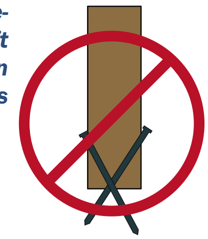
Use of Connectors and Brackets

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 17*

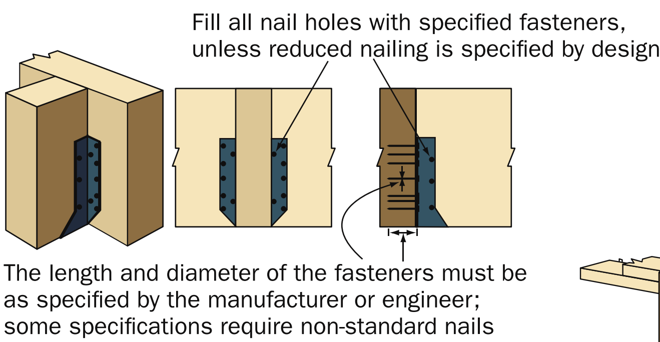
Purpose: To highlight important building connections and illustrate the proper use of various types of connection hardware.

Never rely on toe-nailing for uplift connections in high-wind areas

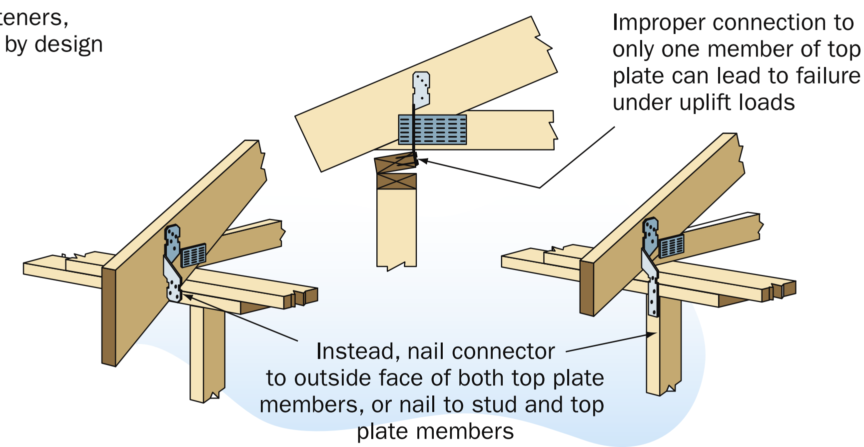


Key Issues

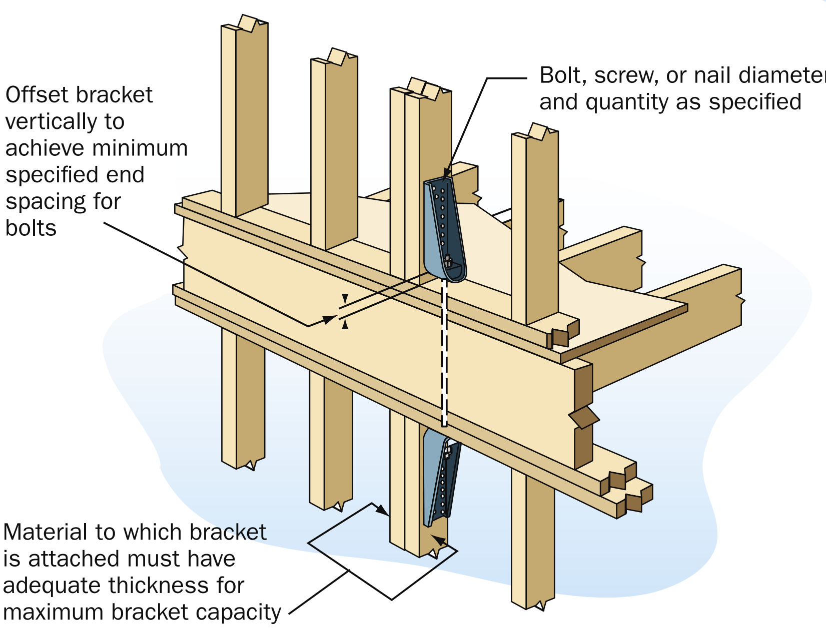
- In high-wind regions, special hardware is used for most framing connections. Toe-nailing is not an acceptable method for resisting uplift loads in high-wind regions.
- Hardware must be installed according to the manufacturer's or engineer's specifications.
- The correct number of the specified fasteners (length and diameter) must be used with connection hardware.
- Avoid cross-grain tension in connections.
- Metal hardware must be adequately protected from corrosion (see NFIP Technical Bulletin 8-96).
- Connections must provide a continuous load path (see Fact Sheet No. 10).



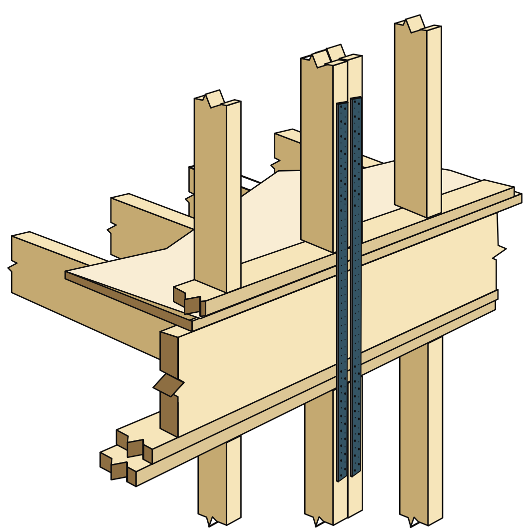
Proper fasteners must be used with connection hardware.



Avoid load path failure at roof-to-wall connections.

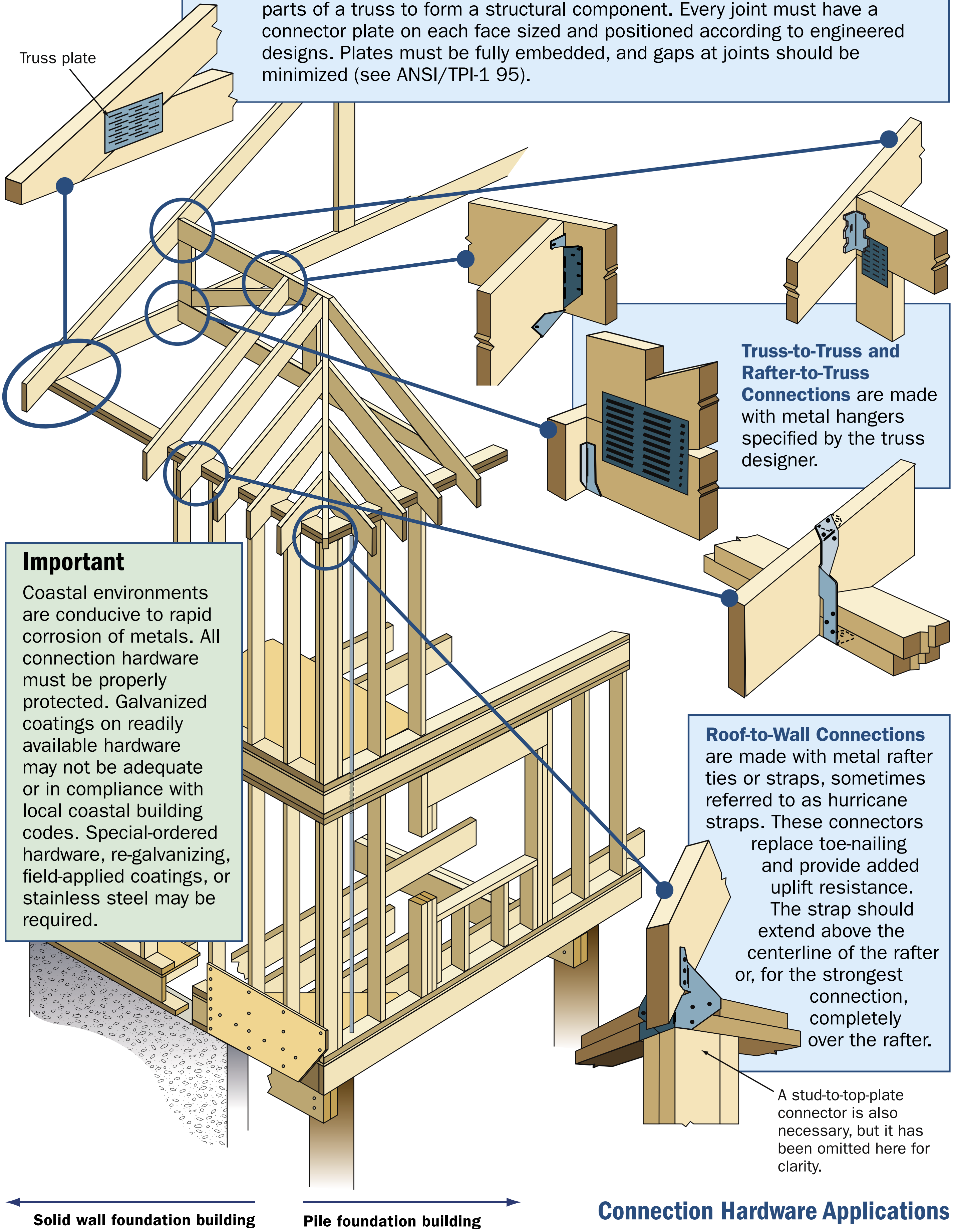


Proper bracket connection.



Proper strap connection.

Truss Member Connections are made with metal plates that connect the individual parts of a truss to form a structural component. Every joint must have a connector plate on each face sized and positioned according to engineered designs. Plates must be fully embedded, and gaps at joints should be minimized (see ANSI/TPI-1 95).



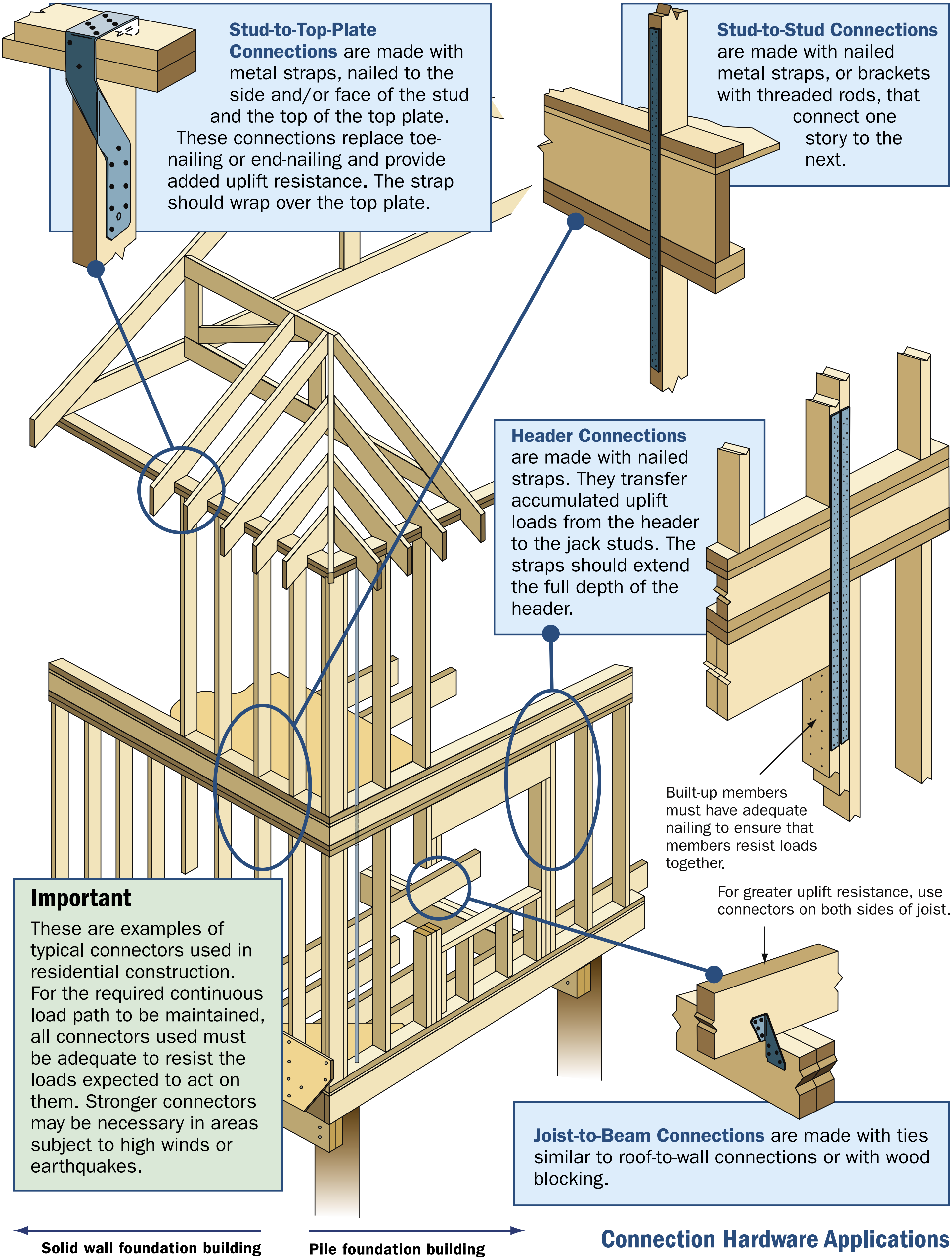
Truss-to-Truss and Rafter-to-Truss Connections are made with metal hangers specified by the truss designer.

Important

Coastal environments are conducive to rapid corrosion of metals. All connection hardware must be properly protected. Galvanized coatings on readily available hardware may not be adequate or in compliance with local coastal building codes. Special-ordered hardware, re-galvanizing, field-applied coatings, or stainless steel may be required.

Roof-to-Wall Connections are made with metal rafter ties or straps, sometimes referred to as hurricane straps. These connectors replace toe-nailing and provide added uplift resistance. The strap should extend above the centerline of the rafter or, for the strongest connection, completely over the rafter.

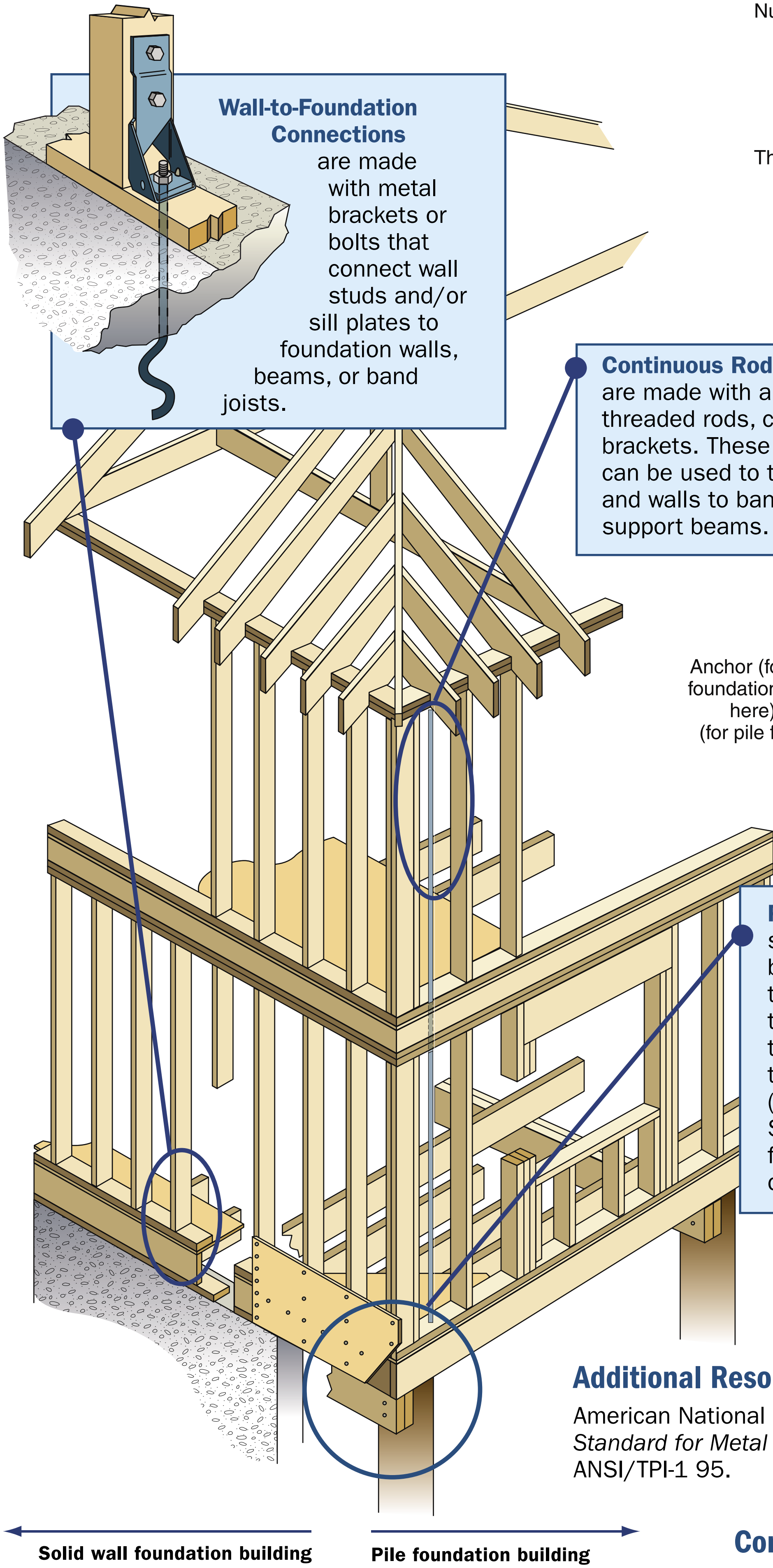
Connection Hardware Applications

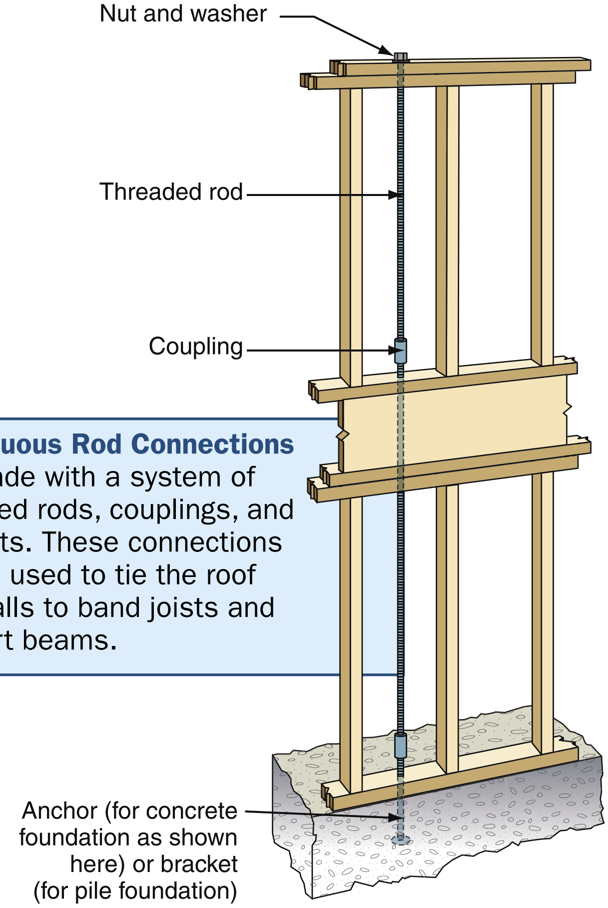


Important

These are examples of typical connectors used in residential construction. For the required continuous load path to be maintained, all connectors used must be adequate to resist the loads expected to act on them. Stronger connectors may be necessary in areas subject to high winds or earthquakes.

