Home Builder's Guide to Coastal Construction

Technical Fact Sheet Series

FEMA 499 / August 2005

FEMA

Prepared by the Federal Emergency Management Agency with assistance from:

U.S. Department of Housing and Urban Development

National Association of Home Builders Research Center

Coastal Construction Fact Sheet Series

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet Guide*

Introduction

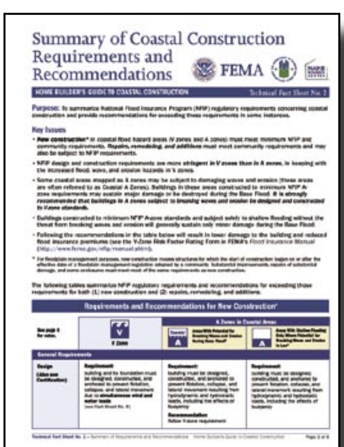
FEMA has produced a series of 31 fact sheets that provide technical guidance and recommendations concerning the construction of ***coastal residential buildings***. The fact sheets present information aimed at improving the performance of buildings subject to flood and wind forces in coastal environments. The fact sheets make extensive use of photographs and drawings to illustrate National Flood Insurance Program (NFIP) regulatory requirements, the proper siting of coastal buildings, and recommended design and construction practices, including structural connections, the building envelope, utilities, and accessory structures. In addition, many of the fact sheets include lists of additional resources that provide more information about the topics discussed.

Available Fact Sheets

The following 31 fact sheets are available as Adobe® Portable Document Format (PDF) files and as plain text (.txt) files. You must have Adobe® Reader to view the PDF files. The latest version of Adobe Reader is recommended. Download the free Reader from www.adobe.com.

Coastal Building Successes and Failures

Fact Sheet No. 1, *Coastal Building Successes and Failures* – Explains how coastal construction requirements differ from those for inland construction, and discusses the characteristics that make for a successful coastal residential building. Includes design and construction recommendations for achieving building success.



Summary of Coastal Construction Requirements and Recommendations

Fact Sheet No. 2, *Summary of Coastal Construction Requirements and Recommendations* – Summarizes NFIP regulatory requirements for new construction and for repairs, remodeling, and additions, and presents recommendations for exceeding those requirements in some instances. Topics include building foundations, enclosures below the Base Flood Elevation (BFE), use of nonstructural fill, use of space below the BFE, utilities, certification requirements, and repairs, remodeling, and additions. Cross-references to related fact sheets are provided.


Using a Flood Insurance Rate Map (FIRM)

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION — Technical Fact Sheet No. 3

Fact Sheet No. 3, *Using a Flood Insurance Rate Map (FIRM)* – Explains the purpose of FIRMs; highlights features of a FIRM that are important to coastal builders, including flood hazard zones and flood elevations; and explains how to obtain FIRMs.


Lowest Floor Elevation

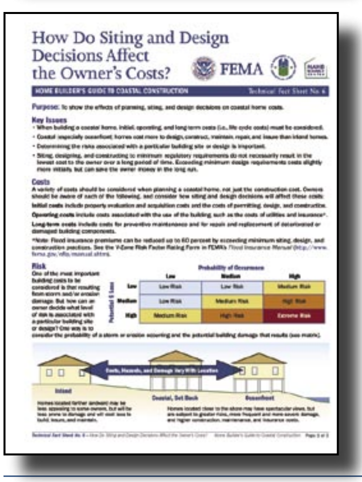
HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION — Technical Fact Sheet No. 4

Fact Sheet No. 4, *Lowest Floor Elevation* – Defines "lowest floor," discusses benefits of exceeding the NFIP minimum building elevation requirements, points out common construction practices that are violations of NFIP regulations, and discusses the NFIP Elevation Certificate. Also includes a copy of the certificate.


V-Zone Design and Construction Certification

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION — Technical Fact Sheet No. 5

Fact Sheet No. 5, *V-Zone Design and Construction Certification* – Explains the certification requirements for structural design and construction in V zones. Also includes a copy of a sample certificate and explains how to complete it.

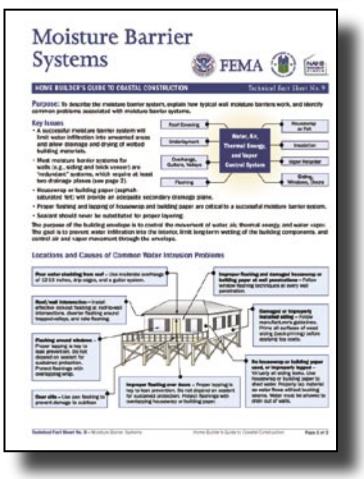

How Do Siting and Design Decisions Affect the Owner's Costs?

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION — Technical Fact Sheet No. 6

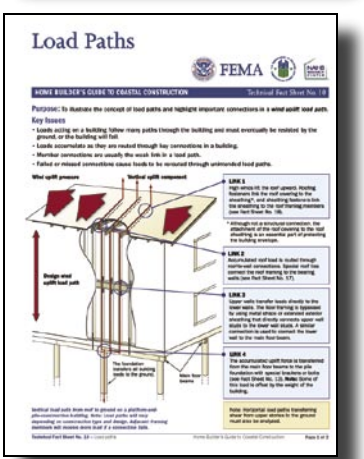
Fact Sheet No. 6, *How Do Siting and Design Decisions Affect the Owner's Costs?* – Discusses effects of planning, siting, and design decisions on coastal home costs. Topics include initial, operating, and long-term costs; risk determination; and the effect on costs of meeting and exceeding code and NFIP design and construction requirements.

Fact Sheet No. 7, *Selecting a Lot and Siting the Building* – Presents guidance concerning lot selection and building siting considerations for coastal residential buildings. Topics include factors that constrain siting decisions, coastal setback lines, common siting problems, and suggestions for builders, designers, and owners.

Fact Sheet No. 8, *Coastal Building Materials* – Provides guidance on the selection of building materials used for coastal construction. Flood, wind, corrosion, and decay resistance are discussed, including protection recommendations.

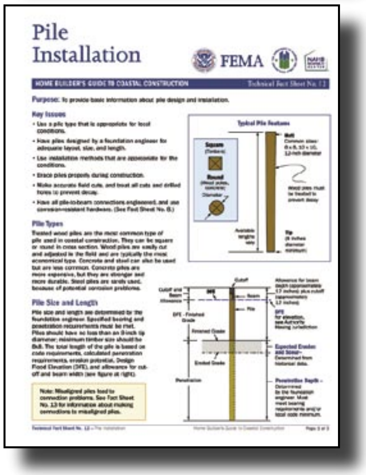


Fact Sheet No. 9, *Moisture Barrier Systems* – Describes the moisture barrier system, explains how typical wall moisture barrier systems work, and discusses common problems associated with moisture barrier systems.



Fact Sheet No. 10, *Load Paths* – Illustrates the concept of load paths and highlights important connections in a typical wind uplift load path.

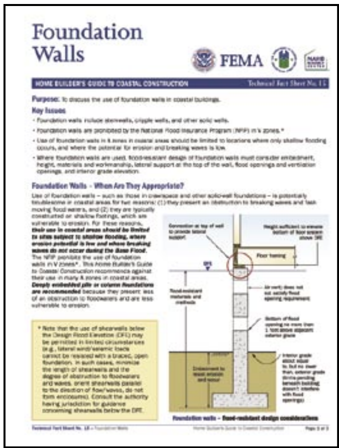
Fact Sheet No. 11, ***Foundations in Coastal Areas*** – Explains foundation design criteria and describes foundation types suitable for coastal environments. Also addresses foundations for high-elevation coastal areas (e.g., bluff areas).



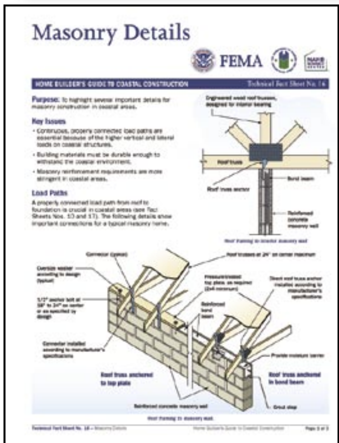
Fact Sheet No. 12, ***Pile Installation*** – Presents basic information about pile design and installation, including pile types, sizes and lengths, layout, installation methods, bracing, and capacities.

Fact Sheet No. 13, ***Wood-Pile-to-Beam Connections*** – Illustrates typical wood-pile-to-beam connections; presents basic construction guidance for various connection methods, including connections for misaligned piles; and illustrates pile bracing connection techniques.

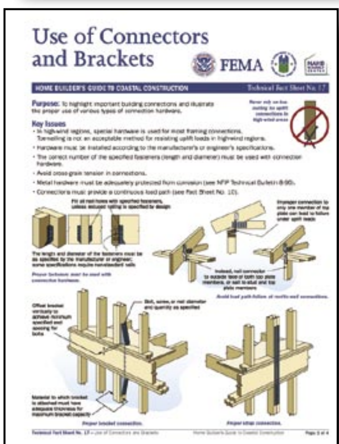
Fact Sheet No. 14, ***Reinforced Masonry Pier Construction*** – Provides an alternative to piles in V zones and A zones in coastal areas where soil properties preclude pile installation, but the need for an "open foundation system" still exists. Includes recommendations for good masonry practice in coastal environments.



Fact Sheet No. 15, ***Foundation Walls*** – Discusses and illustrates the use of foundation walls in coastal buildings. Topics include footing embedment, wall height, materials and workmanship, lateral support, flood openings and ventilation requirements, and interior grade elevations for crawlspaces.

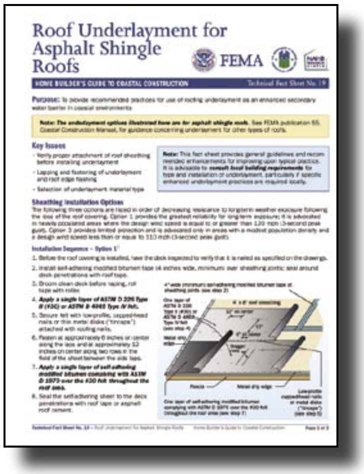


Fact Sheet No. 16, ***Masonry Details*** – Illustrates important roof-to-wall and wall-to-foundation connection details for masonry construction in coastal areas. Topics include load paths, building materials, and reinforcement.



Fact Sheet No. 17, ***Use of Connectors and Brackets*** – Illustrates important building connections and the proper use of connection hardware throughout a building.

Fact Sheet No. 18, ***Roof Sheathing Installation*** – Presents information about proper roof sheathing installation and its importance in coastal construction; also discusses fastening methods that will enhance the durability of a building in a high-wind area. Topics include sheathing types and layout methods for gable-end and hip roofs, fastener selection and spacing, the treatment of ridge vents and ladder framing, and common sheathing attachment mistakes.


Roof Underlayment for Asphalt Shingle Roofs
FEMA

Fact Sheet No. 19, *Roof Underlayment for Asphalt Shingle Roofs* – Presents recommended practices for the use of roofing underlayment as an enhanced secondary water barrier in coastal environments. Optional installation methods are illustrated.


Asphalt Shingle Roofing for High-Wind Regions
FEMA

Fact Sheet No. 20, *Asphalt Shingle Roofing for High-Wind Regions* – Recommends practices for installing asphalt roof shingles that will enhance the wind resistance of roof coverings in high-wind, coastal regions. Issues include installation at hips, eaves, and ridges; shingle characteristics; weathering and durability; and wind resistance.


Tile Roofing for High-Wind Areas
FEMA

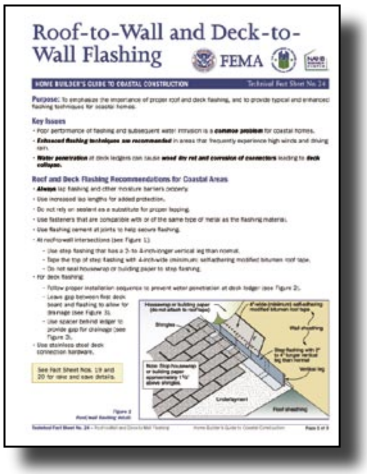
Fact Sheet No. 21, *Tile Roofing for High-Wind Areas* – Presents design and construction guidance for tile roofing attachment methods. Topics include uplift loads, uplift resistance, special considerations concerning tile attachment at hips and ridges, tile installation on critical and essential buildings, and quality control.


Window and Door Installation
FEMA

Fact Sheet No. 22, *Window and Door Installation* – Presents flashing detail concepts for window and door openings that provide adequate resistance to water intrusion in coastal environments, do not depend solely on sealants, are integral with secondary weather barriers (e.g., housewrap), and are adequately attached to the wall. Topics include the American Society for Testing and Materials (ASTM) Standard E 2112 and specific considerations concerning pan flashings, Exterior Insulation Finishing Systems, frame anchoring, shutters, and weatherstripping.

Housewrap

Fact Sheet No. 23, *Housewrap* – Explains the function of housewrap, examines its attributes, and addresses common problems associated with its use. Topics include housewrap vs. building paper and housewrap installation.



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

Fact Sheet No. 24, *Roof-to-Wall and Deck-to-Wall Flashing* – Emphasizes the importance of proper roof and deck flashing, and presents typical and enhanced flashing techniques for coastal homes.

Siding Installation and Connectors

Fact Sheet No. 25, *Siding Installation and Connectors* – Provides basic installation tips for various types of siding, including vinyl, wood, and fiber cement.

Shutter Alternatives

Fact Sheet No. 26, *Shutter Alternatives* – Presents general information about the installation and use of storm shutters in coastal environments. Shutter types addressed include temporary plywood panels; temporary manufactured panels; permanent, manual closing; and permanent, motor-driven.


Enclosures and Breakaway Walls

FEMA

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION

Fact Sheet No. 27, *Enclosures and Breakaway Walls* – Defines enclosures and breakaway walls, and discusses requirements and recommendations for their use below the Base Flood Elevation (BFE).


Decks, Pools, and Accessory Structures

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HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION

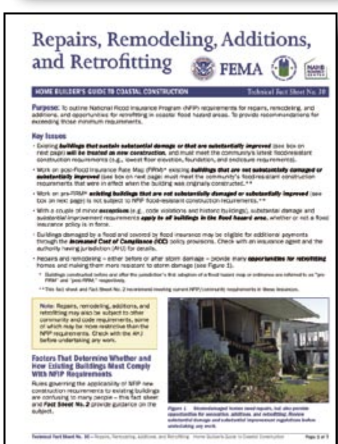
Fact Sheet No. 28, *Decks, Pools, and Accessory Structures* – Summarizes NFIP requirements, general guidelines, and recommendations concerning the construction and installation of decks, access stairs and elevators, swimming pools, and accessory buildings under or near coastal residential buildings.


Protecting Utilities

FEMA

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION

Fact Sheet No. 29, *Protecting Utilities* – Identifies the special considerations that must be made when installing utility equipment, such as fuel, sewage, and water/sewage lines in a coastal home, and presents recommendations for utility protection.


Repairs, Remodeling, Additions, and Retrofitting

FEMA

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION

Fact Sheet No. 30, *Repairs, Remodeling, Additions, and Retrofitting* – Outlines NFIP requirements for repairs, remodeling, and additions, and discusses opportunities for retrofitting in coastal flood hazard areas. Also presents recommendations for exceeding the minimum NFIP requirements. Definitions of "substantial damage" and "substantial improvement" are included.

Fact Sheet No. 31, References – Lists references that provide information relevant to topics covered by the *Home Builder's Guide to Coastal Construction* technical fact sheets.

Coastal Building Successes and Failures

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 — Technical Fact Sheet No. 1

Purpose: To discuss how coastal construction requirements are different from those for inland construction. To discuss the characteristics that make for a successful coastal building.

Is Coastal Construction That Different From Inland Construction?

The short answer is ***yes,*** building in a coastal environment is different from building in an inland area:

- ***Flood levels, velocities,*** and ***wave*** action in coastal areas tend to make coastal flooding more damaging than inland flooding.
- Coastal ***erosion*** can undermine buildings and destroy land, roads, utilities, and infrastructure.
- ***Wind speeds*** are typically higher in coastal areas and require stronger engineered building connections and more closely spaced nailing of building sheathing, siding, and roof shingles.
- ***Wind-driven rain, corrosion,*** and ***decay*** are frequent concerns in coastal areas.

In general, homes in coastal areas must be designed and built to withstand ***higher loads*** and ***more extreme conditions***. Homes in coastal areas will require ***more maintenance*** and upkeep. Because of their exposure to higher loads and extreme conditions, homes in coastal areas will cost more to design, construct, maintain, repair, and insure.

Figure 1. Well-built but poorly sited building.

Building Success

In order for a coastal building to be considered a "success," four things must occur:

- The building must be designed to withstand coastal forces and conditions.
- The building must be constructed as designed.
- The building must be sited so that erosion does not undermine the building or render it uninhabitable.
- The building must be maintained/repaired.

A well-built but poorly sited building can be undermined and will not be a success (see Figure 1). Even if a building is set back or situated farther from the coastline, it will not perform well (i.e., will not be a success) if it is incapable of resisting high winds and other hazards that occur at the site (see Figure 2).

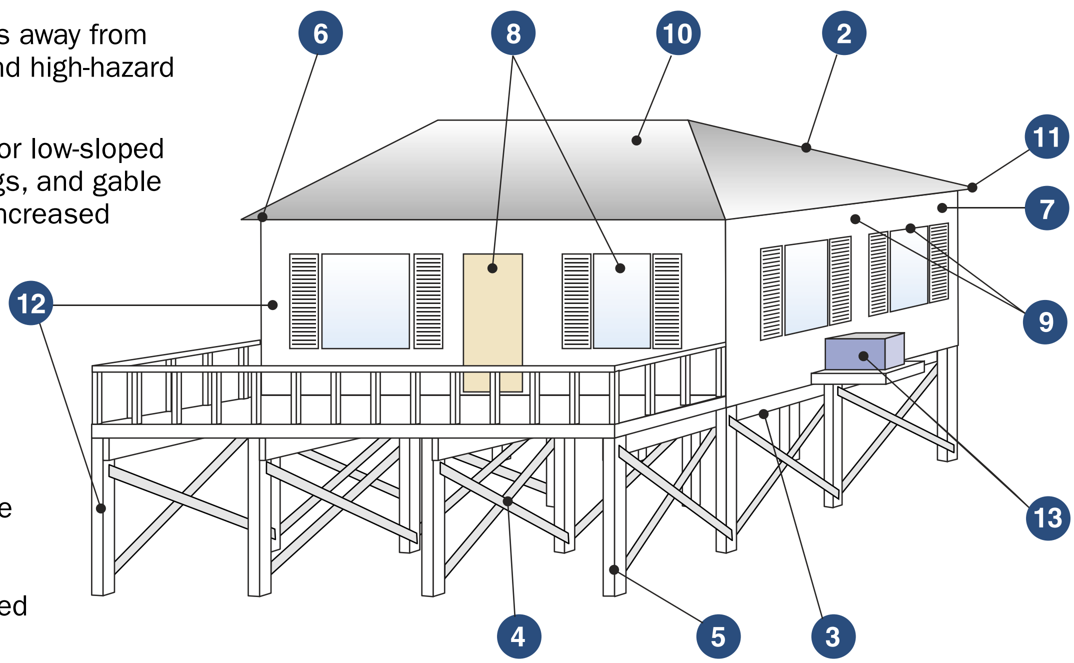
Figure 2. Well-sited building that still sustained damage.

What Should Owners and Home Builders Expect From a "Successful" Coastal Building?

In coastal areas, a building can be considered a success only if it is capable of resisting damage from coastal hazards and coastal processes over a period of decades. This statement does not imply that a coastal residential building will remain undamaged over its intended lifetime. It means that the impacts of a design-level flood, storm, wind, or erosion event (or series of lesser events with combined impacts equivalent to a design event) will be limited to the following:

- The building **foundation** must remain intact and functional.
- The **envelope** (walls, openings, roof, and lowest floor) must remain structurally sound and capable of minimizing penetration by wind, rain, and debris.
- The **lowest floor** elevation must be sufficient to prevent floodwaters from entering the elevated building envelope during the design event.
- The **utility connections** (e.g., electricity, water, sewer, natural gas) must remain intact or be restored easily.
- The building must be **accessible** and **usable** following a design-level event.
- Any damage to **enclosures** below the Design Flood Elevation (DFE)* must not result in damage to the foundation, the utility connections, or the elevated portion of the building.

Recommended Practice



1. **Siting –** Site buildings away from eroding shorelines and high-hazard areas.

2. **Building Form –** Flat or low-sloped porch roofs, overhangs, and gable ends are subject to increased uplift in high winds. Buildings that are both tall and narrow are subject to overturning. Each of these problems can be overcome through the design process, but each must receive special attention. In the design process, chose moderate-sloped hip roofs (4/12 to 6/12) if possible.

3. **Lowest Floor Elevation –** Elevate above the DFE the bottom of the lowest horizontal structural member supporting the lowest floor. Add "freeboard" to reduce damage and lower flood insurance premiums.

4. **Free of Obstructions –** Use an open foundation. Do not obstruct the area below the elevated portion of the building. Avoid or minimize the use of breakaway walls. Do not install utilities or finish enclosed areas below the DFE (owners tend to convert these areas to habitable uses, which is prohibited under the National Flood Insurance Program and will lead to additional flood damage and economic loss).

5. **Foundation –** Make sure the foundation is deep enough to resist the effects of scour and erosion; strong enough to resist wave, current, flood, and debris forces; and capable of transferring wind and seismic forces on upper stories to the ground.

*The DFE is the locally mandated flood elevation, which will be equal to or higher than the Base Flood Elevation (BFE). The BFE is the expected elevation of flood waters and wave effects during the 100-year flood (also known as the Base Flood).

6 **Connections –** Key connections include roof sheathing, roof-to-wall, wall-to-wall, and walls-to-foundation. Be sure these connections are constructed according to the design. Bolts, screws, and ring-shanked nails are common requirements. Standard connection details and nailing should be identified on the plans.

7 **Exterior Walls –** Use structural sheathing in high-wind areas for increased wall strength. Use tighter nailing schedules for attaching sheathing. Care should be taken not to over-drive pneumatically driven nails. This can result in loss of shear capacity in shearwalls.

8 **Windows and Glass Doors –** In high-wind areas, use windows and doors capable of withstanding increased wind pressures. In windborne debris areas, use impact-resistant glazing or shutters.

9 **Flashing and Weather Barriers –** Use stronger connections and improved flashing for roofs, walls, doors, and windows and other openings. Properly installed secondary moisture barriers, such as housewrap or building paper, can reduce water intrusion from wind-driven rain.

10 **Roof –** In high-wind areas, select appropriate roof coverings and pay close attention to detailing. Avoid roof tiles in hurricane-prone areas.

11 **Porch Roofs and Roof Overhangs –** Design and tie down porch roofs and roof overhangs to resist uplift forces.

12 **Building Materials –** Use flood-resistant materials below the DFE. All exposed materials should be moisture- and decay-resistant. Metals should have enhanced corrosion protection.

13 **Mechanical and Utilities –** Electrical boxes, HVAC equipment, and other equipment should be elevated to avoid flood damage and strategically located to avoid wind damage. Utility lines and runs should be installed to minimize potential flood damage.

14 **Quality Control –** Construction inspections and quality control are essential for building success. Even "minor" construction errors and defects can lead to major damage during high-wind or flood events. Keep this in mind when inspecting construction or assessing yearly maintenance needs.

Recommended practice and guidance concerning the topics listed above can be found in the documents referenced in these fact sheets and in many trade publications (e.g., the *Journal of Light Construction,* http://www.jlconline.com).

Will the Likelihood of Success (Building Performance) Be Improved by Exceeding Minimum Requirements?

States and communities enforce regulatory requirements that determine where and how buildings may be sited, designed, and constructed. There are often economic benefits to exceeding the enforced requirements (see box). Designers and home builders can help owners evaluate their options and make informed decisions about whether to exceed these requirements.

Benefits of Exceeding Minimum Requirements

- Reduced building damage during coastal storm events
- Reduced building maintenance
- Longer building lifetime
- Reduced insurance premiums*
- Increased reputation of builder

*Note: Flood insurance premiums can be reduced up to 60 percent by exceeding minimum siting, design, and construction practices. See the V-Zone Risk Factor Rating Form in FEMA's *Flood Insurance Manual* (http://www.fema.gov/nfip/manual.shtm).

