

Attachment of Brick Veneer in High-Wind Regions



FEMA

HURRICANE KATRINA RECOVERY ADVISORY

Purpose: To recommend practices for installing brick veneer that will enhance wind resistance in high-wind areas.

Key Issues

- Brick veneer is frequently blown off walls of residential and commercial buildings (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 in lieu 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) fastener pull-out (Figure 3), failure of masons to embed ties into the mortar (Figure 4), poor bonding between ties and mortar and mortar of poor quality (Figure 5), and tie corrosion (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.



Figure 1. Failed brick veneer. Plastic foam wall sheathing was installed over the wood studs (plywood was temporarily installed after the brick failure).



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 were vulnerable to injury and damage if remaining portions of the wall were to collapse during subsequent storms.



Figure 3. This tie remained embedded in the mortar joint while the smooth-shank nail pulled from the stud.

- Many buildings that exhibited damaged veneer were not in compliance 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. Wall area per tie in some model codes was greater than the current maximum. The current masonry code referenced in model building codes, Building Code Requirements for Masonry Structures, ACI 530/ASCE 5/TMS 402 (ACI 530) addresses brick veneer in two manners: rational design and prescriptive requirements. Essentially all brick veneer in residential and low-rise construction follows the prescriptive requirements. The first edition of American Concrete Institute's (ACI's) 530 limited the use of prescriptive design to areas with a basic wind speed of 110 mph or less. The 2005 edition of ACI 530 extended the prescriptive requirements to include a basic wind speed of 130 mph, with lower area per tie limits. In locations with a basic wind speed above 130 mph, the rational design approach must be used. Compliance with ACI 530-05 should reduce wind damage.
- 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 (available online at www.bia.org). These Technical Notes provide attachment recommendations, but the recommendations are not specific for high-wind regions and are, therefore, inadequate.

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 7-02 "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, and brick veneer standards contained in ACI 530-05. In addition to the general guidance given in BIA Technical Notes 28 and 28B, the following are recommended:

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

Stud Spacing: For new construction, space studs 16" on center, so that ties can be anchored at this spacing.

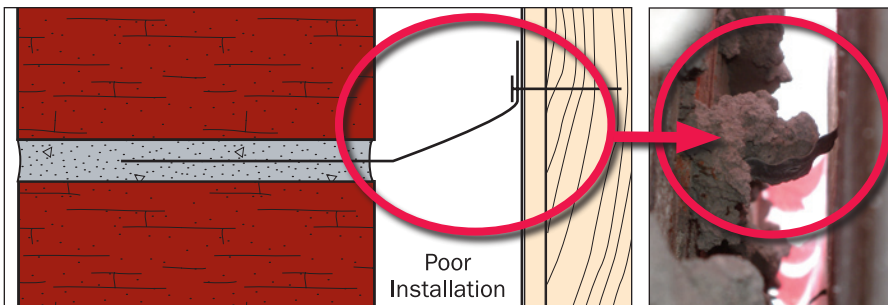


Figure 7. Misalignment of the tie reduces the embedment and promotes veneer failure.



Figure 4. These four ties were never embedded into the mortar joint.



Figure 5. This tie was embedded in the mortar, but the bond was poor.



Figure 6. There were several ties in this portion of the wall, but they failed due to severe corrosion.

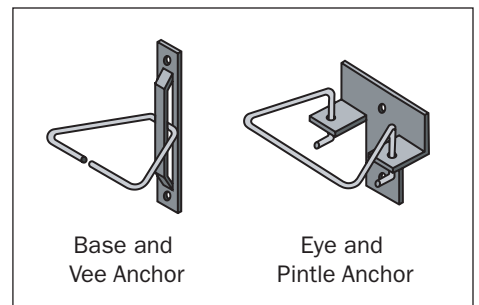


Figure 8. Examples of two-piece adjustable ties

Tie Fasteners: Ring-shank nails are recommended in lieu of smooth-shank nails. A minimum embedment of 2" 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" wide by 6" long, complying with 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.

Tie Installation

- Install ties as the brick is laid so that the ties are properly aligned with the mortar joints.
- Install brick ties spaced per Table 1. Studs should be installed at 16" spacing. Veneer tie locations for 24" stud spacing are included for repairing damaged veneer on existing buildings with the wider stud spacing.
- Locate ties within 8" of door and window openings and within 12" 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 1.5" into the bed joint, with a minimum mortar cover of 5/8" to the outside face of the wall (Figure 10).

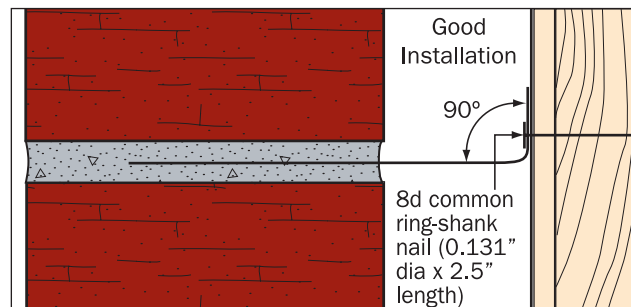


Figure 9. Bend ties at nail heads

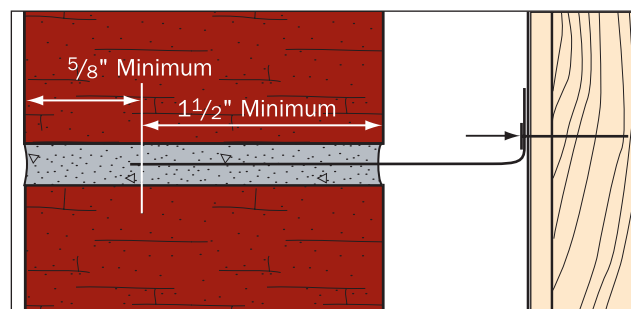


Figure 10. Tie embedment

Table 1. Brick Veneer Tie Spacing

Wind Speed (mph) (3-Second Peak Gust)	Wind Pressure (psf)	Maximum Vertical Spacing for Ties	
		16" stud spacing	24" stud spacing
90	17.8	18.0 ^a	16.0 ^a
100	22.0	18.0 ^a	16.0 ^a
110	26.6	18.0 ^a	14.8
120	31.6	18.0 ^a	NA ^b
130	37.1	15.9	NA ^b
140	43.0	13.7	NA ^b
150	49.4	10.2	NA ^b

Notes:

1. The tie spacing is based on wind loads derived from Method 1 of ASCE 7-02, 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, exposure, or importance factor, an engineered design is recommended.
 2. Fastener strength is for wall framing with a Specific Gravity G=0.55 with moisture contents less than 19% and the following adjustment factors, Ct=0.8; and CD, CM, Ceg, and Ctn=1.0.
 3. Nail embedment depth of 2" for 2.5" long 8d common (0.131" diameter) ring-shank fasteners
- ^a Maximum spacing allowed by ACI 530-05
- ^b 24" stud spacing exceeds the maximum horizontal tie spacing of ACI 530-05 prescribed for wind speeds over 100 mph