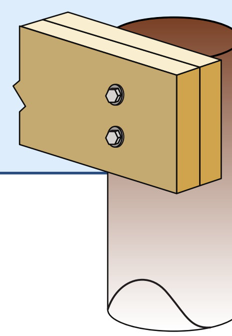
Connection Hardware Applications





Continuous Rod Connections are made with a system of threaded rods, couplings, and brackets. These connections can be used to tie the roof and walls to band joists and support beams.

Pile Connections are made with special brackets, spiked grids, bolts, or other types of connectors that attach the main floor beams to the piles. It is extremely important to follow design specifications for this connection (see Fact Sheet No. 13 for further details).



Additional Resources

American National Standards Institute. *National Design Standard for Metal Plate Connected Timber Trusses,* ANSI/TPI-1 95.

Connection Hardware Applications

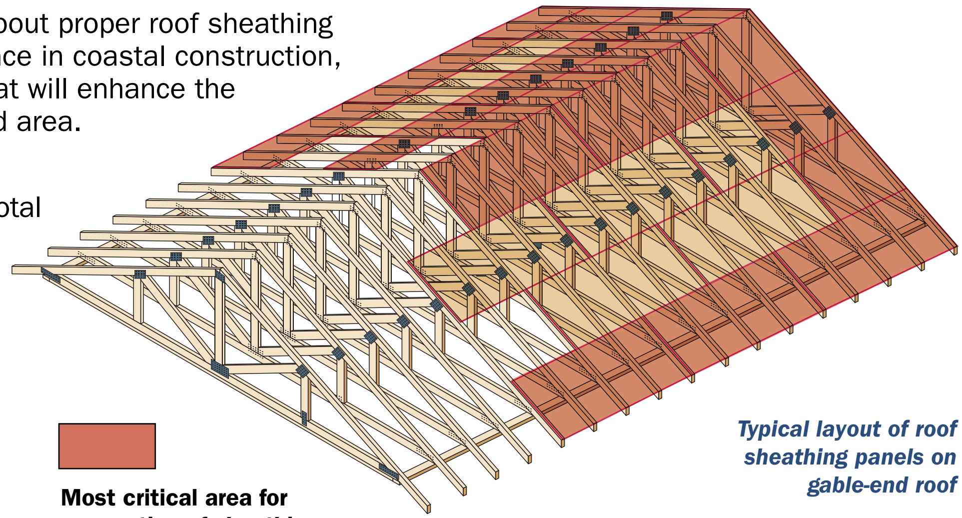
Roof Sheathing Installation

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 — *Technical Fact Sheet No. 18*

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.

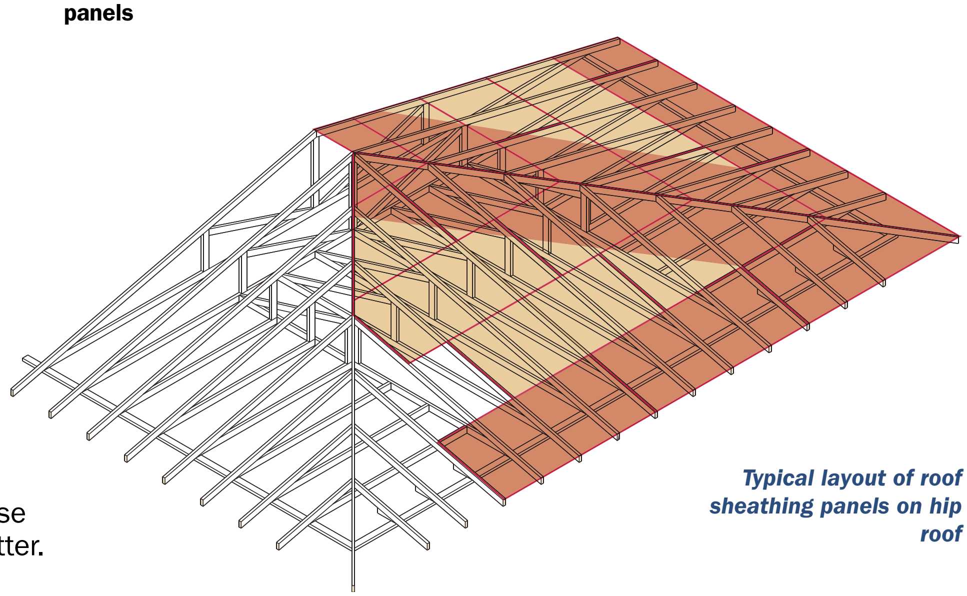
Key Issues

- 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



Typical layout of roof sheathing panels on hip 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.

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

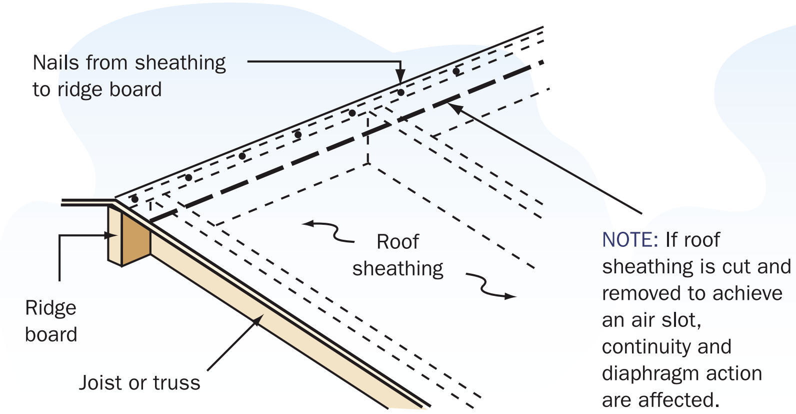
An 8d nail (2.5 inches long) is the minimum size nail to use for fastening sheathing panels. Full round heads are recommended to avoid head pull-through. Deformed-shank (i.e., ring- or screw-shank) nails are required near ridges, gables, and eaves in areas with design wind speeds over 110 mph (3-second 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

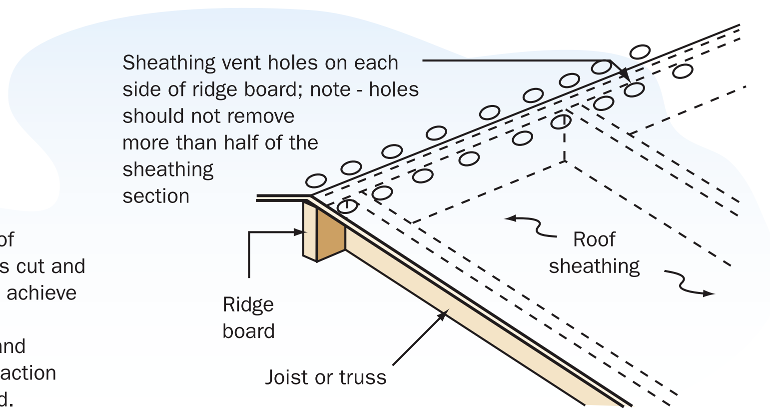
It is ***extremely important*** to have proper fastener spacing on **all** panels. Loss of just one panel in a windstorm can lead to total building failure. Drawings should be checked to verify the required spacing; closer spacing may be required at corners, edges, and ridges. Visually inspect work after 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 below left). Maintain ridge nailing by adding additional blocking set back from the ridge, or by using vent holes (see figure below right). Verify construction with a design professional.



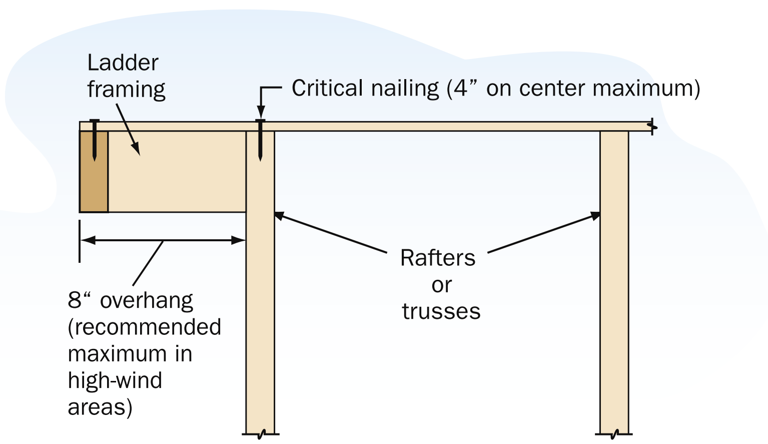
Method for maintaining a continuous load path at the roof ridge by nailing roof sheathing.



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

Ladder Framing at Gable Ends

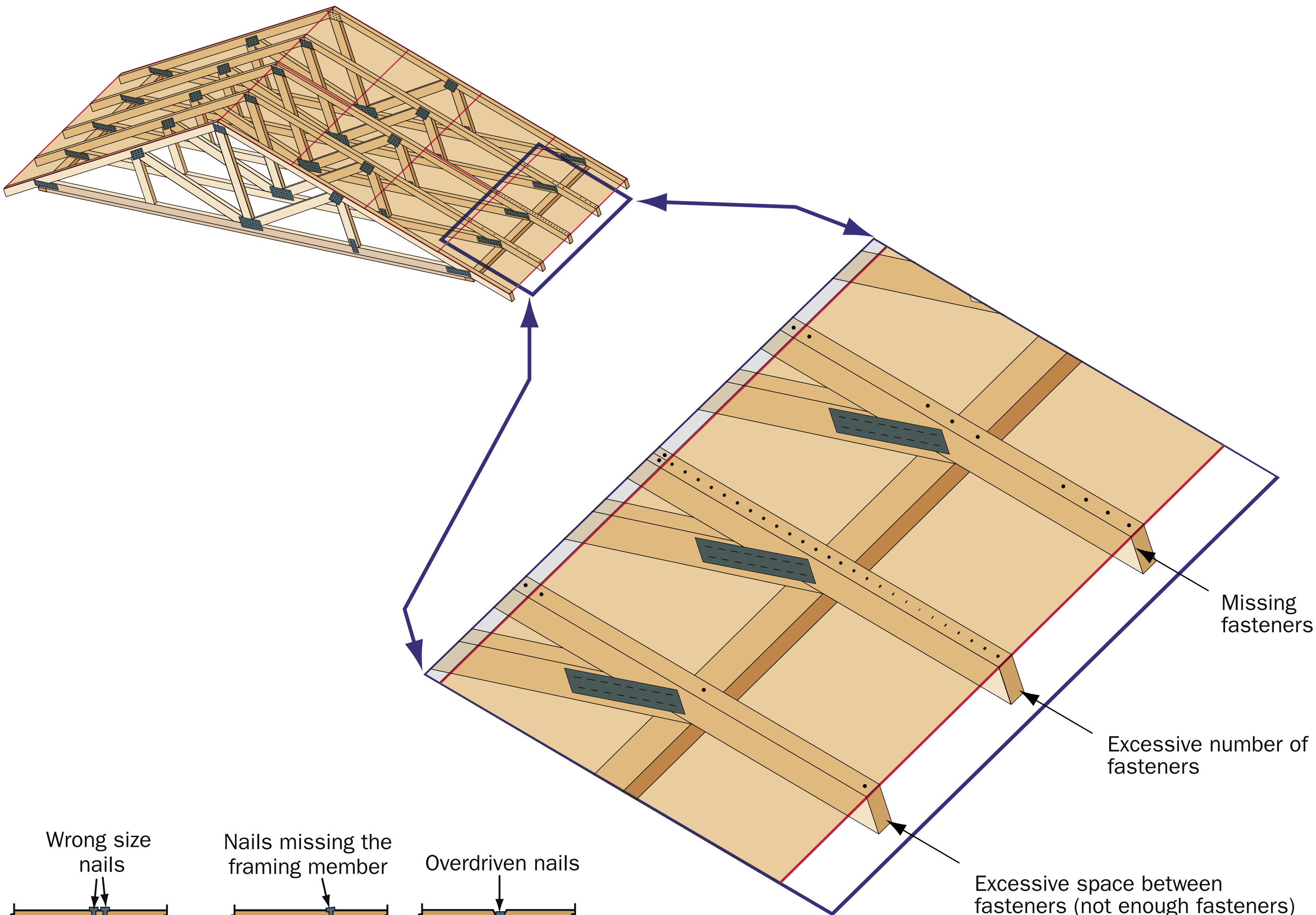
Use extra care when attaching a ladder-framed extension to a gable end. Many homes have been severely damaged by coastal storms because of inadequate connections between the roof sheathing and the gable truss. The critical fasteners occur at the gable-framing member, not necessarily at the edge of the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

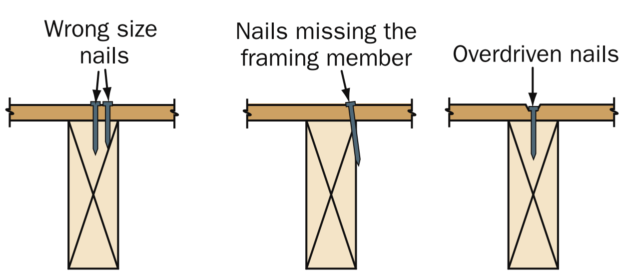


Ladder framing at gable ends.

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 (www.apawood.org)

Roof Underlayment for Asphalt Shingle Roofs

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 — Technical Fact Sheet No. 19

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

- Verify proper attachment of roof sheathing before installing underlayment
- Lapping and fastening of underlayment and roof edge flashing
- Selection of underlayment material type

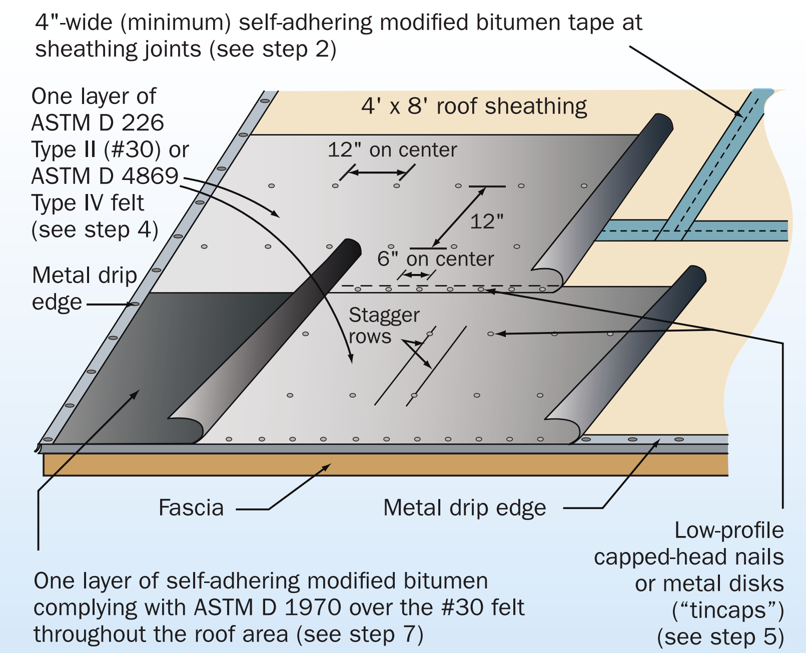
Note: This fact sheet provides general guidelines and recommended enhancements for improving upon typical practice. It is advisable to ***consult local building requirements*** for type and installation of underlayment, particularly if specific enhanced underlayment practices are required locally.