Summary of Coastal Construction Requirements and Recommendations

FEMA

NAHB RESEARCH CENTER

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 2*

Purpose: To summarize National Flood Insurance Program (NFIP) regulatory requirements concerning coastal construction and provide recommendations for exceeding those requirements in some instances.

Key Issues

- ***New construction**** in coastal flood hazard areas (V zones and A zones) must meet minimum NFIP and community requirements. ***Repairs, remodeling, and additions*** must meet community requirements and may also be subject to NFIP requirements.
- NFIP design and construction requirements are more ***stringent in V zones than in A zones***, in keeping with the increased flood, wave, floodborne debris and erosion hazards in V zones.
- Some coastal areas mapped as A zones may be subject to damaging waves and erosion (these areas are often referred to as Coastal A Zones). Buildings in these areas constructed to minimum NFIP A-zone requirements may sustain major damage or be destroyed during the Base Flood. ***It is strongly recommended that buildings in A zones subject to breaking waves and erosion be designed and constructed to V-zone standards.***
- Buildings constructed to minimum NFIP A-zone standards and subject solely to shallow flooding without the threat from breaking waves and erosion will generally sustain only minor damage during the Base Flood.
- Following the recommendations in the table below will result in lower damage to the building and reduced flood insurance premiums (see the V-Zone Risk Factor Rating Form in FEMA's *Flood Insurance Manual* (http://www.fema.gov/nfip/manual.shtm).

* For floodplain management purposes, new construction means structures for which the start of construction began on or after the effective date of a floodplain management regulation adopted by a community. Substantial improvements, repairs of substantial damage, and some enclosures must meet most of the same requirements as new construction.

The following tables summarize NFIP regulatory requirements and recommendations for exceeding those requirements for both (1) new construction and (2) repairs, remodeling, and additions.

Requirements and Recommendations for New Construction[a]

See page 8 for notes.	V Zone	A Zones in Coastal Areas: Coastal A — Areas With Potential for Breaking Waves and Erosion During Base Flood[b]	A Zones in Coastal Areas: A — Areas With Shallow Flooding Only, Where Potential for Breaking Waves and Erosion Is Low[c]
General Requirements			
Design (Also see Certification)	**Requirement:** building and its foundation must be designed, constructed, and anchored to prevent flotation, collapse, and lateral movement due to **simultaneous wind and water loads** [see Fact Sheet No. 5]	**Requirement:** building must be designed, constructed, and anchored to prevent flotation, collapse, and lateral movement resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy **Recommendation:** follow V-zone requirement	**Requirement:** building must be designed, constructed, and anchored to prevent flotation, collapse, and lateral movement resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy

See page 8 for notes.	V Zone	**A Zones in Coastal Areas** Coastal A: Areas With Potential for Breaking Waves and Erosion During Base Flood[b]	A: Areas With Shallow Flooding Only, Where Potential for Breaking Waves and Erosion Is Low[c]
General Requirements (cont.)			
Free of Obstructions	**Requirement:** the space below the lowest floor must be free of obstructions (e.g., free of any building element, equipment, or other fixed objects that can transfer flood loads to the foundation, or that can cause floodwaters or waves to be deflected into the building), or must be constructed with non-supporting breakaway walls, open lattice, or insect screening. [see Fact Sheet Nos. 5, 27]	**Requirement:** none **Recommendation:** follow V-zone requirement	**Requirement:** none
Materials [see Fact Sheet Nos. 1, 8]	**Requirement:** structural and nonstructural building materials at or below Base Flood Elevation (BFE) must be flood-resistant	**Requirement:** structural and nonstructural building materials at or below BFE must be flood-resistant	**Requirement:** structural and nonstructural building materials at or below BFE must be flood-resistant
Construction [see Fact Sheet No. 1] **(Also see Certification)**	**Requirement:** building must be constructed with methods and practices that minimize flood damage	**Requirement:** building must be constructed with methods and practices that minimize flood damage	**Requirement:** building must be constructed with methods and practices that minimize flood damage
Siting [see Fact Sheet Nos. 6, 7]	**Requirement:** all new construction shall be landward of mean high tide; alteration of sand dunes and mangrove stands that increases potential flood damage is prohibited **Recommendation:** site new construction landward of long-term erosion setback and landward of area subject to erosion during 100-year coastal flood event	**Requirement:** encroachments into floodways designated along rivers and streams are prohibited unless they will cause no increase in flood stage; where floodways have not been designated, encroachments into the Special Flood Hazard Area cannot increase the BFE by more than 1 foot **Recommendation:** follow V-zone requirement	**Requirement:** encroachments into floodways designated along rivers and streams are prohibited unless they will cause no increase in flood stage; where floodways have not been designated, encroachments into the Special Flood Hazard Area cannot increase the BFE by more than 1 foot
Foundation			
Structural Fill	**Prohibited** [see Fact Sheet No. 11]	Allowed, but **not recommended;** compaction required where used; protect against scour and erosion[d] [see Fact Sheet No. 11]	**Allowed;** compaction required where used; protect against scour and erosion[d]
Solid Foundation [see Fact Sheet Nos. 11, 15]	**Prohibited**	Allowed, but **not recommended**[d]	**Allowed**[d]
Open Foundation [see Fact Sheet No. 11]	**Required**	**Recommended**[d]	**Allowed**[d]
Lowest Floor Elevation [see Fact Sheet No. 4] **(Also see Certification)**	See **Bottom of Lowest Horizontal Structural Member** (below) [see Fact Sheet No. 5]	**Requirement:** top of floor must be at or above BFE[e] **Recommendation:** elevate bottom of lowest horizontal structural member to or above BFE[e]	**Requirement:** top of floor must be at or above BFE[e] **Recommendation:** elevate bottom of lowest horizontal structural member to or above BFE[e]

See page 8 for notes.	V Zone	A Zones in Coastal Areas Coastal A: Areas With Potential for Breaking Waves and Erosion During Base Flood[b]	A Zones in Coastal Areas A: Areas With Shallow Flooding Only, Where Potential for Breaking Waves and Erosion Is Low[c]
Foundation (cont.)			
Bottom of Lowest Horizontal Structural Member [see Fact Sheet No. 4]	must be at or above BFE[e] [see Fact Sheet No. 5]	Allowed below BFE[e], but **not recommnded**[d] **Recommendation:** follow V-zone requirement	Allowed below BFE[e], but **not recommended**[d] **Recommendation:** follow V-zone requirement
Orientation of Lowest Horizontal Structural Member	**Requirement:** none **Recommendation:** orient perpendicular to wave crest	**Requirement:** none **Recommendation:** follow V-zone requirement	**Requirement:** none
Freeboard [see Fact Sheet Nos. 1, 4]	Not required[e], but **recommended**	Not required[e], but **recommended**	Not required[e], but **recommended**
Enclosures Below BFE			
(Also see Certification) [see Fact Sheet No. 27]	**Prohibited,** except for breakaway walls, open lattice, and screening[f] **Recommendation:** if constructed, use open lattice or screening instead of breakaway walls	Allowed, but **not recommended** **Requirement:** if area is fully enclosed, enclosure walls must be equipped with openings to equalize hydrostatic pressure; size, location, and covering of openings governed by regulatory requirements **Recommendation:** elevate on open foundation; if enclosure is constructed, use breakaway walls (with flood openings), open lattice, or screening, as required in V zone[f,g]	**Allowed** **Requirement:** if area is fully enclosed, enclosure walls must be equipped with openings to equalize hydrostatic pressure; size, location, and covering of openings governed by regulatory requirements[f,g]
Nonstructural Fill			
	Allowed for minor landscaping and site drainage as long as fill does not interfere with free passage of flood waters and debris beneath building, or cause changes in flow direction during coastal storms that could result in damage to buildings	**Allowed**[h] **Recommendation:** follow V-zone requirement	**Allowed** **Recommendation:** follow V-zone requirement
Use of Space Below BFE[i] **(see Fact Sheet No. 27)**			
	Allowed only for parking, building access, and storage	**Allowed only** for parking, building access, and storage	**Allowed only** for parking, building access, and storage
Utilities[i]			
	Requirement: utilities, including ductwork and equipment, must be designed, located, and elevated to prevent flood waters from entering and accumulating in components during flooding; utility lines must not be installed or stubbed out in enclosures below BFE	**Requirement:** utilities, including ductwork and equipment, must be designed, located, and elevated to prevent flood waters from entering and accumulating in components during flooding; utility lines must not be installed or stubbed out in enclosures below BFE	**Requirement:** utilities, including ductwork and equipment, must be designed, located, and elevated to prevent flood waters from entering and accumulating in components during flooding; utility lines must not be installed or stubbed out in enclosures below BFE

See page 8 for notes.	V Zone	A Zones in Coastal Areas: Coastal A — Areas With Potential for Breaking Waves and Erosion During Base Flood[b]	A Zones in Coastal Areas: A — Areas With Shallow Flooding Only, Where Potential for Breaking Waves and Erosion Is Low[c]
Certification			
Elevation	**Requirement:** bottom of lowest horizontal structural member must be at or above BFE[e]; electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities (including ductwork) must be designed and/or located so as to prevent water from entering or accumulating within the components during flooding [see Fact Sheet Nos. 4, 5, 29]	**Requirement:** top of lowest floor must be at or above BFE[e]; electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities (including ductwork) must be designed and/or located so as to prevent water from entering or accumulating within the components during flooding [see Fact Sheet Nos. 4, 29] **Recommendation:** follow V zone requirement	**Requirement:** top of lowest floor must be at or above BFE[e]; electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities (including ductwork) must be designed and/or located so as to prevent water from entering or accumulating within the components during flooding [see Fact Sheet Nos. 4, 29] **Recommendation:** follow V zone requirement
Structure	**Requirement:** registered engineer or architect must certify that design and methods of construction are in accordance with accepted standards of practice for meeting design requirements described under **General Requirements** [see Fact Sheet No. 5]	**Requirement:** none **Recommendation:** follow V zone requirement	**Requirement:** none **Recommendation:** follow V zone requirement
Breakaway Walls [see Fact Sheet Nos. 5, 27] **(Also see Enclosures Below BFE)**	**Requirement:** walls must be designed to break free under larger of (1) design wind load, (2) design seismic load, or (3) 10 psf, acting perpendicular to the plane of the wall; if loading at which breakaway wall is intended to collapse exceeds 20 psf, breakaway wall design shall be certified; when certification is required, registered engineer or architect must certify that walls will collapse under a water load associated with the Base Flood and that elevated portion of building and its foundation will not be subject to collapse, displacement, or lateral movement under simultaneous wind and water loads[f]	Not required, but **recommended**[f,g] with open foundation in lieu of solid walls; if breakaway walls are used and enclose an area, flood openings are required. [see Fact Sheet Nos. 11, 15]	**Requirement:** none[f,g]
Openings in Below-BFE Walls [see Fact Sheet Nos. 11, 15] **(Also see Enclosures Below BFE)**	Not Applicable[j]	**Requirement:** unless number and size of openings meet regulatory requirements, registered engineer or architect must certify that openings are designed to automatically equalize hydrostatic forces on walls by allowing automatic entry and exit of flood waters	**Requirement:** unless number and size of openings meet regulatory requirements, registered engineer or architect must certify that openings are designed to automatically equalize hydrostatic forces on walls by allowing automatic entry and exit of flood waters

Requirements and Recommendations for Repairs, Remodeling, and Additions

See page 8 for notes.	V Zone	A Zones in Coastal Areas: Coastal A — Areas With Potential for Breaking Waves and Erosion During Base Flood[b]	A Zones in Coastal Areas: A — Areas With Shallow Flooding Only, Where Potential for Breaking Waves and Erosion Is Low[c]
Repairs, Remodeling, and Additions (see Fact Sheet No. 30 and consult AHJ[k] for building code requirements)			
Substantial Improvements and Repairs of Substantial Damage	**Requirement:** must meet current NFIP requirements concerning new construction in V zones[k,l] except for siting landward of mean high tide [see Fact Sheet Nos. 4, 5, 7, 11, 15, 27, 29]	**Requirement:** must meet current NFIP requirements concerning new construction in A zones[k,m] [see Fact Sheet Nos. 4, 11, 15, 27, 29] **Recommendation:** follow V-zone requirement	**Requirement:** must meet current NFIP requirements concerning new construction in A zones[k,m] [see Fact Sheet Nos. 4, 11, 15, 27, 29] **Recommendation:** elevate bottom of lowest horizontal structural member to or above BFE
Lateral Additions That Constitute Substantial Improvement	**Requirement:** both addition and existing building must meet current NFIP requirements concerning new construction in V zones[k,l,n] [see Fact Sheet Nos. 4, 5, 7, 11, 15, 27, 29]	**Requirement:** only addition must meet current NFIP requirements concerning new construction in A zones[k,m,o] (See Fact Sheet Nos. 4, 7, 11, 15, 27, 29), *provided* existing building is not subject to any work other than cutting entrance in common wall and connecting existing building to addition; if any other work is done to existing building, it too must meet current NFIP requirements for new construction in A zones **Recommendation:** follow V-zone requirement	**Requirement:** only addition must meet current NFIP requirements concerning new construction in A zones[k,m,o] (See Fact Sheet Nos. 4, 7, 11, 15, 27, 29), *provided* the existing building is not subject to any work other than cutting an entrance in a common wall and connecting the existing building to the addition; if any other work is done to existing building, it too must meet current NFIP requirements for new construction in A zones **Recommendation:** elevate bottom of lowest horizontal structural member of addition to or above BFE (same for existing building if it is elevated)
Lateral Additions That Do *Not* Constitute Substantial Improvement	**Requirement:** *post-Flood Insurance Rate Map (FIRM)* existing building – addition must meet NFIP requirements in effect at time building was originally constructed [k,l,n] pre-FIRM existing building – NFIP requirements concerning new construction not triggered [k] [see Fact Sheet Nos. 4, 5, 7, 11, 15, 27, 29] **Recommendation:** make addition compliant with current NFIP requirements for V-zone construction	**Requirement:** *post-FIRM* existing building – addition must meet NFIP requirements in effect at time building was originally constructed [k,m,o] [see Fact Sheet Nos. 4, 7, 11, 15, 27, 29] *pre-FIRM* existing building – NFIP requirements concerning new construction not triggered[k] **Recommendation:** follow V-zone requirement	**Requirement:** *post-FIRM* existing building – addition must meet NFIP requirements in effect at time building was originally constructed [k,m,o] [see Fact Sheet Nos. 4, 7, 11, 15, 27, 29] *pre-FIRM* existing building – NFIP requirements concerning new construction not triggered[k] **Recommendation:** elevate bottom of lowest horizontal structural member of addition to or above BFE (same for existing building if it is elevated) [see Fact Sheet No. 4]

See page 8 for notes.	V Zone	A Zones in Coastal Areas	
		Coastal A – **Areas With Potential for Breaking Waves and Erosion During Base Flood[b]**	**A** – **Areas With Shallow Flooding Only, Where Potential for Breaking Waves and Erosion Is Low[c]**
Repairs, Remodeling, and Additions (cont.)	**(see Fact Sheet No. 30 and consult AHJ[k] for building code requirements)**		
Vertical Additions That Constitute Substantial Improvement	**Requirement:** entire building must meet current NFIP requirements concerning new construction in V zones[k,l,n] **[see Fact Sheet Nos. 4, 5, 7, 11, 15, 27, 29]**	**Requirement:** entire building must meet current NFIP requirements concerning new construction in A zones[k,m,o] **[see Fact Sheet Nos. 4, 7, 11, 15, 27, 29]** **Recommendation:** follow V-zone requirement	**Requirement:** entire building must meet current NFIP requirements concerning new construction in A zones[k,m,o] **[see Fact Sheet Nos. 4, 7, 11, 15, 27, 29]** **Recommendation:** elevate bottom of lowest horizontal structural member to or above BFE **[see Fact Sheet No. 4]**
Vertical Additions That Do *Not* Constitute Substantial Improvement	**Requirement:** *post-FIRM* existing building – addition must meet NFIP requirements in effect at time building was originally constructed [k,l,n] *pre-FIRM* existing building – NFIP requirements concerning new construction not triggered[k] **[see Fact Sheet Nos. 4, 5, 7, 11, 15, 27, 29]** **Recommendation:** make addition compliant with current NFIP requirements for V-zone construction	**Requirement:** *post-FIRM* existing building – addition must meet NFIP requirements in effect at time building was originally constructed[k,m,o] *pre-FIRM* existing building – NFIP requirements concerning new construction not triggered[k] **[see Fact Sheet Nos. 4, 5, 7, 11, 15, 27, 29]** **Recommendation:** follow V-zone requirement	**Requirement:** *post-FIRM* existing building – addition must meet NFIP requirements in effect at time building was originally constructed[k,m,o] ***pre-FIRM*** existing building – NFIP requirements concerning new construction not triggered[k] **[see Fact Sheet Nos. 4, 5, 7, 11, 15, 27, 29]** **Recommendation:** elevate bottom of lowest horizontal structural member to or above BFE **[see Fact Sheet No. 4]**
Elevating on New Foundation	**Requirement:** new foundation must meet current NFIP requirements concerning new construction in V zones[k,l]; building must be properly connected and anchored to new foundation	**Requirement:** new foundation must meet current NFIP requirements concerning new construction in A zones[k,m]; building must be properly connected and anchored to new foundation **Recommendation:** follow V-zone requirement	**Requirement:** new foundation must meet current NFIP requirements concerning new construction in A zones[k,m]; building must be properly connected and anchored to new foundation **Recommendation:** elevate bottom of lowest horizontal structural member to or above BFE **[see Fact Sheet No. 4]**
Enclosures Below Buildings – When enclosure constitutes a **substantial improvement**	**Requirement:** both enclosure and existing building must meet current NFIP requirements for new construction in V zones[k,l,n] **[see Fact Sheet Nos. 4, 5, 7, 11, 27, 29]**	**Requirement:** both enclosure and existing building must meet current NFIP requirements for new construction in A zones[k,m,o] **[see Fact Sheet Nos. 4, 7, 11, 15, 27, 29]** **Recommendation:** follow V-zone requirement	**Requirement:** both enclosure and existing building must meet current NFIP requirements for new construction in A zones[k,m,o] **[see Fact Sheet Nos. 4, 7, 11, 15, 27, 29]** **Recommendation:** elevate bottom of lowest horizontal structural member to or above BFE **[see Fact Sheet No. 4]**

See page 8 for notes.

	V Zone	A Zones in Coastal Areas: Coastal A – Areas With Potential for Breaking Waves and Erosion During Base Flood[b]	A Zones in Coastal Areas: A – Areas With Shallow Flooding Only, Where Potential for Breaking Waves and Erosion Is Low[c]
Repairs, Remodeling, and Additions (cont.)	**(see Fact Sheet No. 30 and consult AHJ[k] for building code requirements)**		
Enclosures Below Buildings – When enclosure does ***not*** constitute a substantial improvement	**Requirement:** *post-FIRM* existing building – enclosure must meet NFIP requirements in effect at time building was originally constructed[k,l,n] *pre-FIRM* existing building – NFIP requirements concerning new construction not triggered[k] **[see Fact Sheet No. 27]** **Recommendation:** make enclosure compliant with current NFIP requirements for new V-zone construction	**Requirement:** *post-FIRM* existing building – enclosure must meet NFIP requirements in effect at time building was originally constructed[k,m,o] *pre-FIRM* existing building – NFIP requirements concerning new construction not triggered[k] **[see Fact Sheet Nos. 15, 27]** **Recommendation:** construct only breakaway enclosures; install flood openings in enclosure; do not convert enclosed space to habitable use	**Requirement:** *post-FIRM* existing building – enclosure must meet NFIP requirements in effect at time building was originally constructed[k,m,o] *pre-FIRM* existing building – NFIP requirements concerning new construction not triggered[k] **[see Fact Sheet Nos. 15, 27]** **Recommendation:** install flood openings in enclosure; do not convert enclosed space to habitable use
Reconstruction of Destroyed or Razed Building	**Requirement:** where entire building is destroyed, damaged, or purposefully demolished or razed, replacement building must meet current NFIP requirements concerning new construction in V zones[k,l], even if built on foundation from original building **[see Fact Sheet Nos. 4, 5, 30]**	**Requirement:** where entire building is destroyed, damaged, or purposefully demolished or razed, replacement building must meet current NFIP requirements concerning new construction in A zones[k,m], even if built on foundation from original building **[see Fact Sheet Nos. 4, 30]** **Recommendation:** follow V-zone requirement	**Requirement:** where entire building is destroyed, damaged, or purposefully demolished or razed, replacement building must meet current NFIP requirements concerning new construction in A zones[k,m], even if built on foundation from original building **[see Fact Sheet Nos. 4, 30]**
Moving Existing Building	**Requirement:** where existing building is moved to new location or site, relocated building must meet current NFIP requirements concerning new construction in V zones[k,l] **[see Fact Sheet Nos. 4, 5, 30]**	**Requirement:** where existing building is moved to new location or site, relocated building must meet current NFIP requirements concerning new construction in A zones[k,m] **[see Fact Sheet Nos. 4, 30]** **Recommendation:** follow V-zone requirement	**Requirement:** where existing building is moved to new location or site, relocated building must meet current NFIP requirements concerning new construction in A zones[k,m] **[see Fact Sheet Nos. 4, 30]** **Recommendation:** elevate bottom of lowest horizontal structural member to or above BFE **[see Fact Sheet No. 4]**

Notes

a “***Prohibited***” and “***Allowed***” refer to the minimum NFIP regulatory requirements; individual states and communities may enforce more stringent requirements that supersede those summarized here. ***Exceeding minimum NFIP requirements will provide increased flood protection and may result in lower flood insurance premiums.***

b In these areas, buildings are subject to flooding conditions similar to, but less severe than, those in V zones. These areas can be subject to breaking waves ≥ 1.5 feet high (which can destroy conventional wood-frame and unreinforced masonry wall construction) and erosion (which can undermine shallow foundations).

c In these areas, buildings are subject to flooding conditions similar to those in riverine A zones.

d Some coastal communities require ***open foundations in A zones.***

e State or community may require ***freeboard*** or regulate to a higher elevation (e.g., Design Flood Elevation (DFE)).

f Some coastal communities ***prohibit breakaway walls*** and allow only open lattice or screening.

g If an area below the BFE in an A-zone building is fully enclosed by breakaway walls, the walls must meet the requirement for ***openings*** that allow equalization of hydrostatic pressure.

h Placement of ***nonstructural fill*** adjacent to buildings in coastal AO zones is not recommended.

i There are some ***differences between*** what is permitted under ***floodplain management regulations*** and what is covered by ***NFIP flood insurance.*** Building designers should be guided by floodplain management requirements, not by flood insurance policy provisions. For more information, see Section 9.3.1.1 in Chapter 9 of FEMA’s Coastal Construction Manual (FEMA 55).

j ***Walls below BFE*** must be designed and constructed as breakaway walls that meet the minimum requirements of the NFIP regulations. For more information, see Section 6.4.3.3 in Chapter 6 of FEMA’s Coastal Construction Manual (FEMA 55).

k Consult with authority having jurisdiction (AHJ) regarding ***more restrictive requirements for repairs, remodeling, and additions.***

l ***NFIP requirements for new construction in V zones*** include those pertaining to Design and Construction, Flood-Resistant Materials, Siting, Foundations, Lowest Floor Elevation, Enclosures Below the BFE, Free of Obstructions, Utilities, and Certifications.

m ***NFIP requirements for new construction in A zones*** include those pertaining to Design and Construction, Flood-Resistant Materials, Siting, Foundations, Foundation Openings, Lowest Floor Elevation, Enclosures Below the BFE, Utilities, and Certifications.

n An addition in the form of an ***attached garage*** would not have to be elevated to or above the BFE, because its use (parking) would be allowed below the BFE; however, it would have to meet other NFIP requirements for new construction in V zones.

o An addition in the form of an ***attached garage*** would not have to be elevated to or above the BFE, because its use (parking) would be allowed below the BFE; however, it would have to meet other NFIP requirements for new construction in A zones.

Using a Flood Insurance Rate Map (FIRM)

FEMA

Purpose: To explain the purpose of FIRMs, highlight features that are important to coastal builders, and explain how to obtain FIRMs.

What Is a FIRM?

- Flood hazards have been mapped by FEMA for approximately 20,000 communities in the United States, most commonly on ***FIRMs.*** A FIRM is a product of the Flood Insurance Study (FIS) for a community and is available in paper form and digital form.
- FIRMs delineate Special Flood Hazard Areas (SFHAs) — land areas subject to inundation by a flood that has a 1-percent probability of being equaled or exceeded in any given year (hence, the terms "1-percent annual chance flood" and "100-year flood"). SFHAs are shaded on the FIRM and are divided into different flood hazard zones, depending on the nature and severity of the flood hazard.

