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.

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

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.

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.

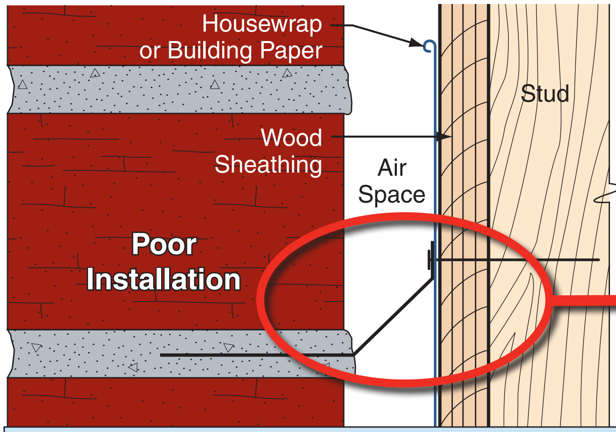


Figure 7. Misalignment of the tie reduces the embedment and promotes veneer failure.

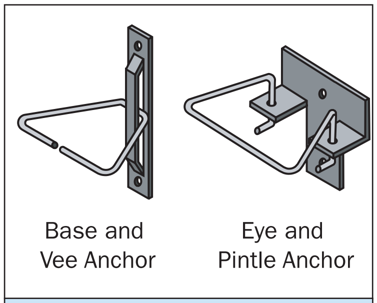


Figure 8. Examples of two-piece adjustable ties.

WALL SYSTEMS 5

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).

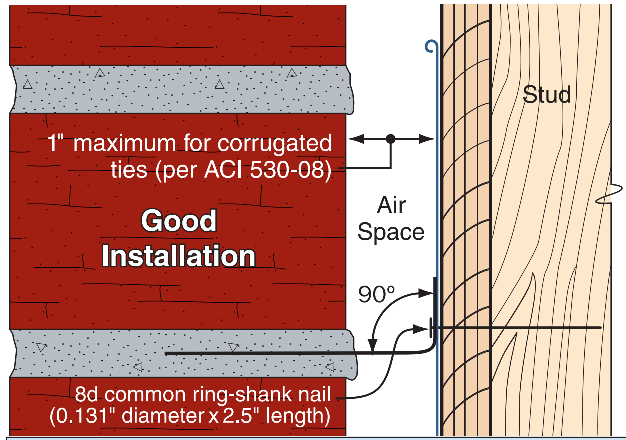


Figure 9. Bend ties at nail heads.

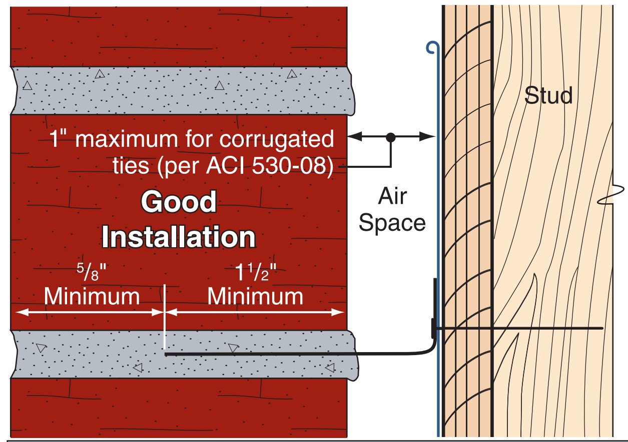


Figure 10. Tie embedment.

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

Developed in association with the National Association of Home Builders Research Center

Window and Door Installation

Purpose: *To provide flashing detail concepts for window and door openings that:*

- *give adequate resistance to water intrusion in coastal environs,*
- *do not depend solely on sealants,*
- *are integral with secondary weather barriers (i.e., housewrap or building paper – see Fact Sheet No. 5.1), and*
- *are adequately attached to the wall.*

Key Issues

Water intrusion around window and door openings can cause dry rot and fastener corrosion that weaken the window or door frame or the wall itself, and lead to water damage to interior finishes, mold growth, and preventable building damage during coastal storms. Proper flashing sequence must be coordinated across responsibilities sometimes divided between two or more trade activities (e.g., weather barrier, window, and siding installation).

To combat wind-driven rain penetration and high wind pressures, window and door frames must be adequately attached to walls and they must be adequately integrated with the wall's moisture barrier system (see Fact Sheet No. 1.9).

ASTM E 2112

Detailed information about window and door installation is provided in the American Society for Testing and Materials (ASTM) standard ASTM E 2112, a comprehensive installation guide intended for use in training instructors who in turn train the mechanics who actually perform window and door installation. The standard concentrates on detailing and installation procedures that are aimed at minimizing water infiltration.

The standard includes a variety of window and door details. The designer should select the details deemed appropriate and modify them if necessary to meet local weather conditions, and the installer should execute the selected details as specified in the standard or as modified by the designer.

Section 1.5 states that if the manufacturer's instructions conflict with E 2112, the manufacturer's instructions shall prevail. However, because a manufacturer's instructions may be inferior to the guidance provided in the standard, any conflict between the manufacturer's requirements and the standard or contract documents should be discussed among and resolved by the manufacturer, designer, and builder.

Specific Considerations

Pan flashings: Windows that do not have nailing flanges, and doors, are typically installed over a pan flashing (see Figure 1). Section 5.16 of ASTM E 2112 discusses pan flashings and refers to Annex 3 for minimum heights of the end dam and rear leg. Annex 3 shows a maximum end dam height of 2 inches, which is too low for areas prone to very high winds (i.e., wind speed greater than 110 mph). Where the wind speed is greater than 110 mph, the end dam should be 3 to 4 inches high (the higher the wind speed, the higher the dam). (Note: Annex 3 says that "high rain and wind are usually not simultaneous." However, this statement is untrue for coastal storms, in which extremely high amounts of rain often accompany very high winds.)

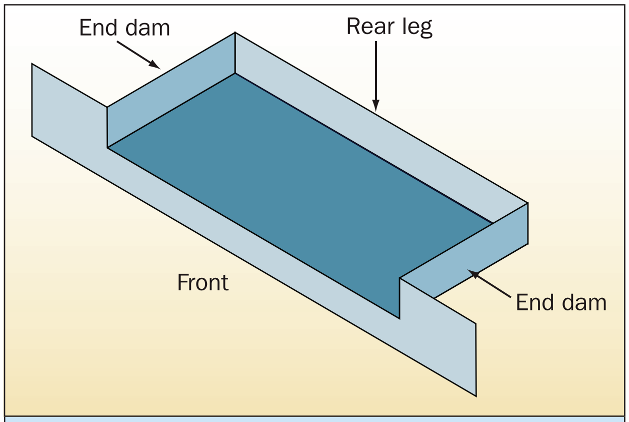


Figure 1. Pan Flashing

Although not discussed in ASTM E 2112, for installations that require an exposed sealant joint, installation of a removable stop (see Figure 2) is recommended to protect the sealant from direct exposure to the weather and reduce the wind-driven rain demand on the sealant.

Exterior Insulation Finishing Systems (EIFS): Although not discussed in ASTM E 2112, when a window or door assembly is installed in an EIFS wall assembly, sealant between the window or door frame and the EIFS should be applied to the EIFS base coat. After sealant application, the top coat is then applied. (The top coat is somewhat porous; if sealant is applied to it, water can migrate between the top and base coats and escape past the sealant.)

Frame anchoring: Window and door frames should be anchored to the wall with the type and number of fasteners specified by the designer.

Shutters: If shutters are installed, they should be anchored to the wall, rather than the window or door frame (see Figure 3).

Weatherstripping: E 2112 does not address door weatherstripping. However, weatherstripping is necessary to avoid wind-driven rain penetration. A variety of weatherstripping products are available as shown in Figures 4 through 9.

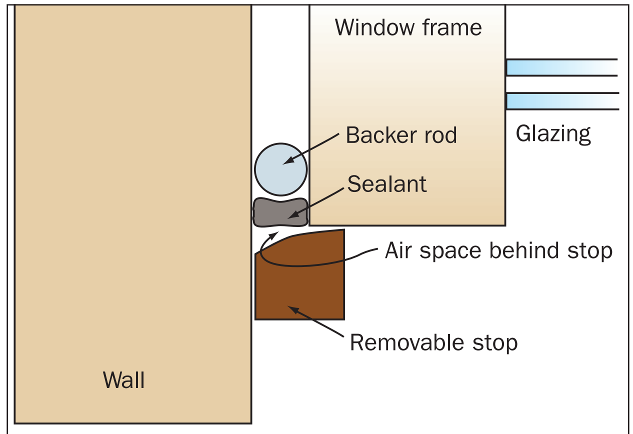


Figure 2. Protection of sealant with a stop.

Figure 3. Hurricane Georges in Puerto Rico. The window lying on the ground was protected by a shutter. However, the shutter was attached to the window frame. The window frame fasteners were over-stressed and the entire assembly failed. Attachment of the shutter directly to the wall framing is a more reliable method of attachment.

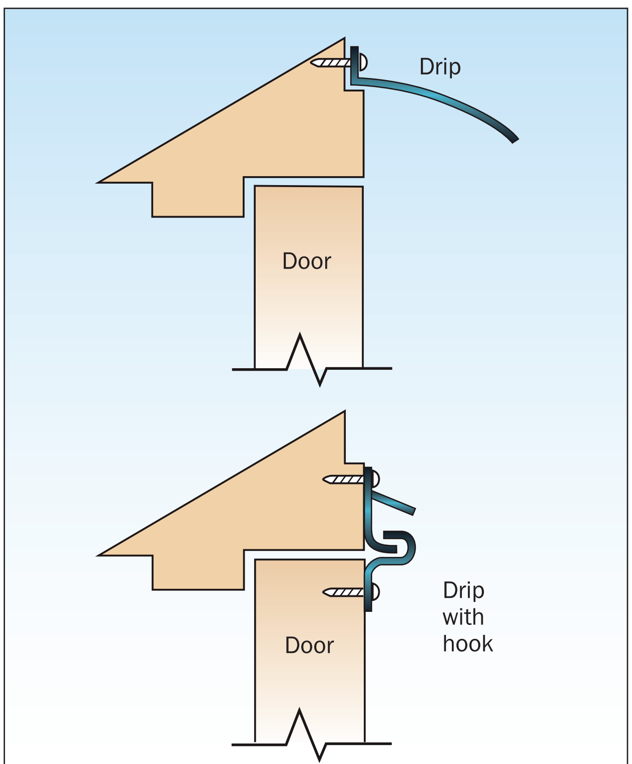


Figure 4. Drip at door head and drip with hook at head

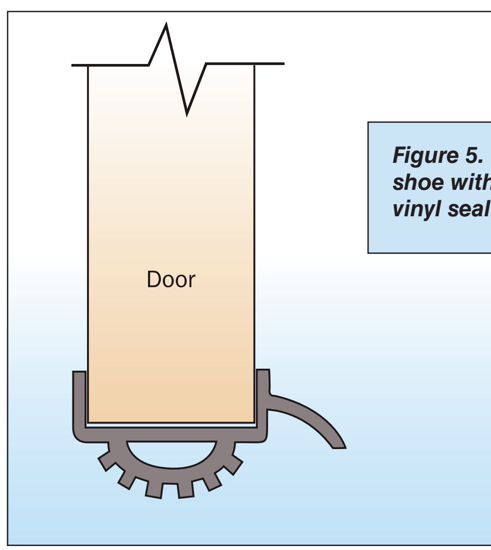


Figure 5. Door shoe with drip and vinyl seal.

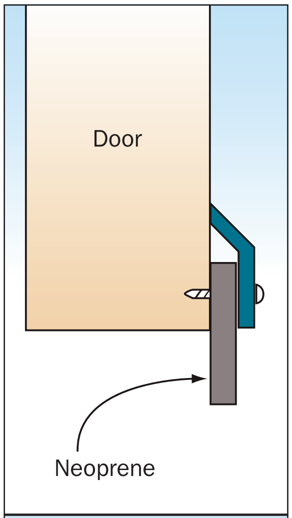


Figure 6. Neoprene door bottom sweep.

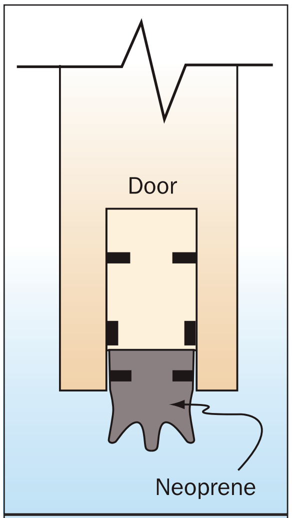


Figure 7. Automatic door bottom.

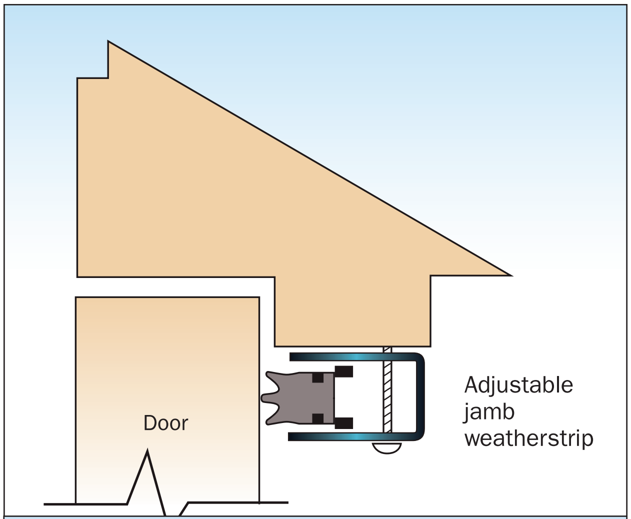


Figure 8. Adjustable jamb/head weatherstripping.

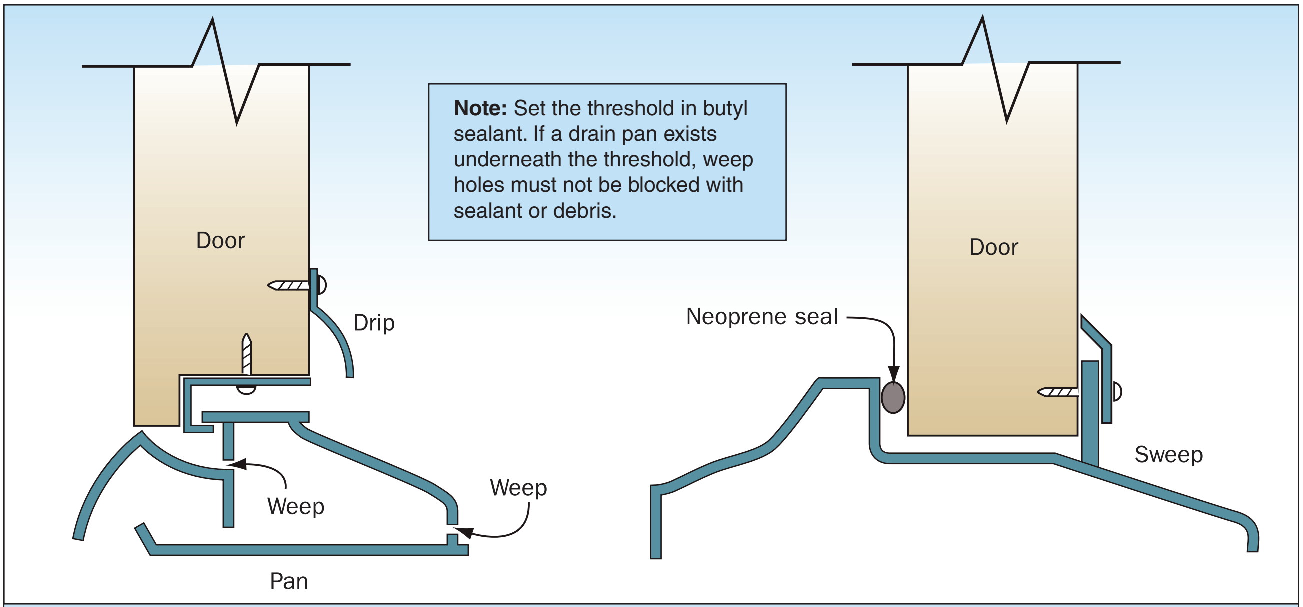


Figure 9. Threshold

Additional Resources

American Society for Testing and Materials. ASTM E 2112, *Standard Practice for Installation of Exterior Windows, Doors and Skylights*. (www.astm.org)

Developed in association with the National Association of Home Builders Research Center

Protection of Openings–Shutters and Glazing

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION   Technical Fact Sheet No. 6.2

OPENINGS 6

Purpose: *To provide general information about the selection and installation of storm shutters and impact-resistant glazing and other types of opening protection in windborne debris regions.*

Opening Requirements in Codes and Standards

What Are "Hurricane-Prone Regions" and "Windborne Debris Regions"?