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). 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).

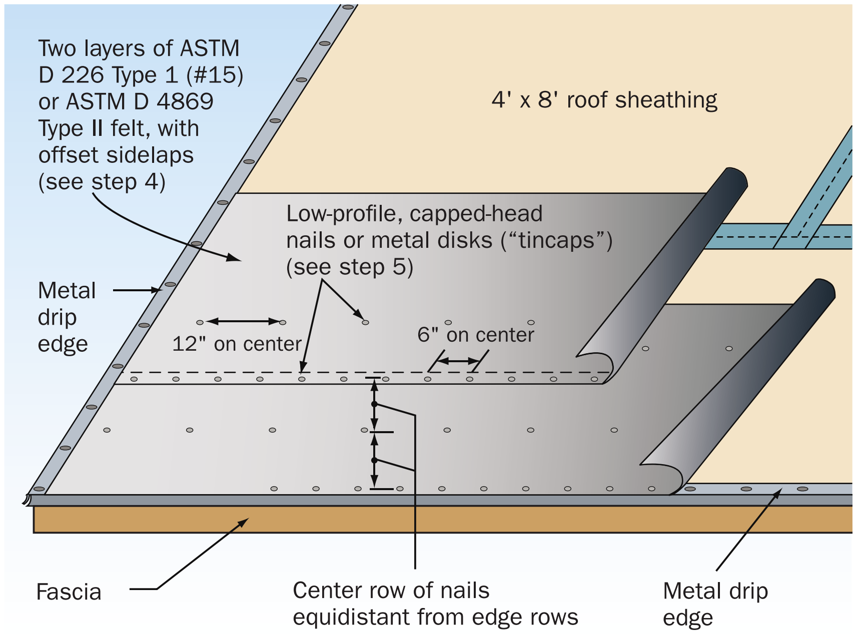
Installation Sequence – Option 1[1]

1. Before the roof covering is installed, have the deck inspected to verify that it is nailed as specified on the drawings.
2. Install self-adhering modified bitumen tape (4 inches wide, minimum) over sheathing joints; seal around deck penetrations with roof tape.
3. Broom clean deck before taping, roll tape with roller.
4. ***Apply a single layer of ASTM D 226 Type II (#30) or ASTM D 4869 Type IV felt.***
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 two rows in the field of the sheet between the side laps.
7. ***Apply a single layer of self-adhering modified bitumen complying with ASTM D 1970 over the #30 felt throughout the roof area.***
8. Seal the self-adhering sheet to the deck penetrations with roof tape or asphalt roof cement.



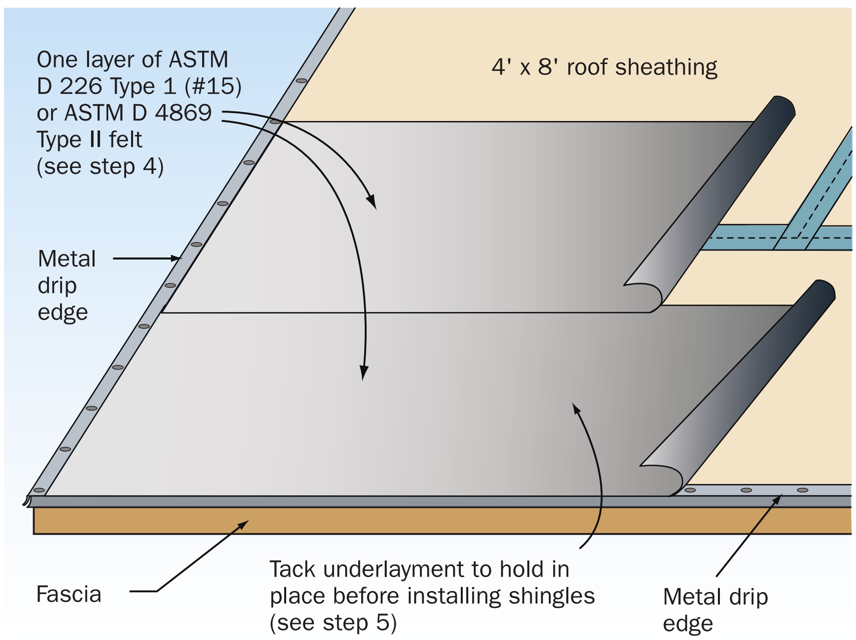
Installation Sequence – Option 2[1]

1. Before the roof covering is installed, have the deck inspected to verify that it is nailed as specified on the drawings.
2. Install self-adhering modified bitumen tape (4 inches wide, minimum) over sheathing joints; seal around deck penetrations with roof tape.
3. Broom clean deck before taping, roll tape with roller.
4. ***Apply two layers of ASTM D 226 Type I (#15) or ASTM D 4869 Type II 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[1,2]

1. Before the roof covering is installed, have the deck inspected to verify that it is nailed as specified on the drawings.
2. Install self-adhering modified bitumen tape (4 inches wide, minimum) over sheathing joints; seal around deck penetrations with roof tape.
3. Broom clean deck before taping, 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.



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

2 **Note:** (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 blowoff 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.

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)

Asphalt Shingle Roofing for High-Wind Regions

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 — *Technical Fact Sheet No. 20*

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

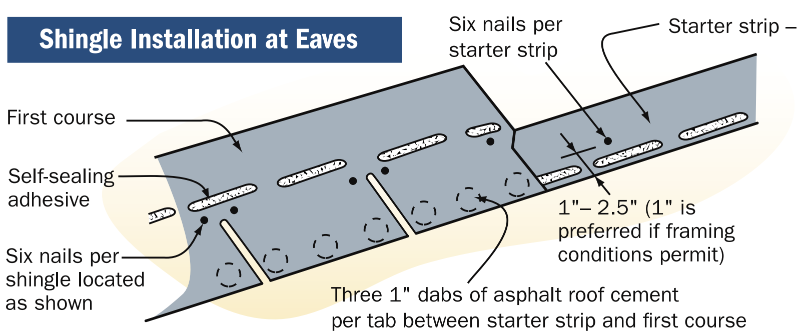
Key Issues

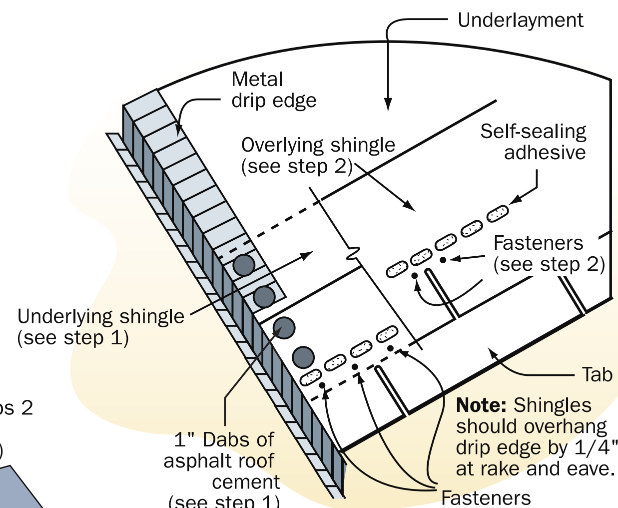
- Special installation methods are recommended for asphalt roof shingles used in high-wind, coastal regions (i.e., greater than 90-mph gust design wind speed).
- Use wind-resistance ratings to choose among shingles, but do not rely on ratings for performance.
- Consult local building code for specific installation requirements. Requirements may vary locally.
- Always use underlayment. See Fact Sheet No. 19 for installation techniques in coastal areas.
- Pay close attention to roof-to-wall flashing and use enhanced flashing techniques (see Fact Sheet No. 24).

Construction Guidance

1 Follow shingle installation procedures for enhanced wind resistance.

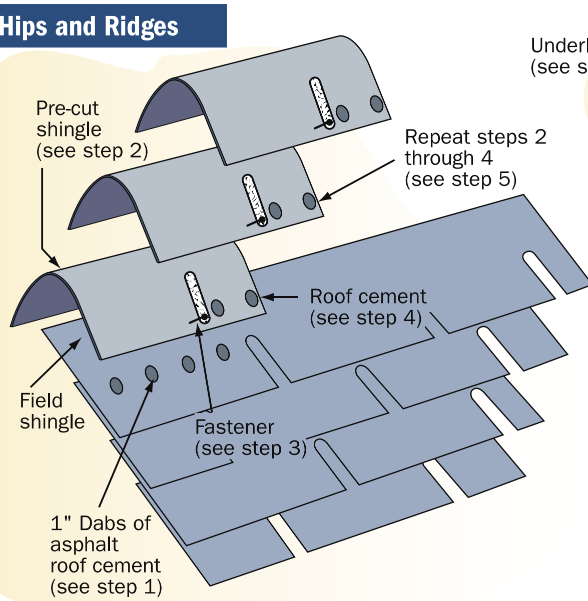
Shingle Installation at Eaves





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

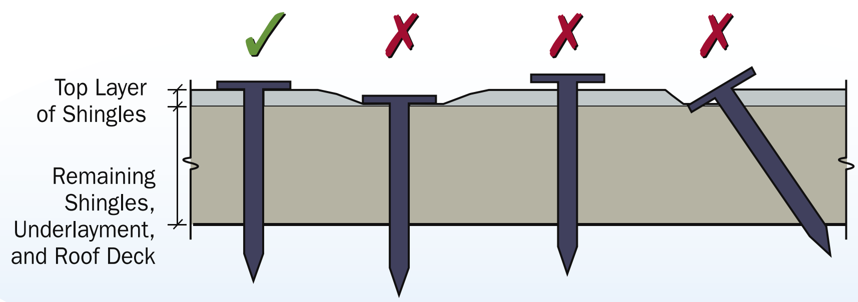
1. Design wind speed based on 3-second peak gust.
2. ASTM D 3462 specifies a minimum fastener pull-through resistance of 20 lb at 73° F. If a higher resistance is desired, it must be specified.

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 products
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.

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).

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.)

Tile Roofing for High-Wind Areas

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 21*

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

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).*

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.

2. Uplift Resistance

For mechanical attachment, the *Concrete and Clay Roof Tile Installation Manua*l 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.

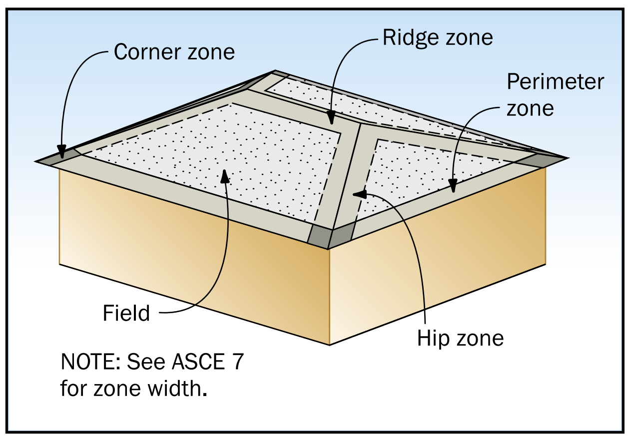


***Figure 1** For critical and essential facilities, clip all tiles in the corner, ridge, perimeter, and hip zones.*

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).

*** 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.**

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.)

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.

Window and Door Installation

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 22*

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. 23), 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. 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 - 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.)

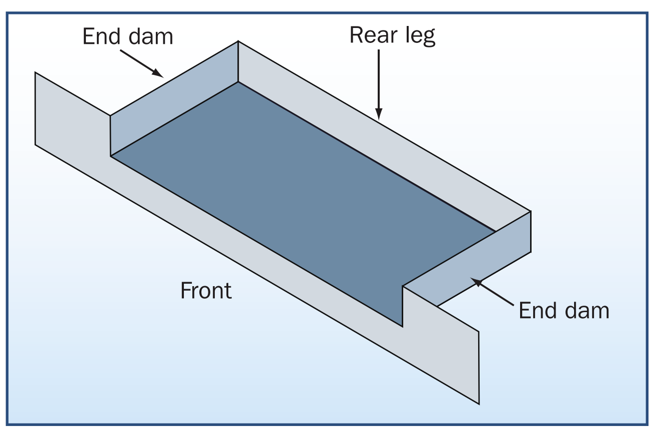


Figure 1 Pan flashing.

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.

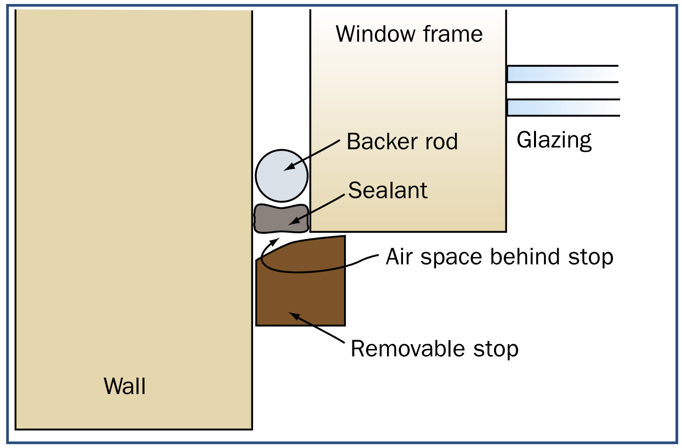


Figure 2
Protection of sealant with a stop.

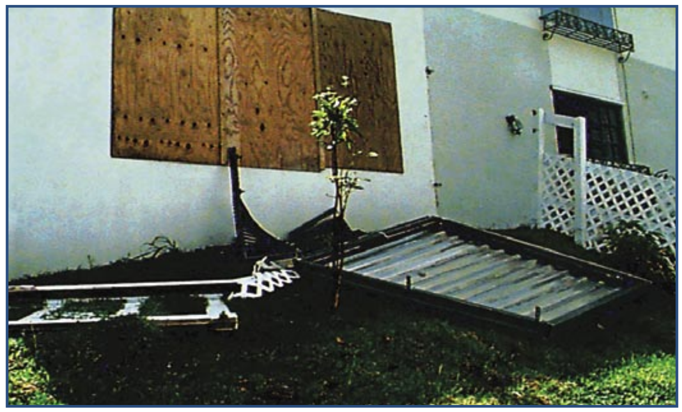


Figure 3
Hurricane Georges in Puerto Rico. The window lying on the ground was protected by a shutter. However, the shutter was attached to the window frame. The window frame fasteners were over-stressed and the entire assembly failed. Attachment of the shutter directly to the wall framing is a more reliable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

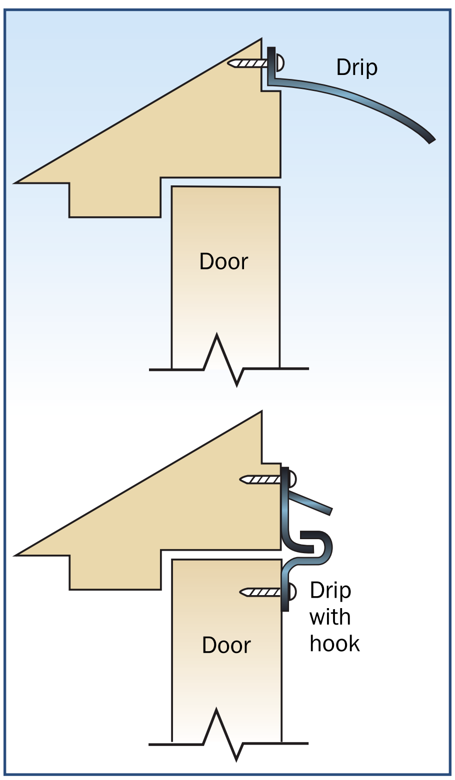


Figure 4
Drip at door head and drip with hook at head

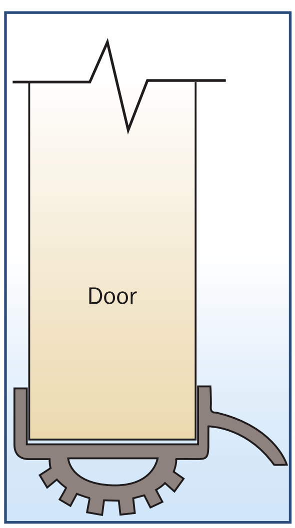


Figure 5
Door shoe with drip and vinyl seal.

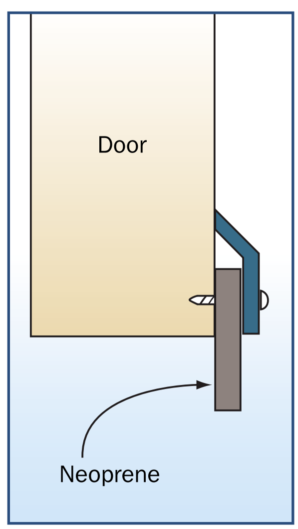


Figure 6
Neoprene door bottom sweep.

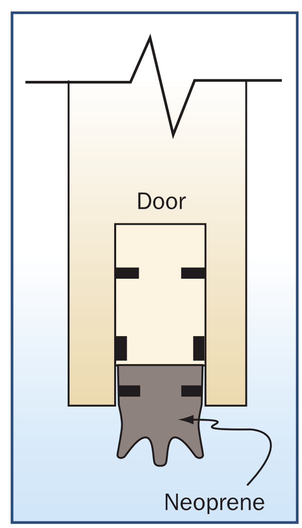


Figure 7
Automatic door bottom.