Why Are FIRMs Important?

- FIRMs show the limits of mapped flood hazard areas in a community.
- The insurance zone designations shown on FIRMs are used in the determination of flood insurance rates and premiums.
- The 100-year flood elevations and flood depths shown on FIRMs are the minimum regulatory elevations on which community floodplain management ordinances are based.
- The information shown on FIRMs can affect the design and construction of new buildings, the improvement and repair of existing buildings, and additions to existing buildings (see Fact Sheet Nos. 2 and 29).

What Are Flood Hazard Zones and Base Flood Elevations, and How Do They Affect Coastal Buildings?

- ***Base Flood Elevations (BFEs)*** are typically shown on FIRMs for flood hazard zones A and V. ***The BFE is the expected elevation of flood waters and wave effects during the 100-year flood (also known as the "Base Flood").*** The BFE is referenced to the vertical datum shown on the FIRM.

FIRMs Are Used By:

- ***Communities***, to regulate new construction* (e.g., foundation type, lowest floor elevation, use of enclosed areas below the lowest floor)
- ***Designers and builders***, to ascertain flood hazards and plan new construction*
- ***Lenders***, to determine whether flood insurance is required
- ***Insurance agents***, to establish flood insurance premiums
- **Land surveyors and engineers,** to complete National Flood Insurance Program (NFIP) elevation certificates (see Fact Sheet No. 4)

Flood Hazard Zones In Coastal Areas

(see the sample FIRM on the next page)

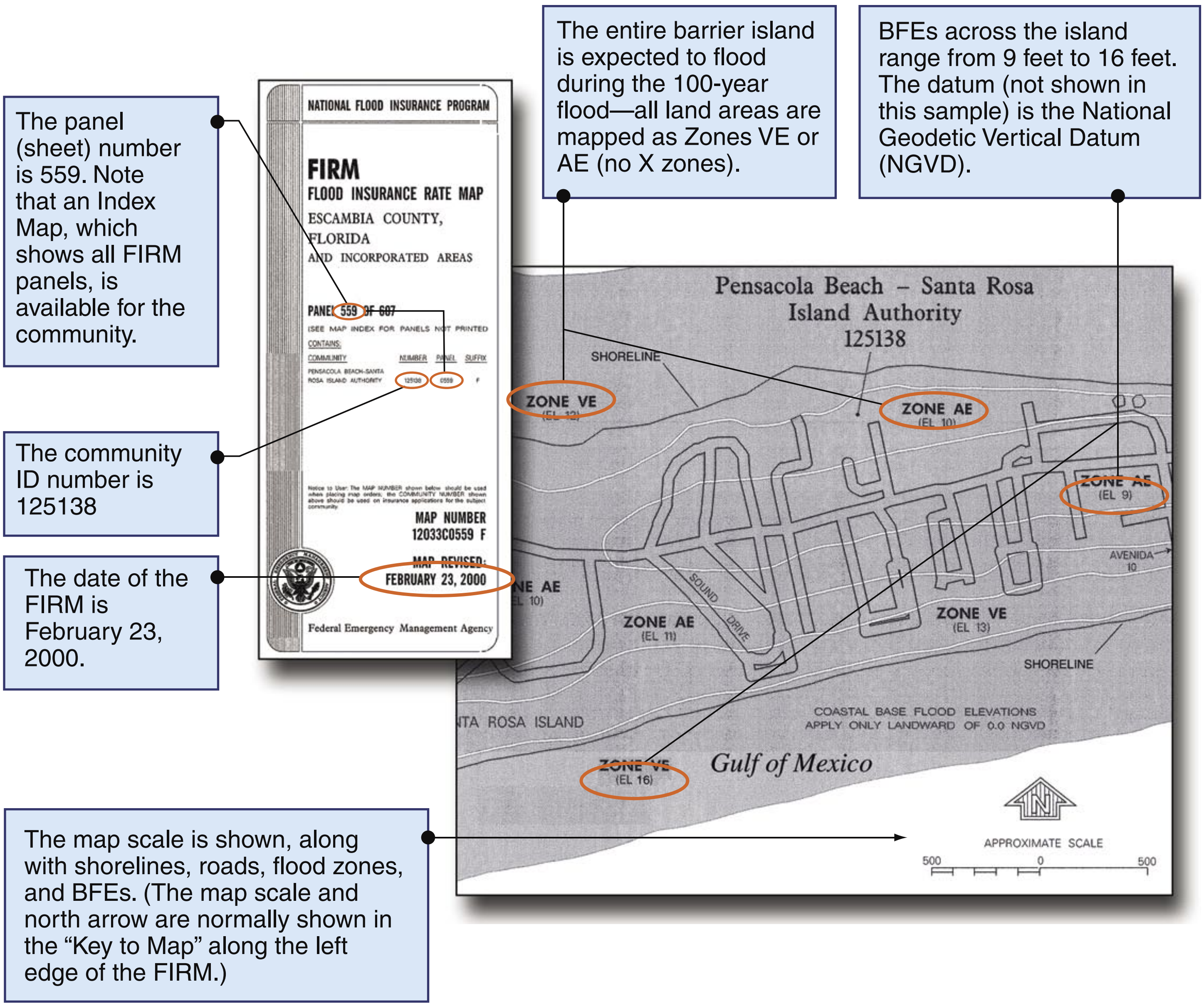
- V zones are those areas closest to the shoreline and subject to wave action, high-velocity flow, and erosion during the 100-year flood.
- A zones are areas subject to flooding during the 100-year flood, but where flood conditions are less severe than those in V zones.
- AO zones are areas subject to shallow flooding or sheet flow during the 100-year flood. If they appear on a coastal FIRM, they will most likely occur on the landward slopes of coastal dunes. Flood depths, rather than BFEs, are shown for AO zones.
- X zones are areas that are not expected to flood during the 100-year flood.
- Newer FIRMs label zones as "VE" (V zone with BFE determined) and "AE" (A zone with BFE determined).
- Older FIRMs label zones with a letter and number (e.g., A1, A10, V10). Ignore the number and look at the letter.
- Older FIRMs label X zones as zone "B" or zone "C." Treat the old and new zone designations the same.

- The ***BFE and flood hazard zone*** will affect the ***lowest floor elevation and foundation type*** for new construction* ***(see Fact Sheet Nos. 4 and 11)***.
- ***Some communities have adopted higher standards for coastal construction*** (e.g., lowest floor elevations above the BFE, restrictions on foundation types and enclosures in A zones). ***Builders should consult their local jurisdiction for details***.
- Most ***communities have adopted the latest FIRM and FIS*** (and, therefore, the flood hazard zone and BFE designations) as part of their efforts to regulate new construction* in coastal floodplains. These communities will have adopted a ***floodplain management ordinance***, which spells out the detailed requirements.

> * Note that "new construction" will include some additions, improvements, repairs, and reconstruction — consult the community about "substantial improvement" and "substantial damage" requirements.

Sample FIRM

This map is a portion of the FIRM for the barrier island community, Pensacola Beach, Florida. As shown below, several things are apparent from the map.



Where Can I Get FIRMs and Other Information?

The FIRM for a community, and the local floodplain management regulations, should be on file and available for viewing at the office of the ***community floodplain administrator***.

FEMA's Map Service Center can be accessed at http://msc.fema.gov/MSC/. ***Index sheets and individual FIRM panels*** can be ***viewed on line*** through the MSC web site, and "***FIRMettes***" (user-selected portions of flood maps such as the sample above) can be created, saved, and printed.

Is There Anything Else I Should Know About Coastal Flood Hazard Zones and Flood Elevations?

- Many FIRMs are ***more than a few years old*** and ***may no longer accurately represent coastal flood hazards***. Sections 7.8 and 7.9 of FEMA's revised *Coastal Construction Manual* (FEMA-55, 2000) describe how coastal flood hazards are mapped and ***how to determine whether coastal FIRMs reflect present day flood hazards***.
- ***FIRMs do not incorporate*** the effects of ***long-term shoreline erosion***. This information should be obtained from other sources (see Fact Sheet No. 7).
- Recent ***post-storm investigations*** and studies have shown flood forces and damage in ***coastal A zones*** can be very similar to those in V zones. Although FIRMs (and minimum NFIP building standards) don't differentiate between A zones in coastal areas and riverine A zones, ***builders should consider adopting V-zone foundation and elevation standards for new construction in many coastal A zones***.
- Many communities and states require lowest floor elevations to be above the BFE. One term used to describe this higher elevation standard is ***Design Flood Elevation (DFE)***.
- Many property owners have ***voluntarily*** constructed their buildings with the lowest floor several feet above the BFE in recognition that the flood elevation in some storms will exceed the BFE.

Copies of FIRMs, FISs, and related products can also be obtained from FEMA for a nominal fee.
Contact FEMA's Map Service Center at:

FEMA
Map Service Center (MSC)
PO Box 1038
Jessup, MD 20794-1038

(800) 358-9616

Lowest Floor Elevation

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 4*

Purpose: To discuss benefits of exceeding the National Flood Insurance Program (NFIP) minimum elevation requirements, to point out common construction practices that are violations of NFIP regulations and result in significantly higher flood insurance premiums, and to discuss the NFIP Elevation Certificate.

Why Is the Lowest Floor Elevation Important?

In inland areas, experience has shown that floods damage areas of buildings not elevated above the flood level and destroy contents of those areas. In coastal areas, wave action causes even more damage, often ***destroying enclosed building areas below the flood level (and any building areas above the flood level that depend on the lower area for structural support). Once waves rise above the lowest structural member in a V zone or coastal A zone, the elevated portion of the building is likely to be severely damaged or destroyed.***

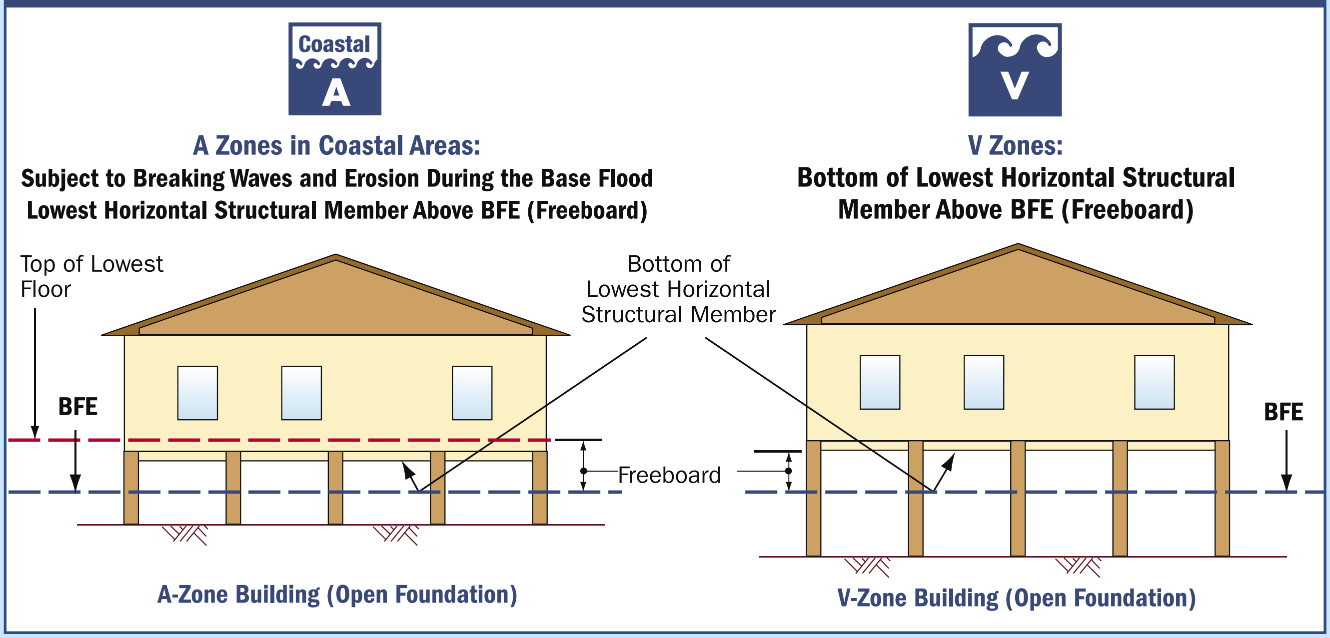
Recommended Lowest Floor Elevations*

Because of the additional hazard associated with wave action in V zones and in A zones in coastal areas, it is recommended that the minimum elevation requirements of the NFIP be exceeded in these areas:

- It is recommended that ***the bottom of the lowest horizontal structural member of V-zone buildings be elevated 1 foot or more above the Base Flood Elevation (BFE),*** i.e., add freeboard.
- It is recommended that ***the lowest horizontal structural member of A-zone buildings in coastal areas be elevated 1 foot or more above the BFE*** (i.e., add freeboard).

*NFIP minimum elevation requirements: A zone – elevate top of lowest floor to or above BFE; V zone – elevate bottom of lowest horizontal structural member to or above BFE. **In both V and A zones, many people have decided to elevate a full story for below-building parking, far exceeding the elevation requirement.** See Fact Sheet No. 2 for more information about NFIP minimum requirements in A and V zones.

Recommended Practice:



What Does FEMA Consider the Lowest Floor?

- The “lowest floor” means **the lowest floor of the lowest enclosed area, except for unfinished or flood-resistant enclosures used solely for parking of vehicles, building access, or storage**.
- If the lowest enclosed area is used for anything other than ***parking of vehicles, building access, or storage***, the floor of that area is considered the lowest floor. This will violate NFIP requirements and drastically increase flood insurance premiums.
- Note that ***any below-BFE finished areas***, including foyers, will violate NFIP requirements, sustain unreimbursable flood damage, and increase flood insurance premiums.
- The floor of a basement (where “basement” means the floor is below grade on all sides) will ***always*** be the lowest floor, regardless of how the space is used.
- Walls of enclosed areas below the BFE must meet special requirements in coastal areas (see Fact Sheet No. 27).

Construction Practices and the Lowest Floor

Setting the lowest floor at the correct elevation is critical. Failure to do so can result in a building being constructed below the BFE. As a result, work can be stopped, certificates of occupancy can be withheld, and correcting the problem can be expensive and time-consuming.

- After piles have been installed, the intended elevation of the lowest floor should be checked before the piles are cut off.
- Alternatively, after piers or columns have been constructed, the intended elevation of the lowest floor should be checked before the lowest horizontal structural supporting members are installed.
- After the lowest horizontal structural supporting members have been installed, the elevation should be checked again, before any further vertical construction is carried out.

Do not modify building plans to create habitable space below the intended lowest floor. Doing so will put the building in violation of flood regulations and building codes.

FEMA Elevation Certificate

The NFIP requires participating communities to adopt a floodplain management ordinance that specifies minimum requirements for reducing flood losses. One such requirement is that communities ***obtain, and maintain a record of, the lowest floor elevations for all new and substantially improved buildings***.
The Elevation Certificate (see following pages) provides a way for a community to comply with this requirement and for insurers to determine flood insurance premiums.

Most communities require permit applicants to retain a surveyor, engineer, or architect to complete and submit the elevation certificate. Note that ***multiple elevation certificates may need to be submitted for the same building***: a certificate *may* be required when the ***lowest floor level is set*** (and before additional vertical construction is carried out); a certificate *will* be required ***upon completion of all construction***.

The Elevation Certificate requires that the following information be ***certified and signed by the surveyor/engineer/architect*** and ***signed by the building owner***:

- elevations of certain floors in the building
- lowest elevation of utility equipment/machinery
- floor slab elevation for attached garage
- adjacent grade elevations
- flood opening information (A zones)

The Elevation Certificate is available on FEMA’s web site: http://www.fema.gov/nfip/elvinst.shtm

FEDERAL EMERGENCY MANAGEMENT AGENCY
NATIONAL FLOOD INSURANCE PROGRAM

O.M.B. No. 3067-0077
Expires December 31, 2005

ELEVATION CERTIFICATE

Important: Read the instructions on pages 1 - 7.

SECTION A - PROPERTY OWNER INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

BUILDING OWNER'S NAME

BUILDING STREET ADDRESS (Including Apt., Unit, Suite, and/or Bldg. No.) OR P.O. ROUTE AND BOX NO.

CITY | STATE | ZIP CODE

PROPERTY DESCRIPTION (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)

BUILDING USE (e.g., Residential, Non-residential, Addition, Accessory, etc. Use a Comments area, if necessary.)

LATITUDE/LONGITUDE (OPTIONAL) (##° - ##' - ##.##" or ##.#####°)

HORIZONTAL DATUM: |__| NAD 1927 |__| NAD 1983

SOURCE: |__| GPS (Type): ____________ |__| USGS Quad Map |__| Other ____________

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP COMMUNITY NAME & COMMUNITY NUMBER	B2. COUNTY NAME	B3. STATE

B4. MAP AND PANEL NUMBER	B5. SUFFIX	B6. FIRM INDEX DATE	B7. FIRM PANEL EFFECTIVE/REVISED DATE	B8. FLOOD ZONE(S)	B9. BASE FLOOD ELEVATION(S) (Zone AO, use depth of flooding)

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in B9.
|__| FIS Profile |__| FIRM |__| Community Determined |__| Other (Describe): ____________

B11. Indicate the elevation datum used for the BFE in B9: |__| NGVD 1929 |__| NAVD 1988 |__| Other (Describe): ____________

B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? |__| Yes |__| No
Designation Date:____________

SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: |__|Construction Drawings* |__|Building Under Construction* |__|Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.

C2. Building Diagram Number _____ (Select the building diagram most similar to the building for which this certificate is being completed - see pages 6 and 7. If no diagram accurately represents the building, provide a sketch or photograph.)

C3. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO
Complete Items C3.a-i below according to the building diagram specified in Item C2. State the datum used. If the datum is different from the datum used for the BFE in Section B, convert the datum to that used for the BFE. Show field measurements and datum conversion calculation. Use the space provided or the Comments area of Section D or Section G, as appropriate, to document the datum conversion.
Datum ____________ Conversion/Comments ____________
Elevation reference mark used____________ Does the elevation reference mark used appear on the FIRM? |__| Yes |__| No

- ❏ a) Top of bottom floor (including basement or enclosure) ____________ . ___ ft.(m)
- ❏ b) Top of next higher floor ____________ . ___ ft.(m)
- ❏ c) Bottom of lowest horizontal structural member (V zones only) ____________ . ___ ft.(m)
- ❏ d) Attached garage (top of slab) ____________ . ___ ft.(m)
- ❏ e) Lowest elevation of machinery and/or equipment servicing the building (Describe in a Comments area.) ____________ . ___ ft.(m)
- ❏ f) Lowest adjacent (finished) grade (LAG) ____________ . ___ ft.(m)
- ❏ g) Highest adjacent (finished) grade (HAG) ____________ . ___ ft.(m)
- ❏ h) No. of permanent openings (flood vents) within 1 ft. above adjacent grade ________
- ❏ i) Total area of all permanent openings (flood vents) in C3.h ________ sq. in. (sq. cm)

License Number, Embossed Seal, Signature, and Date

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information.
I certify that the information in Sections A, B, and C on this certificate represents my best efforts to interpret the data available.
I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.

CERTIFIER'S NAME | LICENSE NUMBER

TITLE | COMPANY NAME

ADDRESS | CITY | STATE | ZIP CODE

SIGNATURE | DATE | TELEPHONE

See reverse side for continuation.

IMPORTANT: In these spaces, copy the corresponding information from Section A.			For Insurance Company Use:
BUILDING STREET ADDRESS (Including Apt., Unit, Suite, and/or Bldg. No.) OR P.O. ROUTE AND BOX NO.			Policy Number
CITY	STATE	ZIP CODE	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

COMMENTS

|__| Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zone AO and Zone A (without BFE), complete Items E1. through E5. If the Elevation Certificate is intended for use as supporting information for a LOMA or LOMR-F, Section C must be completed.

E1. Building Diagram Number _____ (Select the building diagram most similar to the building for which this certificate is being completed – see pages 6 and 7. If no diagram accurately represents the building, provide a sketch or photograph.)

E2. The top of the bottom floor (including basement or enclosure) of the building is |__|__| ft. (m) |__|__| in. (cm) |__| above or |__| below (check one) the highest adjacent grade. (Use natural grade, if available.)

E3. For Building Diagrams 6-8 with openings (see page 7), the next higher floor or elevated floor (elevation b) of the building is |__|__| ft. (m) |__|__|in. (cm) above the highest adjacent grade. Complete Items C3.h and C3.i on front of form.

E4. The top of the platform of machinery and/or equipment servicing the building is |__|__| ft. (m) |__|__| in. (cm) |__| above or |__| below (check one) the highest adjacent grade. (Use natural grade, if available.)

E5. For Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? |__| Yes |__| No |__| Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, C (Items C3.h and C3.i only), and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, C, and E are correct to the best of my knowledge.*

PROPERTY OWNER'S OR OWNER'S AUTHORIZED REPRESENTATIVE'S NAME

ADDRESS	CITY	STATE	ZIP CODE
SIGNATURE	DATE	TELEPHONE	

COMMENTS

|__| Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below.

G1. |__| The information in Section C was taken from other documentation that has been signed and embossed by a licensed surveyor, engineer, or architect who is authorized by state or local law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. |__| A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. |__| The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. PERMIT NUMBER	G5. DATE PERMIT ISSUED	G6. DATE CERTIFICATE OF COMPLIANCE/OCCUPANCY ISSUED

G7. This permit has been issued for: |__| New Construction |__| Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building is: ____________ . ___ ft. (m) Datum:______________

G9. BFE or (in Zone AO) depth of flooding at the building site is: ____________ . ___ ft. (m) Datum:______________

LOCAL OFFICIAL'S NAME	TITLE
COMMUNITY NAME	TELEPHONE
SIGNATURE	DATE

COMMENTS

|__| Check here if attachments

V-Zone Design and Construction Certification

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 5*

Purpose: To explain the certification requirements for structural design and construction in V zones.

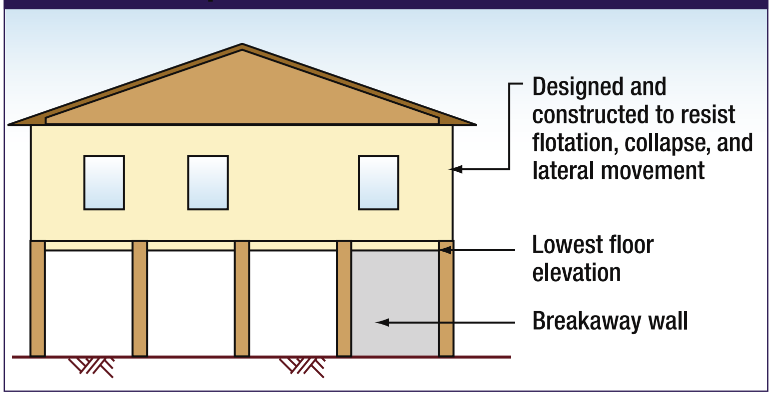
Structural Design and Methods of Construction Certification

As part of the agreement for making flood insurance available in a community, the National Flood Insurance Program (NFIP) requires the community to adopt a floodplain management ordinance that specifies minimum design and construction requirements. Those requirements include a ***certification of the structural design and the methods of construction.***

Specifically, NFIP regulations and local floodplain management ordinances require that:

1. a ***registered professional engineer or architect*** shall ***develop or review*** the ***structural design, specifications, and plans*** for the construction, and
2. a ***registered professional engineer or architect*** shall ***certify that the design and methods of construction*** to be used are in accordance with accepted standards of practice for meeting the following criteria:
   - the ***bottom of the lowest horizontal structural member of the lowest floor*** (excluding the pilings or columns) is elevated to or above the Base Flood Elevation (BFE); and
   - the pile or column foundation and structure attached thereto is ***anchored to resist flotation, collapse, and lateral movement due to the effects of wind and water loads acting simultaneously*** on all building components. Water loading values used shall be those associated with the Base Flood. Wind loading values used shall be those required by applicable state or local building standards.

Required Certifications in V Zones



The community, through its inspection procedures, will verify that the building is built in accordance with the certified design.

Other Certifications Required in V Zones

- Lowest Floor Elevation, by a surveyor, engineer, or architect (see Fact Sheet No. 4)
- Breakaway Wall Collapse, by a registered professional engineer or architect (see Fact Sheet No. 27)

Completing the V-Zone Certification

There is no single V-zone certificate used on a nationwide basis. Instead, local communities and/or states have developed their own certification procedures and documents.