According to the 2009 International Building Code (IBC) and the 2009 International Residential Code (IRC), ***hurricane-prone regions*** are areas vulnerable to hurricanes such as:

1. The U.S. Atlantic Ocean and Gulf of Mexico coasts where the basic wind speed is greater than 90 mph[1] (40 m/s).
2. Hawaii, Puerto Rico, Guam, the U.S. Virgin Islands, and American Samoa.

Wind-borne debris regions are defined as areas within portions of hurricane-prone regions located within 1 mile (1.61 km) of the coastal mean high water line where the basic wind speed is 110 mph (48 m/s)[1] or greater; or portions of hurricane-prone regions where the basic wind speed is 120 mph (53 m/s)[1] or greater; or Hawaii.

Sections 1609.1.2 and R301.2.1.2, of the 2009 editions of the IBC and IRC, respectively, address the Protection of Openings. These sections state that in wind-borne debris regions, glazing in buildings shall be impact resistant or protected with an impact-resistant covering that meets the requirements of an approved impact-resistant standard or the American Society of Testing and Materials (ASTM) standards ASTM E 1996 and ASTM E 1886. Wood structural panels could be used as an alternative to provide protection so long as they meet local building code requirements. Panel attachment should be in accordance with Table 1609.1.2 (IBC) and Table R301.2.1.2 (IRC) and installed using corrosion-resistant attachment hardware and anchors permanently installed on the building. Under provisions of the IBC, wood structural panels are permitted for Group R-3 and R-4 buildings with a mean roof height of 45 feet (13,716 mm) or less where wind speeds do not exceed 140 mph (63 m/s). Under provisions of the IRC, wood structural panels are permitted for buildings with a mean roof height of 33 feet (10,058 mm) or less where wind speeds do not exceed 130 mph[2] (58 m/s). Figure 1 shows a house utilizing wood structural panels to provide opening protection.

Figure 1. Wood structural panels installed in accordance with building code requirements are a cost-effective means of protection, but they should be adequately attached so they themselves do not become windborne debris.

ASCE/SEI 7-05 also discusses the protection of glazed openings in Section 6.5.9.3. The section states, "Glazing in buildings located in wind-borne debris regions shall be protected with an impact-protective system or be impact-resistant glazing according to the requirements specified in ASTM E1886 and ASTM E1996 or other approved test methods and performance criteria. The levels of impact resistance shall be a function of Missile Levels and Wind Zones specified in ASTM E 1886 and ASTM E 1996". Exceptions to this are noted in Section 6.5.9.3.

1 ASCE 7-05 wind speed – in order to recalculate this for ASCE 7-10 divide the ASCE 7-05 wind speed by $0.6^{0.5}$

Anchorage

Window and door assemblies must be strong enough to withstand wind pressures acting on them and be fastened securely enough to transfer those wind pressures to the adjacent wall. Pressure failures of doors or windows can allow glazing to fracture or glazing frames or supports to fail. Anchorage failures can allow entire door or window units to be ripped from the walls. Either type of failure results in the failure of the building envelope and allows wind and water to enter the building.

Note: When glazing protection is provided by shutters, screens, or other panel systems, the glazing and glazing frame should be designed and constructed to resist the full design loads (i.e., do not assume that the shutter will be decreasing the wind pressure on the glazing). Also note that it should be assumed that the shutter will not significantly decrease the wind-driven rain demand on the glazed assembly.

6 OPENINGS

Shutters

Why Are Storm Shutters Needed?

If glazing is not resistant to windborne debris, then shutters are an important part of a hurricane-resistant home. They provide protection for glass doors and windows against windborne debris, which is often present in hurricanes. Keeping the building envelope intact (i.e., no window or door breakage) is vital to the integrity of a home. If the envelope is breached, sudden pressurization of the interior may result in major structural or non-structural damage (e.g., roof loss) and will lead to significant interior and contents damage from wind-driven rain. The addition of shutters will not eliminate the potential for wind-driven rain entering the building, but will improve the building's resistance to it.

Where Are Storm Shutters Required and Recommended?

Model building codes, which incorporate wind provisions from ASCE 7 (1998 edition and later), require that buildings within the ***windborne debris region*** (see Figure 5 of this fact sheet), either (1) be equipped with shutters or impact-resistant glazing and designed as enclosed structures or (2) be designed as partially enclosed structures (as if the windows and doors are broken out). However it should be noted that the alternative to design a Risk Category II building (defined in ASCE 7-10) as a partially enclosed structure was removed from ASCE 7-10 and it now requires that all Risk Category II structures in the wind-borne debris region be designed to be enclosed structures with impact-resistant glazing or equipped with a shutter system. It is also recommended to give strong consideration to the use of opening protection in all hurricane-prone areas where the basic wind speed is 100 mph (3-second gust speed) or greater, even though the IBC and IRC building codes do not require it. Designers should check with the jurisdiction to determine whether state or local requirements for opening protection exceed those of the model code.

Figure 2. Metal panel shutter . The shutter is installed in a track permanently mounted above and below the window frame. The shutter is placed in the track and secured with wing nuts to studs mounted on the track. This type of shutter is effective and quickly installed, and the wing nut and stud system provides a secure anchoring method. Track designs that have permanently mounted studs for the nuts have been shown to be more reliable than track designs using studs that slide into the track.

WARNING: A shutter may look like it is capable of withstanding windborne missiles; unless it is tested, however, its missile resistance is unknown.

What Types of Shutters Are Available?

A wide variety of shutter types are available, from the very expensive motor-driven, roll-up type, to the less expensive temporary wood structural panels. Designers can refer to Miami-Dade County, Florida, which has established a product approval mechanism for shutters and other building materials to ensure they are rated for particular wind and wind-borne debris loads (see the "Additional Resources" section). Figures 3 and 4 illustrate some of the shutter styles available.

Note: Many coastal homes have large and unusually shaped windows, which will require expensive, custom shutters. Alternatively, such windows can be fabricated with laminated (impact-resistant) glass.

Shutter Styles

Shutter styles include colonial, Bahama, roll-up, and accordion.

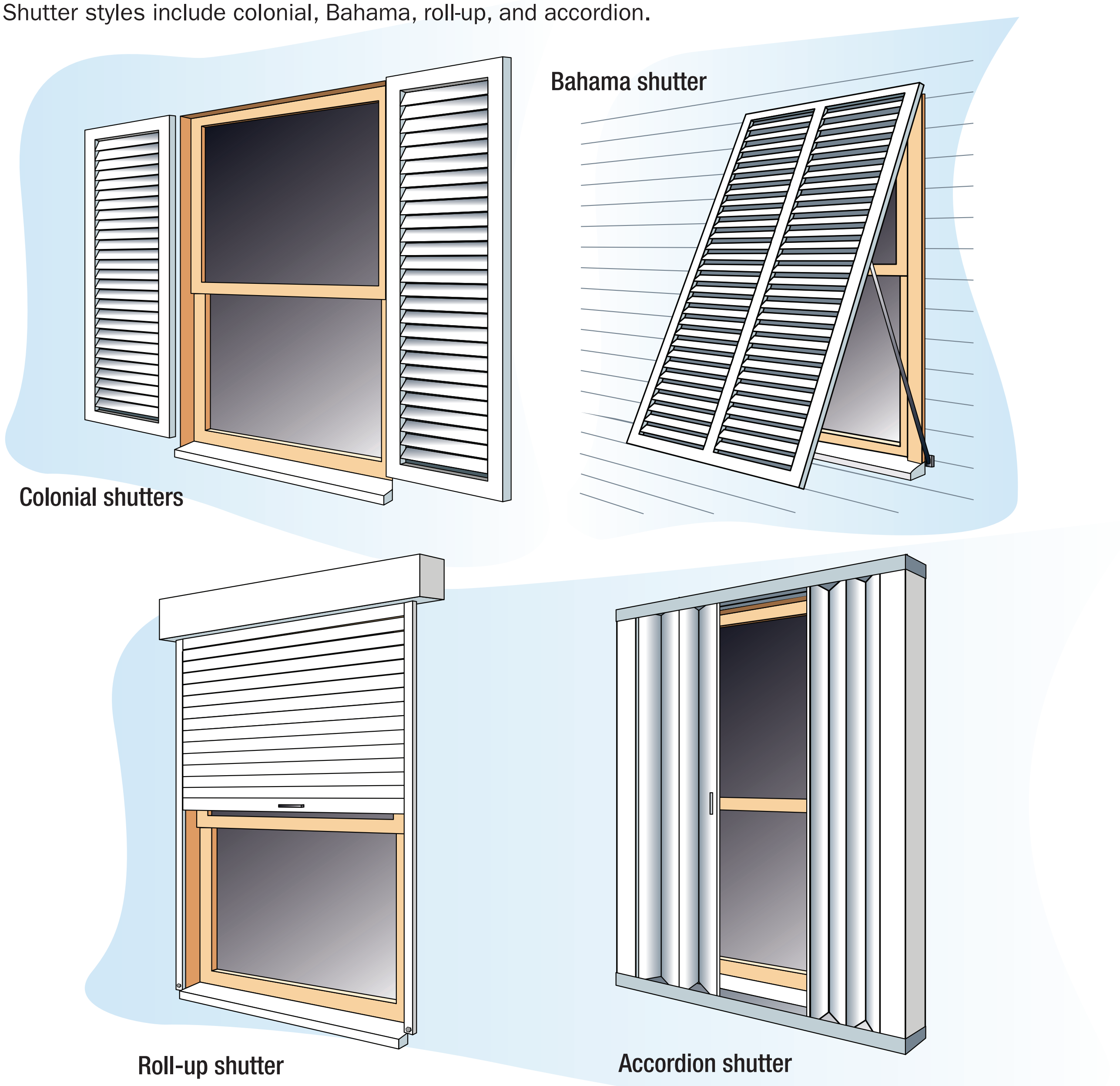
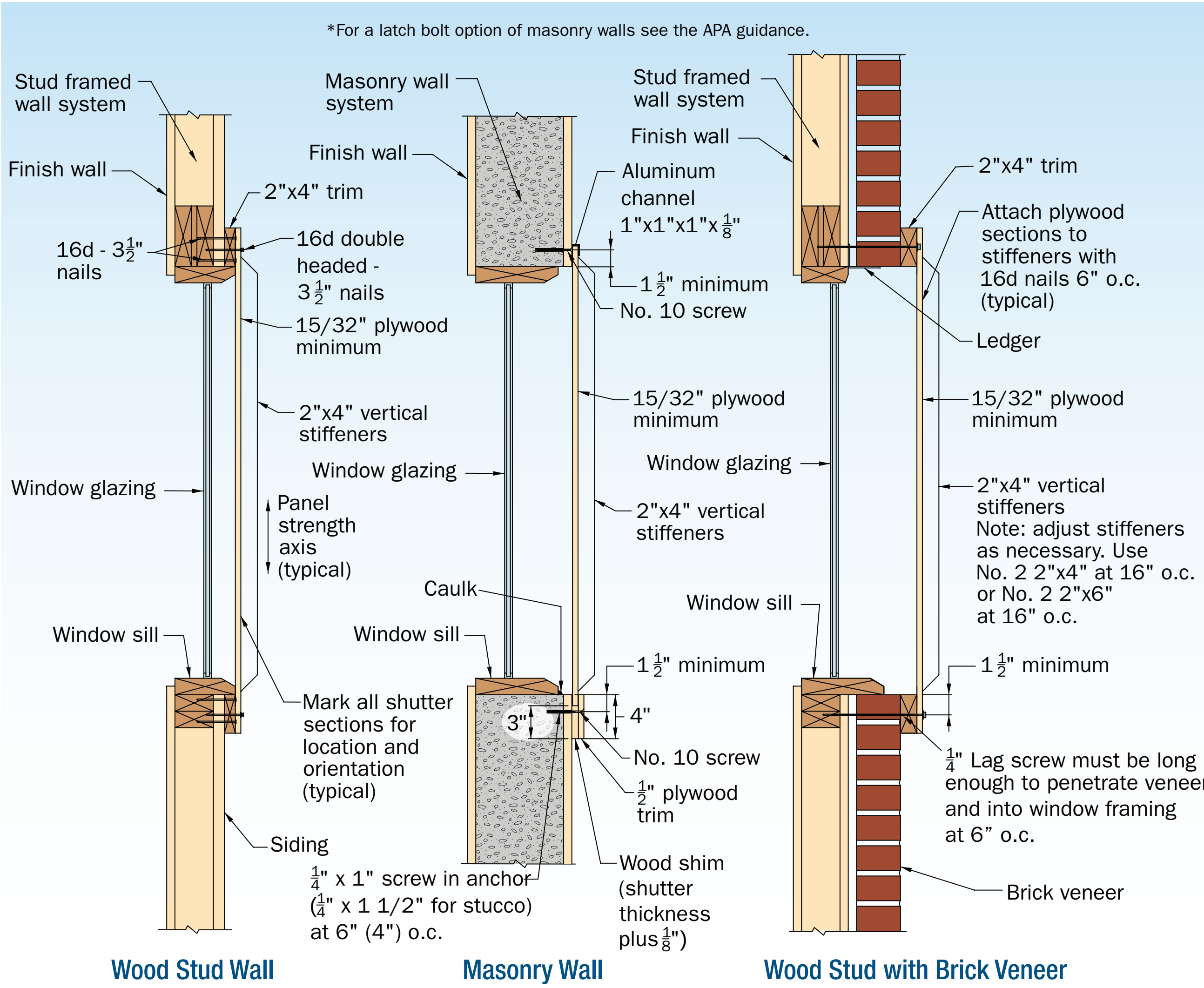


Figure 3. Colonial shutters, Bahama style shutters, Roll-up style shutters, and Accordion style shutters.



See APA Guidance for additional details and nail specifications.
Only for use on residential structures with a mean roof height of 45 feet or less.

Figure 4. Common methods for plywood shutter attachment to wood-frame and masonry walls. (For actual shutter design, refer to design drawings or see the APA, Engineered Wood Association guidelines for constructing plywood shutters.)

Shutter Type Cost Advantages

Shutter Type	Cost	Advantages	Disadvantages
Wood structural panels	Low	Inexpensive	Must be installed and taken down every time they are needed; must be adequately anchored to prevent blow-off; difficult to install on upper levels; storage space is needed.
Metal or polycarbonate panels	Low/ Medium	Easily installed on lower levels	Must be installed and taken down every time they are needed; difficult to install on upper levels; storage space is needed.
Accordion, manual closing	Medium/ High	Always in place; ready to be closed	Always in place; ready to be closed. Must be closed manually from the outside; difficult to access on upper levels.
Permanent, motor-driven	High	Easily opened and closed from the inside	Expensive. (It is important to find a motorized shutter that allows the shutter to be manually raised in order to allow the interior to vent following the storm and prior to electrical power restoration.)

Are There Special Requirements for Shutters in Coastal Areas?

When installing any type of shutter, follow the manufacturer's instructions and guidelines carefully. Be sure to attach the shutters to structurally adequate framing members (see shutter details in Figures 3 and 4 of this fact sheet). Avoid attaching the shutters to the window frame or brick veneer face. Always use hardware that is corrosive-resistant when installing shutters. Figure 5 is the ASCE 7-05 basic wind map for the East Coast of the United States. See page 1 of this fact sheet for the delineation of the areas where opening protection is required.

WARNING: According to the International Window Film Association, "It should be noted that the testing of commercial windows does not imply performance of residential windows." While post-manufacture applied window film may provide more protection than unprotected windows, in residential applications it is no substitute for shutters or impact-resistant glass.

