at the nail head in order to minimize tie flexing when the ties are loaded in tension or compression (Figure 9).
- Embed ties in joints so that mortar completely encapsulates the ties. Embed a minimum of 1 1/2 inches into the bed joint, with a minimum mortar cover of 5/8 inch to the outside face of the wall (Figure 10).

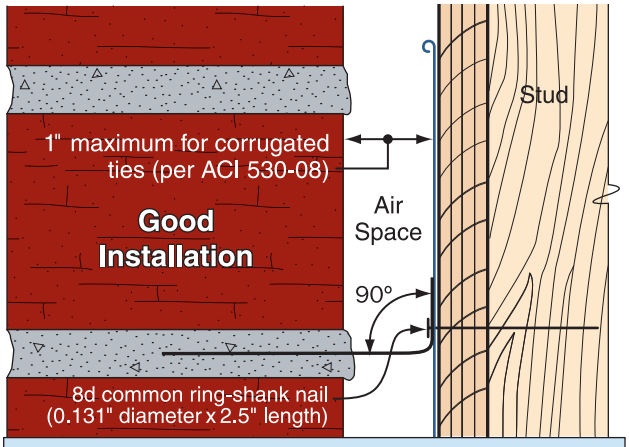

Figure 9. Bend ties at nail heads.

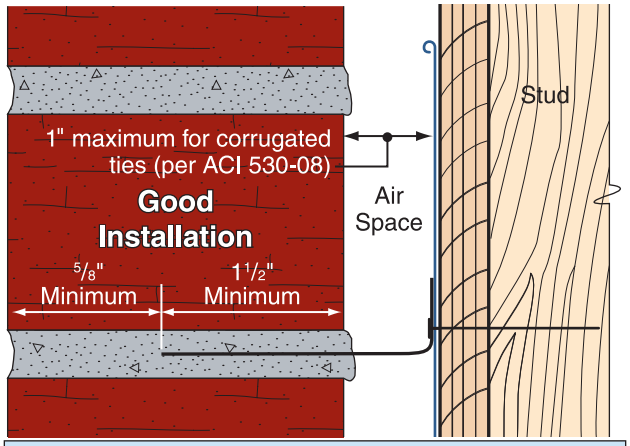

Figure 10. Tie embedment.

Table 1. Brick Veneer Tie Spacing

Wind Speed (mph) (3–Second Peak Gust)	Wind Pressure (psf)	Maximum Vertical Spacing for Ties (inches)	
		16" stud spacing	24" stud spacing
90	–19.5	24[a,b]	16[a]
100	–24.1	24[a,b]	16[a]
110	–29.1	20½ [b]	13½
120	–34.7	17	NA[c]
130	–40.7	15	NA[c]
140	–47.2	13	NA[c]
150	–54.2	11	NA[c]

Notes:

1. The tie spacing is based on wind loads derived from Method 1 of ASCE 7-05, for the corner area of buildings up to 30' high, located in Exposure B with an importance factor (I) of 1.0 and no topographic influence. For other heights, exposures, or importance factors, engineered designs are recommended.
2. Spacing is for 2½" long 8d common (0.131" diameter) ring-shank fasteners embedded 2" into framing. Fastener strength is for wall framing with a Specific Gravity G=0.55 with moisture contents less than 19 percent and the following adjustment factors, C_t=0.8; and C_D, C_M, C_{eg}, and C_{tn}=1.0. Factored withdrawal strength W'=65.6#.
3. The brick veneer tie spacing table is based on fastener loads only and does not take into account the adequacy of wall framing, sheathing, and other building elements to resist wind pressures and control deflections from a high-wind event. Prior to repairing damaged brick veneer, the adequacy of wall framing, wall sheathing, and connections should be verified by an engineer.

a Maximum spacing allowed by ACI 530-08.

b In locales that have adopted the 2006 IBC/IRC, the maximum vertical spacing allowed by ACI 530-05 is 18".

c 24" stud spacing exceeds the maximum horizontal tie spacing of ACI 530-08 prescribed for wind speeds over 110 mph.

Additional Resources

Brick Industry Association (BIA). (http://www.gobrick.com)

- Technical Notes 28 – Anchored Brick Veneer, Wood Frame Construction
- Technical Notes 28B – Brick Veneer/Steel Stud Walls
- Technical Notes 44B – Wall Ties