Registered engineers and architects involved in V-zone construction projects should ***check with the authority having jurisdiction regarding the exact nature and timing of required certifications***.

Page 2 shows a sample certification form developed by one state. It is intended to show one of many possible ways by which a jurisdiction may require that the certification and supporting information be provided. In this instance, three certifications are included on the form (Lowest Floor Elevation, Design and Methods of Construction, Breakaway Wall Collapse).

The Design and Methods of Construction certification should take into consideration the NFIP Free-of-Obstruction requirement for V zones: *the space below the lowest floor must be free of obstructions (e.g., free of any building element, equipment, or other fixed objects that can transfer flood loads to the foundation, or that can cause floodwaters or waves to be deflected into the building), or must be constructed with non-supporting breakaway walls, open lattice, or insect screening.* **(See NFIP Technical Bulletin 5-93 and Fact Sheet No. 27.)**

Note: The V-zone certificate is not a substitute for and cannot be used without the NFIP Elevation Certificate (see Fact Sheet No. 4), which is required for flood insurance rating.

V-ZONE CERTIFICATE

Name____ Policy Number *(Insurance Co. Use)* ___________

Building Address or
Other Description ____

City ____ State ________________ Zip Code __________

SECTION I: Flood Insurance Rate Map (FIRM) Information

Community Number________ Panel Number _________ Suffix _____ Date of FIRM Index _____ FIRM Zone_____

SECTION II: Elevation Information

NOTE: This Certificate does not substitute for an Elevation Certificate

1. Elevation of the Bottom of Lowest Horizontal Structural Member……………………….._____ feet (NGVD)
2. Base Flood Elevation (BFE)……………………………………………………………..._____ feet (NGVD)
3. Elevation of Lowest Adjacent Grade…………………………………………………….._____ feet (NGVD)
4. Approximate Depth of Anticipated Scour/Erosion used for Foundation Design…………_____ feet (NGVD)
5. Embedment Depth of Pilings or Foundation Below Lowest Adjacent Grade……………_____ feet (NGVD)

SECTION III: V-Zone Certification Statement

NOTE: This section must be certified by a registered engineer or architect

I certify that I have developed or reviewed the structural design, plans, and specifications for construction and that the design and methods of construction to be used are in accordance with accepted standards of practice for meeting the following provisions:

- The bottom of the lowest horizontal structural member of the lowest floor (excluding piles and columns) is elevated to or above the BFE; and
- The pile and column foundation and structure attached thereto is anchored to resist flotation, collapse, and lateral movement due to the effects of the wind and water loads acting simultaneously on all building components. Water loading values used are those associated with the base flood. Wind loading values used are those required by the applicable State or local building code. The potential for scour and erosion at the foundation has been anticipated for conditions associated with the base flood, including wave action.

SECTION IV: Breakaway Wall Certification Statement

NOTE: This section must be certified by a registered engineer or architect when breakaway walls exceed a design safe loading resistance of 20 pounds per square foot

I certify that I have developed or reviewed the structural design, plans, and specifications for construction and that the design and methods of construction to be used for the breakaway walls are in accordance with accepted standards of practice for meeting the following provisions:

- Breakaway wall collapse shall result from a water load less than that which would occur during the base flood; and
- **The elevated portion of the building and supporting foundation system shall not be subject to collapse, displacement, or other structural damage due to the effects of wind and water loads acting simultaneously on all building components (wind and water loading val ues to be used are defined in Section III).**

SECTION V: Certification

Signature below certifies: ____ Section III; ____ Section IV

Certifier's Name ______________________________ Company Name______________________________

Title ____________________________________ License Number ______________________________

Street Address ____

City ______________________________ State _________________________ Zip Code ____________

Signature ____________________________ Date ___________________ Telephone Number ___________

How Do Siting and Design Decisions Affect the Owner's Costs?

FEMA

Purpose: To show the effects of planning, siting, and design decisions on coastal home costs.

Key Issues

- When building a coastal home, initial, operating, and long-term costs (i.e., life cycle costs) must be considered.
- Coastal (especially oceanfront) homes cost more to design, construct, maintain, repair, and insure than inland homes.
- Determining the risks associated with a particular building site or design is important.
- Siting, designing, and constructing to minimum regulatory requirements do not necessarily result in the lowest cost to the owner over a long period of time. Exceeding minimum design requirements costs slightly more initially, but can save the owner money in the long run.

Costs

A variety of costs should be considered when planning a coastal home, not just the construction cost. Owners should be aware of each of the following, and consider how siting and design decisions will affect these costs:

Initial costs include property evaluation and acquisition costs and the costs of permitting, design, and construction.

Operating costs include costs associated with the use of the building, such as the costs of utilities and insurance*.

Long-term costs include costs for preventive maintenance and for repair and replacement of deteriorated or damaged building components.

*Note: Flood insurance premiums can be reduced up to 60 percent by exceeding minimum siting, design, and construction practices. See the V-Zone Risk Factor Rating Form in FEMA's *Flood Insurance Manual* (http://www.fema.gov/nfip/manual.shtm).

Risk

One of the most important building costs to be considered is that resulting from storm and/or erosion damage. But how can an owner decide what level of risk is associated with a particular building site or design? One way is to consider the probability of a storm or erosion occurring and the potential building damage that results (see matrix).

Probability of Occurrence

Potential $ Loss	Low	Medium	High
Low	Low Risk	Low Risk	Medium Risk
Medium	Low Risk	Medium Risk	High Risk
High	Medium Risk	High Risk	Extreme Risk

Homes located farther landward may be less appealing to some owners, but will be less prone to damage and will cost less to build, insure, and maintain.

Homes located close to the shore may have spectacular views, but are subject to greater risks, more frequent and more severe damage, and higher construction, maintenance, and insurance costs.

Building sites or designs resulting in extreme or high risk should be avoided — the likelihood of building loss is great, and the long-term costs to the owner will be very high. Building sites or designs resulting in medium or low risk should be given preference.

Siting

Note that over a long period, poor siting decisions are rarely overcome by building design.

Design

- How much more expensive is it to build near the coast as opposed to inland areas? The table below suggests approximately 10 - 30 percent more.
- What about exceeding minimum design requirements in coastal areas? The table suggests that the added construction costs for meeting the practices recommended in the *Home Builder's Guide to Coastal Construction* (beyond typical minimum requirements) are nominal.

Design Item (Items in bold are required by National Flood Insurance Program (NFIP) and/or local building code.)	**Cross-Reference to Fact Sheets**	**Added Initial Costs** (when compared to typical *inland* construction) **Required by Code or NFIP**	**Added Initial Costs** (to exceed Code/NFIP minimum requirements) **for Home Builder's Guide to Coastal Construction Recommended Practices**	**Effect of Design Item on Cost**					
				Reduce wind/storm damage	**Reduce flood damage**	**Longer material life**	**Reduce maintenance**	**Lower insurance**	**Lower utility bills**
A zone, pile/column foundation	1, 4, 11	High	High	✓	✓			✓	
V zone, pile/column foundation	1, 4, 5, 11	High			✓			✓	
Joists sheathed on underside		Low	Low		✓	✓			✓
Structurally sheathed walls		Medium		✓					
Corrosion protection	1, 8	Low		✓	✓	✓	✓		
Decay protection	1, 8	Medium		✓	✓	✓	✓		
Hip roof shape	1	Low	Low	✓					
Enhanced roof sheathing connection	1, 18	Low	Low	✓					
Enhanced roof underlayment	19	Low	Low	✓					
Upgraded roofing materials	1, 20	Medium		✓		✓	✓		
Enhanced flashing	1, 22, 24	Low		✓		✓	✓		
Housewrap	1, 22, 23	Low		✓					✓
Superior siding and connection	25	Medium	Medium	✓			✓		
Protected or impact-resistant glazing	1, 26	High	Medium	✓				✓	
Connection hardware	1, 8, 17	Low		✓	✓				
Flood-resistant materials	1, 8	Low			✓	✓		✓	
Protected utilities and mechanicals	1, 29	Low		✓	✓	✓	✓		✓
Estimated Total Additional Cost (% of building cost)		**15 - 30**	**±5**	✓	✓	✓	✓	✓	✓

Low	<0.5% of base building cost
Medium	0.5% - 2.0% of base building cost
High	>2.0% of base buildig cost

Estimates are based on a 3,000-square-foot home with a moderate number of windows and special features. Many of the upgraded design features are ***required*** by local codes, but the level of protection beyond the code minimum can vary, depending on the owner's preference.

Selecting a Lot and Siting the Building

FEMA

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 7*

Purpose: To provide guidance on lot selection and siting considerations for coastal residential buildings.

Key Issues

- Purchase and siting decisions should be long-term decisions, not based on present-day shoreline and conditions.
- Parcel characteristics, infrastructure, regulations, environmental factors, and owner desires constrain siting options.
- Conformance with local/state shoreline setback lines does not mean buildings will be "safe."
- Information about site conditions and history is available from several sources.

Siting, design, and construction should be considered together (see Fact Sheet No. 6), but know that poor lot selection and siting decisions can rarely be overcome by improved design and construction. Building failures (see Fact Sheet No. 1) are often the result of poor siting.

The Importance of Property Purchase and Siting Decisions

The single most common and costly siting mistake made by designers, builders, and owners is failing to consider future erosion and slope stability when an existing coastal home is purchased or when land is purchased and a new home is built. Purchase decisions—or siting, design, and construction decisions — based on present-day shoreline conditions often lead to future building failures.

Over a long period of time, owners of poorly sited coastal buildings may spend more money on erosion control and erosion-related building repairs than they spent on the building itself.

What Factors Constrain Siting Decisions?

Many factors affect and limit a home builder's or owner's ability to site coastal residential buildings, but the most influential is probably ***parcel size***, followed by ***topography***, ***location of roads and other infrastructure***, ***regulatory constraints***, and ***environmental constraints***.

Given the cost of coastal property, parcel sizes are often small and owners often build the largest building that will fit within the permissible development footprint. Buyers frequently fail to recognize that siting decisions in these cases have effectively been made at the time the land was platted or subdivided, and that shoreline erosion can render these parcels unsuitable for long-term occupation.

In some instances, however, parcel size may be large enough to allow a hazard-resistant coastal building to be sited and constructed, but an ***owner's desire*** to push the building as close to the shoreline as possible increases the likelihood that the building will be damaged or destroyed in the future.

Coastal Setback Lines – What Protection Do They Provide?

Many states require new buildings to be sited at or landward of coastal construction setback lines, which are usually based on ***long-term, average annual erosion rates***. For example, a typical minimum 50-year setback line with an erosion rate of 2.5 feet/year would require a setback of 125 feet, typically measured from a reference feature such as the dune crest, vegetation line, or high-water line.

Building at the 125-foot setback (in this case) does ***not*** mean that a building will be "safe" from erosion for 50 years.

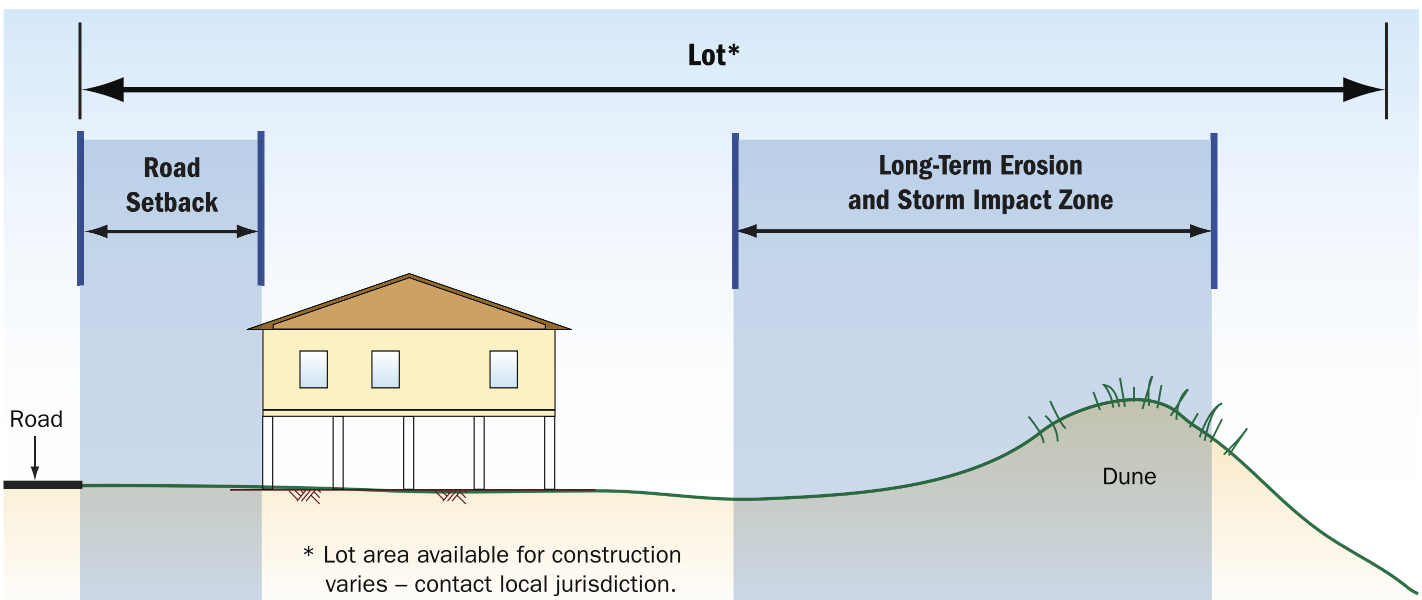
- Storms can cause short-term erosion that far exceeds setbacks based on long-term averages.
- Erosion rates vary over time, and erosion could surpass the setback distance in just a few years' time. The rate variability must also be known to determine the probability of undermining over a given time period.

What Should Builders, Designers, and Owners Do?

- Consult local and state agencies, universities, and consultants for detailed, site-specific erosion and hazard information.
- Look for historical information on erosion and storm effects. How have older buildings in the area fared over time? Use the experience of others to guide siting decisions.
- Determine the owner's risk tolerance, and reject parcels or building siting decisions that exceed the acceptable level of risk.

Common Siting Problems

- Building on a ***small lot between a road and an eroding shoreline*** is a recipe for trouble.
- ***Odd-shaped lots*** that force buildings close to the shoreline increase the vulnerability of the buildings.
- Siting a building near the ***edge of a bluff*** increases the likelihood of building loss, because of both bluff erosion and changes in bluff stability resulting from development activities (e.g., clearing vegetation, building construction, landscaping, changes in surface drainage and groundwater flow patterns).
- Siting near a ***tidal inlet*** with a dynamic shoreline can result in the building being exposed to increasing flood and erosion hazards over time.
- Siting a building ***immediately behind an erosion control structure*** may lead to building damage from wave overtopping and may limit the owner's ability to repair or maintain the erosion control structure.
- Siting a new building ***within the footprint*** of a pre-existing building does not guarantee that the location is a good one.



Recommended building location on a coastal lot.

Siting should consider both long-term erosion and storm impacts.
Siting should consider site-specific experience, wherever available.

Coastal Building Materials

Purpose: To provide guidance on the selection of building materials used for coastal construction.

Key Issues

- The ***durability*** of a coastal home relies on the types of materials used to construct it. For more details, see the U.S. Department of Housing and Urban Development (HUD) report *Durability by Design, A Guide for Residential Builders and Designers*, available on the HUD User website at http://www.huduser.org/publications/destech/durdesign.html.
- Materials and construction methods should be resistant to ***flood and wind damage, driving rain, corrosion, moisture, and decay***.
- All coastal buildings will require ***maintenance and repairs*** (more so than inland construction) — use proper materials and methods for repairs, additions, and other work following initial construction (see Fact Sheet No. 30).

Section 60.3(a)(ii) of the National Flood Insurance Program (NFIP) regulations requires that all new construction and substantial improvements in floodprone areas be constructed with materials below the Base Flood Elevation (BFE) that are resistant to flood damage. (See Fact Sheet No. 30 for a definition of "substantial improvement.")

Flood-Resistant Materials

Flooding accounts for a large percentage of the damage caused by a coastal storm. Building materials exposed to flooding must be resilient enough to sustain a certain amount of water exposure in order to avoid the need for complete replacement after the flood.

FEMA defines a flood-resistant material as *any building material capable of withstanding direct and prolonged contact (i.e., at least 72 hours) with floodwaters without sustaining significant damage (i.e., requires more than cosmetic repair).*

The following are examples of flood-resistant materials:

- **Lumber:** pressure-treated or naturally decay-resistant, including redwood, cedar, some oaks, and bald cypress
- **Concrete:** a sound, durable mix, and when exposed to saltwater or salt spray, made with a sulfate-resisting cement, with a 28-day compressive strength of

Select building materials that can endure periodic flooding.

5,000 psi minimum and a water-cement ratio not higher than 0.40 – consult ACI 318-02, *Building Code Requirements for Structural Concrete and Commentary*, by the American Concrete Institute International

- **Masonry:** reinforced and fully grouted
- **Structural Steel:** coated to resist corrosion
- **Insulation:** plastics, synthetics, and closed-cell foam, or other types approved by local building officials

This table lists examples of flood-resistant materials used in coastal homes.

Location of Material Use	Name of Material
Piles and posts	Round, tapered wood piles preservative-treated for ground contact, at a minimum; square-section piles or wood posts preservative-treated for marine use
Piers	Reinforced concrete or concrete masonry units (CMU) (see "Flood-Resistant Materials" above and Fact Sheet No. 14)
Foundation walls	Reinforced concrete or CMU, or wood that is preservative-treated for foundation or marine use (see Fact Sheet No. 15)
Beams	Solid sawn timbers and glue-laminated products, either naturally decay-resistant or preservative-treated for aboveground exposure; built-up members preservative-treated for ground contact
Decking	Preservative-treated or naturally decay-resistant wood, or composite wood members (e.g., manufactured of recycled sawdust and plastic)
Framing	Sawn wood or manufactured lumber (preservative-treated or naturally resistant to decay if in close proximity to the ground)
Exterior sheathing	High-capacity shearwall sheathing rated "Exterior"
Subflooring	Plywood or oriented strand board (OSB) rated "Exposure 1," or rated "Exterior" if left permanently exposed (e.g., exposed underside of elevated house on open foundation)
Siding	Vinyl or naturally decay-resistant wood (see Fact Sheet No. 25)
Flooring	Latex or bituminous cement formed-in-place, clay, concrete tile, pre-cast concrete, epoxy formed-in-place, mastic flooring, polyurethane formed-in-place, rubber sheets, rubber tiles with chemical-set adhesives, silicone floor formed-in-place, terrazzo, vinyl sheet-goods, vinyl tile with chemical-set adhesives, pressure-treated lumber or naturally decay-resistant lumber
Walls and ceilings	Cement board, brick, metal, cast stone in waterproof mortar, slate, porcelain, glass, glass block, clay tile, concrete, CMU, pressure-treated wood, naturally decay-resistant wood, marine grade plywood or pressure-treated plywood
Doors	Hollow metal
Insulation	Foam or closed-cell
Trim	Natural or artificial stone, steel, or rubber

Many coastal jurisdictions make available a list of approved materials that can be used in coastal environments. Check for locally approved flood-resistant materials. Include all proposed construction and materials in approved plans. For guidance on testing specific materials, refer to *NES Evaluation Protocol for Determination of Flood-Resistant Properties of Building Elements* (NES, Inc. – http://www.nateval.org).

Wind-Resistant Materials

Homes in many coastal areas are often exposed to winds in excess of 90 mph (3-second peak gust). Choose building materials (e.g., roof shingles, siding, windows, doors, fasteners, and framing members) that are designed for use in high-wind areas.

Examples:

- shingles rated for high winds (see Fact Sheet No. 20)
- double-hemmed vinyl siding (see Fact Sheet No. 25)
- deformed-shank nails for sheathing attachments (see Fact Sheet No. 18)
- wind-resistant glazing (see Fact Sheet No. 22)
- reinforced garage doors
- tie-down connectors used throughout structure (from roof framing to foundation — see Fact Sheet Nos. 10 and 17)
- wider framing members (2x6 instead of 2x4)

Remember: A wind-resistant material is only as good as its connection. Always use recommended fasteners and connection methods.

Select building materials that are suitable for the expected wind forces.

Corrosion and Decay Resistance

Coastal environments are conducive to metal corrosion and moisture- and termite-related decay of other building materials. Metal corrosion is most pronounced on coastal homes (within 3,000 feet of the ocean), but moisture- and termite-related decay are prevalent throughout coastal areas.

Corrosion-Resistant Metals

Most jurisdictions require metal building hardware to be hot-dipped galvanized or stainless steel. Some local codes require protective coatings that are thicker than "off-the-shelf" products typically have. For example, a G90 zinc coating (0.75 mil on each face) may be required, which is thicker than the common G60 (0.5 mil on each face) coating.

Recommendations

- Use hot-dipped galvanized or stainless steel hardware. Reinforcing steel should be protected from corrosion by sound materials (masonry, mortar, grout, concrete) and good workmanship (see Fact Sheet No. 16). Use

The term "corrosion-resistant" is widely used but, by itself, is of little help to those specifying or evaluating materials for use in a coastal home. Every material resists corrosion to some extent, or conversely, every material corrodes.

The real issue is *how long will a given material serve its intended purpose at a given home?* The answer depends on the following:

- the material
- where it is used in the home
- whether installation techniques (e.g., drilling, cutting, bending) will compromise its resistance
- its degree of exposure to salt air, moisture, and corrosive agents
- whether maintenance required of the homeowner is performed

The bottom line: **do not blindly specify or accept a product just because it is labeled *corrosion-resistant***. Evaluate the nature of the material, its coating type and thickness (if applicable), and its performance in similar environments before determining whether it is suitable for a particular application.

For guidance on the selection of metal hardware for use in coastal environments, consult an engineer with experience in corrosion protection. For more information about corrosion in coastal environments, see FEMA Technical Bulletin 8-96, *Corrosion Protection for Metal Connectors in Coastal Areas for Structures Located in Special Flood Hazard Areas* (see the Additional Resources section of this fact sheet).

galvanized or epoxy-coated reinforcing steel in situations where the potential for corrosion is high (see Fact Sheet No. 14).

- Avoid joining dissimilar metals, especially those with high galvanic potential (e.g., copper and steel).
- Some wood preservatives should not be used in direct contact with galvanized metal. Verify that wood treatment is suitable for use with galvanized metal, or use stainless steel.
- Metal-plate-connected trusses should not be exposed to the elements. Truss joints near vent openings are more susceptible to corrosion and may require increased corrosion protection.

Metals corrode at a much faster rate near the ocean. Always use well-protected hardware, such as this connector with thick galvanizing. (For information about pile-to-beam connections, see Fact Sheet No. 13).

Moisture Resistance

Materials resistant to moisture can greatly reduce maintenance and extend the life of a coastal home (however, by themselves, such materials cannot prevent all moisture damage. Proper design and installation of moisture barriers (see Fact Sheet No. 9) is also required).

Recommendations

- Control wood decay by separating wood from moisture, using preservative-treated wood, using naturally decay-resistant wood, and applying protective wood finishes.
- Use proper detailing of wood joints and construction to eliminate standing water and reduce moisture absorption by the wood (e.g., avoid exposure of end grain cuts, which absorb moisture up to 30 times faster than the sides of a wood member).
- Do not use untreated wood in ground contact or high-moisture situations. Do not use untreated wood in direct contact with concrete.
- Field-treat any cuts or drill holes that offer paths for moisture to enter wood members.
- For structural uses, employ concrete that is sound, dense, and durable; control cracks with welded wire fabric and/or reinforcing, as appropriate.
- Use masonry, mortar, and grout that conform with the latest building codes.

Termite Resistance

Termite damage to wood construction occurs in many coastal areas (attack is most frequent and severe along the southeastern Atlantic and Gulf of Mexico shorelines, in California, and in Hawaii and other tropical areas). Termites can be controlled by soil treatment, termite shields, and the use of termite-resistant materials.

Wood decay at the base of a wood post supported by concrete.

Recommendations

- Incorporate termite control methods into design in conformance with requirements of the authority having jurisdiction.
- Where a masonry foundation is used and anchorage to the foundation is required for uplift resistance, the upper block cores must usually be completely filled with grout, which may eliminate the requirement for termite shields (see Fact Sheet No. 14).
- Use preservative-treated wood for foundations, sills, above-foundation elements, and floor framing.