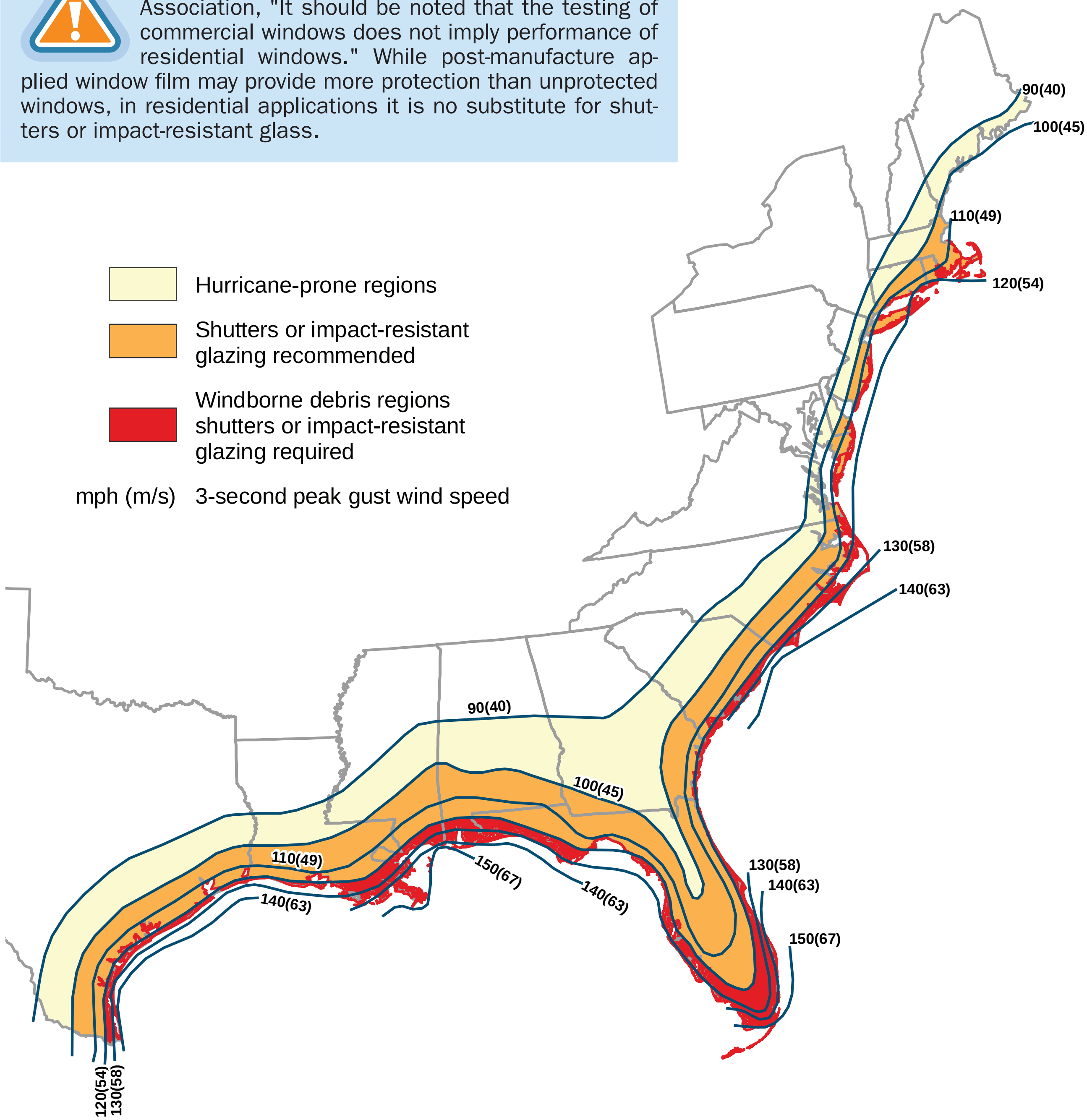


Figure 5. An illustration of the ASCE 7-05 wind speed contours and windborne debris region. See ASCE 7-05 Figure 6-1 for wind load design.

Windborne debris resistant glazing

Laminated glazing systems typically consist of assemblies fabricated with two (or more) panes of glass and an interlayer of a polyvinyl butyral (or equivalent) film laminated into a glazing assembly. During impact testing, the laminated glass in the system can fracture but the interlayer must remain intact to prevent water and wind from entering the building. These systems may also increase the energy efficiency of the building over standard glazing.

Polycarbonate systems typically consist of plastic resins that are molded into sheets, which provide lightweight, clear glazing panels with high impact-resistance qualities. The strength of the polycarbonate sheets is much higher than non-laminated glass (i.e., more than 200 times stronger) or acrylic sheets or panels (i.e., more than 30 times stronger).

Garage Doors

Garage doors many times represent large unreinforced openings. They are commonly damaged during high-wind events and could allow a building to be pressurized if they are breached. A garage door should meet the design wind speed requirements for the area or be retrofitted to withstand the design wind speed. However, the viability of a retrofit depends on the style and age of the door, and may not provide the same level of protection as a new door system.

The 2009 editions of IBC and IRC both comment on the glazing in garage doors in sections 1609.1.2.2 and R301.2.1.2, respectively. Any glazed opening protection on garage doors for wind-borne debris shall meet the requirements of an approved impact-resisting standard or ANSI/DASMA 115-2005.

While some manufacturers provide wind speed and exposure ratings for their products, labels on many garage doors do not include wind speed or wind pressure ratings. While not required to be included on the product labeling, ANSI/DASMA 108 does require that the positive and negative pressure used in testing be recorded on the ANSI/DASMA 108 Test Report Form. If the label attached to the door does not indicate the positive and negative pressure rating, consult the Test Report Form to verify it is an appropriate garage door for the area.

Additional Resources

American Society of Civil Engineers. *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-10. (http://www.asce.org)

The Engineered Wood Association (APA). *Hurricane Shutter Designs Set 5 of 5*. Hurricane shutter designs for woodframe and masonry buildings. (http://www.apawood.org)

International Code Council. *International Building Code*. 2009. (http://www.iccsafe.org)

International Code Council. *International Residential Code*. 2009. (http://www.iccsafe.org)

Information about product testing and approval process for Miami-Dade County, Florida, available at http://www.miamidade.gov/buildingcode/product-control.asp

American Society for Testing and Materials:

> ASTM E1886, *Performance of Exterior Windows, Curtain Walls, Doors, and Storm Shutters Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials*
>
> ASTM E1996, *Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors and Impact Protective Systems Impacted by Windborne Debris in Hurricane*
>
> ASTM E2112, *Standard Practice for Installation of Exterior Windows, Doors and Skylights*
>
> ASTM E330, *Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference*. (http://www.astm.org)

Door and Access Systems Manufacturers Association:

> DASMA 108, *Standard Method for Testing Sectional Garage Doors: Determination of Structural Performance Under Uniform Static Air Pressure Difference*

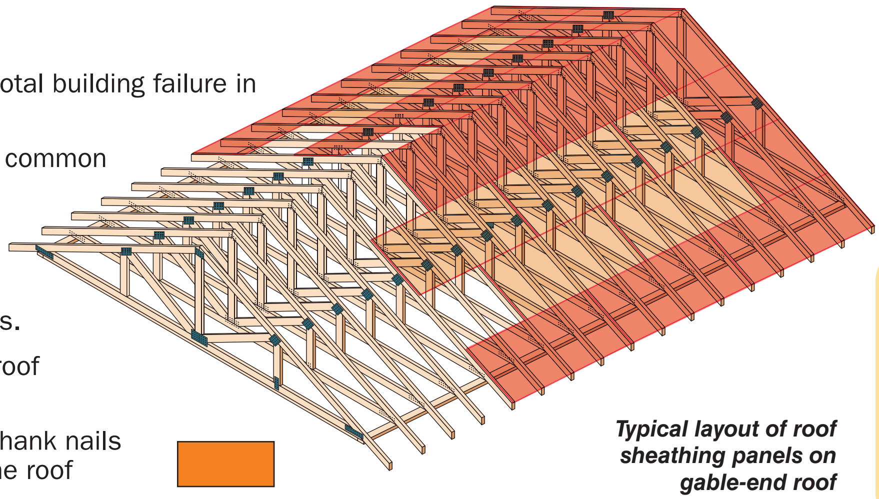
Developed in association with the National Association of Home Builders Research Center

Roof Sheathing Installation

Purpose: *To provide information about proper roof sheathing installation, emphasize its importance in coastal construction, and illustrate fastening methods that will enhance the durability of a building in a high-wind area.*

Key Issues

- Insufficient fastening can lead to total building failure in a windstorm.
- Sheathing loss is one of the most common structural failures in hurricanes.
- Fastener spacing and size requirements for coastal construction are typically different than for non-coastal areas.
- The highest uplift forces occur at roof corners, edges, and ridge lines.
- Improved fasteners such as ring shank nails increase the uplift resistance of the roof sheathing.

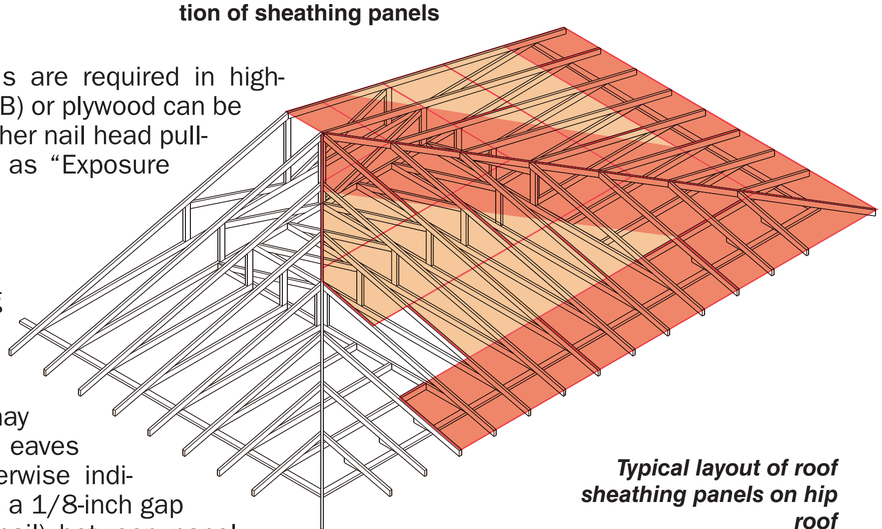


Most critical area for connection of sheathing panels

Typical layout of roof sheathing panels on gable-end roof

Sheathing Type

Typically, 15/32-inch or thicker panels are required in high-wind areas. Oriented Strand Board (OSB) or plywood can be used, although plywood will provide higher nail head pull-through resistance. Use panels rated as "Exposure 1" or better.



Typical layout of roof sheathing panels on hip roof

Sheathing Layout

Install sheathing panels according to the recommendations of the Engineered Wood Association (APA). Use panels no smaller than 4 feet long. Blocking of unsupported edges may be required near gables, ridges, and eaves (follow design drawings). Unless otherwise indicated by the panel manufacturer, leave a 1/8-inch gap (about the width of a 16d common nail) between panel edges to allow for expansion. (Structural sheathing is typically cut slightly short of 48 inches by 96 inches to allow for this expansion gap – look for a label that says "Sized for Spacing.") This gap prevents buckling of panels due to moisture and thermal effects, a common problem.

Fastener Selection

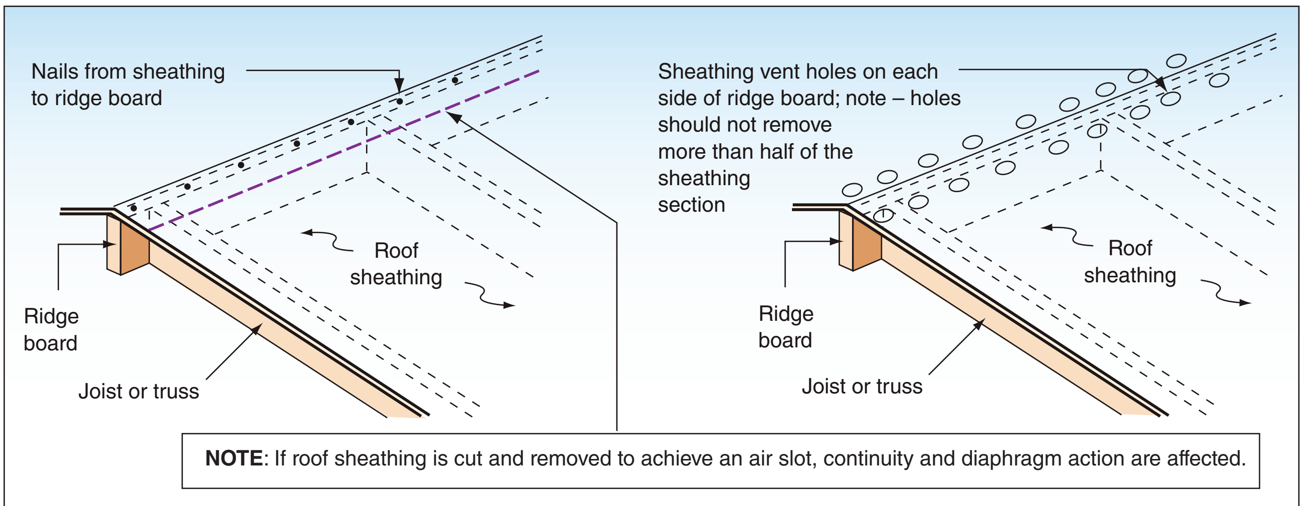
An 8d nail (2.5 inches long) is the minimum size nail to use for fastening sheathing panels. Full round heads are recommended to avoid head pull-through. Deformed-shank (i.e., ring- or screw-shank) nails are required near ridges, gables, and eaves in areas with design wind speeds over 110 mph (3-second gust), but it is recommended that deformed shank nails be used throughout the entire roof. If 8d "common" nails are specified, the nail diameter must be at least 0.131 inch (wider than typical 8d pneumatic nails). Screws can be used for even greater withdrawal strength, but should be sized by the building designer. Staples are not recommended for roof sheathing attachment in high-wind areas.

Fastener Spacing

It is ***extremely important*** to have proper fastener spacing on **all** panels. Loss of just one panel in a windstorm can lead to total building failure. Drawings should be checked to verify the required spacing; closer spacing may be required at corners, edges, and ridges. Visually inspect work after installation to ensure that fasteners have hit the framing members. Tighter fastener spacing schedules can be expected for homes built in high-wind areas. Installing fasteners at less than 3 inches on center can split framing members and significantly reduce fastener withdrawal capacity, unless 3-inch nominal framing is used and the nailing schedule is staggered.

Ridge Vents

When the roof sheathing is used as a structural diaphragm, as it typically is in high-wind and seismic hazard areas, the structural integrity of the diaphragm can be compromised by a continuous vent (see figure A., below left). Maintain ridge nailing by adding additional blocking set back from the ridge, or by using vent holes (see figure B., below right). Verify construction with a design professional.

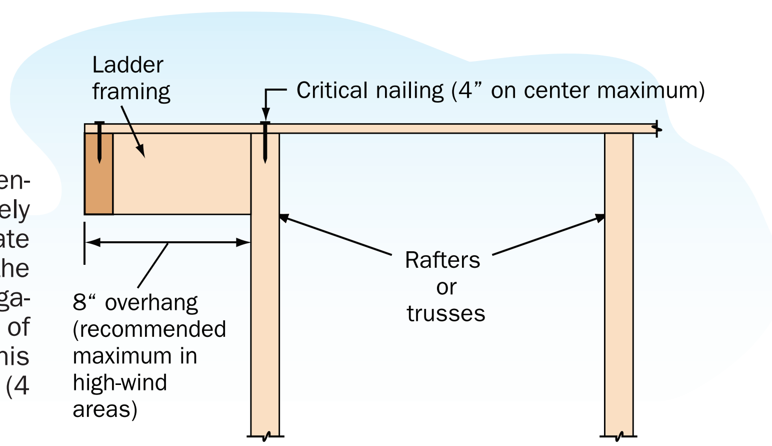


A. Method for maintaining a continuous load path at the roof ridge by nailing roof sheathing.

B. Holes drilled in roof sheathing for ventilation – roof diaphragm action is maintained. (For clarity, sheathing nails are not shown.)