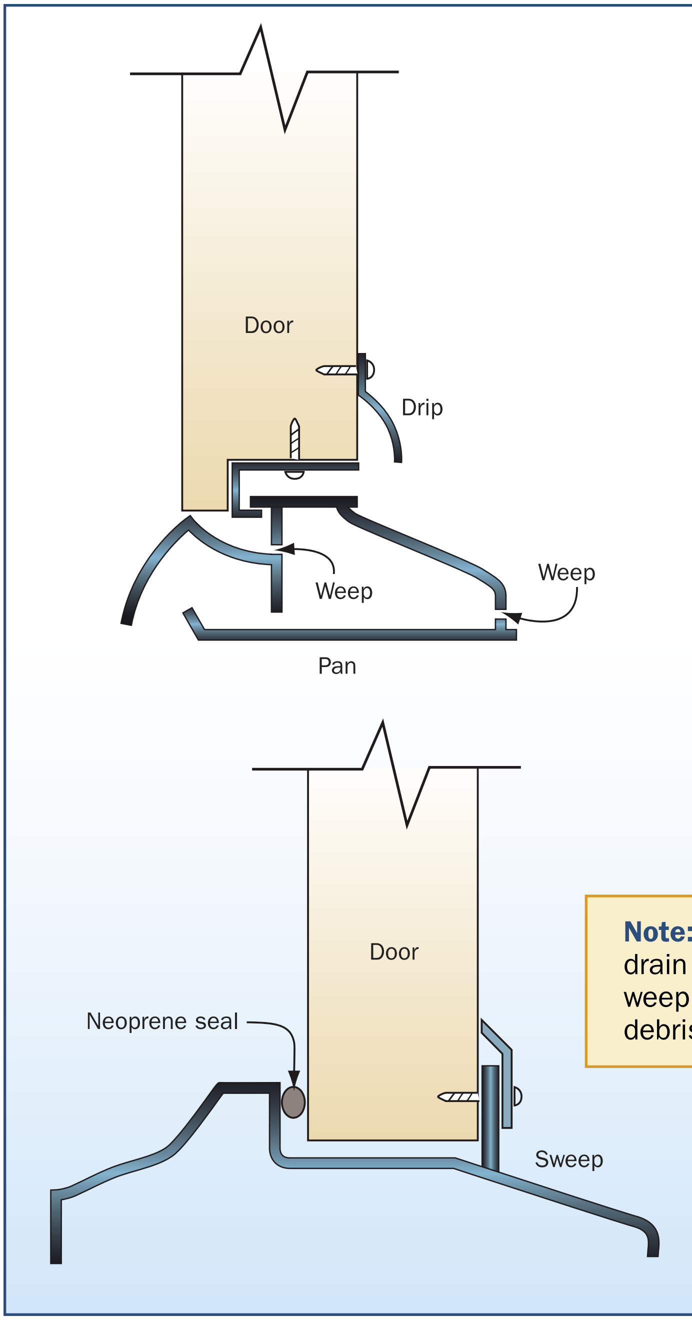


Figure 8 *Thresholds.*

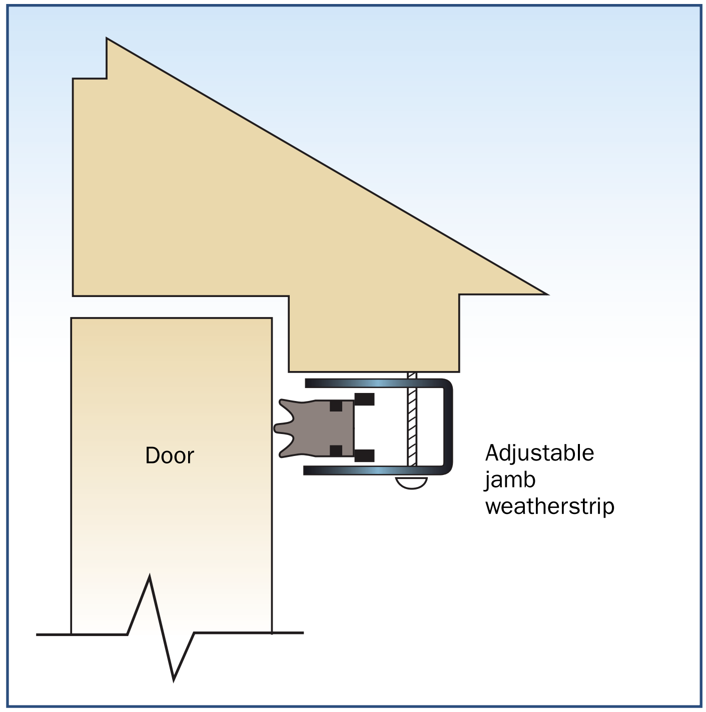


Figure 9
Adjustable jamb/head weatherstripping.

Note: Set the threshold in butyl sealant. If a drain pan exists underneath the threshold, weep holes must not be blocked with sealant or debris.

Additional Resources

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

Housewrap

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 23*

Purpose: To explain the function of housewrap, examine its attributes, and address common problems associated with its use.

Key Issues

- Housewrap has two functions: to prevent airflow through a wall and to stop (and drain) liquid water that has penetrated through the exterior finish.
- Housewrap is not a vapor retarder. It is designed to allow water vapor to pass through.
- The choice to use housewrap or building paper depends on the climate and on specifier or owner preference. Both materials can provide adequate protection.
- Housewrap ***must*** be installed properly or it could be more detrimental than beneficial.

Proper installation, especially in lapping, is the key to successful housewrap use.

Purpose of Housewrap

Housewrap serves as a dual-purpose weather barrier. It not only minimizes the flow of air in and out of a house, but also stops liquid water and acts as a drainage plane. Housewrap is not a vapor retarder. The unique characteristic of housewrap is that it allows water vapor to pass through it while blocking liquid water. This permits moist humid air to escape from the inside of the home, while preventing outside liquid water (rain) from entering the home.

When Should Housewrap Be Used?

Almost all exterior finishes allow at least some water penetration. If this water continually soaks the wall sheathing and framing members, problems such as dryrot and mold growth could occur. Housewrap stops water that passes through the siding and allows it to drain away from the structural members. In humid climates with heavy rainfall, housewrap is recommended to prevent water damage to the framing. Use in dryer climates may not be as critical, since materials are allowed to adequately dry, although housewrap also prevents air movement through the wall cavity, which is beneficial for insulating purposes.

Housewrap or Building Paper?

To answer this question, it is important to know what attributes are most important for a particular climate. Five attributes associated with secondary weather barriers are:

- **Air permeability –** ability to allow air to pass through
- **Vapor permeability –** ability to allow water vapor (gaseous water) to pass through
- **Water resistance –** ability to prevent liquid water from passing through
- **Repels moisture –** ability to prevent moisture absorption
- **Durability –** resistance to tearing and deterioration

As shown in the following table, the climate where the house is located determines the importance of the attribute.

Product Attribute Rating		Poor — Fair — Good — Excellent	
Attribute	When It Is Important	Product Performance	
		Building Paper	Housewrap
Air permeability	Windy and cold climates	Fair	Good
Vapor permeability	Hot, humid climates	Fair	Good
Water resistance	Windy and rainy climates	Good	Excellent
Repels moisture	High rainfall	Good	Good
Durability	Windy, with possible extended exposure	Fair	Good
Cost	Owner preference	Excellent	Fair

In general, housewrap is a good choice for coastal homes.

Installing Housewrap

No matter what product is used (housewrap or building paper), neither will work effectively if not installed correctly. In fact, installing housewrap incorrectly could do more harm than not using it at all. Housewrap is often thought of and installed as if it were an air retarder alone. A housewrap will channel water and collect it whether the installer intends it to or not. This can lead to serious water damage if the housewrap is installed in a manner that does not allow the channeled water out of the wall system. The following are tips for successful installation of housewrap:

- Follow manufacturers' instructions.
- Plan the job so that housewrap is applied before windows and doors are installed.
- Proper lapping is the key – the upper layer should always be lapped over the lower layer.
- Weatherboard-lap horizontal joints at least 6 inches.
- Lap vertical joints 6 to 12 inches (depending on potential wind-driven rain conditions).
- Use 1-inch minimum staples or roofing nails spaced 12 to 18 inches on center throughout.
- Tape joints with housewrap tape.
- Allow drainage at the bottom of the siding.
- Extend housewrap over the sill plate and foundation joint.
- Install housewrap such that water will never be allowed to flow to the inside of the wrap.
- Avoid complicated details in the design stage to prevent water intrusion problems.
- When sealant is required:
  - use backing rods as needed,
  - use sealant that is compatible with the climate,
  - use sealant that is compatible with the materials it is being applied to,
  - surfaces should be clean (free of dirt and loose material), and
  - discuss maintenance with the homeowner.

Avoid These Common Problems

- **Incomplete wrapping**

  Gable ends are often left unwrapped, leaving a seam at the low end of the gable. This method works to prevent air intrusion, but water that gets past the siding will run down the unwrapped gable end and get behind the housewrap at the seam. Also, it is common for builders to pre-wrap a wall before standing it. If this is done, the band joist is left unwrapped. Wrap the band joist by inserting a strip 6-12 inches underneath the bottom edge of the wall wrap. In addition, outside corners are often missed.

- **Improper lapping**

  This often occurs because the housewrap is thought of as an air retarder alone. When applying the housewrap, keep in mind that it will be used as a vertical drainage plane, just like the siding.

- **Improper integration with flashing around doors and windows** – See Fact Sheet No. 22.

- **Relying on caulking or self-sticking tape to address improper lapping**

  Sealant can and will deteriorate over time. A lapping mistake corrected with sealant will have a limited time of effectiveness. If the homeowner does not perform the required maintenance, serious water damage could occur when the sealant eventually fails. ***Therefore, do not rely on sealant or tape to correct lapping errors.***

Roof-to-Wall and Deck-to-Wall Flashing

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 Technical Fact Sheet No. 24

Purpose: To emphasize the importance of proper roof and deck flashing, and to provide typical and enhanced flashing techniques for coastal homes.

Key Issues

- Poor performance of flashing and subsequent water intrusion is a ***common problem*** for coastal homes.
- ***Enhanced flashing techniques are recommended*** in areas that frequently experience high winds and driving rain.
- ***Water penetration*** at deck ledgers can cause ***wood dry rot and corrosion of connectors*** leading to ***deck collapse.***

Roof and Deck Flashing Recommendations for Coastal Areas

- ***Always*** lap flashing and other moisture barriers properly.
- Use increased lap lengths for added protection.
- Do not rely on sealant as a substitute for proper lapping.
- Use fasteners that are compatible with or of the same type of metal as the flashing material.
- Use flashing cement at joints to help secure flashing.
- At roof-to-wall intersections (see Figure 1):
  - Use step flashing that has a 2- to 4-inch-longer vertical leg than normal.
  - Tape the top of step flashing with 4-inch-wide (minimum) self-adhering modified bitumen roof tape.
  - Do not seal housewrap or building paper to step flashing.
- For deck flashing:
  - Follow proper installation sequence to prevent water penetration at deck ledger (see Figure 2).
  - Leave gap between first deck board and flashing to allow for drainage (see Figure 3).
  - Use spacer behind ledger to provide gap for drainage (see Figure 3).
- Use stainless steel deck connection hardware.

See Fact Sheet Nos. 19 and 20 for rake and eave details.

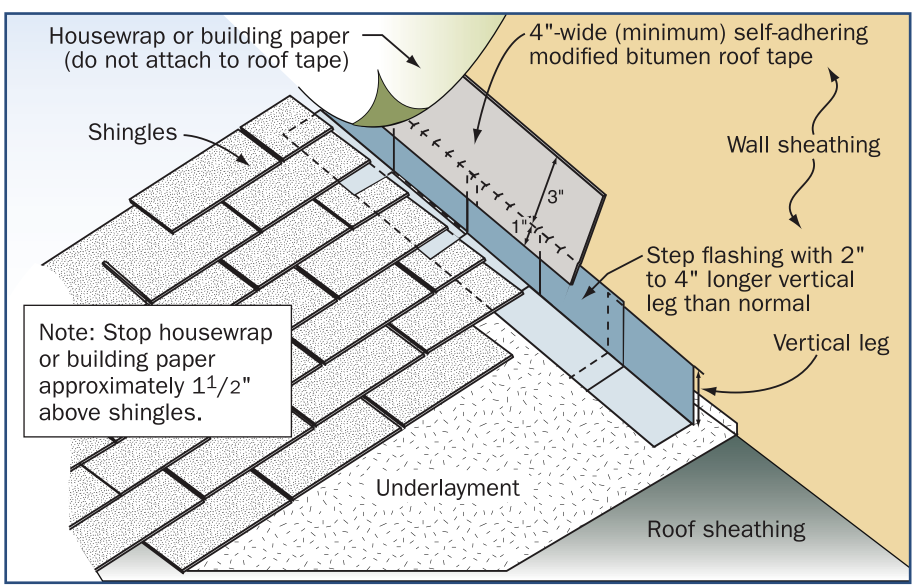


Figure 1
Roof/wall flashing detail.

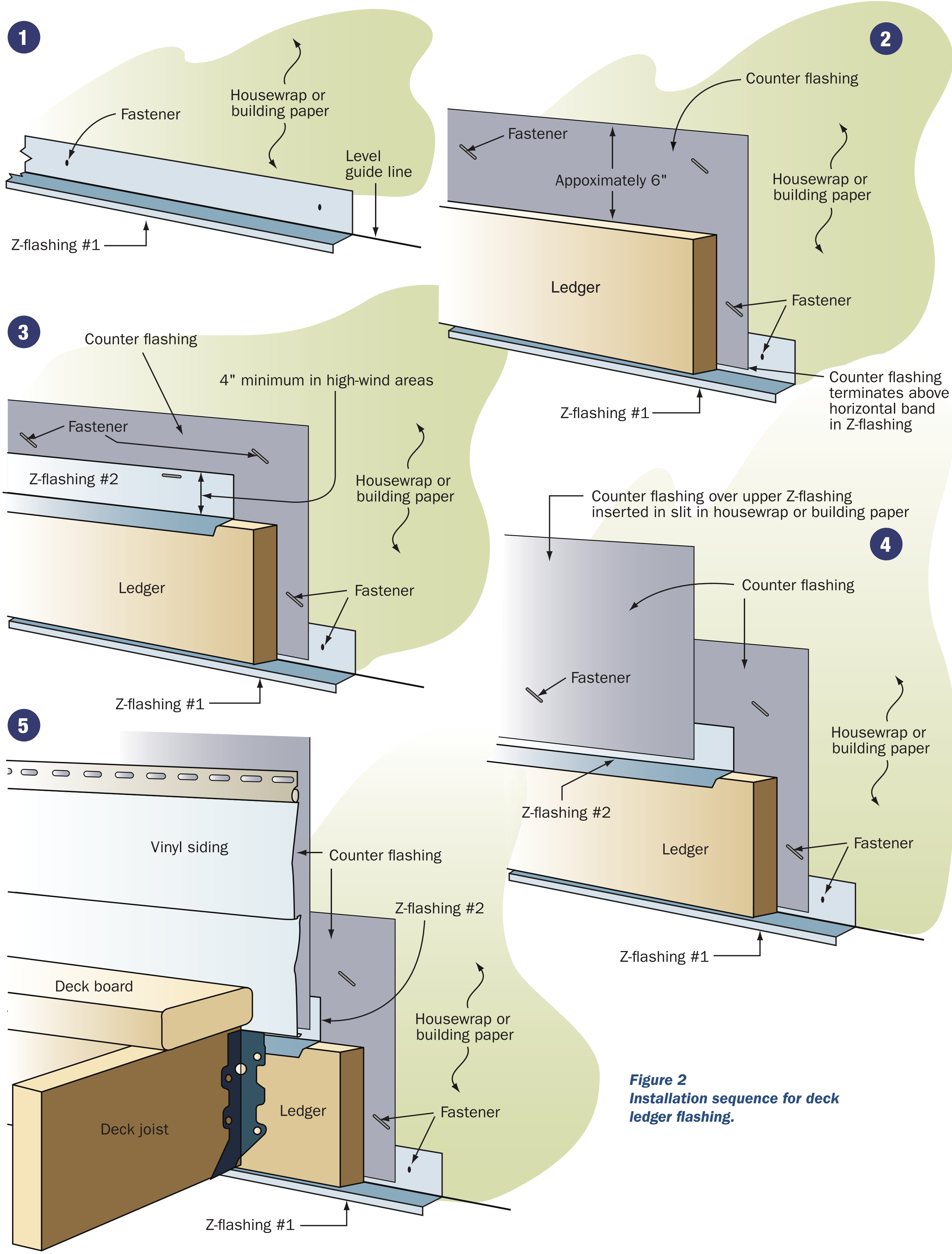


Figure 2
Installation sequence for deck ledger flashing.