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 8-96, *Corrosion Protection for Metal Connectors in Coastal Areas for Structures Located in Special Flood Hazard Areas*. (http://www.fema.gov/fima/techbul.shtm)

American Concrete Institute International. (http://www.aci-int.org/general/home.asp)

American Wood-Preservers' Association. (http://www.awpa.com)

International Code Council Evaluation Service, Inc. Protocol for Testing the Flood Resistance of Materials. (http://www.icc-es.org/index.shtml)

Moisture Barrier Systems

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 9*

Purpose: To describe the moisture barrier system, explain how typical wall moisture barriers work, and identify common problems associated with moisture barrier systems.

Key Issues

- A successful moisture barrier system will limit water infiltration into unwanted areas and allow drainage and drying of wetted building materials.
- Most moisture barrier systems for walls (e.g., siding and brick veneer) are "redundant" systems, which require at least two drainage planes (see page 2).
- Housewrap or building paper (asphalt-saturated felt) will provide an adequate secondary drainage plane.
- Proper flashing and lapping of housewrap and building paper are critical to a successful moisture barrier system.
- Sealant should never be substituted for proper layering.

The purpose of the building envelope is to control the movement of water, air, thermal energy, and water vapor. The goal is to prevent water infiltration into the interior, limit long-term wetting of the building components, and control air and vapor movement through the envelope.

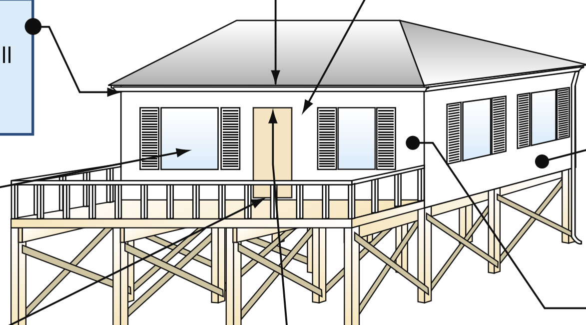
Locations and Causes of Common Water Intrusion Problems

Poor water shedding from roof – Use moderate overhangs of 12-16 inches, drip edges, and a gutter system.

Roof/wall intersection – Install effective kick-out flashing at roof-to-wall intersections, diverter flashing around trapped-valleys, and rake flashing.

Flashing around windows – Proper lapping is key to leak prevention. Do not depend on sealant for sustained protection. Protect flashings with overlapping wrap.

Door sills – Use pan flashing to prevent damage to subfloor.



Improper flashing and damaged housewrap or building paper at wall penetrations – Follow window flashing techniques at every wall penetration.

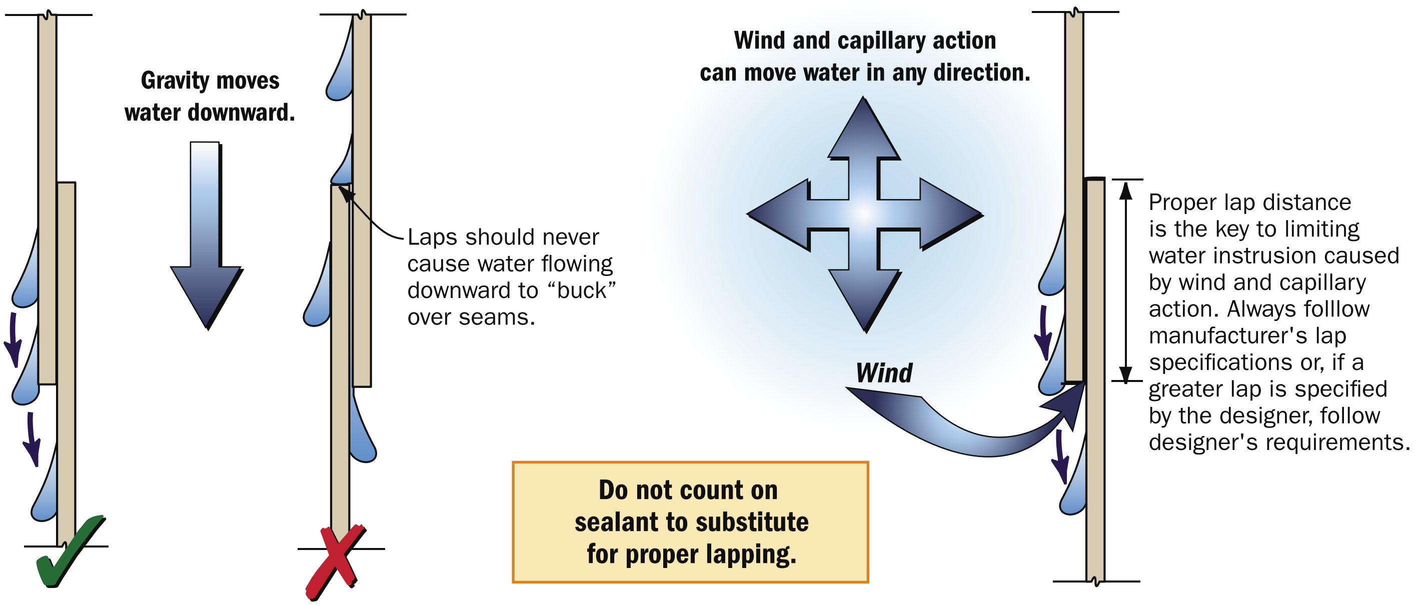
Damaged or improperly installed siding – Follow manufacturer's guidelines. Prime all surfaces of wood siding (back-priming) before applying top coats.

No housewrap or building paper used, or improperly lapped – Virtually all siding leaks. Use housewrap or building paper to shed water. Properly lap material so water flows without bucking seams. Water must be allowed to drain out of walls.

Improper flashing over doors – Proper lapping is key to leak prevention. Do not depend on sealant for sustained protection. Protect flashings with overlapping housewrap or building paper.

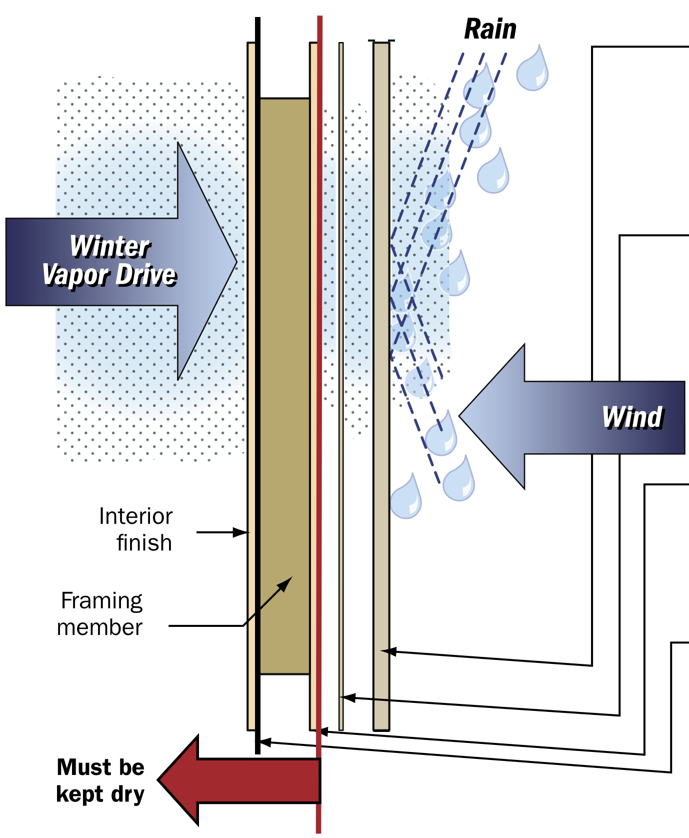
The location of water entry is often difficult to see, and the damage to substrate and structural members behind the exterior wall cladding frequently cannot be detected by visual inspection.

Proper Lapping Is the Key...



Proper lapping of moisture barrier materials is the key to preventing water intrusion. Most water intrusion problems are related to the improper lapping of materials. Usually, flashing details around doors, windows, and penetrations are to blame. If the flashing details are right and the housewrap or building paper is properly installed, most moisture problems will be prevented. Capillary suction is a strong force and will move water in ***any*** direction. Even under conditions of light or no wind pressure, water can be wicked through seams, cracks, and joints upward behind the overlaps of horizontal siding. Proper lap distances and sealant help prevent water intrusion caused by wicking action.

How a Redundant Moisture Barrier Works



Siding
The siding is the first line of defense, but by no means should it be the only protection from outside moisture. Sidings shed most of the water, but some does get through, especially in coastal areas where high winds can drive rain.

Housewrap or Building Paper
Housewrap or building paper is a dual-purpose protection layer. It sheds water that gets through the siding and limits air intrusion from the outside. A unique feature of this barrier is that it sheds water, but allows water vapor to pass through. This permits water vapor from the inside to pass through without condensing on the framing.

Sheathing
If structural sheathing is used, it should be protected from moisture. Prolonged wetting, especially without the ability to drain the moisture and dry out, will damage the sheathing.

Vapor Retarder
In cold regions, a vapor retarder is often used on the warm side of the wall cavity to minimize the movement of vapor from the inside of the building into the wall cavity, where it will condense on the cool framing members. Vapor retarders are typically used only where the predominant vapor drive is from the inside to the outside (cold climates).

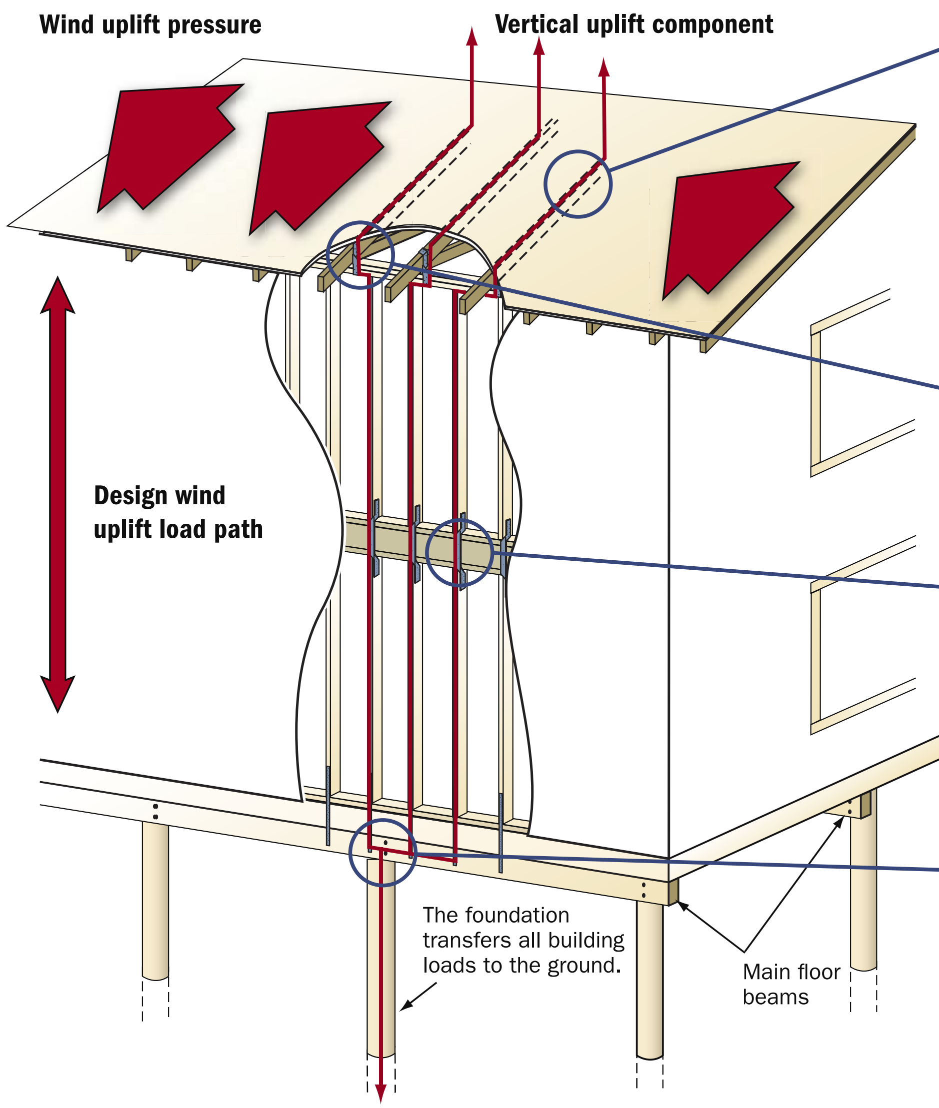
Load Paths

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 10*

Purpose: To illustrate the concept of load paths and highlight important connections in a ***wind uplift load path***.

Key Issues

- Loads acting on a building follow many paths through the building and must eventually be resisted by the ground, or the building will fail.
- Loads accumulate as they are routed through key connections in a building.
- Member connections are usually the weak link in a load path.
- Failed or missed connections cause loads to be rerouted through unintended load paths.



Vertical load path from roof to ground on a platform-and-pile-construction building. Note: Load paths will vary depending on construction type and design. Adjacent framing members will receive more load if a connection fails.

LINK 1
High winds lift the roof upward. Roofing fasteners link the roof covering to the sheathing*, and sheathing fasteners link the sheathing to the roof framing members (see Fact Sheet No. 18).

* Although not a structural connection, the attachment of the roof covering to the roof sheathing is an essential part of protecting the building envelope.

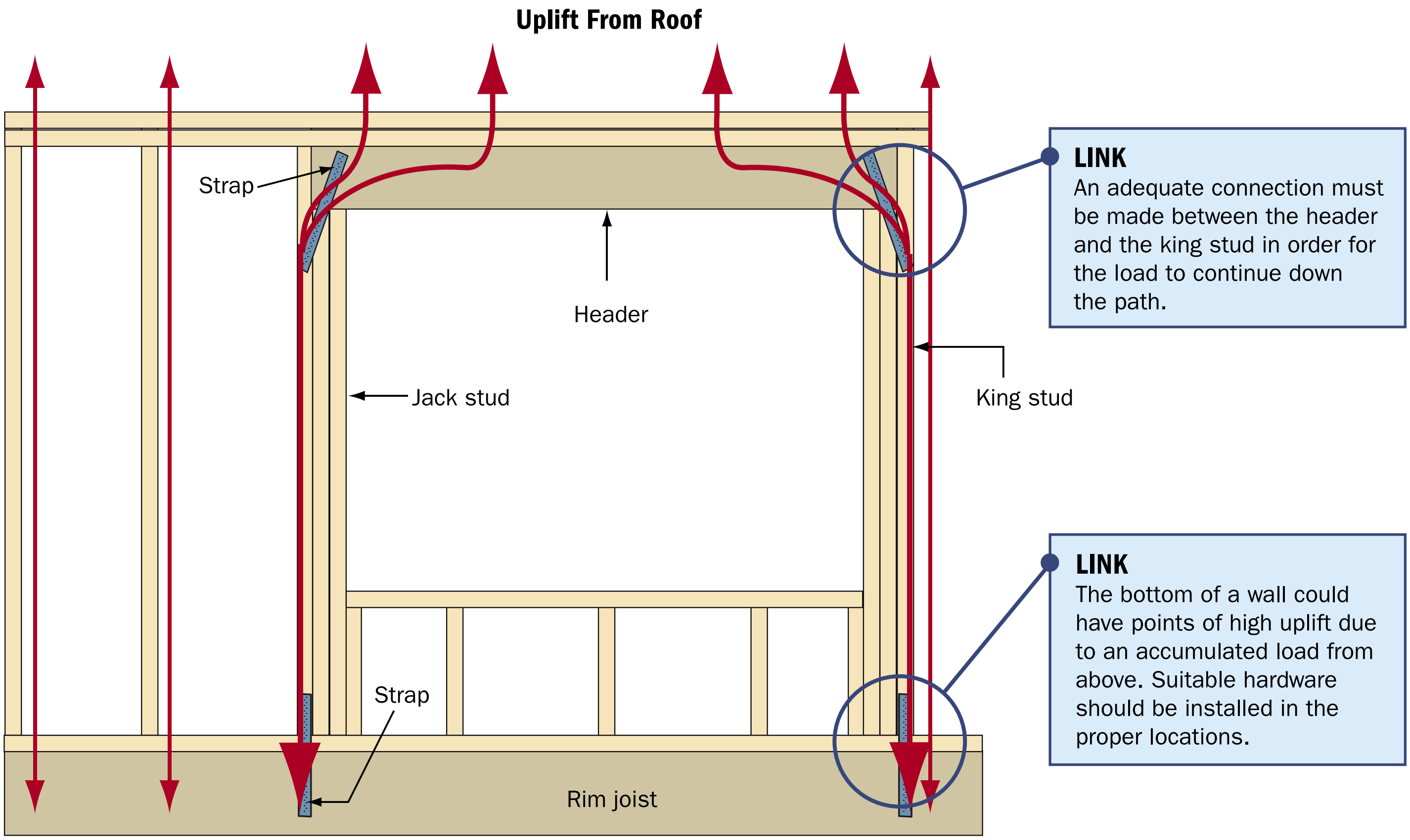
LINK 2
Accumulated roof load is routed through roof-to-wall connections. Special roof ties connect the roof framing to the bearing walls (see Fact Sheet No. 17).

LINK 3
Upper walls transfer loads directly to the lower walls. The floor framing is bypassed by using metal straps or extended exterior sheathing that directly connects upper wall studs to the lower wall studs. A similar connection is used to connect the lower wall to the main floor beam.

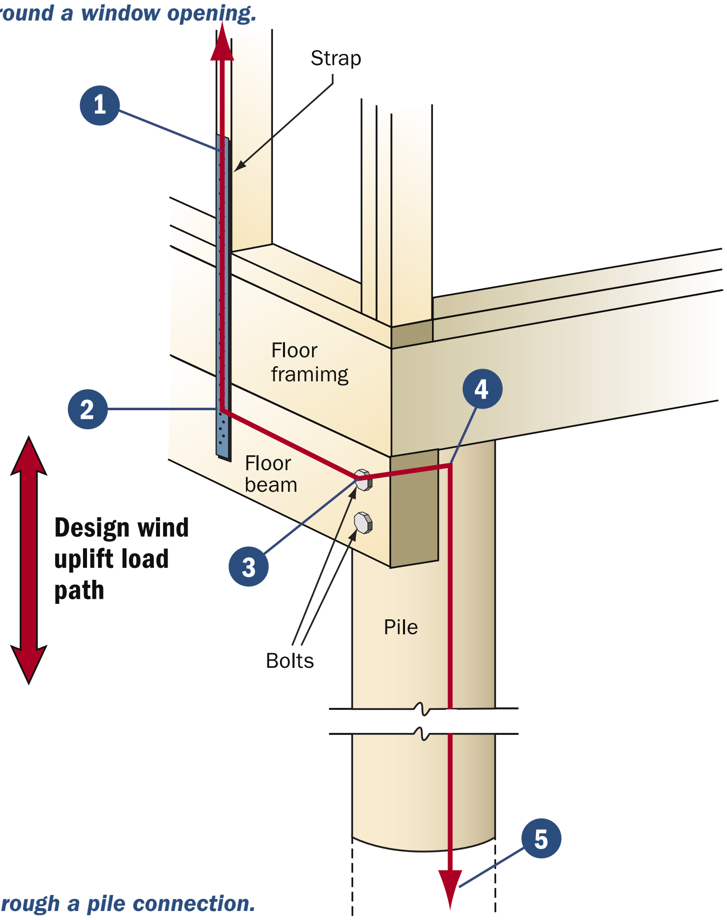
LINK 4
The accumulated uplift force is transferred from the main floor beams to the pile foundation with special brackets or bolts (see Fact Sheet No. 13). **Note:** Some of this load is offset by the weight of the building.

Note: Horizontal load paths transferring shear from upper stories to the ground must also be analyzed.

If a connection fails, an alternative load path will form. If the members and connections in the new load path have inadequate resistance, progressive failure can occur. Loads must be routed around openings, such as windows and doors. Accumulated loads on headers are transferred to the studs on the sides of the opening.



Load path around a window opening.



Load paths can be complex through a connection. It is important that each link within the connection be strong enough to transfer the full design load.

The detail at left shows a typical floor-to-pile connection. Uplift loads are transferred through the joint in the following order.

1. from upper story to strap
2. from strap to floor beam
3. from floor beam to bolts
4. from bolts to pile
5. from pile to ground

Load path through a pile connection.

Foundations in Coastal Areas

Purpose: To describe foundation types suitable for coastal environments.

Key Issues

- Foundations in coastal areas must elevate buildings above the Base Flood Elevation (BFE), while withstanding flood forces, high winds, scour and erosion, and floating debris.
- Foundations used for inland construction are generally not suitable for coastal construction.
- Deeply embedded pile or column foundations are required for many coastal areas; in other coastal areas, they are recommended – instead of solid wall, crawlspace, slab, or other shallow foundations that can be undermined easily. ("Deeply embedded" means sufficient penetration into the ground to accommodate storm-induced scour and erosion and to resist all design vertical and lateral loads without structural damage.)

Storm surge and waves overtopping a barrier island during Hurricane Frederic.

- Areas below elevated buildings in V zones must be "free of obstructions" that can transfer flood loads to the foundation and building (see Fact Sheet No. 27).

Foundation Design Criteria

All foundations for buildings in flood hazard areas must be constructed with flood-damage-resistant materials (see Fact Sheet No. 8) and must do two things in addition to meeting the requirements for conventional construction: (1) elevate the building above the BFE, and (2) prevent flotation, collapse, and lateral movement of the building, resulting from loads and conditions during the design flood event (in coastal areas, these loads and conditions include inundation by fast-moving water, breaking waves, floating debris, erosion, and high winds).

Because the most hazardous coastal areas are subject to erosion and extreme flood loads, ***the only practical way to perform these two functions is to elevate a building on a deeply embedded and "open" (i.e., pile or column) foundation***. This approach resists storm-induced erosion and scour, and it minimizes the foundation surface area subject to lateral flood loads – it is required by the National Flood Insurance Program (NFIP) in V zones (even when the ground elevation lies above the BFE) and is recommended for coastal A zones. However, even a deeply embedded open pile foundation will not prevent eventual undermining and loss due to long-term erosion (see Fact Sheet No. 7).

Performance of Various Foundation Types in Coastal Areas

There are many ways to elevate buildings above the BFE: fill, slab-on-grade, crawlspace, stemwall, solid wall, pier (column), and pile. Not all of these are suitable for coastal areas. In fact, several of them are prohibited in V zones and are not recommended by the *Home Builder's Guide to Coastal Construction* for A zones in coastal areas.

Fill – Because fill is susceptible to erosion, it is ***prohibited as a means of providing structural support to buildings in V zones*** and must ***not*** be used as a means of elevating buildings in ***any other coastal area subject to erosion, waves, or fast-moving water***.

Slab-on-Grade – Slab-on-grade foundations are also susceptible to erosion and are therefore ***prohibited in V zones***. They also are ***not recommended*** for ***A zones in coastal areas***. (Note that parking slabs are often permitted below elevated buildings, but are themselves susceptible to undermining and collapse.)

Building failure caused by undermining of slab-on-grade foundation during Hurricane Fran.

Crawlspace – Crawlspace foundations are ***prohibited in V zones*** and are ***not recommended for A zones in coastal areas***. They are susceptible to erosion when the footing depth is inadequate to prevent undermining. Crawlspace walls are also vulnerable to wave attack. Where used, crawlspace foundations must be equipped with ***flood openings***; grade elevations should be such that water is not trapped in the crawlspace (see Fact Sheet Nos. 15 and 27).

Failure of crawlspace foundation undermined by scour.

Stemwall – Stemwall foundations are similar to crawlspace foundations in construction, but the interior space that would otherwise form the crawlspace is often backfilled with gravel that supports a floor slab. Stemwall foundations have been observed to perform better during storms than many crawlspace and pier foundations. However, the building code may limit stemwall height to just a few feet. Flood openings are not required in a backfilled stemwall foundation. Stemwall foundations are ***prohibited in V zones*** but are ***recommended in A zones subject to limited wave action***, as long as embedment of the wall is sufficient to resist erosion and scour.

Solid Foundation Walls – Solid foundation walls are ***prohibited by the NFIP in V zones*** and are not recommended for ***A zones subject to breaking waves or other large flood forces*** – the walls act as an obstruction to flood flow. Like crawlspace walls, they are susceptible to erosion when the footing depth is inadequate to prevent undermining. Solid walls have been used in some regions to elevate buildings one story in height. Where used, the walls must allow floodwaters to pass between or through the walls (using flood openings). See Fact Sheet Nos. 15 and 27.

Pier (column) failures: footings undermined and columns separated from footings.