Ladder Framing at Gable Ends

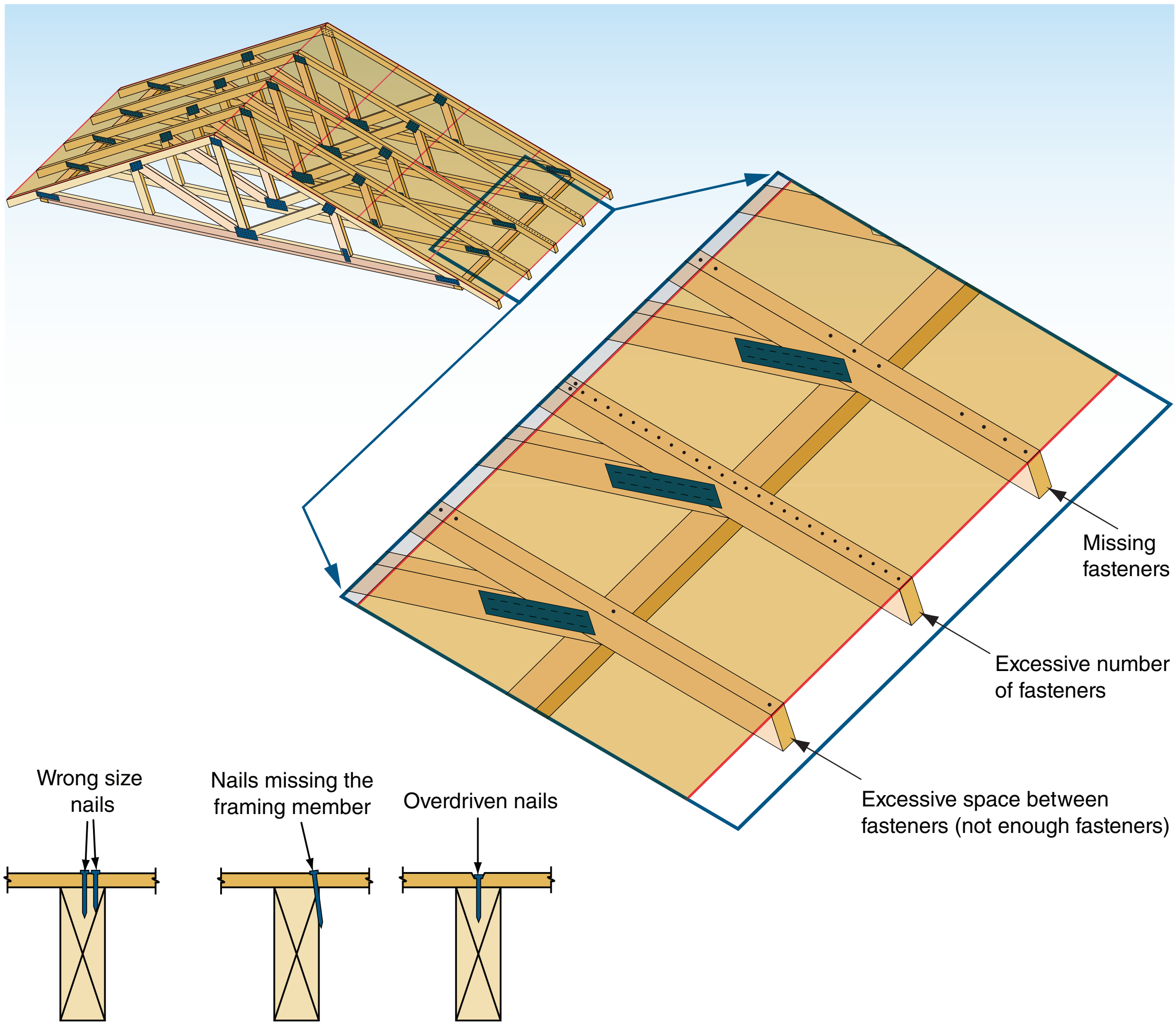
Use extra care when attaching a ladder-framed extension to a gable end. Many homes have been severely damaged by coastal storms because of inadequate connections between the roof sheathing and the gable truss. The critical fasteners occur at the gable-framing member, not necessarily at the edge of the sheathing. Nailing accuracy is crucial along this member. Tighter nail spacing is recommended (4 inches on center maximum).



Ladder framing at gable ends.

Common Sheathing Attachment Mistakes

Common mistakes include using the wrong size fasteners, missing the framing members when installing fasteners, overdriving nails, and using too many or too few fasteners.



Additional Resources

Engineered Wood Association (APA), (www.apawood.org)

Developed in association with the National Association of Home Builders Research Center

Roof Underlayment for Asphalt Shingle Roofs

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 7.2

Purpose: *To provide recommended practices for use of roofing underlayment as an enhanced secondary water barrier in coastal environments.*

Note: The underlayment options illustrated here are for asphalt shingle roofs. See FEMA publication 55, Coastal Construction Manual, for guidance concerning underlayment for other types of roofs.

Key Issues

- Verifying proper attachment of roof sheathing before installing underlayment.
- Lapping and fastening of underlayment and roof edge flashing.
- Selecting underlayment material type.

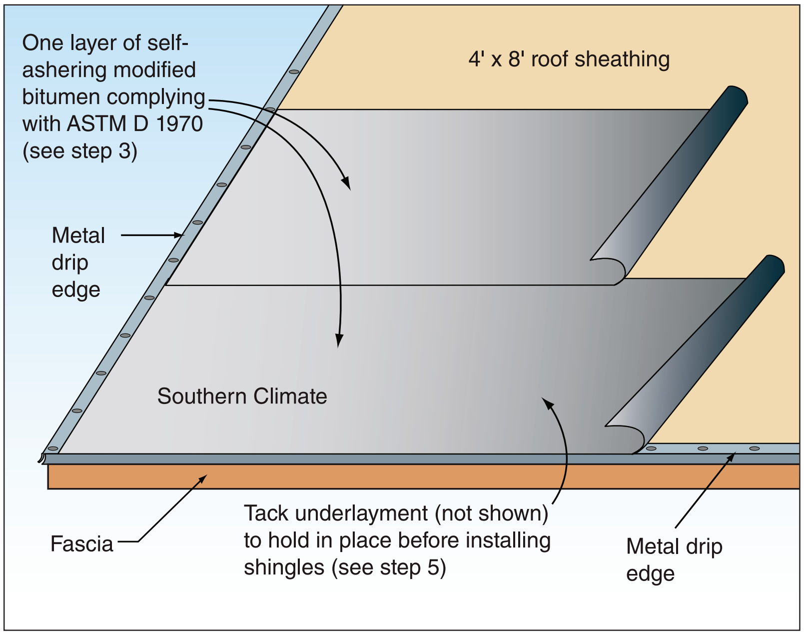
Note: This fact sheet provides general guidelines and recommended enhancements for improving upon typical practice. It is advisable to ***consult local building requirement***s for type and installation of underlayment, particularly if specific enhanced underlayment practices are required locally.

Sheathing Installation Options

The following three options are listed in order of decreasing resistance to long-term weather exposure following the loss of the roof covering. Option 1 provides the greatest reliability for long-term exposure; it is advocated in heavily populated areas where the design wind speed is equal to or greater than 120 mph (3-second peak gust).[1] Option 3 provides limited protection and is advocated only in areas with a modest population density and a design wind speed less than or equal to 110 mph (3-second peak gust).[1]

Installation Sequence – Option 1[2] (for moderate climates)

1. Before the roof covering is installed, have the deck inspected to verify that it is nailed as specified on the drawings.
2. Broom clean deck before installing self-adhering modified bitumen products. If the sheathing is OSB, check with the OSB manufacturer to determine if a primer needs to be applied before installing these products.
3. **In Southern Climates, apply a single layer of self-adhering modified bitumen complying with ASTM D 1970 throughout the roof area.**
4. Seal the self-adhering sheet to the deck penetrations with roof tape or asphalt roof cement.

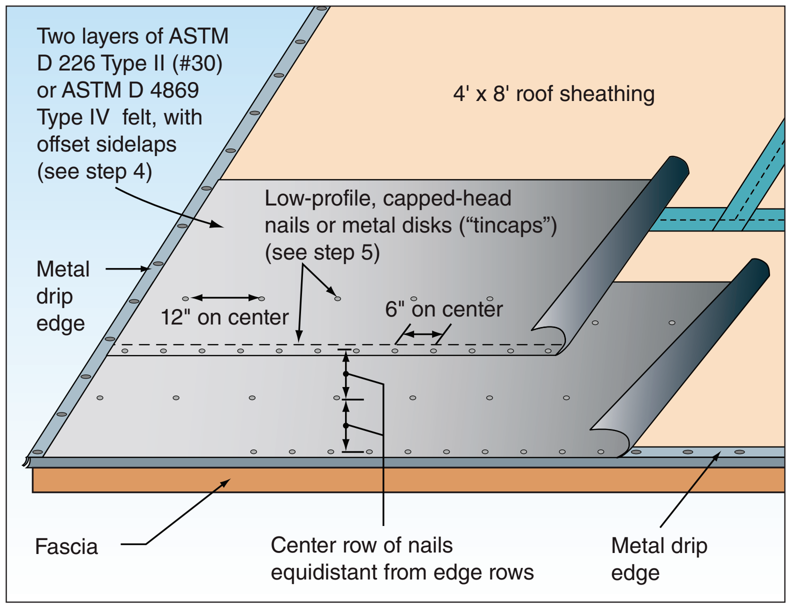


1 The 110 and 120 mph speeds are based on ASCE 7-05. If ASCE 7-10 is being used, the equivalent wind speeds are 139 and 152 mph for Risk Category II buildings.

5. **Apply a single layer of ASTM D 226 Type I (#15) or ASTM D 4869 Type II felt.** Tack underlayment to hold in place before installing shingles.
6. **In northern climates**, after step 2, install self-adhering modified bitumen tape (4 inches wide, minimum) over sheathing joints; seal around deck penetrations with roof tape. Roll tape with roller.
7. **Apply a single layer of ASTM D 226 Type II (#30) or ASTM D 4869 Type IV felt. Attach per steps 8 and 9. Then install a single layer of self-adhering modified bitumen per steps 3 and 4, followed by installation of the shingles.**
8. Secure felt with low-profile, capped-head nails or thin metal disks ("tincaps") attached with roofing nails.
9. Fasten at approximately 6 inches on center along the laps and at approximately 12 inches on center along two rows in the field of the sheet between the side laps.

Installation Sequence – Option 2[2]

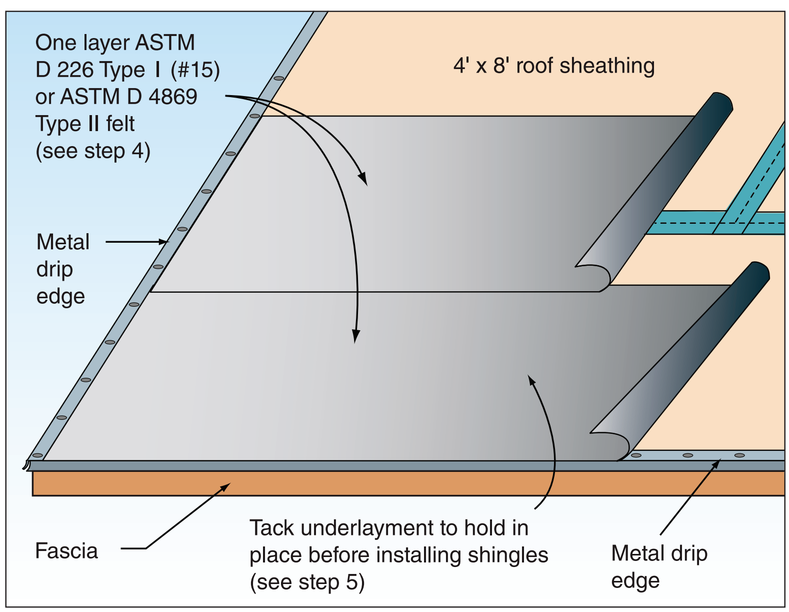
1. Before the roof covering is installed, have the deck inspected to verify that it is nailed as specified on the drawings.
2. Broom clean deck before taping. If the sheathing is OSB, check with the OSB manufacturer to determine if a primer needs to be applied before installing self-adhering modified bitumen products.
3. Install self-adhering modified bitumen tape (4 inches wide, minimum) over sheathing joints; seal around deck penetrations with roof tape. Roll tape with roller.
4. **Apply two layers of ASTM D 226 Type II (#30) or ASTM D 4869 Type IV felt with offset side laps.**



5. Secure felt with low-profile, capped-head nails or thin metal disks ("tincaps") attached with roofing nails.
6. Fasten at approximately 6 inches on center along the laps and at approximately 12 inches on center along a row in the field of the sheet between the side laps.

Installation Sequence – Option 3[2,3]

1. Before the roof covering is installed, have the deck inspected to verify that it is nailed as specified on the drawings.
2 Broom clean deck before taping. If the sheathing is OSB, check with the



2 If the building is within 3,000 feet of saltwater, stainless steel or hot-dip galvanized fasteners are recommended for the underlayment attachment.

3 (1) If the roof slope is less than 4:12, tape and seal the deck at penetrations and follow the recommendations given in The NRCA Roofing and Waterproofing Manual, by the National Roofing Contractors Association. (2) With this option, the underlayment has limited blow-off resistance. Water infiltration resistance is provided by the taped and sealed sheathing panels. This option is intended for use where temporary or permanent repairs are likely to be made within several days after the roof covering is blown off.

OSB manufacturer to determine if a primer needs to be applied before installing self-adhering modified bitumen products.

3. Install self-adhering modified bitumen tape (4 inches wide, minimum) over sheathing joints; seal around deck penetrations with roof tape. Roll tape with roller.
4. **Apply a single layer of ASTM D 226 Type I (#15) or ASTM D 4869 Type II felt.**
5. Tack underlayment to hold in place before applying shingles.

General Notes

- Weave underlayment across valleys.
- Double-lap underlayment across ridges (unless there is a continuous ridge vent).
- Lap underlayment with minimum 6-inch leg "turned up" at wall intersections; lap wall weather barrier over turned-up roof underlayment.

Additional Resources

National Roofing Contractors Association (NRCA). The NRCA Roofing and Waterproofing Manual. (www.NRCA.net)

ASTM Standard D6135, 2005, "Standard Practice for Application of Self-Adhering Modified Bituminous Waterproofing," ASTM International, West Conshohocken, PA, 2005, 10.1520/D6135-05, www.astm.org.

Developed in association with the National Association of Home Builders Research Center

NAHB RESEARCH CENTER

Asphalt Shingle Roofing for High Wind Regions

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 7.3

Purpose: *To recommend practices for installing asphalt roof shingles that will enhance wind resistance in high-wind, coastal regions.*

Key Issues

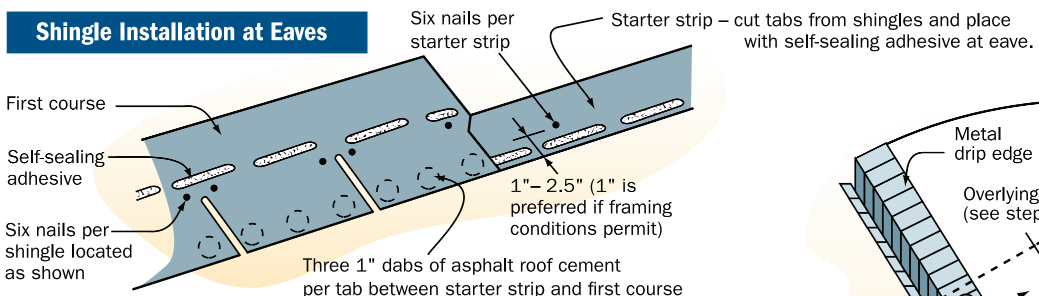
- Special installation methods are recommended for asphalt roof shingles used in high-wind, coastal regions (i.e., greater than 90-mph gust design wind speed).
- Use wind-resistance ratings to choose among shingles, but do not rely on ratings for performance.
- Consult local building code for specific installation requirements. Requirements may vary locally.
- Always use underlayment. See Fact Sheet No. 7.2 for installation techniques in coastal areas.
- Pay close attention to roof-to-wall flashing and use enhanced flashing techniques (see Fact Sheet No. 5.2).

ROOFING 7

Construction Guidance

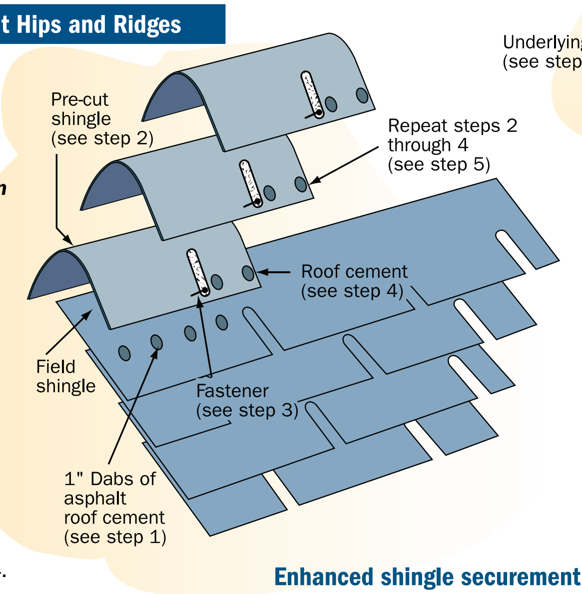
1. Follow shingle installation procedures for enhanced wind resistance.

Shingle Installation at Eaves

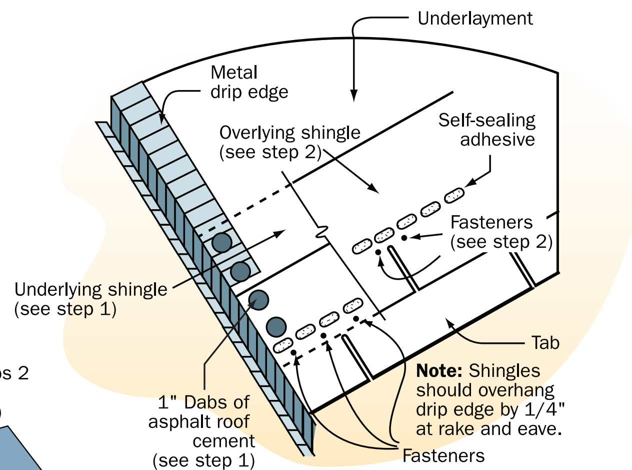


Shingle Installation at Hips and Ridges

1. Apply four 1-inch dabs of roof cement to field shingle.
2. ***Set pre-cut shingle in place and press down in dabs of roof cement before installing fasteners.***
3. Install fastener on each side of ridge. Note: Because of extra thickness of shingles at hips and ridges, longer nails may be needed.
4. Apply two 1-inch dabs of roof cement to shingle where shown.
5. Repeat steps 2 through 4.