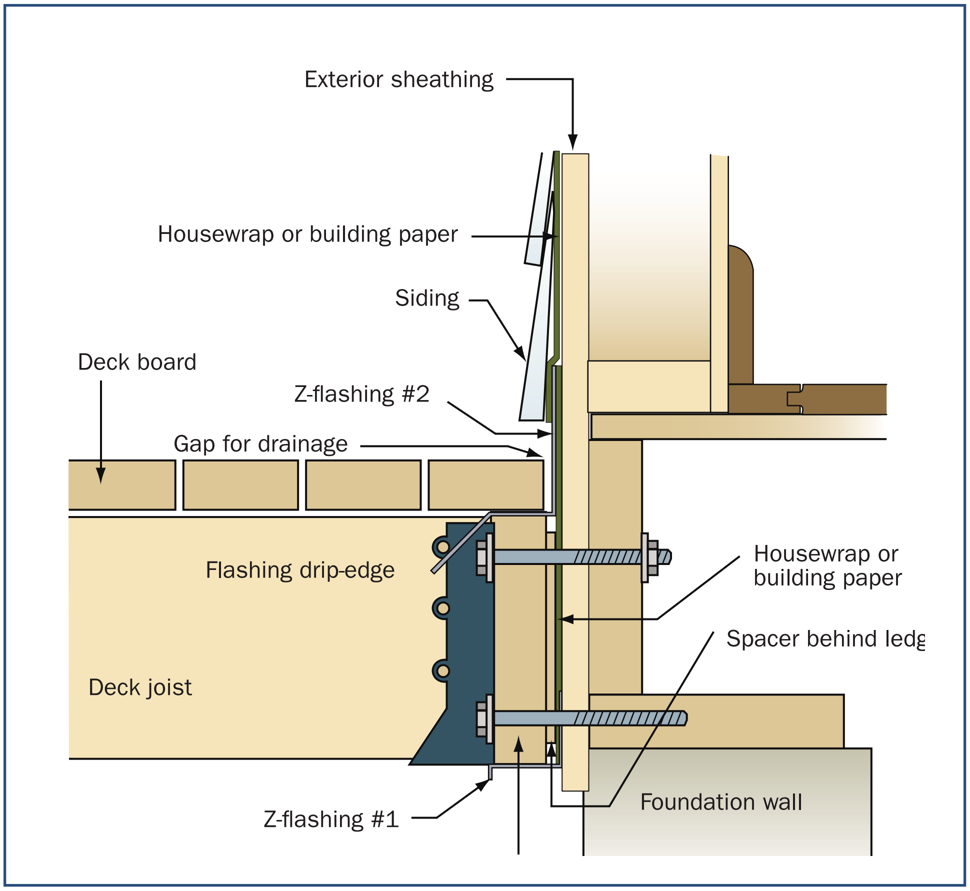


Figure 3
Deck ledger flashing.

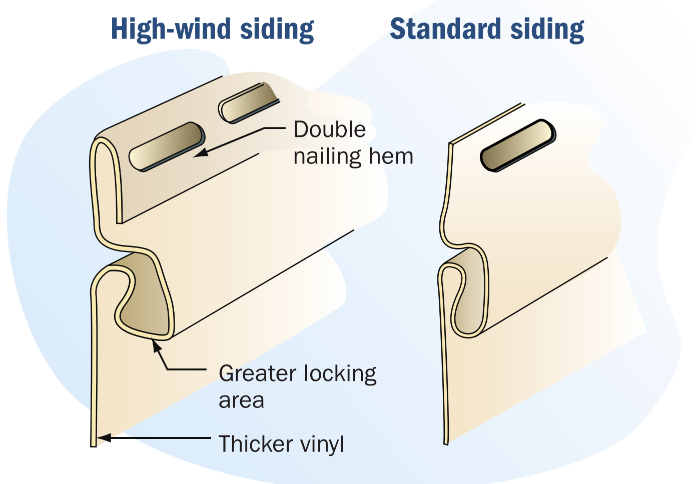
Siding Installation and Connectors

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 25*

Purpose: To provide basic installation tips for various types of siding.

Key Issues

- Always follow manufacturer's installation instructions.
- Use products that are suitable for a coastal environment. Many manufacturers do not rate their products in a way that makes it easy to determine whether the product will be adequate for the coastal environment. Require suppliers to provide information about product reliability in this environment.
- Use high-wind installation procedures if available. These may include spacing nails closer together, using longer nails, or both.
- Use recommended fasteners to avoid staining. Avoid using dissimilar metals together.
- Coastal buildings require more maintenance than inland structures. This maintenance requirement needs to be considered in both the selection and installation of siding.

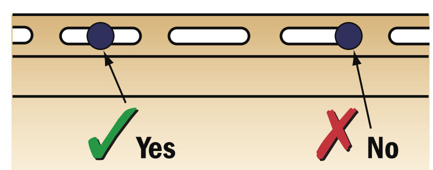


Features of typical high-wind siding and standard siding.

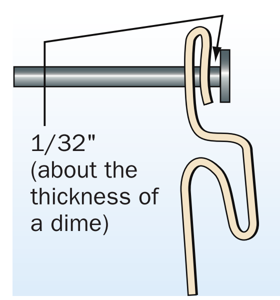
Vinyl Siding

Vinyl siding can be used successfully in a coastal environment if properly installed.

- Choose siding that has been rated for high winds. These products typically have an enhanced nailing hem and are sometimes made from thicker vinyl. Thick, rigid panels provide greater wind resistance, withstand dents, and lie flatter and straighter against the wall. Optimum panel thickness should be 0.040 inch to 0.048 inch, depending on style and design. Thinner gauge vinyl works well for stable climates; thicker gauge vinyl is recommended for areas with high winds and extreme temperature changes.
- Position nails in the center of the nailing slot.
- Do not drive the head of the nail tight against the nail hem (unless the hem has been specifically designed for this). Allow 1/32-inch clearance between the fastener head and the siding panel.
- Drive nails straight and level to prevent distortion and buckling in the panel.
- Do not caulk the panels where they meet the receiver of inside corners, outside corners, or J-trim. Do not caulk the overlap joints.
- Do not face-nail or staple through siding.
- Use aluminum, galvanized steel, or other corrosion-resistant nails when installing vinyl siding. Aluminum trim pieces require aluminum or stainless steel fasteners.
- Nail heads should be 5/16 inch minimum in diameter. Shank should be 1/8 inch in diameter.



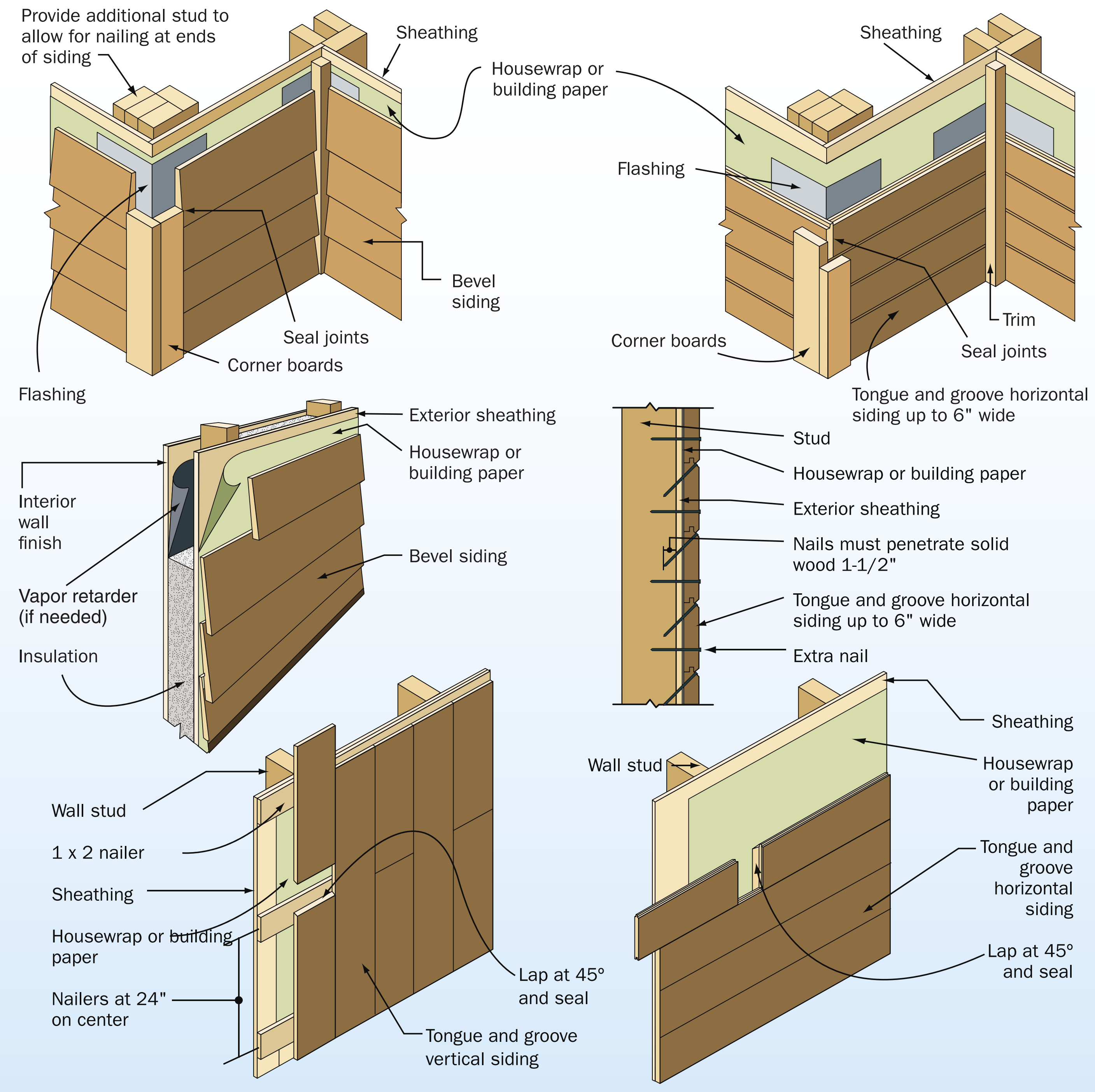
Proper and improper fastener locations.



Allow 1/32-inch clearance between the fastener head and the siding panel.

Wood Siding

- Use naturally decay-resistant wood such as redwood, cedar, or cypress.
- Wood siding should be back-primed before installation.
- Carefully follow manufacturer's detailing instructions to prevent excessive water intrusion.
- Use high-quality stainless steel nails to prevent siding damage (staining).



Fiber Cement Siding

Installation procedures are similar to those for wood siding, but require specialized cutting blades and safety precautions because of the dust produced during cutting with power tools. Manufacturer's installation recommendations should be strictly adhered to, and particular attention paid to the painting and finishing recommendations for a high-quality installation.

Shutter Alternatives

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 — Technical Fact Sheet No. 26

Purpose: To provide general information about the installation and use of storm shutters in coastal areas.

Plywood panels are a cost-effective means of protection.

Why Are Storm Shutters Needed?

Shutters are an important part of a hurricane-resistant or storm-resistant home. They provide protection for glass doors and windows against windborne debris, which is often present in coastal storms. Keeping the building envelope intact (i.e., no window or door breakage) during a major windstorm is vital to the structural integrity of a home. If the envelope is breached, sudden pressurization of the interior can cause major structural damage (e.g., roof loss) and will lead to significant interior and contents damage from wind-driven rain.

Temporary, manufactured 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.

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 most hazardous portion of the ***hurricane-prone region***, called the ***windborne debris region*** (see page 4 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). Designing a partially enclosed structure typically requires upgrading structural components and connections, but will not provide protection to the interior of the building. Designers and owners should assume that a total loss of the building interior and contents will occur in partially enclosed structures.

Using opening protection (e.g., shutters or laminated glass) is recommended in

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.

windborne debris regions, as opposed to designing a partially enclosed structure. The *Home Builder's Guide to Coastal Construction* also recommends giving strong consideration to the use of opening protection in all hurricane-prone areas where the basic wind speed is 100 mph (3-second peak gust) or greater, even though the model 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.

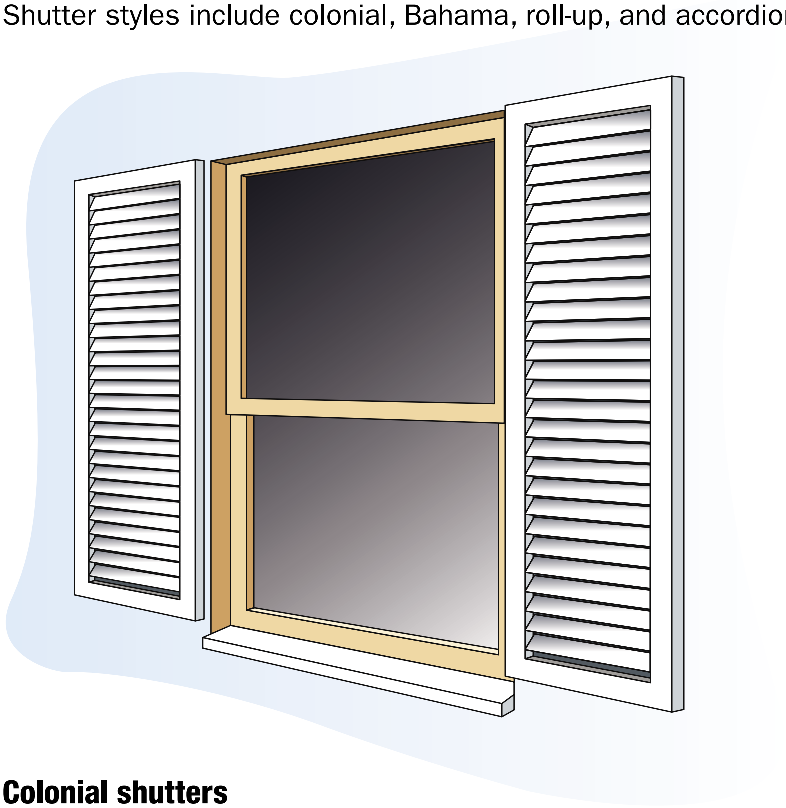
What Types of Shutters Are Available?

A wide variety of shutter types are available, from the very expensive motor-driven, roll-up type, to the less expensive temporary plywood panels (see photograph on page 1 of this fact sheet). 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 windborne debris loads (see Additional Resources on page 5 of this fact sheet).

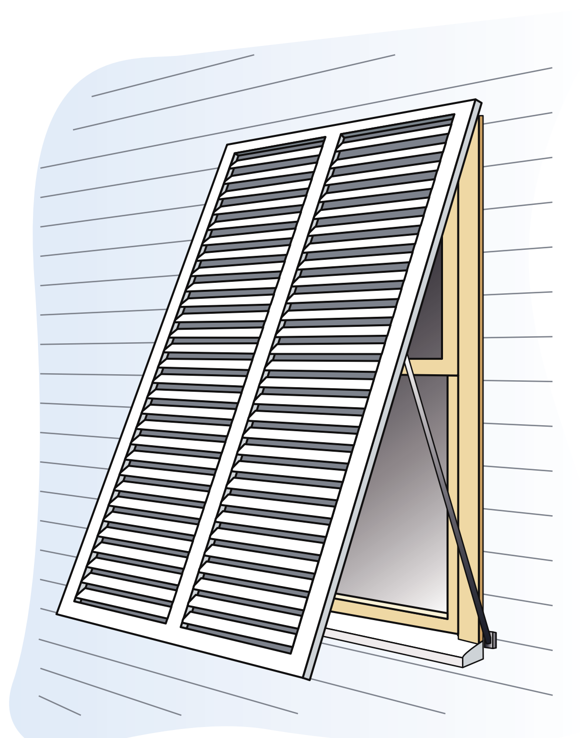
Shutter Type	Cost	Advantages	Disadvantages
Temporary plywood panels	Low	Inexpensive	Must be installed and taken down every time they are needed; must be adequately anchored to prevent blow-off; difficult to install on upper levels
Temporary manufactured panels	Low/Medium	Easily installed on lower levels	Must be installed and taken down every time they are needed; difficult to install on upper levels
Permanent, manual-closing	Medium/High	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

Shutter Styles

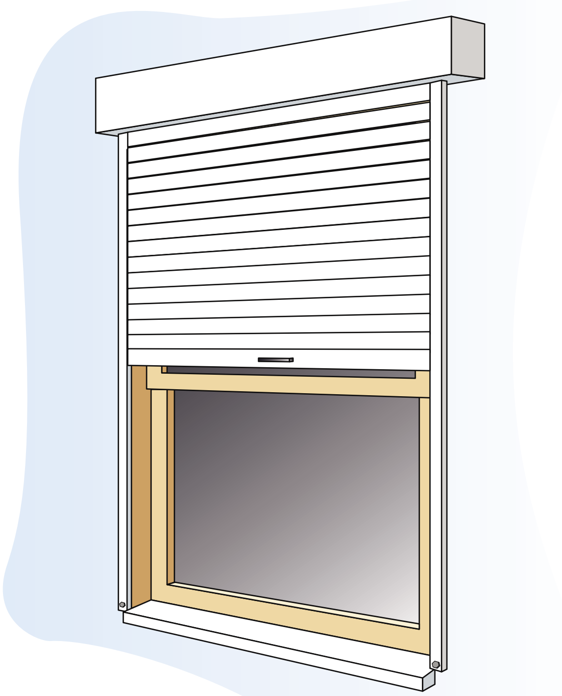
Shutter styles include colonial, Bahama, roll-up, and accordion.