Pier (column) – Pier foundations are ***recommended for A zones where erosion potential and flood forces are small***. This open foundation is commonly constructed with reinforced and grouted masonry units atop a concrete footing. Shallow pier foundations are extremely vulnerable to erosion and overturning if the footing depth and size are inadequate. They are also vulnerable to breakage if materials and workmanship are not first rate. Fact Sheet No. 14 provides guidance on how to determine whether pier foundations are appropriate, and how to design and construct them.

Pile – Pile foundations are ***recommended for V zones and many A zones in coastal areas***. These open foundations are constructed with square or round, wood, concrete, or steel piles, driven or jetted into the ground, or set into augered holes. Critical aspects of a pile foundation include the pile size, installation method and embedment depth, bracing, and the connections to the elevated structure (see Fact Sheet Nos. 12 and 13). Pile foundations with ***inadequate embedment*** will lead to ***building collapse. Inadequately sized*** piles are ***vulnerable to breakage by waves and debris***.

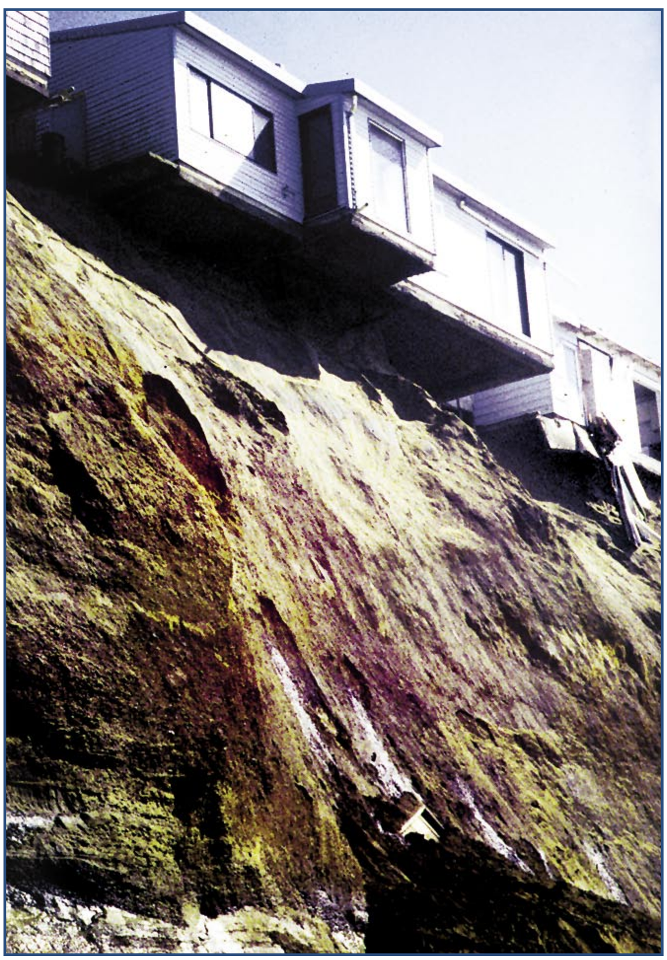
Pile failures led to collapse of floor of elevated building.

Insufficient pile embedment and failure of connections at tops of piles allowed elevated building to be floated off its foundation.

Foundations for High-Elevation Coastal Areas

Foundation design is problematic in bluff areas that are vulnerable to coastal erosion but outside mapped flood hazard areas. Although NFIP requirements may not apply, the threat of undermining is not diminished.

Moreover, both shallow and deep foundations will fail in such situations. Long-term solutions to the problem may involve better siting (see Fact Sheet No. 7), moving the building when it is threatened, or (where permitted and economically feasible) controlling erosion through slope stabilization and structural protection.



House undermined by bluff erosion. Photograph by Lesley Ewing. Courtesy of California Coastal Commission.

Foundations in V Zones With Ground Elevations Above the BFE

In some instances, coastal areas will be mapped on an NFIP Flood Insurance Rate Map (FIRM) as V zones, but will have dunes or bluffs with ground elevations above the BFE shown on the FIRM. ***Deeply embedded pile or column foundations are still required in these areas, and solid or shallow foundations are still prohibited***. The presence of a V-zone designation in these instances indicates that the dune or bluff is expected to erode during the base flood event and that V-zone wave conditions are expected after the erosion occurs. The presence of ground elevations above the BFE in a V zone should not be taken to mean that the area is free from Base Flood and erosion effects.

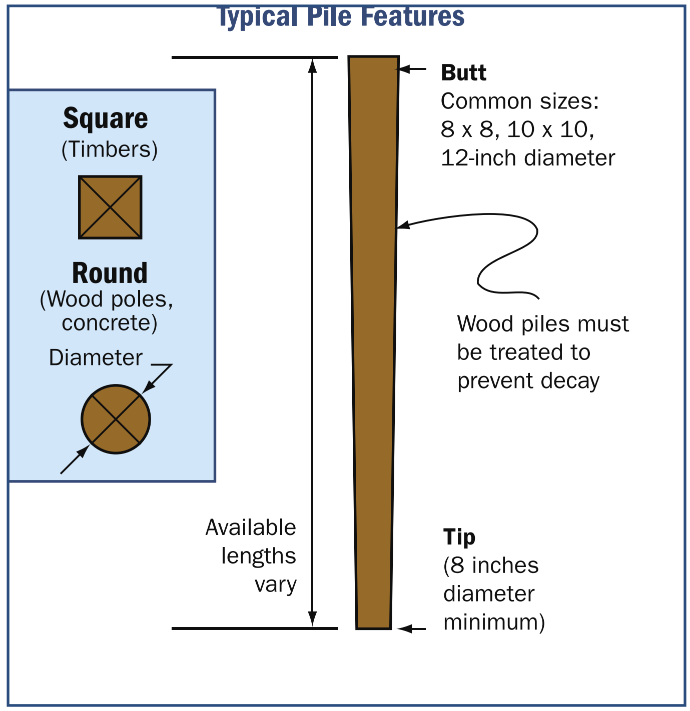
Pile Installation

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 12*

Purpose: To provide basic information about pile design and installation.

Key Issues

- Use a pile type that is appropriate for local conditions.
- Have piles designed by a foundation engineer for adequate layout, size, and length.
- Use installation methods that are appropriate for the conditions.
- Brace piles properly during construction.
- Make accurate field cuts, and treat all cuts and drilled holes to prevent decay.
- Have all pile-to-beam connections engineered, and use corrosion-resistant hardware. (See Fact Sheet No. 8.)



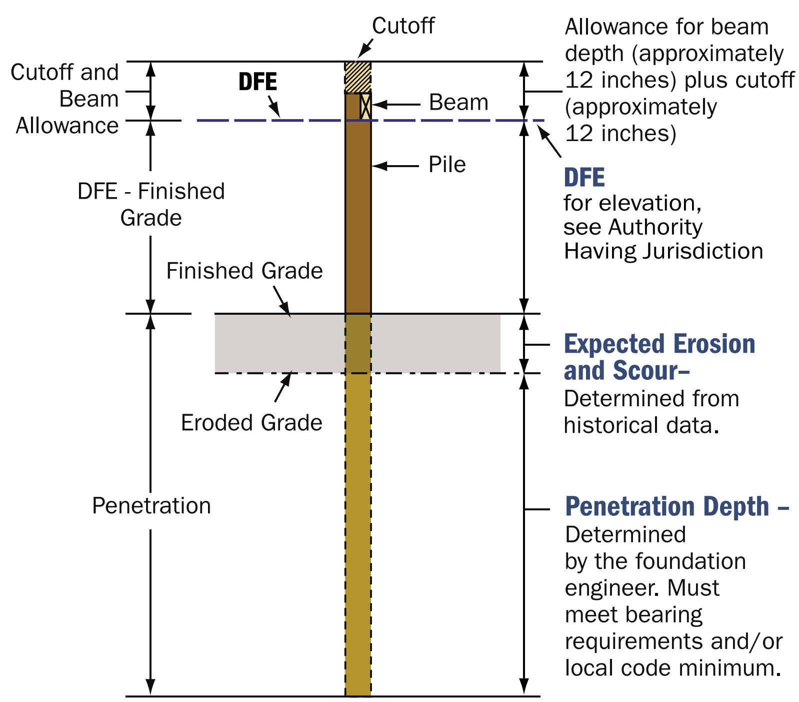
Pile Types

Treated wood piles are the most common type of pile used in coastal construction. They can be square or round in cross section. Wood piles are easily cut and adjusted in the field and are typically the most economical type. Concrete and steel can also be used but are less common. Concrete piles are more expensive, but they are stronger and more durable. Steel piles are rarely used, because of potential corrosion problems.

Pile Size and Length

Pile size and length are determined by the foundation engineer. Specified bearing and penetration requirements must be met. Piles should have no less than an 8-inch tip diameter; minimum timber size should be 8x8. The total length of the pile is based on code requirements, calculated penetration requirements, erosion potential, Design Flood Elevation (DFE), and allowance for cut-off and beam width (see figure at right).

Note: Misaligned piles lead to connection problems. See Fact Sheet No. 13 for information about making connections to misaligned piles.



Pile Layout

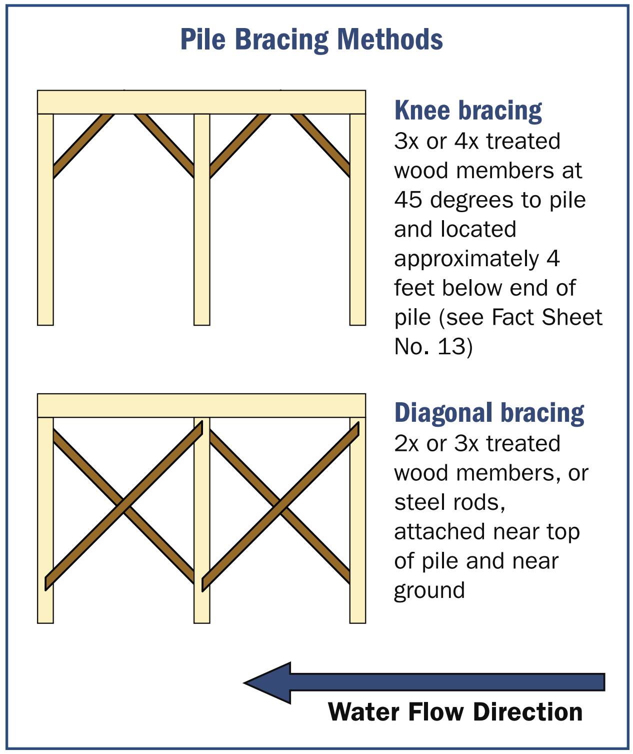
The pile layout is determined by the foundation engineer. Accurate placement and correction of misaligned piles is important. Pile placement should not result in more than 50 percent of the pile cross-section being cut for girder or other connections. Verify proper pile locations on drawings before construction and clarify any discrepancies. Layout can be done by a licensed design professional, a construction surveyor, the foundation contractor, or the builder. The layout process must always include establishing an elevation for the finished first floor. Construction of the first-floor platform should not begin until this elevation is established (see Fact Sheet No. 4).

Installation Methods

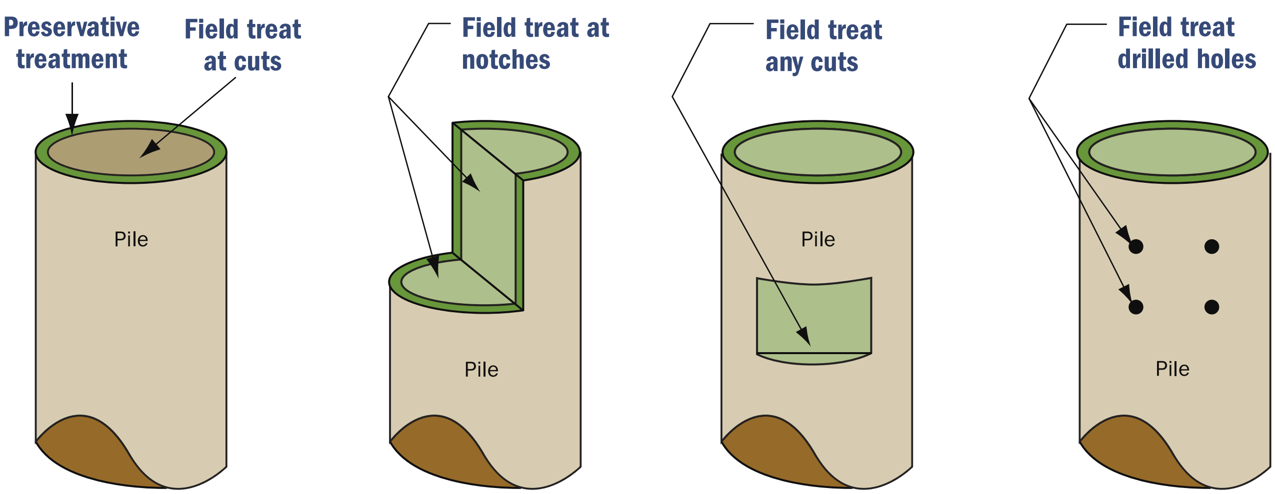
Piles can be driven, augured, or jetted into place. The installation method will vary with soil conditions, bearing requirements, equipment available, and local practice. One common method is to initially jet the pile to a few feet short of required penetration, then complete the installation by driving with a drop hammer.

Pile Bracing

Pile bracing is determined by the foundation engineer. Common bracing methods include knee and diagonal bracing. Bracing is often oriented perpendicular to the shoreline so that it is not struck broadside by waves, debris, and velocity flow (see figure at right). Temporary bracing or jacking to align piles and hold true during construction is the responsibility of the contractor.



To avoid costly pile repairs or replacement, measure, locate, and double-check the required pile cutoff elevations before cutting off piles.



Field Cutting and Drilling

A chain saw is the common tool of choice for making cuts and notches in wood piles. After making cuts, exposed areas should be field-treated to prevent decay.

Connections

The connection of the pile to the structural members is one of the most critical connections in the structure. Always follow design specifications and use corrosion-resistant hardware (see Fact Sheet Nos. 8 and 13).

Verification of Pile Capacity

Generally, pile capacity for residential construction is not verified in the field. If a specified minimum pile penetration is provided, bearing is assumed to be acceptable for the local soil conditions. Subsurface soil conditions can vary from the typical assumed conditions, so verification of pile capacity may be prudent, particularly for expensive coastal homes. Various methods are available for predicting pile capacity. Consult a foundation engineer for the most appropriate method for the site.

Additional Resources

American Forest and Paper Association (AF&PA). *National Design Specification for Wood Construction*. (www.afandpa.org)

American Society for Standards and Testing (ASTM). *Standard Specification for Round Timber Piles*, ASTM D25. (www.astm.org)

American Wood-Preservers Association (AWPA). *All Timber Products – Preservative Treatment by Pressure Processes*, AWPA C1-00; *Lumber, Timber, Bridge Ties and Mine Ties – Preservative Treatment by Pressure Processes*, AWPA C2-01; *Piles – Preservative Treatment by Pressure Process*, AWPA C3-99; and others. (www.awpa.com)

Pile Buck, Inc. *Coastal Construction*. (www.pilebuck.com)

Wood-Pile-to-Beam Connections

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 — Technical Fact Sheet No. 13

Purpose: To illustrate typical wood-pile-to-beam connections, provide basic construction guidelines on various connection methods, and show pile bracing connection techniques.

NOTE: The pile-to-beam connection is one of the most critical links in the structure. ***This connection must be designed by an engineer.*** See Fact Sheet No. 10 for "load path" information. The number of bolts and typical bolt placement dimensions shown are for illustrative purposes only. Connection designs are not limited to those shown here, and not all of the information to be considered in the designs is included in these illustrations. ***Final designs are the responsibility of the engineer.***

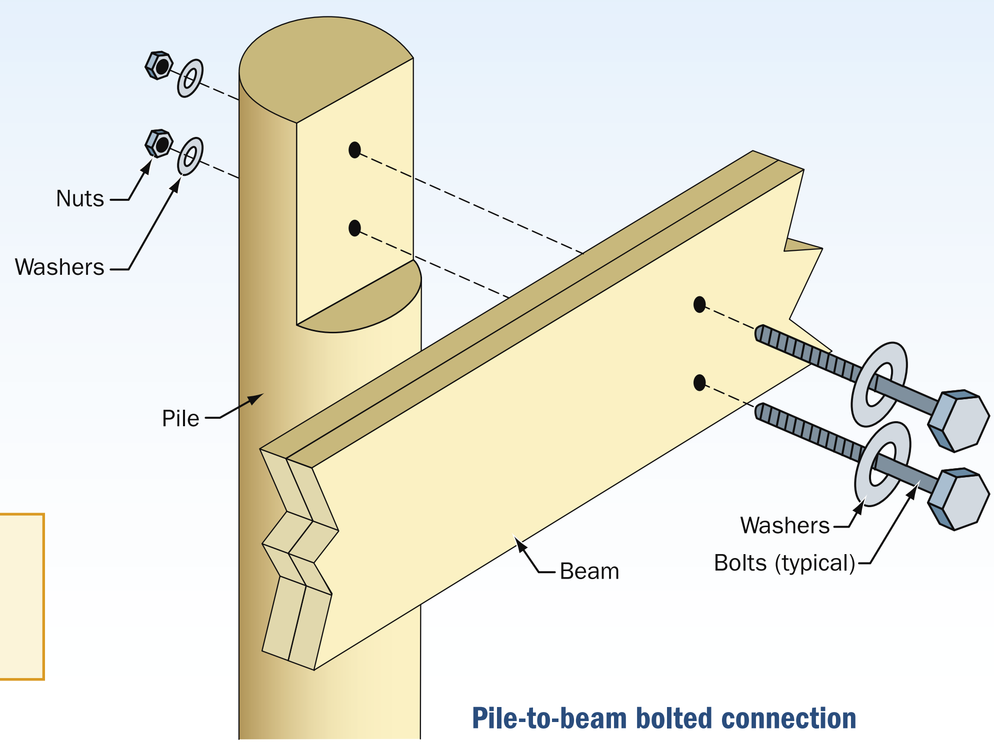
Key Issues

- Verify pile alignment and correct, if necessary, before making connections.
- Carefully cut piles to ensure required scarf depths.
- Limit cuts to no more than 50 percent of pile cross-section.
- Use corrosion-resistant hardware, such as hot-dipped galvanized or stainless steel (see Fact Sheet No. 8).
- Accurately locate and drill bolt holes.
- Field-treat all cuts and holes to prevent decay.
- Use sufficient pile and beam sizes to allow proper bolt edge distances.

Pile-to-beam connections must:

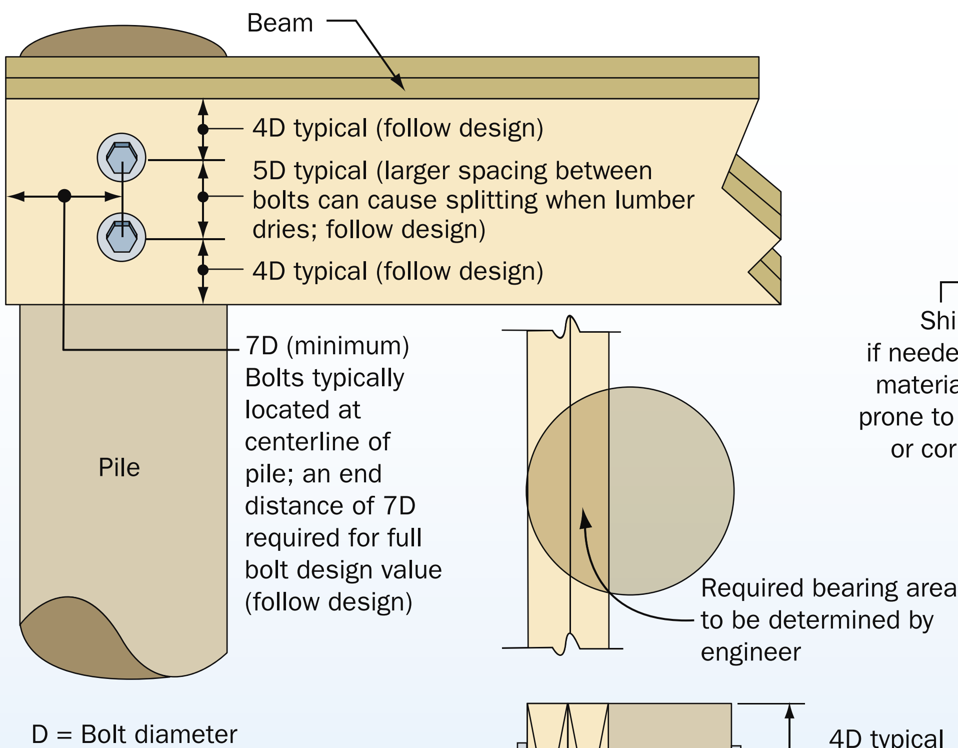
1. provide required ***bearing*** area for beam to rest on pile
2. provide required ***uplift*** (tension) resistance
3. maintain beam in an ***upright*** position
4. be capable of resisting ***lateral*** loads (wind and seismic)
5. be constructed with ***durable*** connectors and fasteners

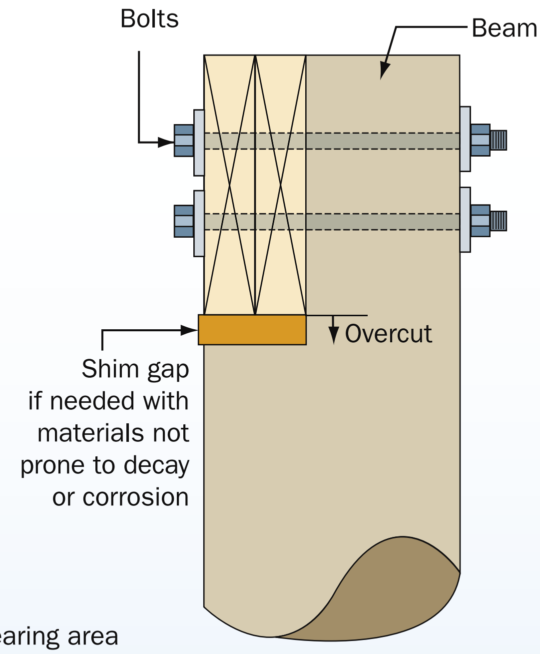
Note: Pile-to-beam connections must be designed by an engineer.



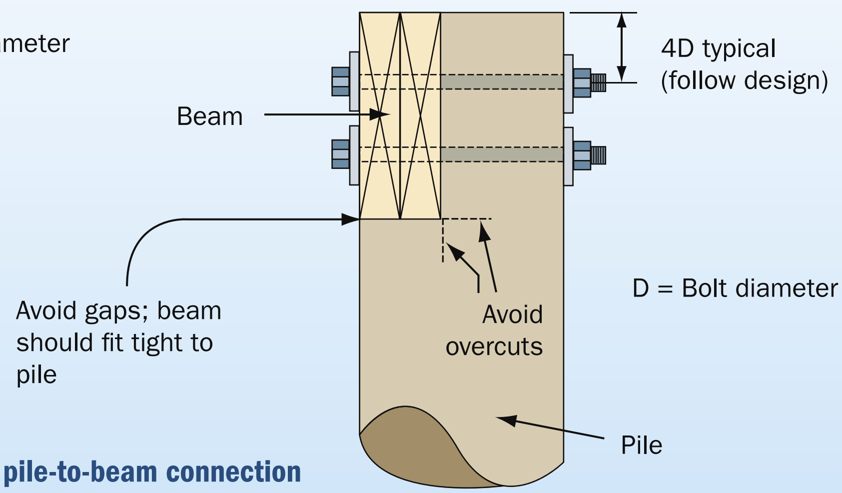
Pile-to-beam bolted connection

Bolt end and edge distance on beam





Connection to overcut pile – shim used to provide adequate bearing



Proper pile-to-beam connection

Note: Pile-to-beam connections must be designed by an engineer.

Problem: Misaligned piles – some piles are shifted in or out from their intended (design) locations.