Enhanced shingle securement



Shingle Installation at Rakes

1. Apply two 1-inch dabs of asphalt roof cement on underlying shingle, and two 1-inch dabs on metal drip edge as shown.
2. Set overlying shingle in place and install fasteners except for last fastener at rake.
3. ***Press shingle down to set in dabs of asphalt cement before installing final fastener.***
4. Install final fastener at rake edge.
5. Repeat steps for each course.

2. Consider shingle physical properties.

Properties	Design Wind Speed[1] >90 to 120 mph	Design Wind Speed[1] >120 mph
Fastener Pull-Through[2] Resistance	Minimum Recommended 25 lb at 73 degrees Fahrenheit (F)	Minimum Recommended 30 lb

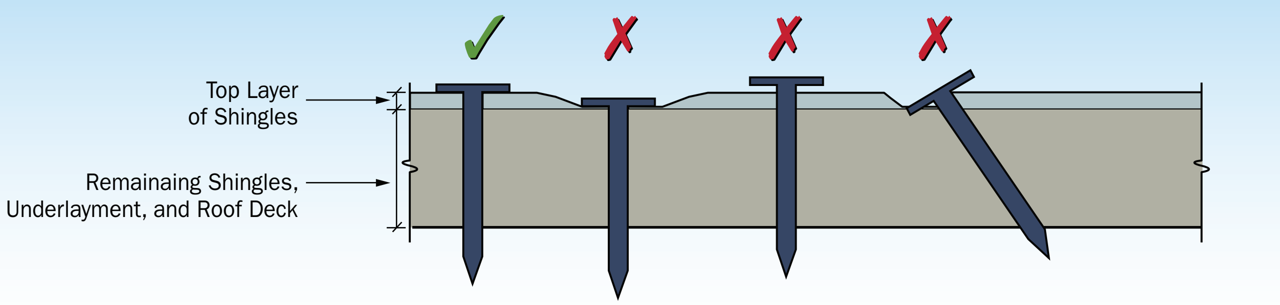
1. Design wind speed based on 3-second peak gust.
2. ASTM D 3462 specifies a minimum fastener pull-through resistance of 20 lb at 73° F. If a higher resistance is desired, it must be specified.

3. Ensure that the fastening equipment and method results in properly driven roofing nails for maximum blow-off resistance. The minimum required bond strength must be specified (see **Wind-Resistance Ratings**, below).

Shingle Type	Standard	Characteristics
Organic-Reinforced	ASTM D 225	Relatively high fastener pull-through resistance
Fiberglass-Reinforced	ASTM D 3462	Considerable variation in fastener pull-through resistance offered by different product
SBS Modified Bitumen	A standard does not exist for this product. It is recommended that SBS Modified Bitumen Shingles meet the physical properties specified in ASTM 3462.	Because of the flexibility imparted by the SBS polymers, this type of shingle is less likely to tear if the tabs are lifted in a windstorm.

Fastener Guidelines

- Use roofing nails that extend through the underside of the roof sheathing, or a minimum of 3/4 inch into planking.
- Use roofing nails instead of staples.
- Use stainless steel nails when building within 3,000 feet of saltwater.



"The Good, the bad, and the ugly" – Properly driving roofing nails.

Weathering and Durability

Durability ratings are relative and are not standardized among manufacturers. However, selecting a shingle with a longer warranty (e.g., 30-year instead of 20-year) should provide greater durability in coastal climates and elsewhere.

Organic-reinforced shingles are generally more resistant to tab tear-off but tend to degrade faster in warm climates. Use fiberglass-reinforced shingles in warm coastal climates and consider organic shingles only in cool coastal climates. Modified bitumen shingles may also be considered for improved tear-off resistance of tabs. Organic-reinforced shingles have limited fire resistance – verify compliance with code and avoid using in areas prone to wildfires.

After the shingles have been exposed to sufficient sunshine to activate the sealant, inspect roofing to ensure that the tabs have sealed. Also, shingles should be of "interlocking" type if seal strips are not present.

Wind-Resistance Ratings

Wind resistance determined by test methods ASTM D 3161 and UL 997 does not provide adequate information regarding the wind performance of shingles, even when shingles are tested at the highest fan speed prescribed in the standard. Rather than rely on D 3161 or UL 997 test data, wind resistance of shingles should be determined in accordance with UL 2390. Shingles that have been evaluated in accordance with UL 2390 have a Class D (90 mph), G (120 mph), or H (150 mph) rating. Select shingles that have a class rating equal to or greater than the basic wind speed specified in the building code. If the building is sited in Exposure D, or is greater than 60 feet tall, or is a Category III or IV, or is sited on an abrupt change in topography (such as an isolated hill, ridge, or escarpment), consult the shingle manufacturer. (Note: for definitions of Exposure D and Category III and IV, refer to ASCE 7.)

Developed in association with the National Association of Home Builders Research Center

Tile Roofing for High Wind Regions

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION   Technical Fact Sheet No. 7.4

Purpose: *To provide recommended practices for designing and installing extruded concrete and clay tiles that will enhance wind resistance in high-wind areas.*

Key Issues

Missiles: Tile roofs are very vulnerable to breakage from windborne debris (missiles). Even when well attached, they can be easily broken by missiles. If a tile is broken, debris from a single tile can impact other tiles on the roof, which can lead to a progressive cascading failure. In addition, tile missiles can be blown a considerable distance, and a substantial number have sufficient energy to penetrate shutters and glazing, and potentially cause injury. In hurricane-prone regions where the basic wind speed is equal to or greater than 110 mph (3-second peak gust), the windborne debris issue is of greater concern than in lower-wind-speed regions. Note: There are currently no testing standards requiring roof tile systems to be debris impact resistant.

Attachment methods: Storm damage investigations have revealed performance problems with mortar-set, mechanical (screws or nails and supplementary clips when necessary), and foam-adhesive (adhesive-set) attachment methods. In many instances, the damage was due to poor installation. Investigations revealed that the mortar-set attachment method is typically much more susceptible to damage than are the other attachment methods. Therefore, in lieu of mortar-set, the mechanical or foam-adhesive attachment methods in accordance with this fact sheet are recommended.

To ensure high-quality installation, licensed contractors should be retained. This will help ensure proper permits are filed and local building code requirements are met. For foam-adhesive systems, it is highly recommended that installers be trained and certified by the foam manufacturer.

Uplift loads and resistance: Calculate uplift loads and resistance in accordance with the Design and Construction Guidance section below. Load and resistance calculations should be performed by a qualified person (i.e., someone who is familiar with the calculation procedures and code requirements).

Corner and perimeter enhancements: Uplift loads are greatest in corners, followed by the perimeter, and then the field of the roof (see Figure 1 on page 2).

However, for simplicity of application on smaller roof areas (e.g., most residences and smaller commercial buildings), use the attachment designed for the corner area throughout the entire roof area.

Hips and ridges: Storm damage investigations have revealed that hip and ridge tiles attached with mortar are very susceptible to blow-off. Refer to the attachment guidance below for improved attachment methodology.

Quality control: During roof installation, installers should implement a quality control program in accordance with the Quality Control section on page 3 of this fact sheet.

Classification of Buildings

Category I	Buildings that represent a low hazard to human life in the event of a failure
Category II	All other buildings not in Categories I, III, and IV
Category III	Buildings that represent a substantial hazard to human life
Category IV	Essential facilities

ROOFING 7

Design and Construction Guidance

1. Uplift Loads

In Florida, calculate loads and pressures on tiles in accordance with the current edition of the Florida Building Code (Section 1606.3.3). In other states, calculate loads in accordance with the current edition of the International Building Code (Section 1609.7.3).

As an alternative to calculating loads, design uplift pressures for the corner zones of Category II buildings are provided in tabular form in the Addendum to the Third Edition of the *Concrete and Clay Roof Tile Installation Manual* (see Tables 6, 6A, 7, and 7A).[1]

Note: In addition to the tables referenced above, the *Concrete and Clay Roof Tile Installation Manual* contains other useful information pertaining to tile roofs. Accordingly, it is recommended that designers and installers of tile obtain a copy of the Manual and its Addendum. Hence, the tables are not incorporated in this fact sheet.

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2. Uplift Resistance

For mechanical attachment, the *Concrete and Clay Roof Tile Installation Manual* provides uplift resistance data for different types and numbers of fasteners and different deck thicknesses. For foam-adhesive-set systems, the Manual refers to the foam-adhesive manufacturers for uplift resistance data. Further, to improve performance where the basic wind speed is equal to or greater than 110 mph, it is recommended that a clip be installed on each tile in the first row of tiles at the eave for both mechanically attached and foam-adhesive systems.

For tiles mechanically attached to battens, it is recommended that the tile fasteners be of sufficient length to penetrate the underside of the sheathing by ¼ inch minimum. For tiles mechanically attached to counter battens, it is recommended that the tile fasteners be of sufficient length to penetrate the underside of the horizontal counter battens by ¼ inch minimum. It is recommended that the batten-to-batten connections be engineered.

For roofs within 3,000 feet of the ocean, straps, fasteners, and clips should be fabricated from stainless steel to ensure durability from the corrosive effects of salt spray.

3. Hips and Ridges

The *Concrete and Clay Roof Tile Installation Manual* gives guidance on two attachment methods for hip and ridge tiles: mortar-set or attachment to a ridge board. On the basis of post-disaster field investigations, use of a ridge board is recommended. For attachment of the board, refer to Table 21 in the Addendum to the *Concrete and Clay Roof Tile Installation Manual*.

Fasten the tiles to the ridge board with screws (1-inch minimum penetration into the ridge board) and use both adhesive and clips at the overlaps.

For roofs within 3,000 feet of the ocean, straps, fasteners, and clips should be fabricated from stainless steel to ensure durability from the corrosive effects of salt spray.

4. Critical and Essential Buildings (Category III or IV)

Critical and essential buildings are buildings that are expected to remain operational during a severe wind event such as a hurricane. It is possible that people may be arriving or departing from the critical or essential facility during a hurricane. If a missile strikes a tile roof when people are outside the building, those people may be struck by tile debris dislodged by the missile strike. Tile debris may also damage the facility. It is for these reasons that tiles are not recommended on critical or essential buildings in hurricane-prone regions (see ASCE 7 for the definition of hurricane-prone regions).

If it is decided to use tile on a critical or essential facility and the tiles are mechanically attached, it is recommended that clips be installed at all tiles in the corner, ridge, perimeter, and hip zones (see ASCE 7 for the width of these zones). (See Figure 1.)

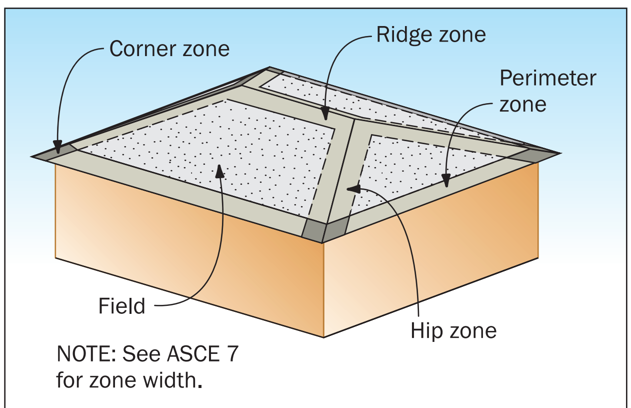

Figure 1. For critical and essential facilities, clip all tiles in the corner, ridge, perimeter, and hip zones.

1. You can order the *Concrete and Clay Roof Tile Installation Manual* online at the website of the Florida Roofing, Sheet Metal and Air Conditioning Contractor's Association, Inc., (www.floridaroof.com) or by calling (407) 671-3772. Holders of the Third Edition of the Manual who do not have a copy of the Addendum can download it from the website.

5. Quality Control

It is recommended that the applicator designate an individual to perform quality control (QC) inspections. That person should be on the roof during the tile installation process (the QC person could be a working member of the crew). The QC person should understand the attachment requirements for the system being installed (e.g., the type and number of fasteners per tile for mechanically attached systems and the size and location of the adhesive for foam-adhesive systems) and have authority to correct noncompliant work. The QC person should ensure that the correct type, size, and quantity of fasteners are being installed.

For foam-adhesive systems, the QC person should ensure that the foam is being applied by properly trained applicators and that the work is in accordance with the foam manufacturer's application instructions. At least one tile per square (100 square feet) should be pulled up to confirm the foam provides the minimum required contact area and is correctly located.

If tile is installed on a critical or essential building in a hurricane-prone region, it is recommended that the owner retain a qualified architect, engineer, or roof consultant to provide full-time field observations during application.

Developed in association with the National Association of Home Builders Research Center

Minimizing Water Intrusion Through Roof Vents in High-Wind Regions

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION   Technical Fact Sheet No. 7.5

Purpose: *To describe practices for minimizing water intrusion through roof vent systems that can lead to interior damage and mold growth in high-wind regions (i.e., greater than 90-miles per hour [mph] basic [gust design] wind speed).*[1]

ROOFING 7

Key Issues

- Hurricane winds can drive large amounts of water through attic ventilation openings. The accumulating water soaks insulation and gypsum board, which can lead to mold growth and, in some cases, to the collapse of ceilings.
- Attic ventilation can be provided by a number of devices, most of which have been observed to allow water intrusion under certain conditions and some of which have been observed to blow off. These devices include:
  - Soffit vents
  - Ridge vents
  - Gable end vents
  - Off-ridge vents
  - Gable rake vents
  - Turbines
- Adequate ventilation of attics is generally required to promote the health of wood structural members and sheathing in the attic.
- Attic ventilation can reduce the temperatures of roof coverings, which will typically prolong the life of the roof covering. However, roof color can have more of an impact on roof covering temperature than the amount of ventilation that is or is not provided.
- An unvented attic can be an effective way to prevent water intrusion and this type of attic is gaining popularity for energy efficiency reasons, provided the air conditioning system is sized appropriately. However, an unvented attic is best accomplished when it is specifically designed into the house and all of the appropriate details are handled properly. On an existing house, any attempt to change to an unvented attic configuration needs to be done very carefully with the advice of knowledgeable experts. There are a number of changes that have to be made to produce a successful transition from a ventilated to an unvented attic. One side effect of going to an unvented attic may be to void the warranty for the roof covering.

The Unvented Attic

The most conservative approach to preventing wind-driven rain from entering the attic is to eliminate attic ventilation, but unvented attics are controversial. Although allowed by the International Residential Code (IRC), provided the Code's criteria are met, unvented attics may not comply with local building codes.

However, when unvented attics are allowed by the building code or code compliance is not an issue, and when climatic and interior humidity conditions (e.g., no indoor swimming pools) are conducive to an unvented design, an unvented attic is a reliable way to prevent wind-driven rain from entering the attic.

Air barrier: Refer to Fact Sheet 5.3, *Siding Installations in High-Wind Regions* for recommendations regarding attic air barriers.

The following information is intended to help minimize water intrusion through new and existing attic ventilation systems, not to change from a ventilated to an unvented system. With the exception of the plugging of gable rake vents, all other shuttering of openings or plugging of vents should be done on a temporary basis and removed once the storm threat is over so that the attic is once again properly ventilated.

1 The 90 mph speed is based on ASCE 7-05. If ASCE 7-10 is being used, the equivalent wind speed is 116 mph for Risk Category II buildings

Mitigation Guidance

Soffit Vents

Key Issues

- It is important to keep the soffit material in place. While some water can be blown into the attic through almost any type of soffit vent, the amount of water intrusion increases dramatically when the soffit material is missing (Figure 1).
- Plywood or wood soffits are generally adequately anchored to wood framing attached to the roof structure and/or the walls. However, it has been common practice for vinyl and aluminum soffit panels to be installed in tracks that are frequently very poorly connected to the walls and fascia at the edge of the roof overhang. When these poorly anchored soffits are blown off, water intrusion increases significantly. Properly installed vinyl and aluminum soffit panels are fastened to the building structure or to nailing strips placed at intervals specified by the manufacturer.

Figure 1. Missing soffit material.

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Proper Installation

The details of proper installation of vinyl and aluminum soffits depend on the type of eave to which they are attached. The key elements are illustrated in Figure 2.

A. Roof truss or rafter framing should extend across the bottom of the eaves, or be added to create a structural support for the soffit. As an alternative, soffits can be attached directly to the undersides of the angled rafters.

B. Nailing strips should be provided, if necessary, to allow attachment of the soffit at the ends. Intermediate nailing strips may be needed, depending on the maximum span permitted for the soffit. If this is not known, the span between attachment points should not exceed 12” in high-wind regions.

C. A J-channel (illustrated), F-channel, or other receiver as specified by the manufacturer should cover the ends of the soffit panels. Fasteners should be those specified by the manufacturer. Fasteners should be used through the nailing strip of each panel and at any other points (such as in the “valleys” of the soffit) if specified.