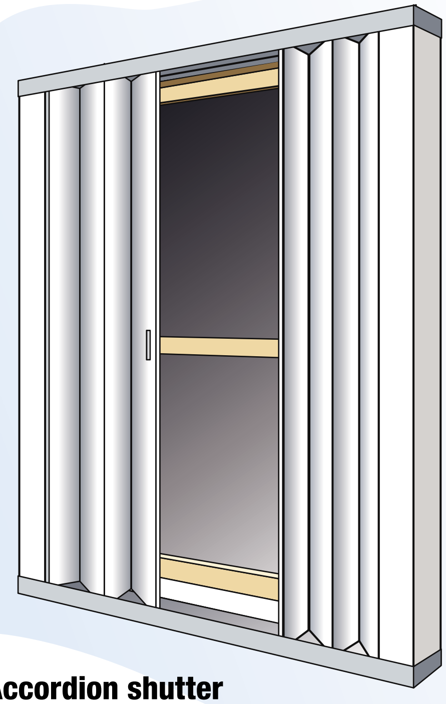
Colonial shutters



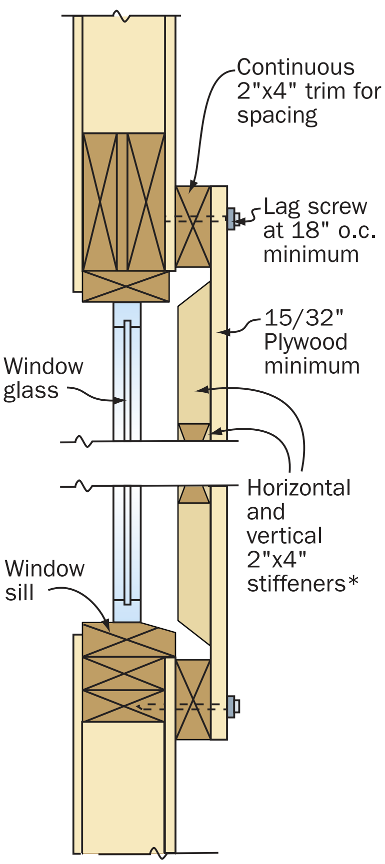
Bahama shutter



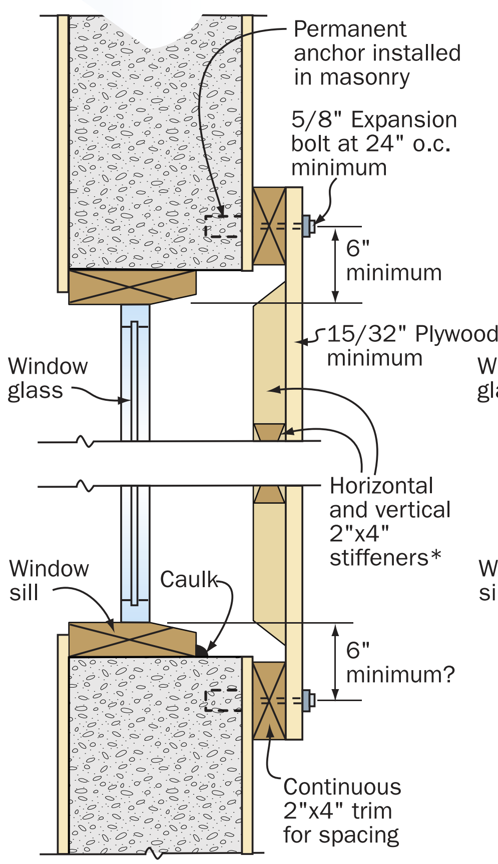
Roll-up shutter



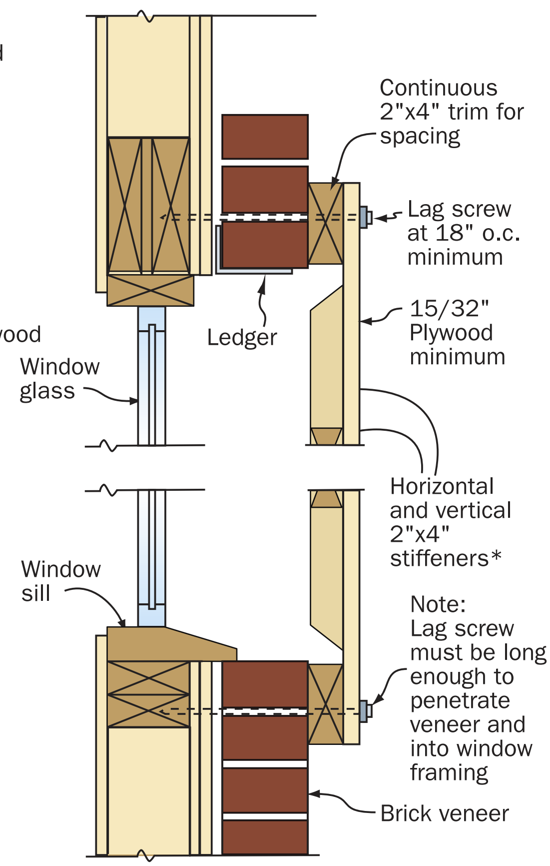
Accordion shutter



Wood Stud Wall



Masonry Wall



Wood Stud Wall With Brick Veneer

*Stiffener can be on either side, although for inside location, adequate space between windowpane and stiffener must be provided.

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

Are There Special Requirements for Shutters in Coastal Areas?

ASCE 7 and the International Building Code (IBC) state that shutters (or laminated glazing) shall be tested in accordance with the American Society for Testing and Materials (ASTM) standards ASTM E 1886 and ASTM E 1996 (or other approved test methods). E 1886 specifies the test procedure; E 1996 specifies missile loads. The IBC allows the use of wood panels (Table 1609.1.4) and prescribes the type and number of fasteners to be used to attach the panels. A shutter may look like it is capable of withstanding windborne missiles; unless it is tested, however, its missile resistance is unknown.

When installing any type of shutter, carefully follow manufacturer's instructions and guidelines. Be sure to attach shutters to structurally adequate framing members (see shutter details on page 3 of this fact sheet). Avoid attaching shutters to the window frame or brick veneer face. Always use hardware not prone to corrosion when installing shutters.

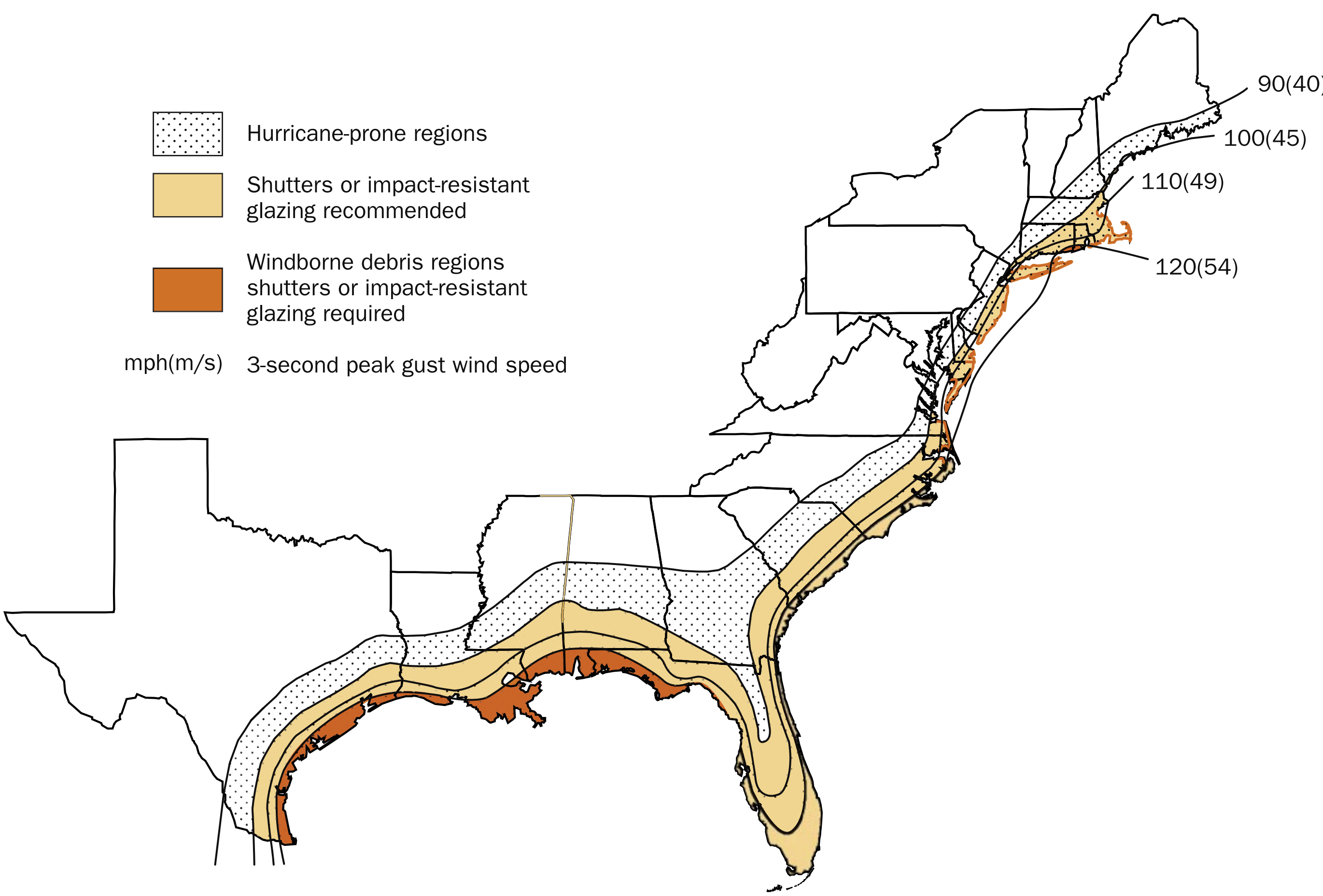
What Are "Hurricane-Prone Regions" "Windborne Debris Regions"?

ASCE 7, the IBC, and the International Residential Code (IRC) define ***hurricane-prone regions*** as:

- the U.S. Atlantic Ocean and Gulf of Mexico coasts where the basic wind speed is greater than 90 mph (3-second peak gust), and
- Hawaii, Guam, Puerto Rico, the U.S. Virgin Islands, and American Samoa.

ASCE 7, the IBC, and the IRC define ***windborne debris regions*** as areas within hurricane-prone regions located:

- within 1 mile of the coast where the basic wind speed is equal to or greater than 110 mph (3-second peak gust) and in Hawaii, or
- in all areas where the basic wind speed is equal to or greater than 120 mph (3-second peak gust), including Guam, Puerto Rico, the U.S. Virgin Islands, and American Samoa.



Additional Resources

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

International Code Council. *International Building Code*. 2003. (http://www.iccsafe.org)

International Code Council. *International Residential Code*. 2003. (http://www.iccsafe.org)

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

Miami-Dade County, Florida, product testing and approval process – information available at http://www.miamidade.gov/buildingcode/pc_home.asp

Enclosures and Breakaway Walls

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 — Technical Fact Sheet No. 27

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

Key Issues

- Spaces below elevated buildings can be used only for building access, parking, and storage.
- 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.
- Non-breakaway enclosures are prohibited in V-zone buildings. Breakaway enclosures in V zones must meet specific requirements and must 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 (see Fact Sheet No. 15).
- For V zones, enclosures below the elevated building will result in higher flood insurance premiums.
- Breakaway enclosure walls should be considered expendable, and the building owner will incur substantial costs when the walls are replaced.

Space Below the BFE – What Can it Be Used For?

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

What Is an Enclosure?

An "***enclosure***" is formed when any space below the BFE is enclosed on all sides by walls or partitions. A V-zone building elevated on an open foundation (see Fact Sheet No. 11), without an enclosure or other obstructions below the BFE, is said to be free-of-obstructions, and enjoys favorable flood insurance premiums (a building is still classified free-of-obstructions if insect screening or open wood lattice is used to surround space below the BFE). See FEMA Technical Bulletin 5-93, *Free of Obstruction Requirements* for more information.

WARNING

Home builders and homeowners should consider the long-term effects of the construction of enclosures below elevated residential buildings and post-construction conversion of enclosed space to habitable use in A zones and V zones. Designers and owners 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 by flood insurance and can result in significant costs to the building owner, and (3) even the presence of properly constructed 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.

This *Home Builder's Guide to Coastal Construction* recommends the use of insect screening or open wood lattice instead of solid enclosures beneath elevated residential buildings.

Breakaway walls that failed under the flood forces of Hurricane Ivan.

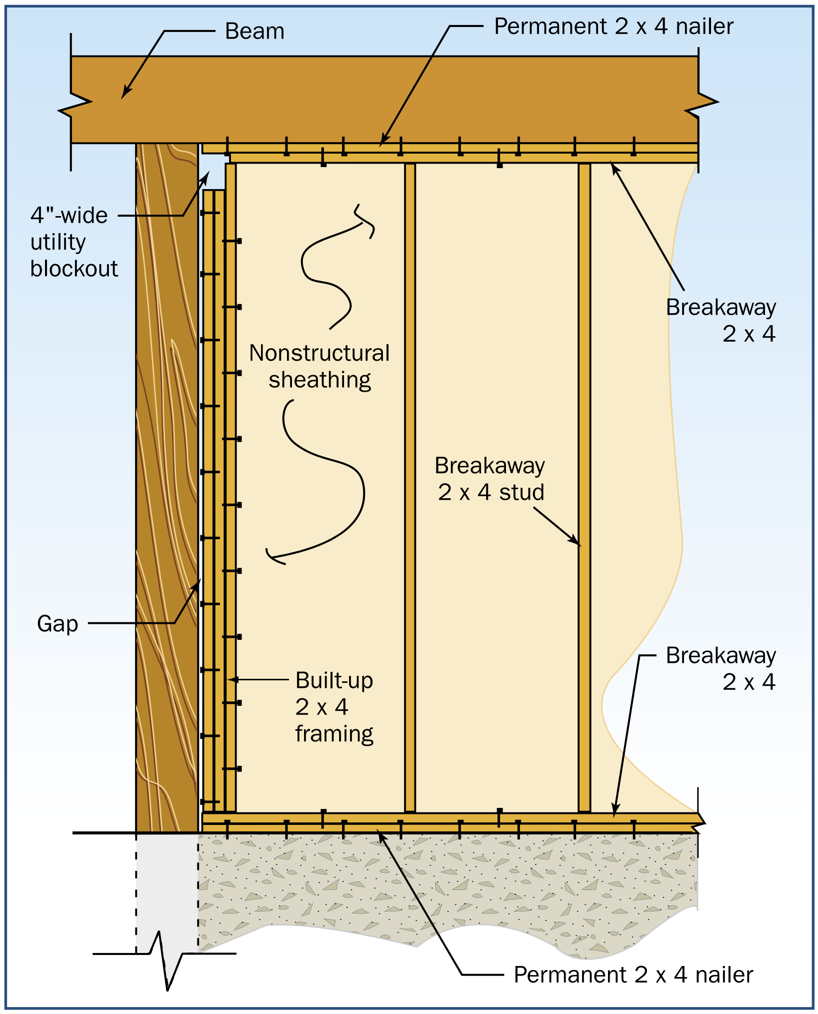
Enclosures can be divided into two types, ***breakaway*** and ***non-breakaway***.

- ***Breakaway*** enclosures are designed to fail under Base Flood conditions without jeopardizing the elevated building – ***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, under the NFIP, can be used in an A zone (they may or may not provide structural support to the elevated building), but they must be equipped with flood openings to allow the automatic entry and exit of floodwaters. ***The Home Builder's Guide to Coastal Construction recommends their use only in A zone areas subject to shallow, slow-moving floodwaters without breaking waves.***

Open wood lattice installed beneath an elevated house in a V zone.

Breakaway Walls

Breakaway walls must be designed to break free under the larger of the design wind load, the design seismic load, or 10 psf, acting perpendicular to the plane of the wall. If the loading at which the breakaway wall is intended to collapse exceeds 20 psf, ***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. (See the sample certification at the bottom of page 2 of Fact Sheet No. 5.) ***Utilities should not be attached to or pass through breakaway walls.***



Recommended breakaway wall construction.

Flood Openings

Where permitted and used in A zones, foundation walls and enclosures must be equipped with openings that allow the ***automatic entry and exit of floodwaters.***

Note the following:

- Flood openings must be provided ***in at least two of the walls*** forming the enclosure.
- ***The bottom of each flood opening*** must be ***no more than 1 foot above the adjacent grade*** outside the wall.
- ***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 Technical Bulletin 4-93, *Openings in Foundation Walls*.

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. Construction without enclosures should be encouraged. 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 non-breakaway portions of a building should not be extended 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.
- Breakaway enclosures in V zones will result in ***substantially higher flood insurance premiums*** (especially where the enclosed area is 300 square feet or greater). Insect screening or lattice is recommended instead.
- If enclosures are constructed in ***A zones with the potential for breaking waves, open foundations with breakaway enclosures are recommended*** in lieu of foundation walls or crawlspaces. If breakaway walls are used, they must be equipped with flood openings that allow flood waters to enter the enclosure during smaller storms. Breakaway enclosures in A zones will ***not*** lead to higher flood insurance premiums.

Siding on the non-breakaway portions of this elevated building was extended over breakaway enclosure walls and was damaged when breakaway walls failed under flood forces.

- 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 on page 2 of this fact sheet. Specifically, the doors must be designed to break free under the larger of the design wind load, the design seismic load, or 10 psf, acting perpendicular to the plane of the door. If the loading at which the door is intended to collapse is greater than 20 psf, ***the door must be designed and certified to collapse under Base Flood conditions***. See the **Breakaway Walls** section of this fact sheet for information about certification requirements.

Decks, Pools, and Accessory Structures

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 — Technical Fact Sheet No. 28

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

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 was not.