Possible Solutions (see drawings on page 3 and details on page 4):

Option 1 (see page 3) – beam cannot be shifted

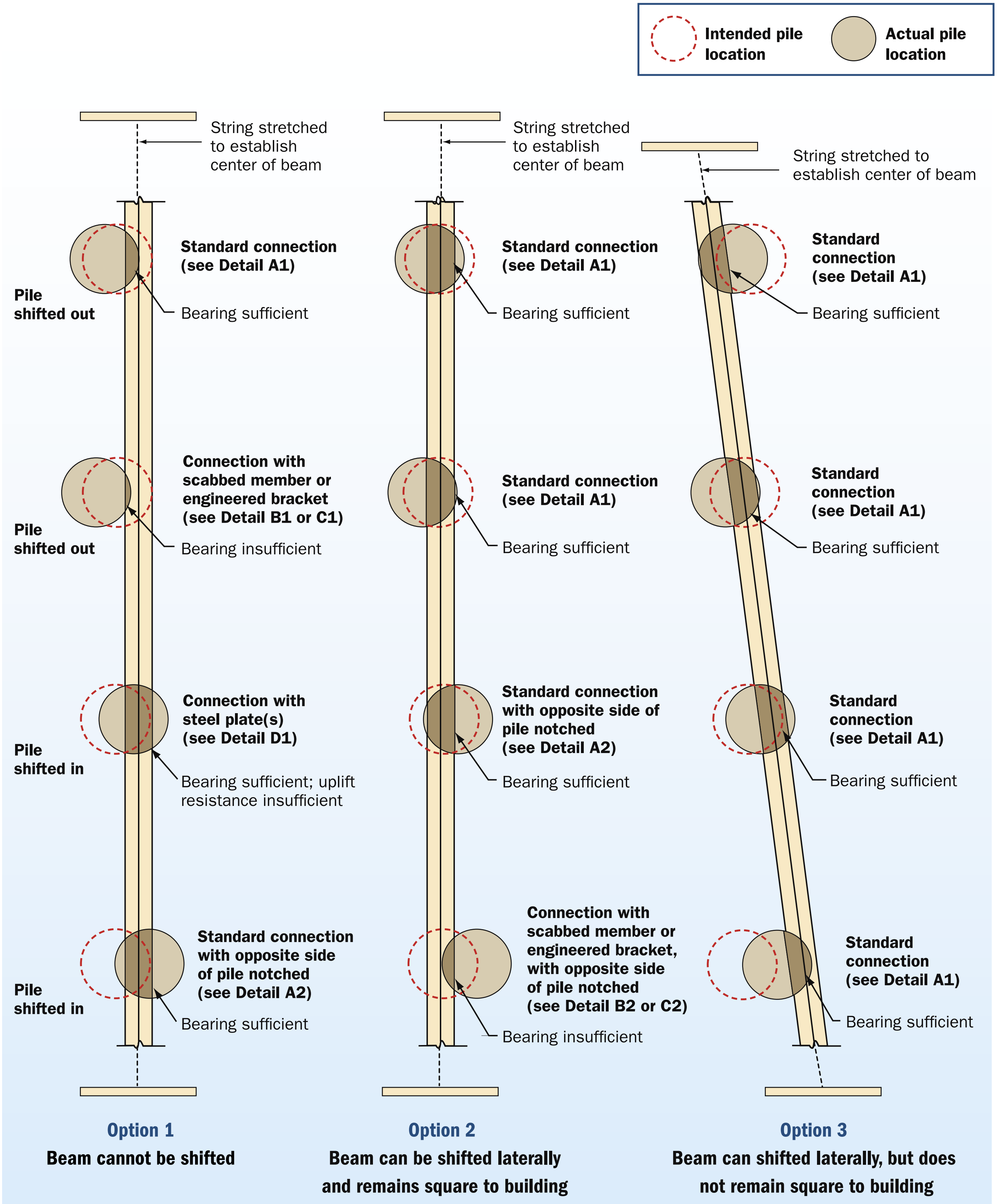
Option 2 (see page 3) – beam can be shifted laterally and remains square to building

Option 3 (see page 3) – beam can be shifted laterally, but does not remain square to building

Option 4 (not shown) – beam cannot be shifted, and connections shown in this fact sheet cannot be made; install and connect sister piles; ***an engineer must be consulted for this option***

Option 5 (not shown) – beam cannot be shifted, and connections shown in this fact sheet cannot be made; remove and reinstall piles, as necessary

Connections to misaligned piles

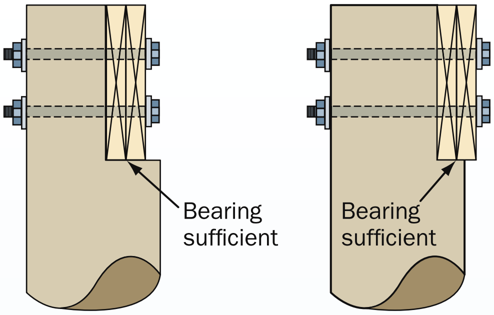


Note: Pile-to-beam connections must be designed by an engineer.

Connections to misaligned piles (see drawings on page 3 and details below)

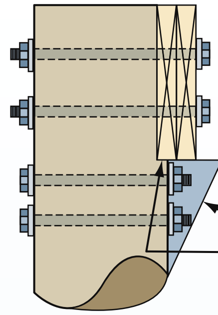
1. The ability to construct the pile-to-beam connections designed by the engineer is directly dependent on the accuracy of pile installation and alignment.
2. Misaligned piles will require the contractor to modify pile-to-beam connections in the field.
3. Badly misaligned piles will require removal and reinstallation, sister piles, or special connections, all to be determined by the engineer.

Detail A1 **Standard connection**



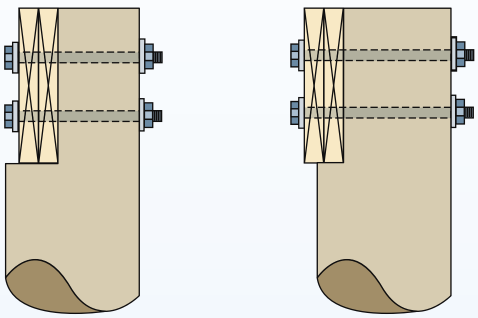
If bearing area under beam is sufficient, a standard bolted connection can be used; if bearing area is insufficient, install scabbed member (Detail B1/B2) or engineered bracket Detail (C1/C2)

Detail C1 **Insufficient bearing – engineered bracket for bearing**

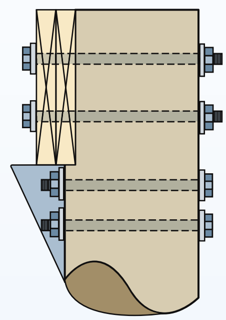


If bearing area under beam is insufficient, install engineered bracket; connection to be designed by an engineer

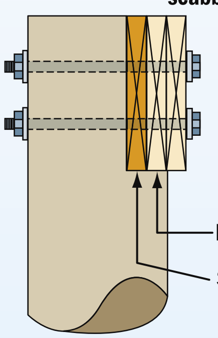
Detail A2 **Standard connection with pile notched on opposite side to avoid overnotching**



Detail C2 **Engineered bracket with pile notched on opposite side to avoid overnotching**

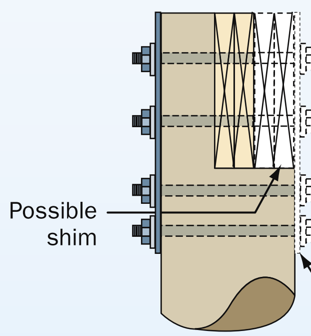


Detail B1 **Insufficient bearing – scabbed member for bearing**



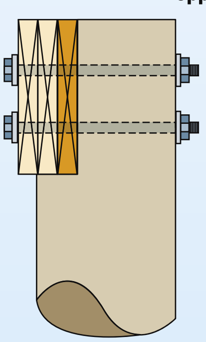
If bearing area under beam is insufficient, deepen notch and install scabbed member to achieve bearing; do not overnotch

Detail D1 **Insufficient uplift capacity – steel plate(s) for uplift resistance**

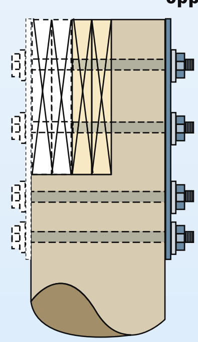


Notch side of pile that leaves the greatest pile section; use 1/4" or thicker galvanized steel plate(s) to satisfy uplift resistance requirements; connection to be designed by an engineer

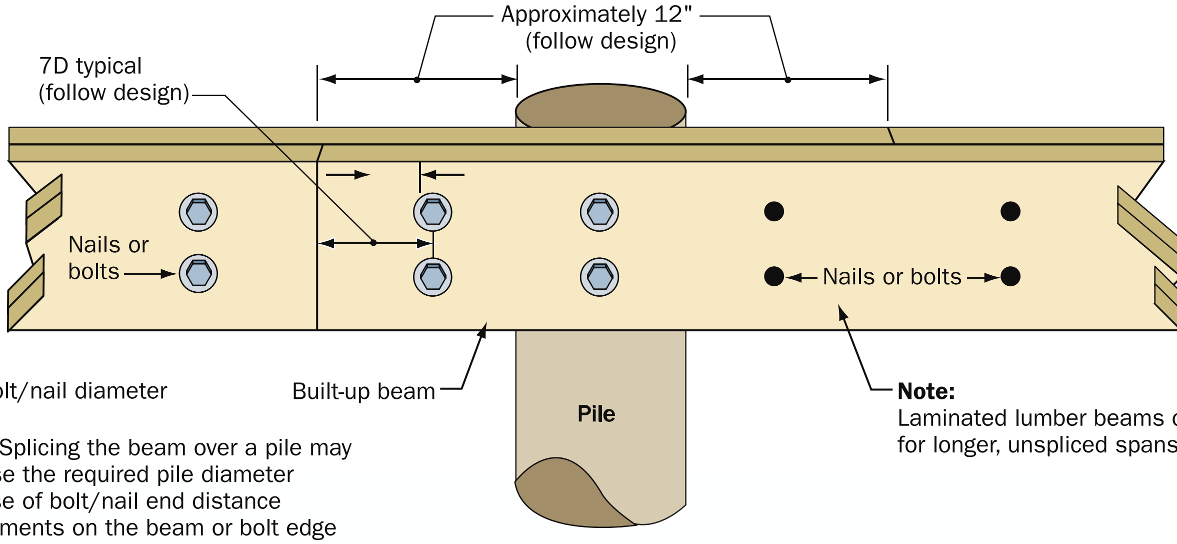
Detail B2 **Scabbed member with pile notched on opposite side to avoid overnotching**



Detail D2 **Steel plate(s) with pile notched on opposite side to avoid overnotching**



Note: Pile-to-beam connections must be designed by an engineer.

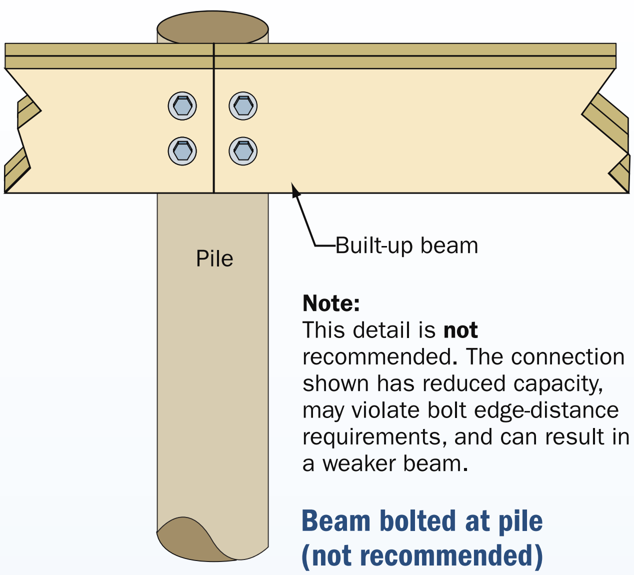


D = Bolt/nail diameter

Note: Splicing the beam over a pile may increase the required pile diameter because of bolt/nail end distance requirements on the beam or bolt edge distance requirements on the pile.

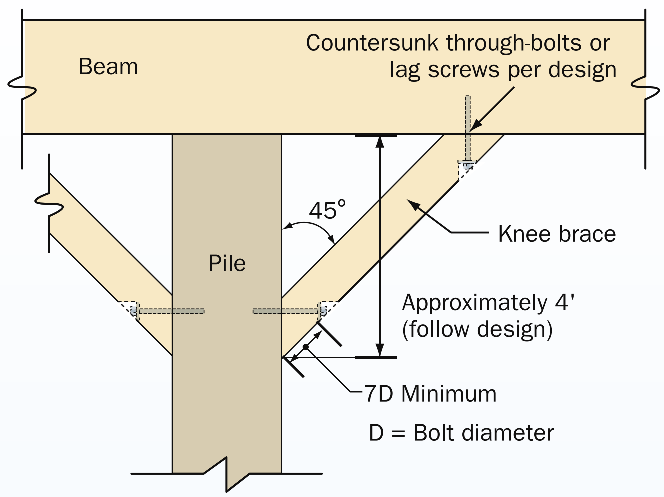
Note:
Laminated lumber beams can be used for longer, unspliced spans.

Lapped splice (built-up beam)



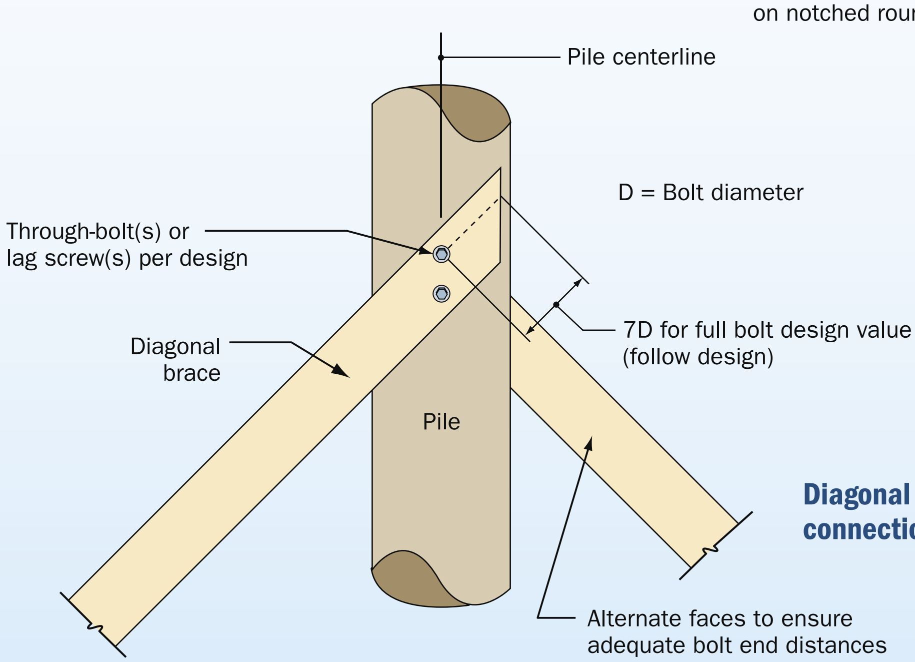
Note:
This detail is **not** recommended. The connection shown has reduced capacity, may violate bolt edge-distance requirements, and can result in a weaker beam.

Beam bolted at pile (not recommended)



Knee brace connection on square pile*

*Knee braces of this type can also be used on notched round piles.



Note: Pile-to-beam connections must be designed by an engineer.

Diagonal brace connections on round pile

Reinforced Masonry Pier Construction

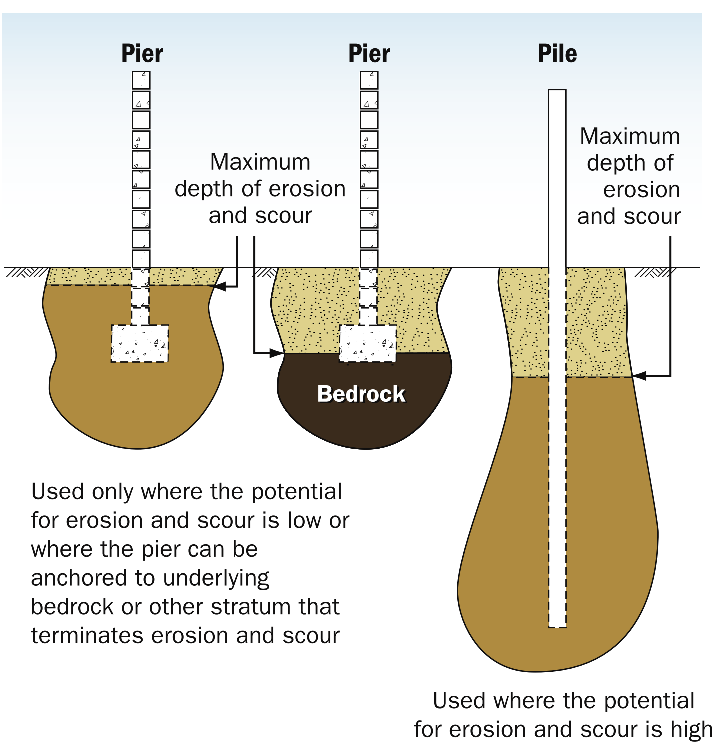
FEMA

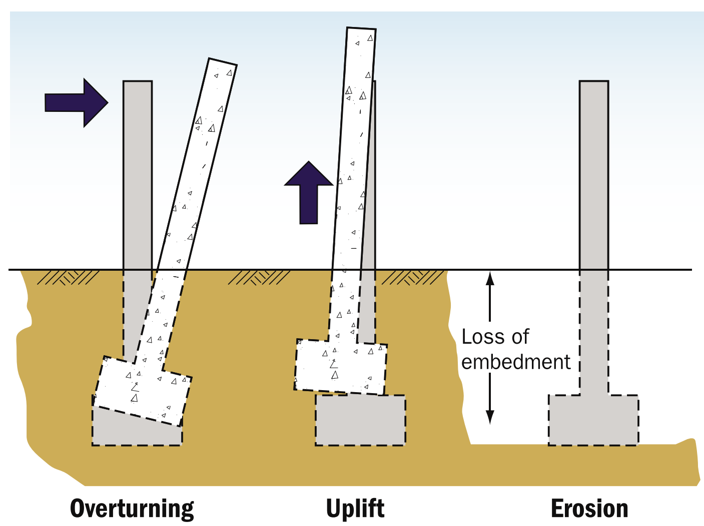
Purpose: To provide an alternative to piles in V zones and A zones in coastal areas where soil properties preclude pile installation, yet the need for an "open foundation system" still exists. Examples of appropriate conditions for the use of piers are where rock is at or near the surface or where the potential for erosion and scour is low.

Key Issues

- The footing must be designed for the soil conditions present. Pier foundations are generally not recommended in V zones or in A zones in coastal areas.
- The connection between the pier and its footing must be properly designed and constructed to resist separation of the pier from the footing and rotation to due to lateral (flood, wind, debris) forces.
- The top of the footing must be below the anticipated erosion and scour depth.
- The piers must be reinforced with steel and fully grouted.
- There must be a positive connection to the floor beam at the top of the pier.
- Special attention must be given to the application of mortar in order to prevent saltwater intrusion into the core, where the steel can be corroded.

Piers vs. Piles





Piers are subject to upward, downward, and horizontal loads. Pier reinforcement and footing size are critical to resisting these loads; therefore, pier and footing design must be verified by an engineer.

In coastal areas, masonry pier foundations are not recommended in V zones with erodible soils, or in A zones subject to waves and erosion — use pile foundations in these areas.

Pier foundations are most appropriate in areas where:

- erosion and scour potential are low,
- flood depths and lateral forces are low, and
- soil can help resist overturning of pier.

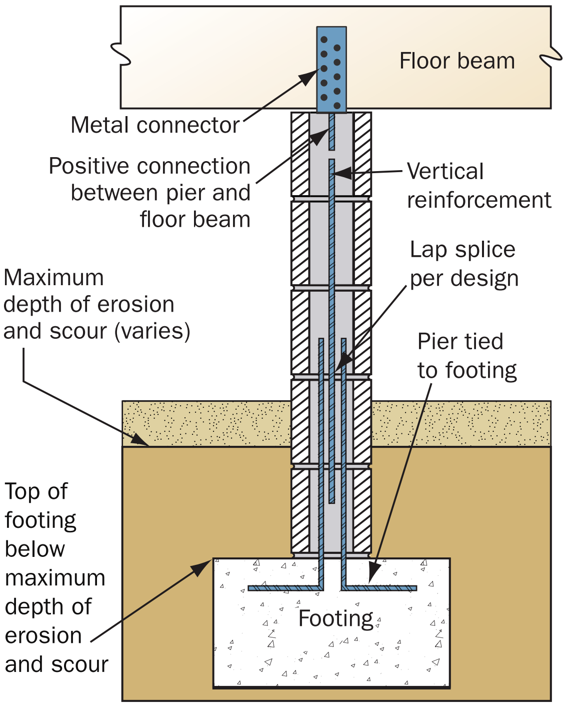
The small footings on the piers in this photograph did not prevent these piers from overturning during Hurricane Iniki.

The combination of high winds and moist (sometimes salt-laden) air can have a damaging effect on masonry construction by forcing moisture into even the smallest of cracks or openings in the masonry joints. The entry of moisture into reinforced masonry construction can lead to corrosion of the reinforcement steel and subsequent cracking and spalling of the masonry. Moisture resistance is highly influenced by the quality of the materials and the quality of the masonry construction at the site.

Good Masonry Practice

- Masonry units and packaged mortar and grout materials should be stored off the ground and covered.
- Masonry work in progress must be well protected.
- Mortar and grouts must be carefully batched and mixed. The 2003 International Building Code (IBC 2003) specifies grout proportions by volume for masonry construction.

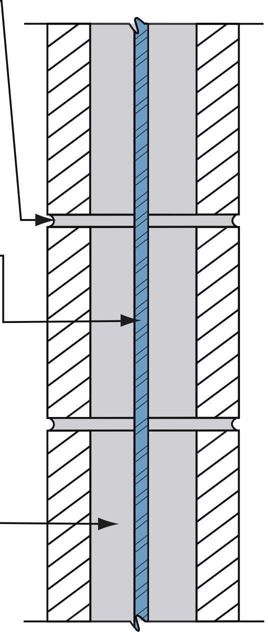
Recommendations for Masonry Piers in Coastal Regions



Head and bed joints must be well mortared and tooled to prevent water intrusion. Type S mortar for below grade is recommended. Concave joints and V-joints provide the best moisture resistance.

Reinforcing bars must be protected from saltwater to prevent corrosion. Good grout practice will normally protect reinforcing. Galvanized or epoxy-coated bars may enhance pier performance, but holidays and chipped coatings must be painted, and lap splice lengths must be increased by 50 percent for epoxy-coated bars.

Grout should be in conformance with the requirements of the IBC 2003. Cleanouts should be placed at the bottom of fully grouted cells to ensure that the grout completely fills the cells from top to bottom.



Foundation Walls

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 — Technical Fact Sheet No. 15

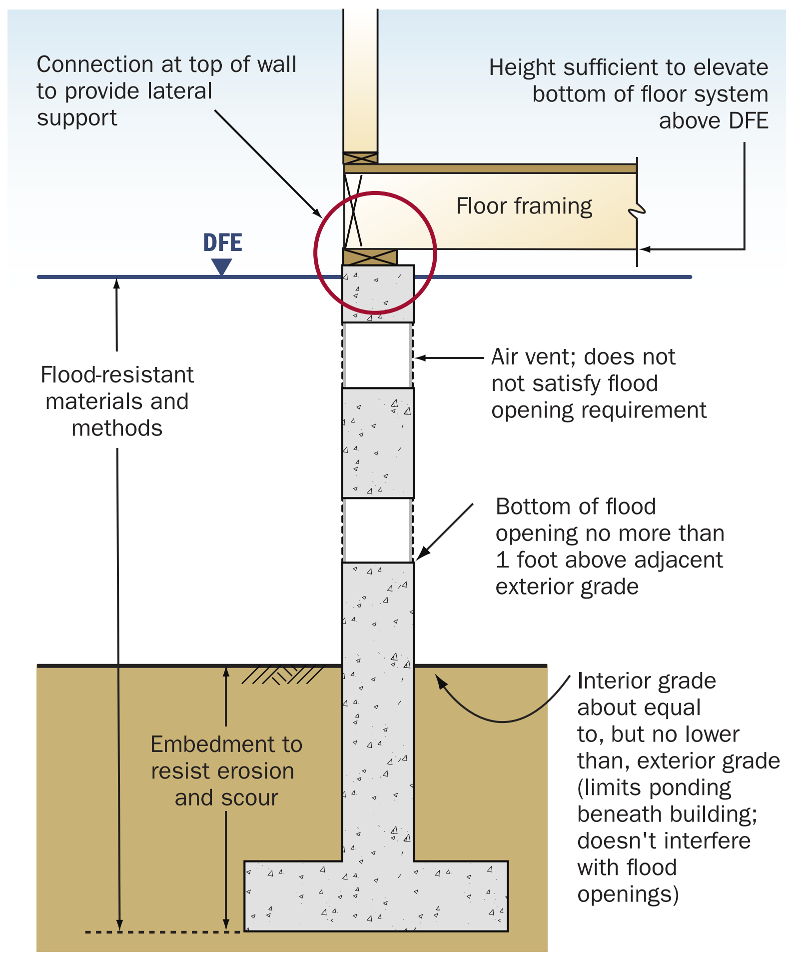
Purpose: To discuss the use of foundation walls in coastal buildings.