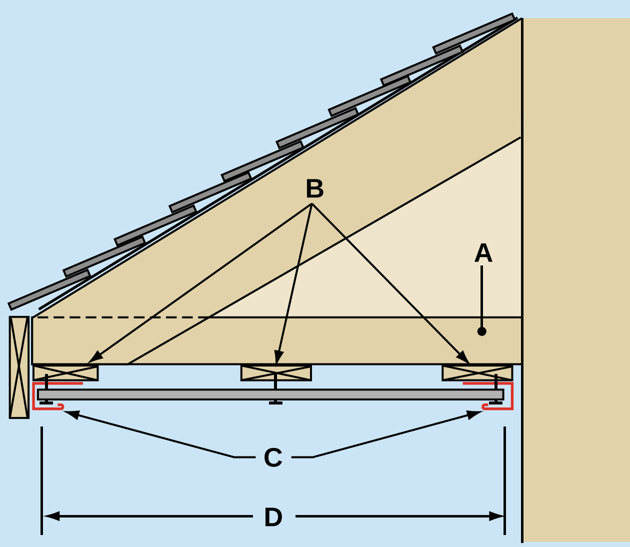


Figure 2. Key soffit installation points.

D. The overall span (eave depth) of the soffit should not exceed any limits specified by the manufacturer, and any required intermediate attachment points should be used.

Checking Soffit Material Installation

As previously noted, the most critical soffit installations to check are those where vinyl or aluminum soffit panels are used. Soffits should be fastened to the eave structure; they should not be loose in the channels. Pushing up on the soffit material and the channels used to support the material can be revealing. If it moves readily or is easy to deform, it probably is not attached very well. Similarly, if the width of the overhang is greater than 12 inches, there should be an intermediate support running along the middle of the soffit and the panels should be attached to this support in addition to the supports at the ends of the panels. If the reader is concerned about the installation but cannot be sure, there are a couple of tools with a viewing screen connected to a small camera lens and light mounted at the end of a flexible tube that can be used to observe the connections. These devices allow inspection through a small hole that is drilled in an inconspicuous location that can be later filled with sealant. In order to ensure that there is a strong connection at the wall, there should be wood blocking running along the wall above the track where the soffit channel is attached and the channel should be fastened to that blocking. If there is no wood blocking, and there is either no vertical nailing surface on the channel or occasional tabs that have been cut and bent up to allow fastening to the wall, strengthening of the anchorage of the soffit material is clearly indicated.

Remedial Measures

If the inspection indicates a poorly attached soffit, the best way to ensure that the soffit material is adequately anchored in place is to remove it and install adequate wood blocking to allow solid anchorage of the soffit material. In some cases, it may be possible to remove the soffit material and reinstall it. However, it is also likely that some or all of the material will need to be replaced, so make sure that it can be matched before it is removed. Short of removing and properly reinstalling the soffit material, testing has shown that the anchorage can be greatly improved by applying a bead of sealant (Figure 3) along the bottom edge of the wall channel to adhere it to the wall surface below followed by applying large dabs of sealant in indentations between the soffit panels and the wall channel at one end (Figure 4) and the fascia flashing at the other end. Surfaces receiving sealant should be cleaned in order to facilitate bonding. Extra resistance can be gained by installing screws that mechanically tie the soffit panels to both the fascia flashing and to the wall channel (Figure 5). Note that use of sealant is a remedial measure only and is not a substitute for proper installation and fastening of soffits in a new installation.

Figure 3. Applying a bead of sealant. (Note: Black sealant was used so that it would be visible in the photograph. Normally a matching sealant color would be used.)

Figure 4. Applying dabs of sealant.

Figure 5. Screws through wall channel.

ROOFING 7

Wind-driven rain penetration: Currently there is no adequate standard test method to evaluate the potential for wind-driven rain to enter attics through soffit vent openings, such as those shown in Figure 6. To avoid water entry at soffit vents, options include eliminating soffit vents and providing an alternate method for air to enter the attic, or design for an unvented attic. Another approach is to place filter fabric (like that used for heating, ventilation, or cooling [HVAC] system filters) above the vent openings; however, such an approach needs to be custom designed.

Figure 6. Fiber cement soffit with ventilation slots (red arrow).

Fascia cover: Field investigations after Hurricane Ike showed many cases where the aluminum fascia cover (fascia cap) from the fascia board was blown off (Figure 7). The fascia cover normally covers the ends of vinyl and aluminum soffits. When the fascia cover is blown off, the ends of the soffit panels are exposed to wind and wind-driven rain.

Rain screen wall venting: In lieu of providing soffit vents, another method to provide attic air intake is through a pressure-equalized rain screen wall system as discussed in *Siding Installation in High-Wind Regions*, Hurricane Ike Recovery Advisory. This alternative approach eliminates soffit vents and their susceptibility to wind-driven rain entry.

Figure 7. Loss of fascia cover exposes ends of vinyl soffit to direct entry of wind-driven rain.

The IRC currently has no guidelines for the installation of fascia covers. Aluminum fascia covers are typically tucked under the roof drip edge and face-nailed every few feet. More frequent nailing would help secure the fascia cover, but would also inhibit normal thermal movement, which can cause unattractive warping and dimpling of the cover. Vinyl fascia covers are available, which are attached to a continuous strip of utility trim placed underneath the drip edge. This provides a somewhat more secure, continuous attachment and allows for thermal movement. Aluminum fascia covers can also be field notched and installed with utility trim.

Ridge Vents

Key Issues

- Ridge vents are frequently fastened down using ordinary roofing nails since these are normally handy. It is fairly common to find ridge vents dislodged or blown off during a hurricane (Figure 8). Even a partially dislodged ridge vent can begin to act like a scoop that collects wind-driven rain and directs it into the attic.
- Most roofing manufacturers now make ridge vents that have passed wind-driven water tests. They are identified as having passed Florida Building Code's Product Approvals or Testing Application Standard (TAS) 100(A). Typically, they include a baffle in front of the vent tubes that provide the passageway for hot attic gasses to escape. This baffle is intended to trip any flow of wind and water blowing up the surface of the roof and deflect it over the top of the roof ridge.

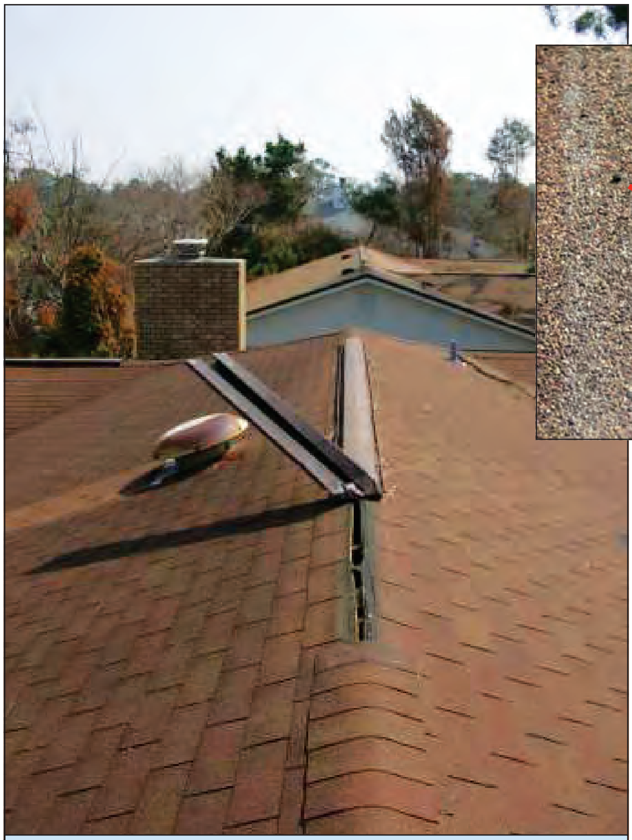


Figure 8. *This metal ridge vent was attached with widely spaced roofing nails.*

Slotting the Deck

When ridge venting is being added to a roof that previously did not have it, it is necessary to cut a slot through the decking. When doing so, it is important to set the depth of the saw blade so that it only slightly projects below the bottom of the decking. At the residence shown in Figure 8, the saw blade cut approximately 1 1/2 inches into the trusses and cut a portion of the truss plate (red arrow).

Checking Ridge Vents and Their Installation

When they are used, ridge vents are the last part of the roof to be installed. Consequently, the connection is readily accessible and frequently visible without having to pry up the edge of the vent cover top. Check the type and condition of the fasteners. If the fasteners are nails, replacement of the fasteners is in order. If the vent has clear holes or slots without any baffle or trip next to the edge of the vent channels, the vent is probably not one that is resistant to water intrusion and you should consider replacing the ridge vent with one that has passed the wind-driven water intrusion tests.

Remedial Measures

Replace nails with gasketed stainless steel wood screws that are slightly larger than the existing nails and, if possible, try to add fasteners at locations where they will be embedded in the roof structure below and not just into the roof sheathing. Close spacing of fasteners is recommended (e.g., in the range of 3 to 6 inches on center, commensurate with the design wind loads). If the ridge vents are damaged or are one of the older types that are not resistant to water intrusion, they should be replaced with vents that have passed the wind-driven water intrusion tests.

Figure 9. Gable end vent.

Gable End Vents

Key Issues

- Virtually all known gable end vents (Figure 9) will leak when the wall they are mounted on faces into the wind-driven rain. The pressures developed between the outside surface of the wall and the inside of the attic are sufficient to drive water uphill for a number of inches and, if there is much wind flow through the vent, water carried by the wind will be blown considerable distances into the attic.

Remedial Measures

If it is practical and possible to shutter gable end vents from the outside of the house, this is the preferable way to minimize water intrusion through gable end vents (Figure 10). Install permanent anchors in the wood structure around the gable vent and precut, pre-drill, and label plywood or other suitable shutter materials so that they are ready for installation by a qualified person just before a storm approaches. If installation of shutters from the outside is difficult because of the height or other considerations, but there is access through the attic, the gable vent opening can be shuttered from the inside. However, careful attention needs to be paid to sealing around the shutter and making sure that any water that accumulates in the cavity can drain to the outside of the house and not into the wall below.

Figure 10. Shuttered gable end vent.

Off-ridge Vents

Key Issues

Poorly anchored off-ridge vents can flip up and become scoops that direct large amounts of wind-driven rain into the attic (Figure 11).

Some vents are also prone to leaking when winds blow from certain directions. This will depend on the location of the vent on the roof surface and the geometry of the roof, as well as the geometry of the particular vent.

Checking Off-Ridge Vent Installations

Off-ridge vents typically have a flange that lies against the top surface of the roof sheathing and is used to anchor the vent to the roof sheathing. Frequently, roofing nails are used to attach the flange to the roof sheathing. The off-ridge vents should be checked to make sure that they are well anchored to the roof sheathing. If they seem loose, or there are not many fasteners holding them down, it could be a weak link

Figure 11. Two off-ridge vents are shown in this photograph. The vent that is covered with roofing felt flipped up and allowed a substantial amount of water to enter the residence. Carpeting, kitchen cabinets, and a large amount of gypsum board had to be replaced because of the water intrusion.

in preventing water intrusion when a storm occurs. Since the flange and fasteners are hidden below the roof covering, it is not possible to simply add nails or screws to improve the anchorage as these will create holes through the roof covering.

Remedial Measures

If the off-ridge vent is attached to the roof sheathing with long, thin nails, it may be possible to improve the anchorage by cinching the nails (bending them over against the underside of the roof sheathing). However, if they are short and/or thick, trying to bend them over may cause more harm than good. Some homeowners have had covers made that can be installed from the inside of the attic over the hole where the off-ridge vent is installed. This will be easiest if the vent is larger than the hole and the cover can be attached to the sheathing in an area where the fasteners cannot be driven through the roof covering. Otherwise, it will be important to ensure that the fasteners are short enough that they will not extend through the roof sheathing and damage the roof cover. If the edge of the hole in the roof deck is flush with the inside edge of the vent, it may be possible to install metal straps that are screwed into the walls of the vent and attached with short screws to the bottom surface of the roof sheathing. Again, it is critical to use screws that are short enough that they will not extend through the roof sheathing and damage the roof covering. The strapping should be connected to the walls of the vent with short stainless steel sheet metal screws.

Gable Rake Vents

Key Issues

- Gable rake vents are formed when porous soffit panels or screen vents are installed on the bottom surface of the roof overhang at the gable end and there is a clear path for wind to blow into the attic. This usually happens when the gable overhang is supported by what are called outriggers. Outriggers are typically used when gable overhangs exceed 12 inches. In these cases, the last roof truss or rafter (the gable end truss or rafter) is smaller than the trusses or rafters at the next location inside the attic. Outriggers (2x4s) are installed over top of the last gable truss or rafter, one end is anchored to the second truss or rafter back from the gable end, and the other end sticks out past the gable end wall to support the roof sheathing on the overhang.

Finding Out if You Have Gable Rake Vents and Whether You Still Need Them

The easiest way to tell if the roof has gable rake vents is to look in the attic on a cool sunny day and see if light is visible in gaps just below the sheathing at the gable end. The presence of the outriggers (2x4s running perpendicular to the gable truss and disappearing into the gable overhang) should also be visible. If there is also a gable end vent or a ridge vent, then the gable rake vent will probably not be needed in order to provide adequate venting for the attic.

Remedial Measures

The best solution if venting provided by the gable rake vents is not needed is to simply plug them up with metal flashing (Figure 12) or pieces of wood that are cut and anchored. They should be well attached and completely seal as many of the openings as possible

Figure 12. Metal plugs (red arrows) in gable rake vents.

and particularly those near the gable peak. Sealant can be used to seal around the edges of the metal or wood plugs.

Turbines

Key Issues

- The rotating top portion of many turbines is not designed to withstand high-wind conditions and they are frequently installed with just a friction fit to the short standpipe that provides the venting of the attic. It is possible to find high-wind rated turbines on store shelves in hurricane-prone regions but, in hurricane winds, the turbines will be rotating at tremendous speeds and can be easily damaged by windborne debris.
- The flange on the standpipe that provides the connection of the pipe to the roof sheathing may also be poorly anchored to the roof sheathing.

Checking Turbines and Their Installation

Check any turbines to make sure that the stand pipes are not loose and that the turbine head is anchored to the stand pipe by sheet metal screws and not simply by a friction fit (Figure 13).

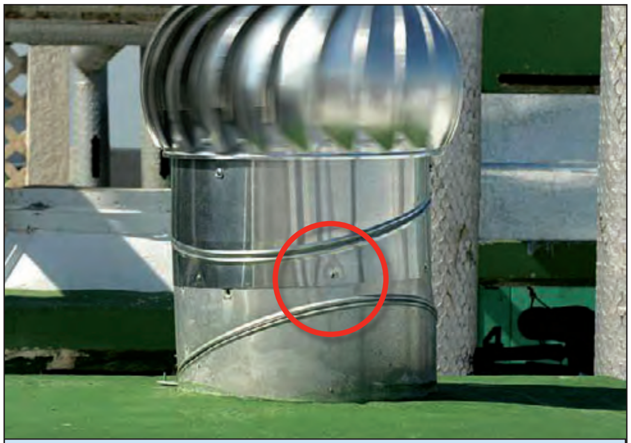


Figure 13. This turbine head is attached to the standpipe with dimple punches. Sheet metal screws should be added to strengthen the connection.

Remedial Measures

Loose standpipes should be securely anchored to the roof sheathing. If the standpipe is attached to the roof sheathing with long, thin nails, it may be possible to improve the anchorage by cinching the nails (bending them over against the underside of the roof sheathing). However, if they are short and/or thick, trying to bend them over may cause more harm than good. Some homeowners have had covers made that can be installed from the inside of the attic over the hole where the standpipe is installed. This will be easiest if the standpipe is larger than the hole and the cover can be attached to the sheathing in an area where the fasteners cannot be driven through the roof cover. Otherwise, it will be important to ensure that the fasteners are short enough that they will not extend through the roof sheathing and damage the roof cover.

If the edge of the hole in the roof deck is flush with the inside edge of the standpipe, it may be possible to install metal straps that are screwed into the walls of the standpipe and attached with short screws to the bottom surface of the roof sheathing. Again, it is critical to use screws that are short enough that they will not extend through the roof sheathing and damage the roof cover. The strapping should be connected to the walls of the standpipe with short stainless steel sheet metal screws.

Beyond any remedial measures taken to anchor the standpipe to the roof sheathing or to plug the hole from the attic side, it is also important to try and seal the standpipe from the outside so that water does not build up in the pipe and leak into the roof sheathing around the hole. The best approach is to have a qualified person remove the top active portion of the turbine vent before the storm and plug the hole at the top of the standpipe. A wooden plug can be used that covers the entire hole and has blocks that rest against the walls of the standpipe where screws can be installed to anchor the plug to the standpipe. Some homeowners have had the entire turbine wrapped in plastic to keep water out during a storm (Figure 14). This can work as long as the turbine or wrapping does not get dislodged. The smaller area provided by removing the turbine top and plugging the hole is considered preferable.