- Any deck, accessory building, or other construction element that is structurally dependent on or attached to a V-zone building is considered part of the building and must meet the NFIP regulatory requirements for construction in the V zone (see NFIP Technical Bulletin 5-93 and Fact Sheet Nos. 2, 4, 5, 8, 11, 27, and 30). 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.
- 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 A zones 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 V-zone building, 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 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 a V zone are excluded from the NFIP breakaway wall requirements (see NFIP Technical Bulletin 9-99 and Fact Sheet No. 27), but must meet the NFIP requirement for the use of flood-resistant materials (see NFIP Technical Bulletin 2-93 and Fact Sheet No. 8). Large solid staircases that block flow under a building are a violation of NFIP free-of-obstruction requirements (see NIFIP Technical Bulletin 5-93)
- 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.

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.

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.

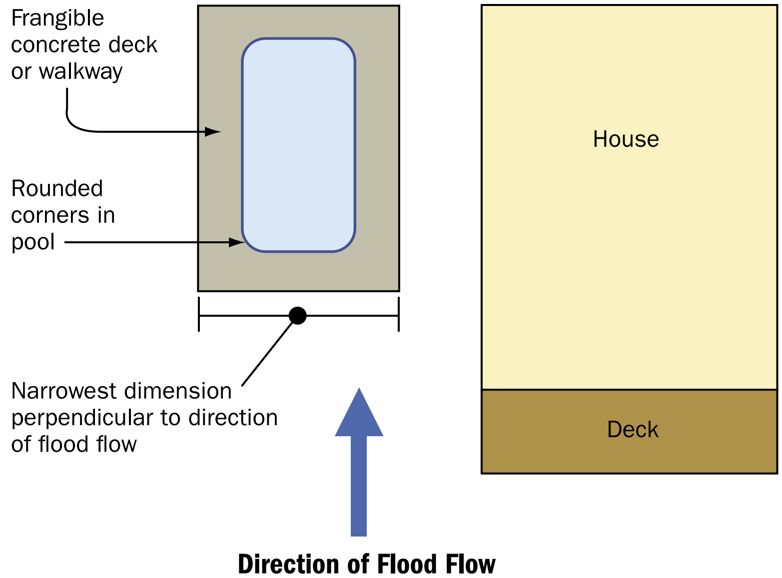
Large solid stairs such as these block flow under a building and are a violation of NFIP free-of-obstruction requirements.

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 a V zone, 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 a V-zone site 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 V zones.

Accessory Buildings

Requirements

- Unless properly elevated (to or above the DFE) on piles or columns, an accessory building in a 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 5-93.
- If a community wishes to allow unelevated accessory buildings, it must define "small" and "low cost." NFIP Technical Bulletin 5-93 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.

Small accessory building anchored to resist wind forces.

- When an accessory building is placed in a V zone, 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.
- Accessory buildings (including their foundations) must not be attached to the primary building; otherwise, failure of the accessory building could damage the primary building.
- Orienting the narrowest dimension of an accessory building perpendicular to the expected flow of water will create less of an obstruction to flowing water or wave action, and may result in less damage.

Additional Resources

FEMA. NFIP Technical Bulletin 2-93, *Flood Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas.* (http://www.fema.gov/fima/techbul.shtm)

FEMA. NFIP Technical Bulletin 4-93, *Elevator Installation for Buildings Located in Special Flood Hazard Areas.* (http://www.fema.gov/fima/techbul.shtm)

FEMA. NFIP Technical Bulletin 5-93, *Free-of-Obstructions Requirements for Buildings Located in Coastal High Hazard Areas.* (http://www.fema.gov/fima/techbul.shtm)

Protecting Utilities

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 29*

Purpose: To identify the special considerations that must be made when installing utility equipment in a coastal home.

Key Issues: Hazards, requirements, and recommendations

Special considerations must be made when installing utility systems in coastal homes. ***Proper placement and connection*** of utilities and mechanical equipment can ***significantly reduce the costs of damage caused by coastal storms*** and will ***enable homeowners to reoccupy their homes*** soon after electricity, sewer, and water are restored to a neighborhood.

Coastal Hazards That Damage Utility Equipment

- Standing or moving floodwaters
- Impact from floating debris in floodwaters
- Erosion and scour from floodwaters
- High winds
- Windborne missiles

Electrical lines and box dislocated by hurricane forces.

Common Utility Damage in Coastal Areas

Floodwaters cause corrosion and contamination, short-circuiting of electronic and electrical equipment, and other physical damage.

Electrical – Floodwaters can corrode and short-circuit electrical system components, possibly leading to electrical shock. In velocity flow areas, electrical panels can be torn from their attachments by the force of breaking waves or the impact of floating debris.

Water/Sewage – Water wells can be exposed by erosion and scour caused by floodwaters with velocity flow. A sewage backup can occur even without the structure flooding.

Fuel – Floodwaters can float and rupture tanks, corrode and short-circuit electronic components, and sever pipe connections. In extreme cases, damage to fuel systems can lead to fires.

Basic Protection Methods

The primary protection methods are ***elevation*** or ***component protection***.

Elevation of utilities and mechanical equipment is the preferred method of protection.

Elevation

Elevation refers to the location of a component and/or utility system above the Design Flood Elevation (DFE).

Component Protection

Component protection refers to the implementation of design techniques that protect a component or group of components from flood damage when they are located below the DFE.

NFIP Utility Protection Requirements

The NFIP regulations [Section 60.3(a)(3)] state that:

All new construction and substantial improvements shall be constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding.

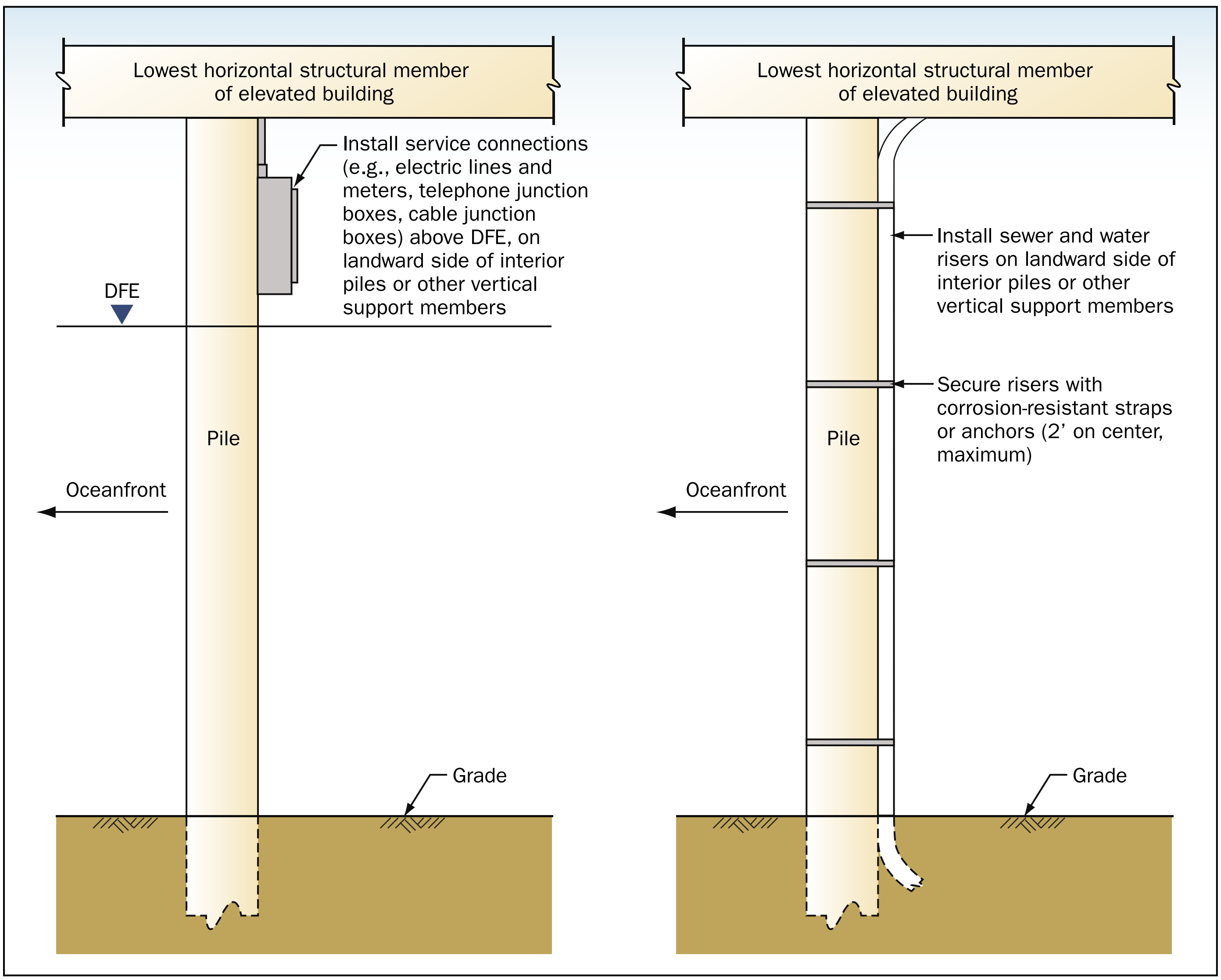
Utility Protection Recommendations

Electrical

- Limit switches, wiring, and receptacles below the DFE to those items required for life safety. Substitute motion detectors above the DFE for below-DFE switches whenever possible. Use only ground-fault-protected electrical outlets below the DFE.
- Install service connections (e.g., electrical lines, panels, and meters; telephone junction boxes; cable junction boxes) above the DFE, on the landward side of interior piles or other vertical support members.
- Use drip loops to minimize water entry at penetrations.
- Never attach electrical components to breakaway walls.

Water/Sewage

- Attach plumbing risers on the landward side of interior piles or other vertical support members.



Recommended installation techniques for electrical and plumbing lines and other utility components.

- When possible, install plumbing runs inside joists for protection.
- Never attach plumbing runs to breakaway walls.

HVAC

- Install HVAC components (e.g., condensers, air handlers, ductwork, electrical components) above the DFE.
- Mount outdoor units on the leeward side of the building.
- Secure the unit so that it cannot move, vibrate, or be blown off its support.
- Protect the unit from damage by windborne debris.

Elevated air conditioning compressors.

Fuel

- Fuel tanks should be installed so as to prevent their loss or damage. This will require one of the following techniques: (1) elevation above the DFE and anchoring to prevent blowoff, (2) burial and anchoring to prevent exposure and flotation during erosion and flooding, (3) anchoring at ground level to prevent flotation during flooding and loss during scour and erosion. The first method (elevation) is preferred.
- Any anchoring, strapping, or other attachments must be designed and installed to resist the effects of corrosion and decay.

Additional Resources

American Society of Civil Engineers. *Flood Resistant Design and Construction* (SEI/ASCE 24-98). (http://www.asce.org)

FEMA. NFIP Technical Bulletin 5-93, *Free-Of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas*. (http://www.fema.gov/fima/techbul.shtm)

FEMA. *Protecting Building Utilities From Flood Damage*. FEMA 348. November 1999. (http://www.fema.gov/hazards/floods/lib06b.shtm)

Repairs, Remodeling, Additions, and Retrofitting

FEMA

Purpose: To outline National Flood Insurance Program (NFIP) requirements for repairs, remodeling, and additions, and opportunities for retrofitting in coastal flood hazard areas (some communities may have more restrictive requirements). To provide recommendations for exceeding those minimum requirements.

Key Issues

- Existing ***pre-FIRM* buildings that sustain substantial damage or that are substantially improved will be treated as new construction,*** and must meet the NFIP's flood-resistant construction requirements (e.g., lowest floor elevation, foundation, and enclosure requirements). (See box on next page for definitions of substantial damage and substantial improvement.)
- Work on pre-FIRM* ***buildings that are not substantially damaged or substantially improved*** is not subject to NFIP flood-resistant construction requirements.**
- Work on post-FIRM* ***buildings that are not substantially damaged or substantially improved*** must meet at least the NFIP's flood-resistant construction requirements that were in effect when the building was originally constructed.**
- Your Authority Having Jurisdiction (AHJ) will determine whether the building is substantially damaged or substantially improved when you apply for permits.
- With a couple of minor ***exceptions*** (e.g., code violations and historic buildings), *substantial damage* and *substantial improvement* requirements ***apply to all buildings in the flood hazard area***, whether or not a flood insurance policy is in force.
- Buildings damaged by a flood and covered by flood insurance may be eligible for additional payments through the ***Increased Cost of Compliance (ICC)*** policy provisions. Check with an insurance agent and the AHJ for details.
- Repairs and remodeling – either before or after storm damage – provide many ***opportunities for retrofitting*** homes and making them more resistant to storm damage (see Figure 1).

* Existing pre-FIRM (Flood Insurance Rate Map) buildings are buildings constructed before the jurisdiction's first adoption of a floodplain management ordinance. Post-FIRM buildings are buildings constructed after the jurisdiction adopted these regulations.

** See Fact Sheet No. 2 for recommended requirements for exceeding the NFIP regulatory requirements in V zones and in A zones in coastal areas.

Note: Repairs, remodeling, additions, and retrofitting may also be subject to other community and code requirements, some of which may be more restrictive than the NFIP requirements. Check with the AHJ before undertaking any work.

Figure 1 Storm-damaged homes need repairs, but also provide opportunities for renovation, additions, and retrofitting. Review substantial damage and substantial improvement regulations before undertaking any work.

Factors That Determine Whether and How Existing Buildings Must Comply With NFIP Requirements

Rules governing the applicability of NFIP new construction requirements to existing buildings are confusing to many people – this fact sheet and ***Fact Sheet No. 2*** provide guidance on the subject.

When repairs, remodeling, additions, or improvements to an existing building are undertaken, four basic factors determine whether and how the existing building must comply with NFIP requirements for new construction:

- ***value of damage/work –*** whether the value of the building damage and/or work triggers substantial damage or substantial improvement regulations (see box below)
- ***nature of work –*** whether the work involves remodeling of a building; expansion of a building, either laterally or vertically (an addition); reconstruction of a destroyed, damaged, or purposely demolished building; or relocation of an existing building
- ***pre-FIRM or post-FIRM building –*** different requirements may apply to pre-FIRM buildings
- ***flood hazard zone –*** different requirements may apply in V zones and A zones

Two other factors occasionally come into play (consult the AHJ regarding whether and how these factors apply):

- ***code violations –*** NFIP regulations allow communities to exclude from substantial damage and substantial improvement calculations the cost of certain work to correct existing violations of state or local health, sanitary, or safety code requirements that have been cited by a code official.
- ***historic structures –*** a building that is on the National Register of Historic Places or that has been designated as historic by federally certified state or local historic preservation offices (or that is eligible for such designation) may be exempt from certain substantial damage and substantial improvement requirements, provided any work on the building does not cause the building to lose its historic designation.

A Zones Subject to Breaking Waves and Erosion. Home Builder's Guide to Coastal Construction **(**HGCC) Recommendations: Treat buildings and lateral additions in A zones subject to breaking waves and erosion like V-zone buildings. Elevate these lateral additions (except garages) such that the bottom of the lowest horizontal structural member is at or above the BFE. For garages (in A zones subject to breaking waves and erosion) below the BFE, construct with breakaway walls.

Substantial Damage and Substantial Improvement

It is not uncommon for existing coastal buildings to be modified or expanded over time, often in conjunction with the repair of storm damage. *All repairs, remodeling, improvements, additions, and retrofitting to buildings in flood hazard areas must be carried out in conformance with floodplain management regulations adopted by the community pertaining to* ***substantial damage*** *and* ***substantial improvement****.*

What Is Substantial Damage?

Substantial damage is damage, ***of any origin***, where the cost to restore the building to its pre-damage condition equals or exceeds **50 percent of the building's market value before the damage occurred**.

What Is Substantial Improvement?

Substantial improvement is any reconstruction, rehabilitation, addition, or improvement of a building, the cost of which equals or exceeds **50 percent of the building's pre-improvement market value**.

When repairs and improvements are made at the same time, all costs are totaled and compared with the 50-percent-of-market-value threshold.

Note that some jurisdictions have enacted more restrictive requirements – some use a less-than-50-percent damage/improvement threshold. Some track the cumulative value of damage and improvements over time. Consult the AHJ for local requirements.

What Costs Are Included in Substantial Damage and Substantial Improvement Determinations?

- all ***structural items and major building components*** (e.g., foundations; beams; trusses; sheathing; walls and partitions; floors; ceilings; roof covering; windows and doors; brick, stucco, and siding; attached decks and porches)

- ***interior finish elements*** (e.g., tile, linoleum, stone, carpet; plumbing fixtures; drywall and wall finishes; built-in cabinets, bookcases and furniture; hardware)
- ***utility and service equipment*** (e.g., HVAC equipment; plumbing and wiring; light fixtures and ceiling fans; security systems; built-in appliances; water filtration and conditioning systems)
- market value of ***all labor and materials*** for repairs, demolition, and improvements, including management, supervision, overhead, and profit (do not discount volunteer or self labor or donated/discounted materials)

What Costs Are *Not* Included in Substantial Damage and Substantial Improvement Determinations?