Figure 14. Plastic wrapped turbines.

Metal Roof Systems in High-Wind Regions

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 7.6

Purpose: *To describe practices for designing and installing metal roof systems 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

Damage investigations have revealed that some metal roofing systems have sufficient strength to resist extremely high winds (Figure 1), while other systems have blown off during winds that were well below design wind speeds given in ASCE 7. When metal roofing (or hip, ridge, or rake flashings) blows off during hurricanes, water may enter the building at displaced roofing; blown-off roofing can damage buildings and injure people. Here is general guidance for achieving successful wind performance:

1. Always follow the manufacturer's installation instructions and local building code requirements.
2. Calculate loads on the roof assembly in accordance with ASCE 7 or the local building code, it is recommended to use whichever procedure results in the highest loads.
3. Specify/purchase a metal roof system that has sufficient uplift resistance to meet the design uplift loads.
   - For standing seam metal panel systems, the 2009 International Building Code (IBC) requires test methods UL 580 or ASTM E 1592. For standing seam systems, it is recommended that design professionals specify E 1592 testing, because it gives a better representation of the system's uplift performance capability.
   - For safety factor determination, refer to Chapter F in standard NAS-01, published by the American Iron and Steel Institute.
   - For through-fastened steel panel systems, the IBC allows uplift resistance to be evaluated by testing or by calculations in accordance with standard NAS-01.

Figure 1. This structural standing seam roof system survived Hurricane Andrew (Florida, 1992), but some hip flashings were blown off. The estimated wind speed was 170 mph (peak gust, at 33 feet for Exposure C).

   - For architectural panels with concealed clips, test method UL 580 is commonly used. However, it is recommended that design professionals specify ASTM E 1592 because it gives a better representation of the system's uplift performance capability. When testing architectural panel systems via ASTM E 1592, the deck joints need to be unsealed in order to allow air flow to the underside of the metal panels. Therefore, underlayment should be eliminated from the test specimen, and a 1/8 inch minimum between deck panel side and end joints should be specified.
   - For safety factor determination, refer to Chapter F of the *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100-07).

This fact sheet addresses wind and wind-driven rain issues. For general information on other aspects of metal roof system design and construction (including seam types, metal types, and finishes), see the "Additional Resources" section.

1 The 90 mph speed is based on ASCE 7-05. If ASCE 7-10 is being used, the equivalent wind speed is 116 mph for Risk Category II buildings.

- For copper roofing testing, see "NRCA analyzes and tests metal," Professional Roofing, May 2003.
- For metal shingles, it is recommended that uplift resistance be based on test method UL 580 or 1897.
- Specify the design uplift loads for field, perimeter, and corners of the roof. Also specify the dimension of the width of the perimeter. (Note: For small roof areas, the corner load can be used throughout the entire roof area.)

4. Suitably design the roof system components (see the "Construction Guidance" section).
5. Obtain the services of a professional roofing contractor to install the roof system.

For observations of metal roofing performance during Hurricanes Charley (2004, Florida), Ivan (2004, Alabama and Florida), and Katrina (Alabama, Louisiana, and Mississippi, 2005), respectively; see Chapter 5 in FEMA MAT reports 488, 489, and 549.

For attachment of corrugated metal panels, see FEMA 55, *Coastal Construction Manual, Appendix K*, available online at: http://www.fema.gov/library/viewRecord.do?id=1671.

An advantage of exposed fastener panels (versus panels with concealed clips) is that, after installation, it is easy to verify that the correct number of fasteners was installed. If fastening was not sufficient, adding exposed fasteners is easy and economical.

Metal Roofing Options

A variety of metal panel systems (including composite foam panels) are available for low-slope (i.e., 3:12 or less) and steep-slope (i.e., greater than 3:12) roofs. Metal shingles are also available for steep-slope roofs. Common metal roofing options are:

Standing-Seam Hydrostatic (i.e., water-barrier) Systems: These panel systems are designed to resist water infiltration under hydrostatic pressure. They have standing seams that raise the joint between panels above the water line. The seam is sealed with sealant tape (or sealant) in case it becomes inundated with water backed up by an ice dam or driven by high wind.

Most hydrostatic systems are structural systems (i.e., the roof panel has sufficient strength to span between purlins or nailers). A hydrostatic architectural panel (which cannot span between supports) may be specified, however, if continuous or closely spaced decking is provided.

Hydrokinetic (i.e., water-shedding) panels: These panel systems are not designed to resist water infiltration under hydrostatic pressure and therefore require a relatively steep slope (typically greater than 3:12) and the use of an underlayment to provide secondary protection against water that infiltrates past the panels. Most hydrokinetic panels are architectural systems, requiring continuous or closely spaced decking to provide support for gravity loads.

Some hydrokinetic panels have standing ribs and concealed clips (Figure 2), while others (such as 5V-crimp panels, R-panels [box-rib] and corrugated panels) are through-fastened (i.e., attached with exposed fasteners). Panels are available that simulate the appearance of tile.

Metal Shingles: Metal shingles are hydrokinetic products and require a relatively steep-slope and the use of an underlayment. Metal shingles are available that simulate the appearance of wood shakes and tiles.

Figure 2. This architectural panel system has concealed clips. The panels unlatched from the clips. The first row of clips (just above the red line) was several inches from the end of the panels. The first row of clips should have been closer to the eave.

7 ROOFING

Construction Guidance

- Consult local building code requirements and manufacturer's literature for specific installation requirements. Requirements may vary locally.
- Underlayment: If a robust underlayment system is installed, it can serve as a secondary water barrier if the metal roof panels or shingles are blown off (Figures 2 and 3). For enhanced underlayment recommendations, see Fact Sheet No. 7.2, *Roof Underlayment for Asphalt Shingle Roofs*. Fact Sheet 7.2 pertains to underlayment options for asphalt shingle roofs. For metal panels and tiles, where Fact Sheet 7.2 recommends a Type I (#15) felt, use a Type II (#30) felt because the heavier felt provides greater resistance to puncture by the panels during application. Also, if a self-adhering modified bitumen underlayment is used, specify/purchase a product that is intended for use underneath metal (such products are more resistant to bitumen flow under high temperature).

Figure 3. These architectural panel system have snap-lock seams. One side of the seam is attached with a concealed fastener. Although a large number of panels blew away, the underlayment did not.

- Where the basic (design) wind speed is 110 mph[2] or greater, it is recommended that not less than two clips be used along the eaves, ridges, and hips. Place the first eave clip within 2 to 3 inches of the eave, and place the second clip approximately 3 to 4 inches from the first clip. Figures 2 and 4 illustrate ramifications of clips being too far from the eave.
- For copper panel roofs in areas with a basic wind speed greater than 90 mph,[3] it is recommended that Type 304 or 316 stainless steel clips and stainless steel screws be used instead of more malleable copper clips.

Figure 4. These eave clips were too far from the panel ends. The clip at the left was 13" from the edge of the deck. The other clip was 17" from the edge. It would have been prudent to install double clips along the eave.

- When clip or panel fasteners are attached to nailers (Figures 5–7), detail the connection of the nailer to the nailer support (including the detail of where nailers are spliced over a support).

Figure 5. The panels blew off the upper roof and landed on the lower roof of this house. The upper asphalt shingle roof shown had been re-covered with 5V-Crimp panels that were screwed to nailers. The failure was caused by inadequate attachment of the nailers (which had widely-spaced nails) to the sheathing. Note that the hip flashing on the lower roof blew off.

2 The 110 mph speed is based on ASCE 7-05. If ASCE 7-10 is being used, the equivalent wind speed is 142 mph for Risk Category II buildings.

3 The 90 mph speed is based on ASCE 7-05. If ASCE 7-10 is being used, the equivalent wind speed is 116 mph for Risk Category II buildings.

Figure 6. Blow-off of nailers caused these panels to progressively fail. The nailers were installed directly over the trusses. In an assembly such as this where there is no decking, there is no opportunity to incorporate an underlayment. With loss of the panels, rainwater was free to enter the building.

Figure 7. This residence had metal shingles that simulated the appearance of tile. The shingles typically blew off the battens, but some of the battens were also blown away.

7 ROOFING

- When clip or panel fasteners are loaded in withdrawal (tension), screws are recommended in lieu of nails.
- For roofs located within 3,000 feet of the ocean line, 300 series stainless steel clips and fasteners are recommended.
- For concealed clips over a solid substrate, it is recommended that chalk lines be specified so that the clips are correctly spaced.
- Hip, ridge, and rake flashings: Because exposed fasteners are more reliable than cleat attachment, it is recommended that hip, ridge, and rake flashings be attached with exposed fasteners. Two rows of fasteners are recommended on either side of the hip/ridge line. Close spacing of fasteners is recommended (e.g., spacing in the range of 3 to 6 inches on center, commensurate with the design wind loads), as shown in Figure 8 in order to avoid flashing blow-off as shown in Figure 9.

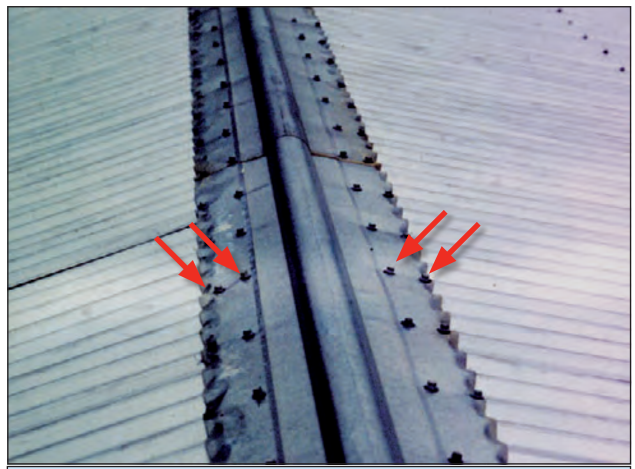


Figure 8. The ridge flashing on these corrugated metal panels had two rows of fasteners on each side of the ridge line.

Figure 9. The ridge flashing fasteners were placed too far apart. A significant amount of water leakage can occur when ridge flashings are blown away.

Additional Resources

For general information on other aspects of metal roof system design and construction (including seam types, metal types, and finishes), see:

Copper and Common Sense, (http://www.reverecopper.com)

Copper Development Association, (http://www.copper.org/publications)

Metal Building Manufacturers Association, *Metal Roofing Systems Design Manual*, 2000, (http://www.mbma.com/display.cfm?p=44&pp6&i=47)

Metal Construction Association, (http://www.metalconstruction.org/pubs)

National Institute of Building Sciences, *Whole Building Design Guide*, (http://www.wbdg.org/design/env_roofing.php)

National Roofing Contractors Association, *The NRCA Roofing Manual: Metal Panel and SPF Roof Systems,* 2008, (http://www.nrca.net/rp/technical/manual/default.aspx)

Sheet Metal and Air Conditioning Contractors National Association, *Architectural Sheet Metal Manual*, 2003, (http://www.smacna.org/bookstore)

American Iron and Steel Institute, *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100-07), 2007, (http://www.steel.org)

American Iron and Steel Institute (http://www.professionalroofing.net/article.aspx?id=266)

FEMA MAT reports 488, 489, FEMA 543 (Section 3.4.3.4), 549, FEMA 577 (Section 4.3.3.8). (http://www.fema.gov/library).

International Organization of Standards (ISO), Document ISO 14021, (http:// www.iso.org).

Professional Roofing, "NRCA analyzes and tests metal," May 2003, (http://www.professionalroofing.net)

Developed in association with the National Association of Home Builders Research Center

Enclosures and Breakaway Walls

Purpose: *To discuss requirements and recommendations for enclosures and breakaway walls below the Base Flood Elevation (BFE).*

Key Issues

- Areas enclosed by solid walls below the BFE ("enclosures") are subject to strict regulation under the National Flood Insurance Program (NFIP). Note that some local jurisdictions enforce stricter regulations for enclosures.
- Spaces below elevated buildings can be used only for building access, parking, and storage.
- Enclosures in V Zone buildings must be breakaway (non-breakaway enclosures are prohibited). Breakaway enclosures in V Zones must be built with flood-resistant materials, meet specific design requirements, and be certified by a registered design professional.
- Enclosures (breakaway and non-breakaway) in A Zone buildings must be built with flood-resistant materials and equipped with flood openings that allow water levels inside and outside to equalize.
- Breakaway enclosure walls should be considered expendable, and the building owner could incur significant costs when the walls are replaced. Breakaway wall replacement is not covered under flood insurance policies.
- For V Zones, breakaway wall enclosures below an elevated building will result in higher flood insurance premiums; however, surrounding below-BFE space with insect screening, open lattice, slats, or shutters (louvers) can result in much lower flood insurance premiums (Figure 1) and will likely reduce damage during less-than-base-flood events. It is also recommended that breakaway walls be designed to break into smaller sections so that they're less likely to damage the foundation or the upper portions of buildings.

Figure 1. Wood louvers installed beneath an elevated house in a V Zone are a good alternative to solid breakaway walls.

WARNING

Designers, builders, and homeowners should realize that: (1) enclosures and items within them are likely to be destroyed even during minor flood events; (2) enclosures, and most items within them, are not covered under flood insurance, which can result in significant costs to the building owner; and (3) even the presence of properly constructed breakaway wall enclosures will increase flood insurance premiums for the entire building (the premium rate will increase as the enclosed area increases). Including enclosures in a building design can have significant cost implications.

The Hurricane Ike Mitigation Assessment Team (MAT) observed some breakaway walls in excess of 11 feet high. While FEMA promotes elevating homes above the BFE (i.e., adding freeboard), one of the unintended consequences appears to be the increasing size of flood-borne debris elements due to taller breakaway walls.

Space Below the BFE — What Can It Be Used For?

NFIP regulations state that the area below an elevated building can only be used for ***parking, building access, and storage***. These areas must not be finished or used for recreational or habitable purposes. Only minimal electrical equipment is allowed and no mechanical or plumbing equipment is to be installed below the BFE.

Figure 2. Breakaway walls beneath this building failed as intended under the flood forces of Hurricane Ike.

What is an Enclosure?

An ***"enclosure"*** is formed when any space below the BFE is enclosed on all sides by walls or partitions. Enclosures can be divided into two types—breakaway and non-breakaway.

- **Breakaway** enclosures are designed to fail under base flood conditions without jeopardizing the elevated building (Figure 2) – **any below-BFE enclosure in a V Zone must be breakaway.** Breakaway enclosures are permitted in A Zones but must be equipped with flood openings.
- **Non-breakaway enclosures** can be constructed in an A Zone. They may be used to provide structural support to the elevated building. All A Zone enclosures must be equipped with flood openings to allow the automatic entry and exit of floodwaters. **It is recommended that they be used only in A Zone areas subject to shallow, slow-moving floodwaters without breaking waves (i.e., do not use in Coastal A Zones).**

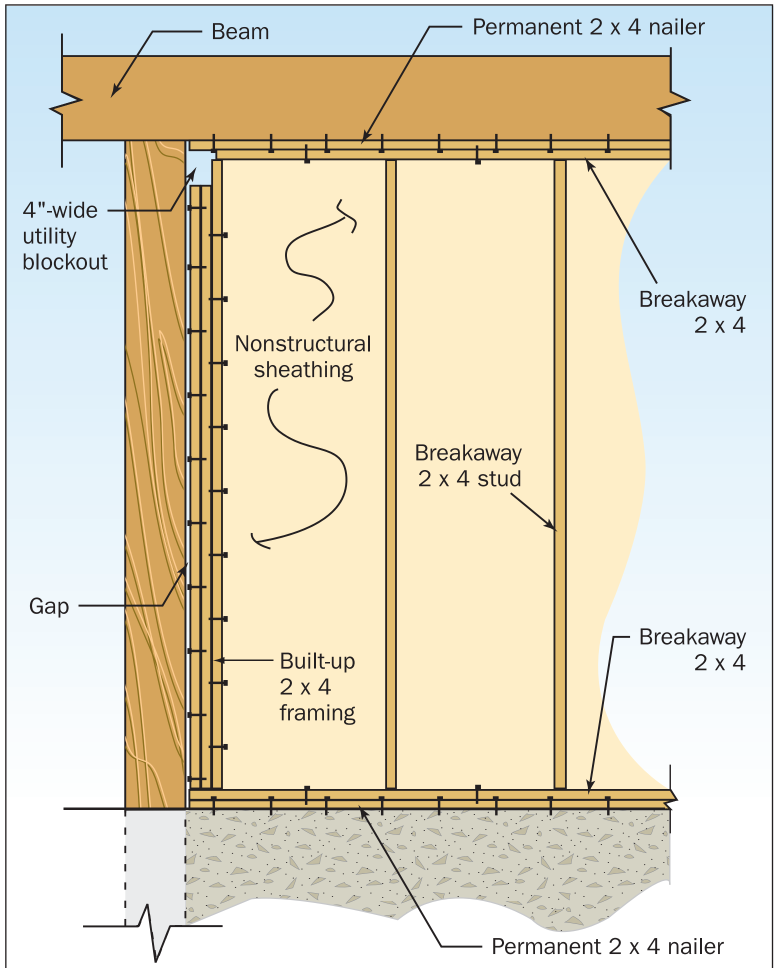


Figure 3. An example of an NFIP-compliant breakaway wall constructed of preservative treated or decay resistant lumber.

Breakaway Walls

Breakaway walls must be designed to break free under the larger of the following Allowable Stress Design loads: 1) the design wind load, 2) the design seismic load, or 3) 10 pounds per square foot (psf), acting perpendicular to the plane of the wall (see Figure 3 for an example of a compliant breakaway wall). If the Allowable Stress Design loading exceeds 20 psf for the designed breakaway wall, the **breakaway wall design must be certified.** When certification is required, a registered engineer or architect must certify that the walls will collapse under a water load associated with the base flood and that the elevated portion of the building and its foundation will not be subject to collapse, displacement, or lateral movement under simultaneous wind and water loads. **Breakaway walls must break away cleanly and must not damage the elevated building** (Figure 4). **Utilities should not be attached to, or pass through, breakaway walls.** See FEMA (2008a) Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls* for more information.

Figure 4. Building siding extended down and over the breakaway wall. Lack of a clean separation allowed damage to spread upward as the breakaway wall failed.

Obstruction Considerations

A V Zone building, elevated on an open foundation without an enclosure or other obstructions below the BFE, is said to be free of obstructions, and will receive a favorable flood insurance premium (see FEMA (2008b) Technical Bulletin 5-08, *Free-of-Obstruction Requirements* for more information).

The following building scenarios are also classified by the NFIP *Flood Insurance Manual* as ***free of obstructions***:

- Below BFE space is surrounded by insect screening and/or by wooden or plastic lattice, slats, or shutters (louvers), if at least 40 percent of the lattice and louver area is open. Lattice can be no thicker than ¼ inch; slats or louvers can be no thicker than 1 inch.
- Below BFE space is surrounded by a combination of one solid breakaway wall (or garage door), and all other sides of the enclosure are either insect screening, wooden or plastic lattice, slats, or louvers.

The following building scenarios are classified by the NFIP *Flood Insurance Manual* as ***with obstructions***:

- Below BFE space is fully enclosed by solid breakaway walls.
- Below BFE space is enclosed by a combination of two or more solid breakaway walls, with the remaining sides of the enclosure comprised of either insect screening, or wooden or plastic lattice, slats, or louvers.

Flood Openings

Foundation walls and other enclosure walls of A Zone buildings (including Coastal A Zone buildings) must be equipped with openings that allow the **automatic entry and exit of floodwaters** (Figure 5).

A Zone opening requirements are as follows:

- Flood openings must be provided in **at least two of the walls** forming the enclosure.
- **The bottom of each opening is to be located no higher than 1 foot above the grade that is immediately under each opening. If the interior and exterior grades are different, the higher of the final interior grade and the finished exterior grade that is immediately under each opening is used to make the determination.**
- **Louvers, screens, or covers** may be installed over flood openings as long as they do not interfere with the operation of the openings during a flood.
- Flood openings may be sized according to either a prescriptive method (1 square inch of flood opening per square foot of enclosed area) or an engineering method (which must be certified by a registered engineer or architect).

Details concerning flood openings can be found in FEMA (2008c) Technical Bulletin 1-08, *Openings in Foundation Walls and Walls of Enclosures*.

Figure 5. Flood opening in a below-BFE enclosure wall.

Other Considerations

Enclosures are strictly regulated because, if not constructed properly, they can transfer flood forces to the main structure (possibly leading to structural collapse). There are other considerations as well.

- Owners may be tempted to convert enclosed areas below the BFE into habitable space, leading to life-safety concerns and uninsured losses. Buildings without enclosures below the lowest floor should be encouraged. If enclosures are constructed, contractors **should not stub out utilities in enclosures** (utility stub-outs make it easier for owners to finish and occupy the space).

- Siding used on the elevated portions of a building should not extend down over breakaway walls. Instead, a clean separation should be provided so that any siding installed on breakaway walls is structurally independent of siding elsewhere on the building. Without such a separation, the failure of breakaway walls can result in damage to siding elsewhere on the building (see Figure 4).
- Solid breakaway wall enclosures in V Zones will result in **higher flood insurance premiums** (especially where the enclosed area is 300 square feet or greater). Insect screening, lattice, slats, or louvers are recommended.

It is recommended to use insect screening, open wooden or plastic lattice, slats, or louvers instead of solid breakaway walls beneath elevated residential buildings.

- If enclosures are constructed in **Coastal A Zones, open foundations with breakaway enclosures are recommended** instead of foundation walls or crawlspaces. If solid breakaway walls are used, then they must be equipped with flood openings that allow floodwaters to enter and exit the enclosure. Use of breakaway enclosures in Coastal A Zones (or any A Zone) will not lead to higher flood insurance premiums.

It is recommended that flood openings be considered for solid breakaway walls in V Zones, even though they are not required by the NFIP. The presence of flood openings may relieve flood forces against the solid breakaway walls, reduce damage to the walls, and reduce flood-borne debris.

- Garage doors installed in below-BFE enclosures of V Zone buildings—even reinforced and high-wind-resistant doors—must meet the performance requirement discussed in the *Breakaway Walls* section of this Fact Sheet. Specifically, the doors must be designed to break free under the larger of the following Allowable Stress Design loads: design wind load, the design seismic load, or 10 psf, acting perpendicular to the plane of the door. If the Allowable Stress Design loading exceeds 20 psf for the designed door, **the door must be designed and certified to collapse under base flood conditions**. See the *Breakaway Walls* section for information about certification requirements.

There are two other enclosure scenarios that should be mentioned, both of which have construction and flood insurance consequences. Contractors and designers should be cautious when an owner asks for either type of enclosure, and consultation with the community and a knowledgeable flood insurance agent is recommended.

- **Below-BFE enclosures** that do not extend all the way to the ground (sometimes called "hanging" enclosures or "elevated" enclosures, occurs when there is an enclosure floor system tied to the building foundation and above the ground – see Figure 6). In V Zones, the enclosure walls must be breakaway, and the enclosure floor system must either break away or the building foundation must be designed to accommodate flood loads transferred from the enclosure floor system to the foundation. In V Zones, the enclosure walls must be breakaway, and the enclosure floor system must either break away or the building foundation must be designed to accommodate flood loads transferred from the enclosure floor system to the foundation.

Figure 6. Example of an enclosure that does not extend to grade. This type of enclosure presents special construction and flood insurance issues. Contractors should proceed with caution when an owner requests such an enclosure.

- In A Zones, the enclosure walls must have proper flood vents, with the bottom no higher than 1 foot above the enclosure floor. These types of enclosures were not contemplated when flood insurance premium rate tables were constructed, and can result in significantly higher flood insurance premiums than had the enclosure walls extended to the ground. The NFIP is working to correct this rating issue; until then, owners will pay a substantial premium penalty for this type of construction.

- **Two-story enclosures** below elevated buildings (see Figure 7). As some BFEs are established higher and higher above ground, some owners have constructed two-story solid wall enclosures below the elevated building, with the upper enclosure having a floor system approximately midway between the ground and the elevated building. These types of enclosures present unique problems. In A Zones both levels of the enclosure must have flood openings in the walls unless there is some way to relieve water pressure through the floor system between the upper and lower enclosures; in V Zones, the enclosure walls (and possibly enclosure floor systems) must be breakaway; special ingress and egress code requirements may be a factor; these enclosures may result in substantially higher flood insurance premiums.

Figure 7. Example of a two-story enclosure below the BFE. This type of enclosure presents special construction and flood insurance issues. Contractors should proceed with caution when an owner requests such an enclosure.

Additional Resources

FEMA. 2008a. *Design and Construction Requirements for Breakaway Walls*. Technical Bulletin 9-08, (http://www.fema.gov/library/viewRecord.do?id=1722).

FEMA. 2008b. *Free-of-Obstruction Requirements.* Technical Bulletin 5-08, (http://www.fema.gov/library/viewRecord.do?id=1718).

FEMA. 2008c. *Openings in Foundation Walls and Walls of Enclosures.* Technical Bulletin 1-08, (http://www.fema.gov/library/viewRecord.do?id=1579).

FEMA. 2009. Hurricane Ike Recovery Advisory, *Design and Construction in Coastal A Zones,* (http://www.fema.gov/library/viewRecord.do?id=1569).

Developed in association with the National Association of Home Builders Research Center

Decks, Pools, and Accessory Structures

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 8.2

Purpose: *To summarize National Flood Insurance Program (NFIP) requirements and general guidelines for the construction and installation of decks, access stairs and elevators, swimming pools, and accessory buildings under or near coastal buildings.*

Key Issues

- Any deck, accessory building, or other construction element that is structurally dependent on or attached to a building in V Zone is considered part of the building and must meet the NFIP regulatory requirements for construction in V Zone (see NFIP Technical Bulletin 5-08 and Fact Sheet Nos. 1.2, 1.4, 1.5, 1.7, 3.1, 8.1, 9.1). Attached construction elements that do not meet these requirements are prohibited.
- If prohibited elements are attached to a building that is otherwise compliant with NFIP requirements, a higher flood insurance premium may be assessed against the entire building.

Damage from Hurricane Opal in Florida. This deck was designed to meet State of Florida Coastal Construction Control Line (CCCL) requirements. The house predated the CCCL and did not meet the requirements.

- Swimming pools, accessory buildings, and other construction elements outside the perimeter (footprint) of, and not attached to, a coastal building may alter the characteristics of flooding significantly or increase wave or debris impact forces affecting the building and nearby buildings. If such elements are to be constructed, a design professional should consider their potential effects on the building and nearby buildings.
- This *Home Builder's Guide to Coastal Construction* strongly recommends that all decks, pools, accessory structures, and other construction elements in Zone A in coastal areas be designed and constructed to meet the NFIP V Zone requirements.
- Post-storm investigations frequently reveal envelope and structural damage (to elevated buildings) initiated by failure of a deck due to flood and/or wind forces. Decks should be given the same level of design and construction attention as the main building, and failure to do so could lead to severe building damage.

Decks

Requirements

- If a deck is structurally attached to a building in Zone V, the bottom of the lowest horizontal member of the deck must be elevated to or above the elevation of the bottom of the building's lowest horizontal member.
- A deck built below the Design Flood Elevation (DFE) must be structurally independent of the main building and must not cause an obstruction.
- If an at-grade, structurally independent deck is to be constructed, a design professional must

ATTACHMENTS 8

evaluate the proposed deck to determine whether it will adversely affect the building and nearby buildings (e.g., by diverting flood flows or creating damaging debris).

Recommendations

- Decks should be built on the same type of foundation as the primary building. Decks should be structurally independent of the primary structure and designed to resist the expected wind and water forces.
- Alternatively, decks can be cantilevered from the primary structure; this technique can minimize the need for additional foundation members.
- A "breakaway deck" design is discouraged because of the large debris that can result.
- A "breakaway deck" on the seaward side poses a damage hazard to the primary structure.
- Decks should be constructed of flood-resistant materials, and all fasteners should be made of corrosion-resistant materials.

Access Stairs and Elevators

Requirements

- Open stairs and elevators attached to or beneath an elevated building in V Zone are excluded from the NFIP breakaway wall requirements (see NFIP Technical Bulletin 5-08 and Fact Sheet No. 8.1), but must meet the NFIP requirement for the use of flood-resistant materials (see NFIP Technical Bulletin 2-08 and Fact Sheet No. 1.7). Large solid staircases that block flow under a building are a violation of NFIP free-of-obstruction requirements (see NFIP Technical Bulletin 5-08)

The rails on these stairs were enclosed with siding, presenting a greater obstacle to the flow of flood water and contributing to the flood damage shown here.

- Although they need not be designed to break away under flood forces, access stairs and elevators are obstructions; therefore, the loads they may transfer to the main building must be considered by the design professional.

Large solid stairs such as these block flow under a building and are a violation of NFIP free-of-obstruction requirements.

Recommendations

- Open stair handrails and risers should be used because they allow wind and water to pass through rather than act as a barrier to flow.
- The bottom of the stair, like the foundation of the primary structure, should be designed and constructed to remain in place during a windstorm or a flood.
- Stairways not considered the primary means of egress can be constructed with hinged connections that allow them to be raised in the event of an impending storm or flood (check code requirements before employing this technique).
- Elevators should be installed in accordance with the guidance in NFIP Technical Bulletin 4-93 and the building code.

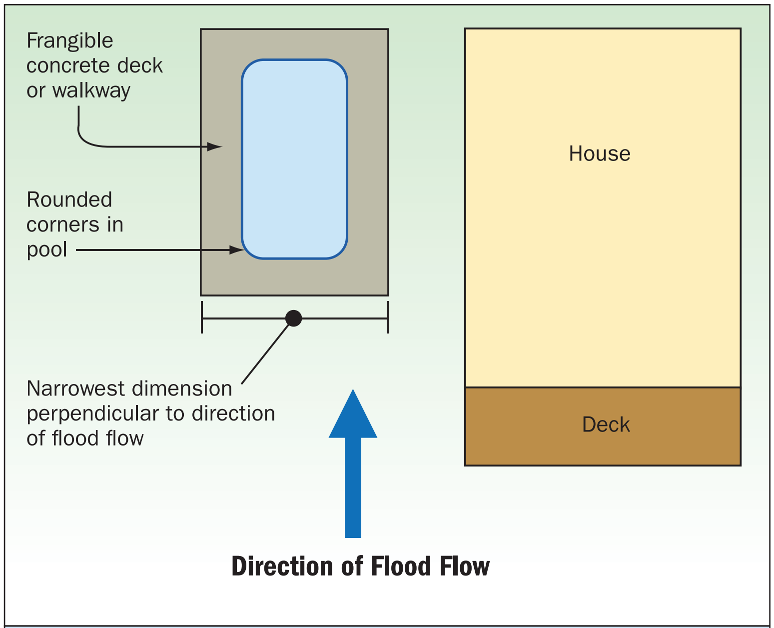
Swimming Pools

Requirements

- An at-grade or elevated pool adjacent to a coastal building is allowed only if the pool will not act as an obstruction that will result in damage to the building or nearby buildings.
- When a pool is constructed near a building in Zone V, the design professional must assure community officials that the pool will not increase the potential for damage to the foundation or elevated portion of the building or any nearby

buildings. Pools can be designed to break up ("frangible pools") during a flood event, thereby reducing the potential for adverse impacts on nearby buildings.

- Any pool constructed adjacent to a coastal building must be structurally independent of the building and its foundation.
- A swimming pool may be placed beneath a coastal building only if the top of the pool and the accompanying pool deck or walkway are flush with the existing grade and only if the lower area (below the lowest floor) remains unenclosed. Under the NFIP, lower-area enclosures around pools constitute a recreational use and are not allowed, even if constructed to breakaway standards.



Siting and design recommendations for swimming pools in coastal areas.

Recommendations

- Pools should be oriented with their narrowest dimension perpendicular to the direction of flood flow.
- Concrete decks or walkways around pools should be frangible (i.e., they will break apart under flood forces).
- Molded fiberglass pools should be installed and elevated on a pile-supported structural frame.
- No aboveground pools should be constructed in V Zone unless they are above the DFE and have an open, wind- and flood-resistant foundation.
- Pool equipment should be located above the DFE whenever practical.
- Check with community officials before constructing pools in Zone V.

Accessory Buildings

Requirements

- Unless properly elevated (to or above the DFE) on piles or columns, an accessory building in V Zone is likely to be destroyed during a coastal storm; therefore, these buildings must be limited to small, low-value structures (e.g., small wood or metal sheds) that are disposable. See NFIP Technical Bulletin 5-08.
- If a community wishes to allow unelevated accessory buildings, it must define "small" and "low cost." NFIP Technical Bulletin 5-08 defines "small" as less than 100 square feet and "low cost" as less than $500. Unelevated accessory buildings must be unfinished inside, constructed with flood-resistant materials, and used only for storage.
- When an accessory building is placed in Zone V, the design professional must determine the effect that debris from the accessory building will have on nearby buildings. If the accessory building is large enough that its failure could create damaging debris or divert flood flows, it must be elevated above the DFE.

Recommendations

- Whenever practical, accessory buildings should not be constructed. Instead, the functions of an accessory building should be incorporated into the primary building.
- All accessory buildings should be located above the DFE whenever practical.
- All accessory buildings should be designed and constructed to resist the locally expected wind and water forces whenever practical.
- The roof, wall, and foundation connections in accessory buildings should meet the requirements for connections in primary buildings.
- Accessory buildings below the DFE should be anchored to resist being blown away by high winds or carried away by floodwaters.