- ***design costs***, including plans and specifications, surveys, and permits
- ***clean-up***, debris removal, transportation, and landfill costs
- ***contents*** (e.g., furniture, rugs, appliances not built in)
- ***outside improvements*** (e.g., landscaping, irrigation systems, sidewalks and patios, fences, lighting, swimming pools and hot tubs, sheds, gazebos, detached garages)

Below are some examples of remodeling, additions, or repairs to buildings described in Fact Sheet No. 2 that illustrate the NFIP substantial damage and substantial improvement requirements. Check with the AHJ before undertaking any work even if the building is not substantially damaged or being substantially improved. The AHJ may have adopted more restrictive requirements than the NFIP requirements.

Substantial Improvement and Substantial Damage Examples

Example 1. Renovation/Remodeling

This example addresses the renovation/remodeling of an existing building that does not affect the external dimensions of the building.

If the cost of remodeling a building is equal to or greater than 50 percent of the market value of the building, the work constitutes a substantial improvement and the existing building must meet current NFIP requirements for new construction (see Figure 2).

Renovated/Remodeled Pre-FIRM Building in V Zone. Substantial Improvement.

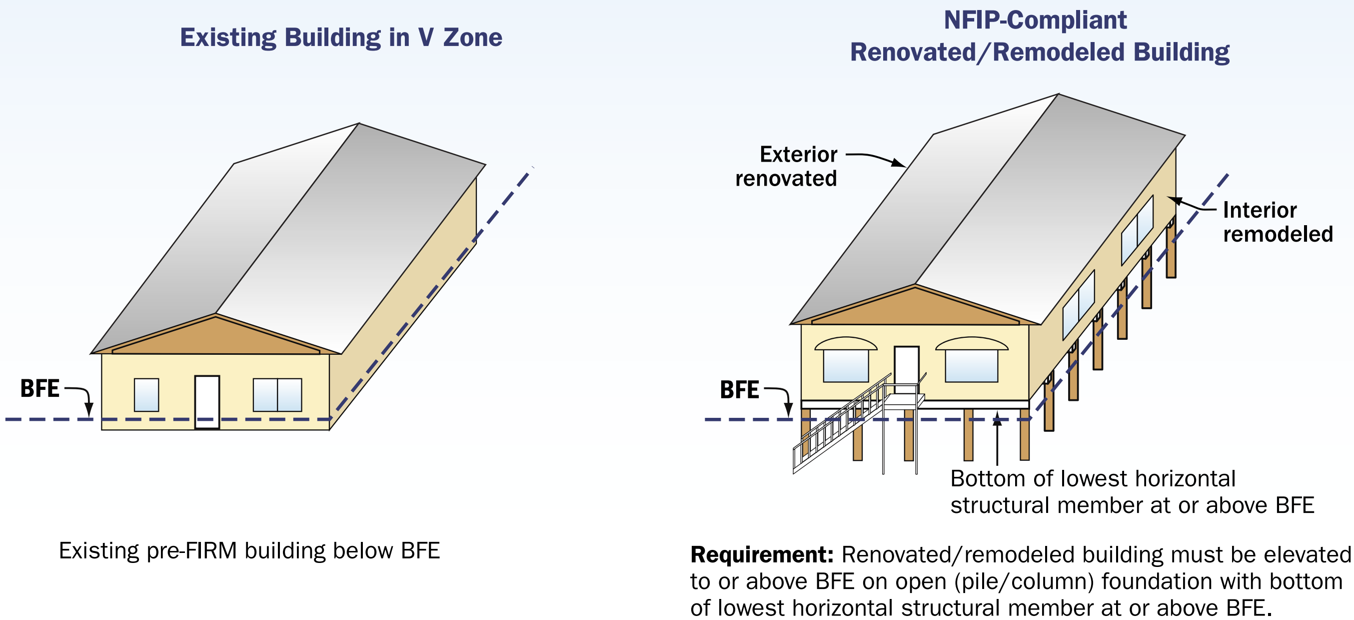


Figure 2 ***Substantial improvement: Renovated/remodeled building in a V zone.***

Example 2. Lateral Addition

- If a ***lateral addition*** constitutes a ***substantial improvement to a V-zone building***, ***both the addition and the existing building must comply*** with the current floor elevation, foundation, and other flood requirements for new V-zone construction (see Figure 3).
- If a ***lateral addition*** constitutes a ***substantial improvement to an A-zone building, only the addition must comply*** with the current floor elevation, foundation, and other flood requirements for new construction, as long as the alterations to the existing building are the minimum necessary.* Minimum alterations necessary means the existing building is not altered, except for cutting an entrance through the existing building wall into the addition, and except for the minimum alterations necessary to tie the addition to the building. If more extensive alterations are made to the existing building, it too must be brought into compliance with the requirements for new construction.

* However, ***the Home Builders Guide to Coastal Construction (HGCC) recommends that both the existing building and the addition be elevated to the current BFE, in a manner consistent with current NFIP requirements, and using a V-zone-type foundation in A zones subject to breaking waves or erosion***.

- If a ***lateral addition does not constitute a substantial improvement, see Fact Sheet No 2 for HGCC recommendations.***

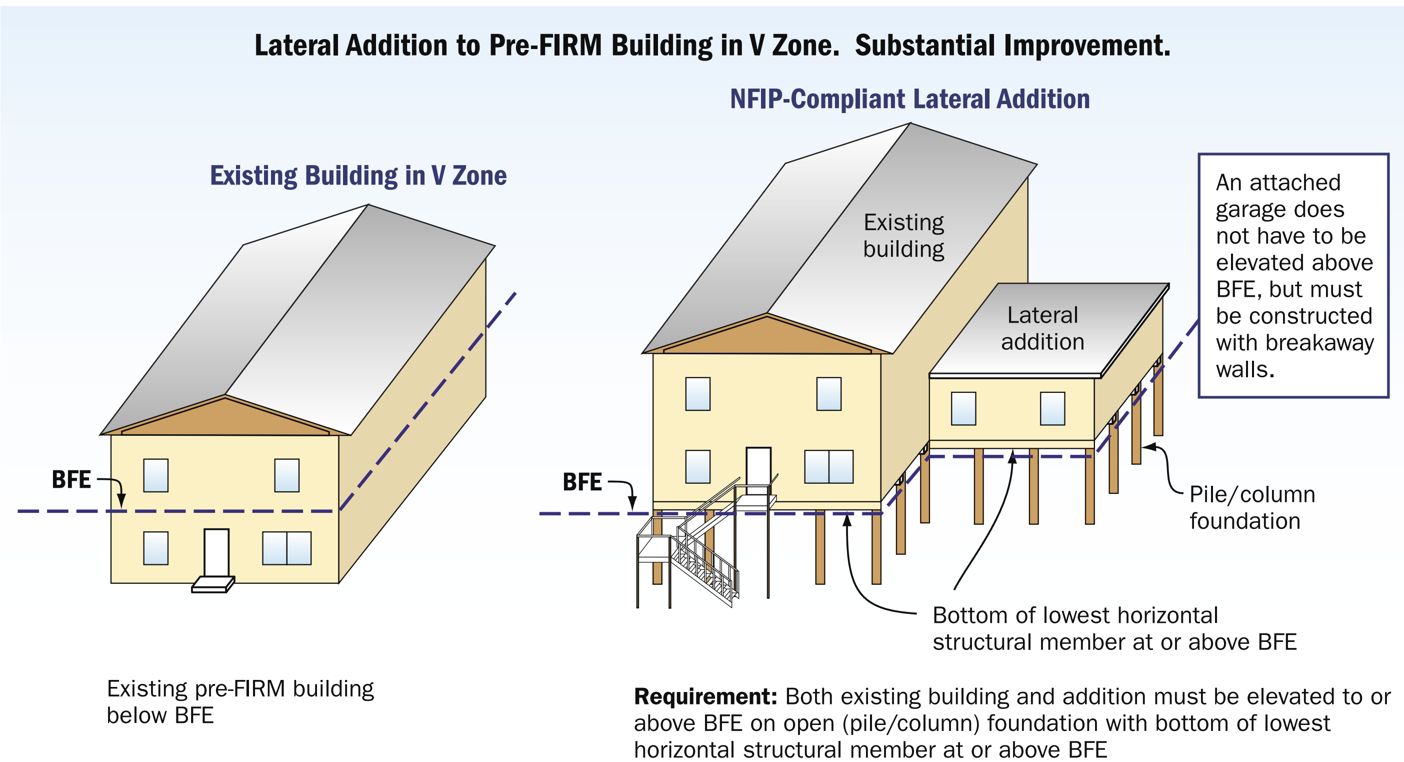


Figure 3 Substantial improvement: Lateral addition to a pre-FIRM building in a V zone.

Example 3. Vertical Addition

- If a ***vertical addition to a V-zone or A-zone building*** constitutes a ***substantial improvement, both the addition and the existing building must comply*** with the current floor elevation, foundation, and other flood requirements for new construction (see Figures 4 and 5).
- If a ***vertical addition does not constitute a substantial improvement, see Fact Sheet No. 2 for HGCC recommendations.***

Note: For requirements concerning enclosures below elevated buildings, see Fact Sheet No. 27.

Example 4. Reconstruction of a Destroyed or Razed Building

In all cases (***pre-FIRM*** or ***post-FIRM***, ***V zone*** or ***A zone***) where an ***entire building is destroyed, damaged, or purposefully demolished or razed***, the replacement building is considered "new construction" and ***the replacement building must meet the current NFIP requirements***, even if it is built on the foundation of the original building.

Example 5. Moving an Existing Building

When an existing building is ***moved to a new location or site in a V zone or A zone***, the work is considered "new construction" and ***the relocated building must comply with current NFIP requirements***.

Figure 4 ***Vertical addition to a home damaged by Hurricane Fran. Pre-existing 1-story home became the second story of a home elevated to meet new foundation and floor elevation requirements.***

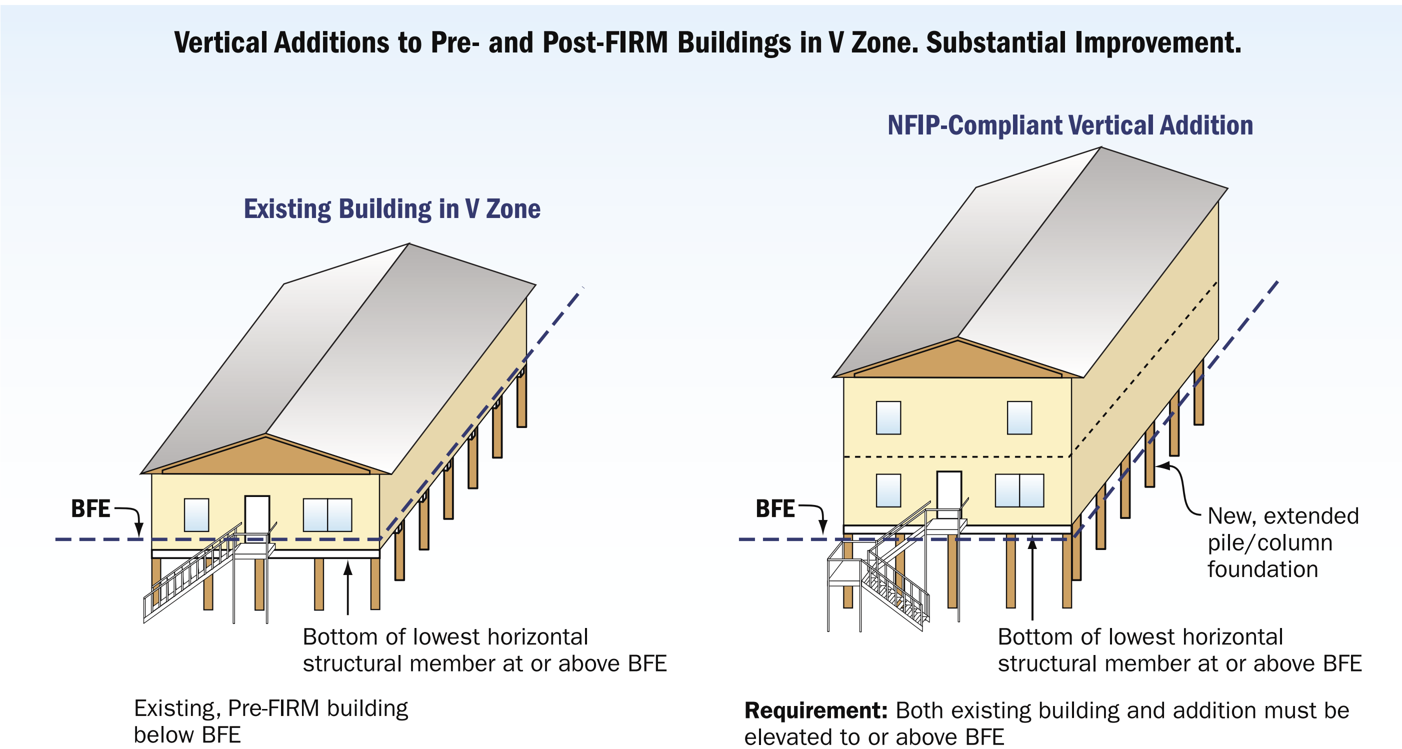


Figure 5 ***Substantial improvement: Vertical addition to a pre-FIRM building in a V zone.***

Insurance Implications

Designers and owners should know that the work described above may have insurance consequences.

In general, most changes to an existing building that result from less-than-substantial damage, or that do not constitute substantial improvement, will not change the status from pre-FIRM to post-FIRM and thus would not affect the insurance rate. However, failure to comply with the substantial damage or substantial improvement requirements of the NFIP will result in a building's status being changed and may result in higher flood insurance premiums.

Retrofit Opportunities

Retrofit opportunities will present themselves every time repair or maintenance work is undertaken for a major element of the building. Improvements to the building that are made to increase resistance to the effects of natural hazards should focus on those items that will potentially return the largest benefit to the building owner. For example:

- When the ***roof covering*** is replaced, the attachment of the sheathing to the trusses or rafters can be checked, and hurricane/seismic connectors can be installed at the rafter-to-wall or truss-to-wall connections. When reroofing, tear-off is recommended in lieu of re-covering.
- ***Gable ends*** can be braced in conjunction with other retrofits, or by themselves.
- If ***siding*** or ***roof sheathing*** has to be replaced, hurricane/seismic connectors can be installed at the rafter-to-wall or truss-to-wall connections, the exterior wall sheathing attachment can be checked, and structural sheathing can be added to shearwalls. Adding wall-to-foundation ties may also be possible.
- Exterior ***siding*** attachment can be improved with more fasteners at the time the exterior is re-coated.
- ***Window***, ***door***, and ***skylight*** reinforcement and attachment can be improved whenever they are accessible.
- When ***windows*** and ***doors*** are replaced, glazing and framing can be used that is impact-resistant and provides greater UV protection.
- Hurricane ***shutters*** can be added at any time (see Fact Sheet No. 26).
- ***Floor-framing-to-beam connections*** can be improved whenever they are accessible.
- ***Beam-to-pile connections*** can be improved whenever they are accessible.
- At any time, deficient ***light-gauge metal connectors*** that are accessible should be replaced with stainless steel connectors, where available. ***Heavier-gauge metal connectors*** can be replaced with either stainless steel connectors or metal connectors with heavier galvanizing.
- When ***HVAC equipment*** is replaced, the replacement equipment should be more durable — so that it will last longer in a coastal environment — and should be elevated to or above the BFE and adequately anchored to resist wind and seismic loads.
- ***Utility attachment*** can be improved when the outside equipment is replaced or relocated.
- In the ***attic space***, at any time, ***straps*** should be added to rafters across the ridge beam, straps should be added from rafters to top wall plates, and gable wall framing should be ***braced***. In addition, the uplift resistance of the roof sheathing can be increased through the application of Engineered Wood Association AFG-01-rated structural ***adhesive*** at the joints between the roof sheathing and roof rafters or trusses. The adhesive should be applied in a continuous bead and extended to the edges of the roof (where some of the highest uplift pressures occur). At the last rafter or truss at gable ends, where only one side of the joint is accessible, wood strips made of quarter-round molding may be embedded in the adhesive to increase the strength of the joint. For more information about the use of adhesive, see **Additional Resources**, below.
- At any time, reinforcement or replacement of ***garage doors*** with new wind- and debris-resistant doors can be considered. However, the ability of the adjacent walls and building to accommodate the increased wind loads and flood loads (transferred from the garage door to the building) should first be determined. If the existing building cannot accommodate the increased loads transferred from the new/reinforced garage door, the structure will first require reinforcement. This may or may not be feasible. Also, in a V zone, the new/reinforced garage door must be designed and certified to break away during the Base Flood (see Fact Sheet No. 27).
- To minimize the effects of corrosion, ***metal light fixtures*** can be replaced at any time with fixtures that have either wood or vinyl exteriors. However, wood may require frequent treatment or painting.
- To minimize the effects of corrosion, carbon steel ***handrails*** can be replaced at any time with vinyl-coated, plastic, stainless steel, or wood handrails. However, wood may require frequent treatment or painting.

Additional Resources

Clemson University Department of Civil Engineering and South Carolina Sea Grant Extension Program. *Not Ready to Re-Roof? Use Structural Adhesives to Strengthen the Attachment of Roof Sheathing* and *Holding on to Your Roof – A guide to retrofitting your roof sheathing using adhesives*. (http://www.haznet.org/haz_outreach/outreach_factsheets.htm)

FEMA. 1991. *Answers to Questions about Substantially Damaged Buildings.* FEMA 213. (http://www.fema.gov/hazards/floods/lib213.shtm)

FEMA. 2000. *Coastal Construction Manual*, Chapter 14. FEMA-55. (http://www.fema.gov/hazards/floods/lib55.shtm)