Key Issues

- Foundation walls include stemwalls, cripple walls, and other solid walls.
- Foundation walls are prohibited by the National Flood Insurance Program (NFIP) in V zones.*
- Use of foundation walls in A zones in coastal areas should be limited to locations where only shallow flooding occurs, and where the potential for erosion and breaking waves is low.
- Where foundation walls are used, flood-resistant design of foundation walls must consider embedment, height, materials and workmanship, lateral support at the top of the wall, flood openings and ventilation openings, and interior grade elevation.

Foundation Walls – When Are They Appropriate?

Use of foundation walls – such as those in crawlspace and other solid-wall foundations – is potentially troublesome in coastal areas for two reasons: (1) they present an obstruction to breaking waves and fast-moving flood waters, and (2) they are typically constructed on shallow footings, which are vulnerable to erosion. For these reasons, ***their use in coastal areas should be limited to sites subject to shallow flooding, where erosion potential is low and where breaking waves do not occur during the Base Flood***. The NFIP prohibits the use of foundation walls in V zones*. This *Home Builder's Guide to Coastal Construction* recommends against their use in many A zones in coastal areas. ***Deeply embedded pile or column foundations are recommended*** because they present less of an obstruction to floodwaters and are less vulnerable to erosion.



Foundation walls – flood-resistant design considerations

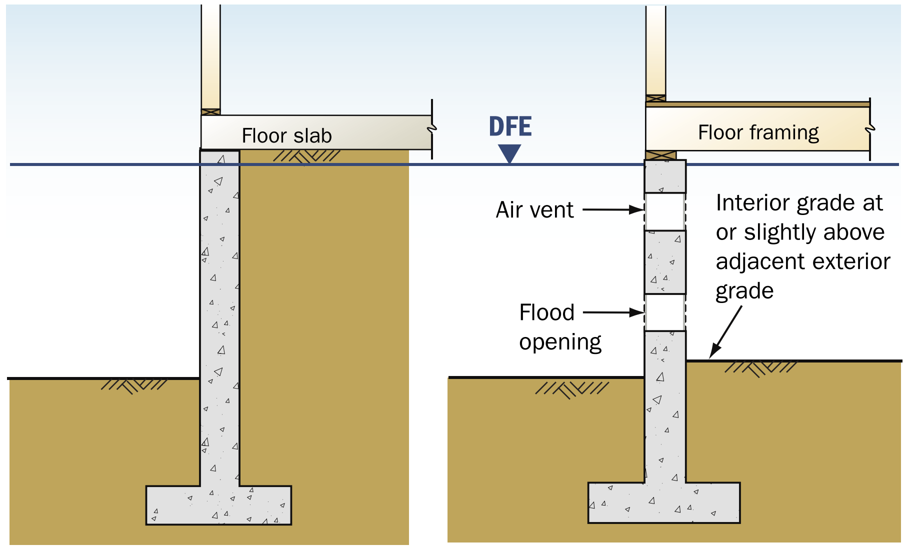
* Note that the use of shearwalls below the Design Flood Elevation (DFE) may be permitted in limited circumstances (e.g., lateral wind/seismic loads cannot be resisted with a braced, open foundation. In such cases, minimize the length of shearwalls and the degree of obstruction to floodwaters and waves, orient shearwalls parallel to the direction of flow/waves, do not form enclosures). Consult the authority having jurisdiction for guidance concerning shearwalls below the DFE.

Design Considerations for Foundation Walls

The design of foundation walls is covered by building codes and standards (e.g., *Standard for Hurricane Resistant Residential Construction*, SSTD 10, by the Southern Building Code Congress International). For flood design purposes, there are six additional design considerations: (1) embedment, (2) height, (3) materials and workmanship, (4) lateral support at the top of the wall, (5) flood openings and ventilation openings, and (6) interior grade elevation.

Embedment – The top of the footing should be no higher than the anticipated depth of erosion and scour (this basic requirement is the same as that for piers; see figure at right and Fact Sheet No. 14). If the required embedment cannot be achieved without extensive excavation, consider a pile foundation instead.

Height – The wall should be high enough to elevate the bottom of the floor system to or above the DFE (see Fact Sheet No. 4).



Floor slab atop backfilled stemwall foundation

Floor joist system and crawlspace

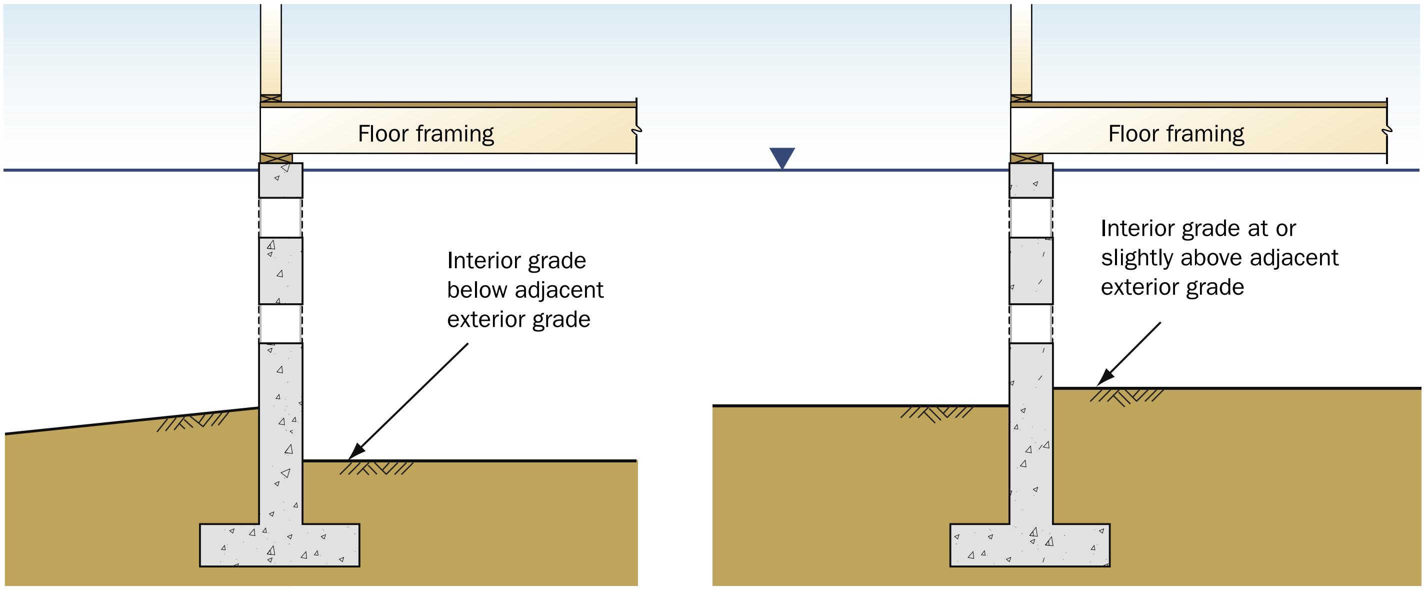
Materials and Workmanship – Foundation walls can be constructed from many materials, but masonry, concrete, and wood are the most common. Each material can be specified and used in a manner to resist damage due to moisture and inundation (see Fact Sheet No. 8). Workmanship for flood-resistant foundations is crucial. Wood should be preservative-treated for foundation or marine use (aboveground or ground-contact treatment will not be sufficient). Cuts and holes should be field-treated. Masonry should be reinforced and fully grouted (see Fact Sheet No. 16 for masonry details). ***Concrete*** should be reinforced and composed of a high-strength, low water-to-cement ratio mix.

Lateral Support at the Top of the Wall – Foundation walls must be designed and constructed to withstand all flood, wind, and seismic forces, as well as any unbalanced soil/hydrostatic loads. The walls will typically require lateral support from the floor system and diaphragm, and connections to the top of the walls must be detailed properly. Cripple walls, where used, should be firmly attached and braced.

Flood Openings and Ventilation Openings – Any area below the DFE enclosed by foundation walls must be equipped with openings capable of automatically equalizing the water levels inside and outside the enclosure. Specific flood opening requirements are included in Fact Sheet No. 27. Flood openings are not required for backfilled stemwall foundations supporting a slab. ***Air ventilation openings required by building codes do not generally satisfy the flood opening requirement***; the air vents are typically installed near the top of the wall, the flood vents must be installed near the bottom, and opening areas for air flow may be insufficient for flood flow.

Interior Grade Elevation – Conventional practice for crawlspace construction calls for excavation of the crawlspace and use of the excavated soil to promote drainage away from the structure (see left-hand figure on page 3). This approach may be acceptable for non-floodplain areas, but in floodplains, this practice can result in increased lateral loads (e.g., from saturated soil) against the foundation walls and ponding in the crawlspace area. If the interior grade of the crawlspace is below the DFE, NFIP requirements can be met by ensuring that the interior grade is at or above the lowest exterior grade adjacent to the building (see right-hand figure on page 3). When floodwaters recede, the flood openings in the foundation walls allow floodwaters to automatically exit the crawlspace. FEMA may accept a crawlspace elevation up to 2 feet below the lowest adjacent exterior grade; however, the community must adopt specific requirements in order for this type of crawlspace to be constructed in a floodplain.

If a stemwall and floor slab system is used, the interior space beneath the slab should be backfilled with compacted gravel (or such materials as required by the building code). As long as the system can act monolithically, it will resist most flood forces. However, if the backfill settles or washes out, the slab will collapse and the wall will lose lateral support.



Conventional practice - not recommended

Recommended practice

Crawlspace construction: interior grade elevation for A zones not subject to breaking waves and erosion

Masonry Details

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 Technical Fact Sheet No. 16

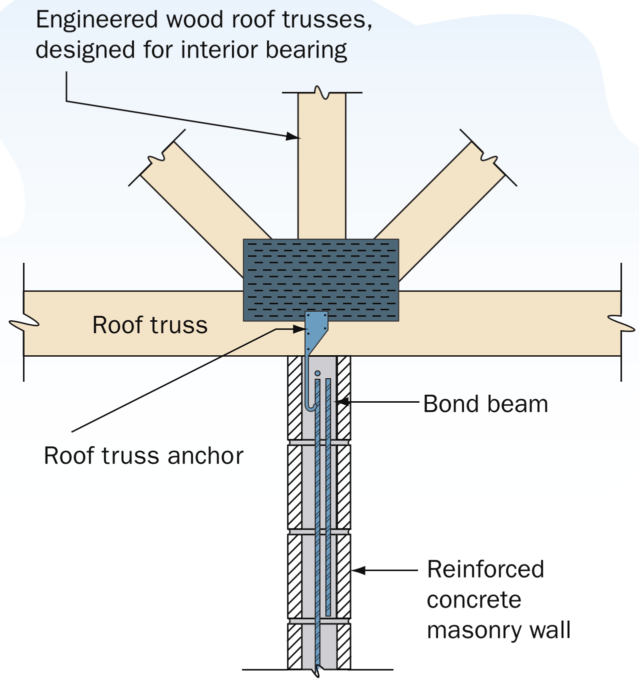
Purpose: To highlight several important details for masonry construction in coastal areas.

Key Issues

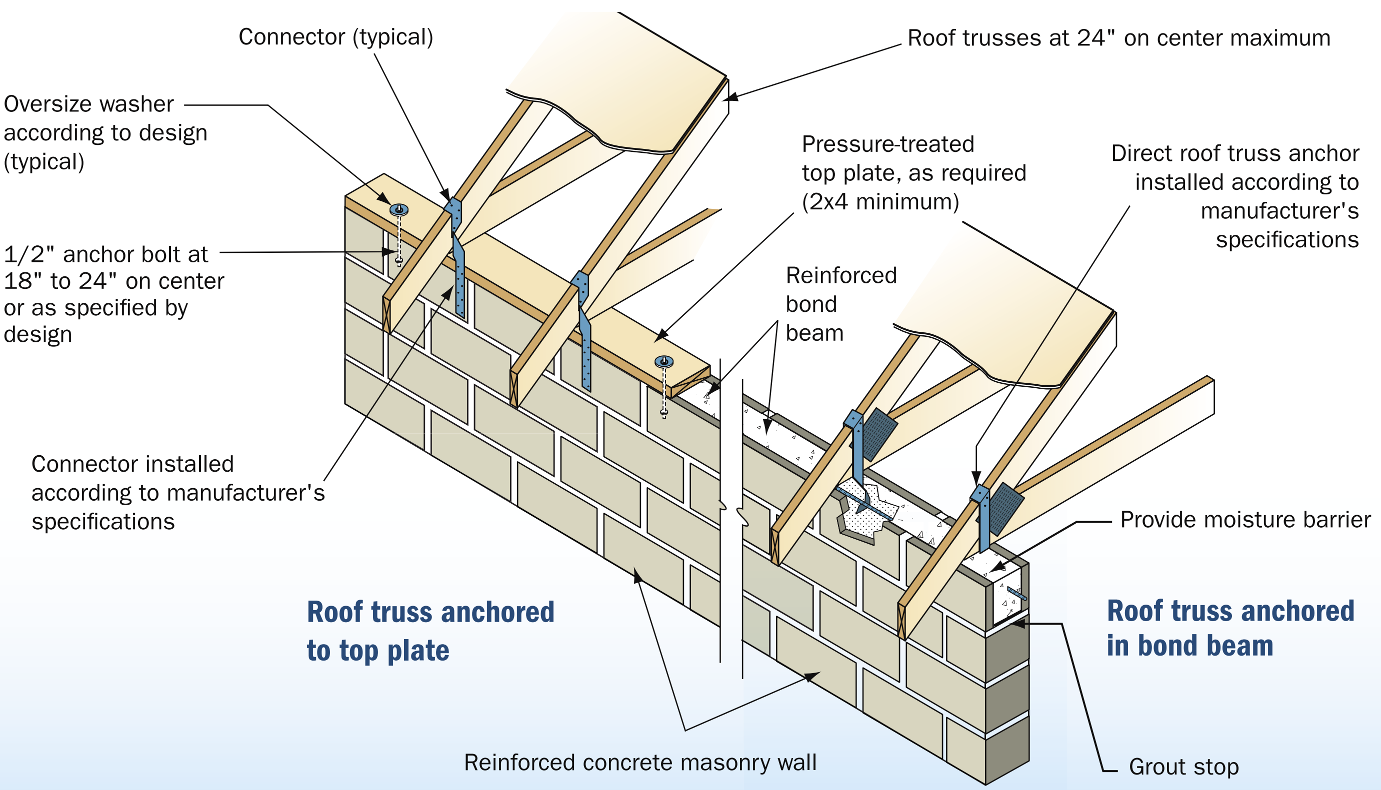
- Continuous, properly connected load paths are essential because of the higher vertical and lateral loads on coastal structures.
- Building materials must be durable enough to withstand the coastal environment.
- Masonry reinforcement requirements are more stringent in coastal areas.

Load Paths

A properly connected load path from roof to foundation is crucial in coastal areas (see Fact Sheets Nos. 10 and 17). The following details show important connections for a typical masonry home.

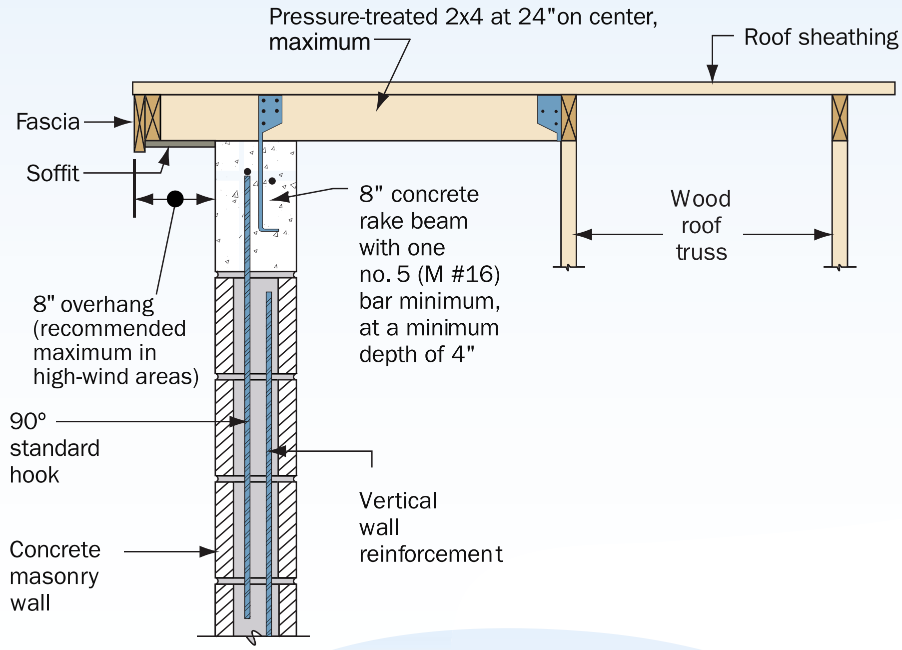


Roof framing to interior masonry wall

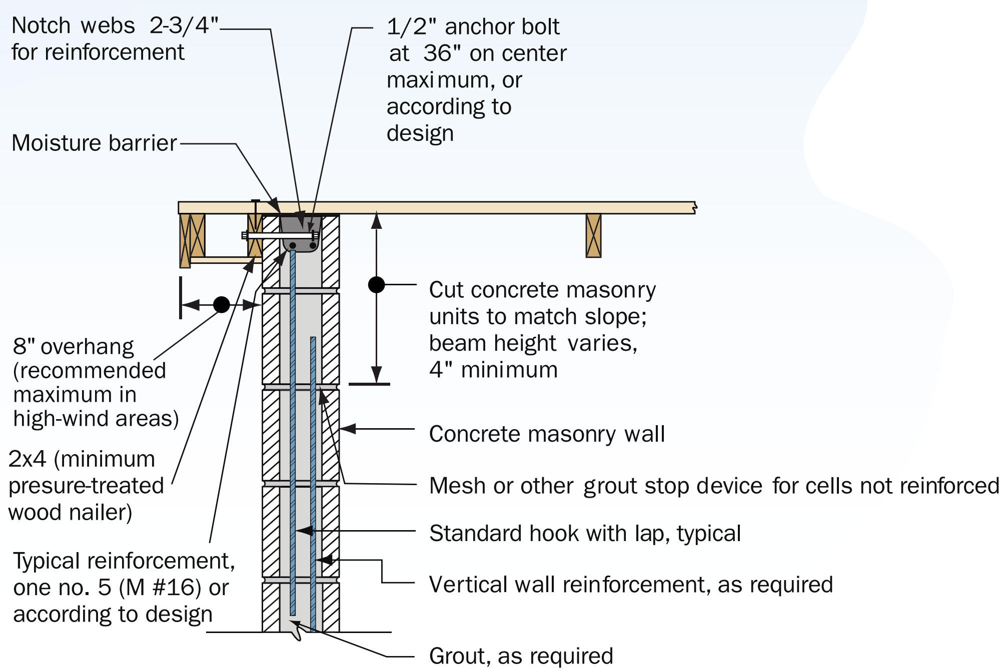


Roof framing to masonry wall.

Gable end wall – cut concrete rake beam with outlooker-type overhang



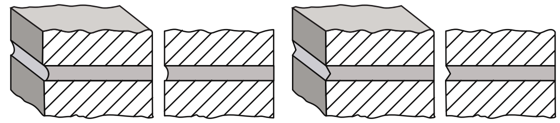
Gable end wall – cut masonry rake beam with ladder-type overhang



Gable endwall connection.

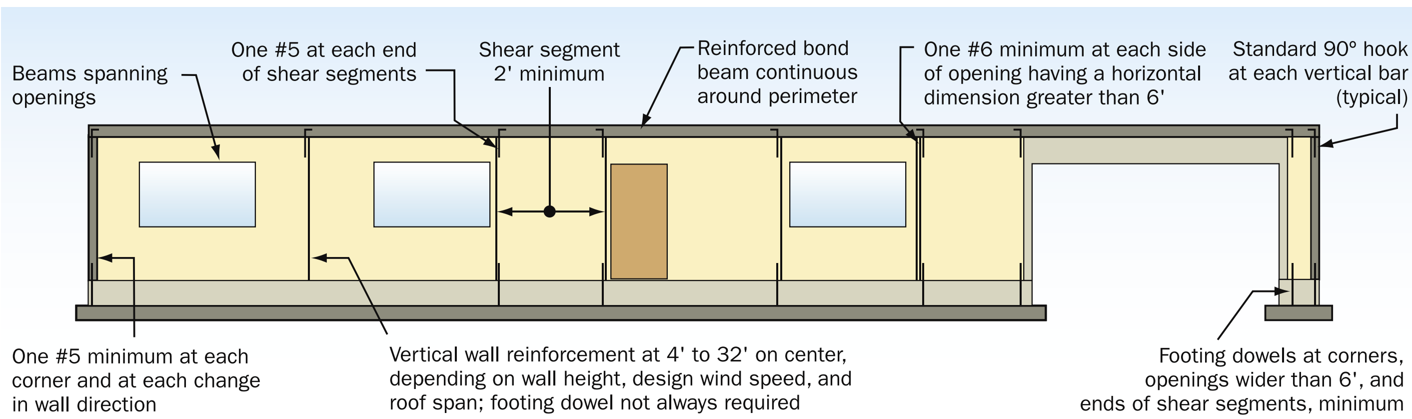
Durability – High winds and salt-laden air can damage masonry construction. The entry of moisture into large cracks can lead to corrosion of the reinforcement and subsequent cracking and spalling. Moisture resistance is highly dependent on the materials and quality of construction.

Quality depends on:



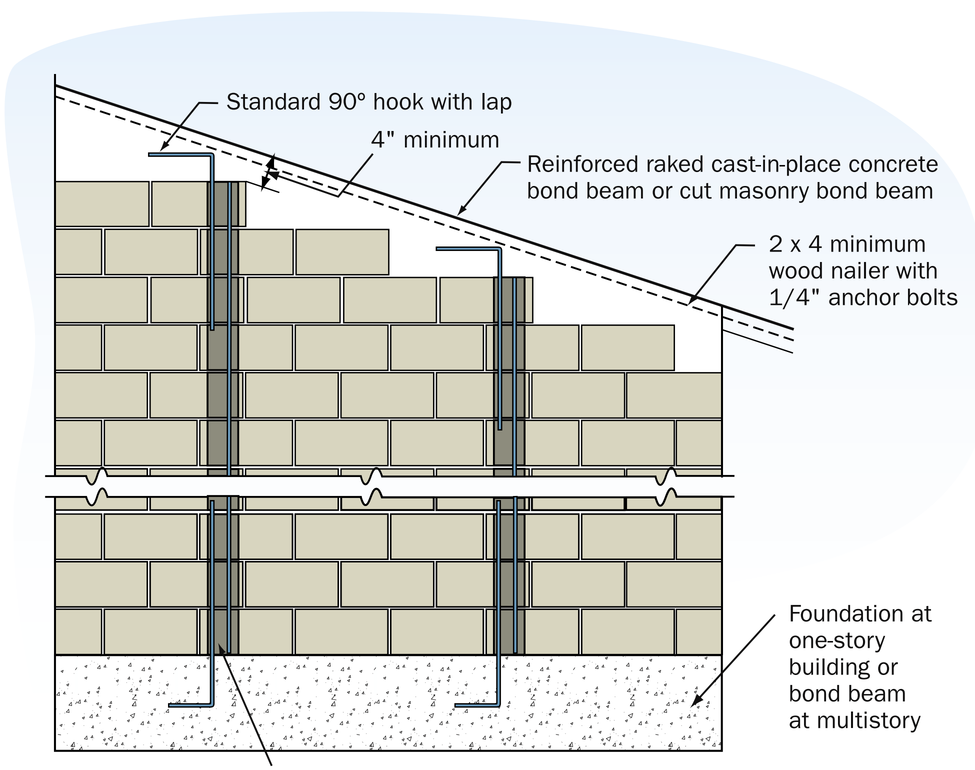
- **Proper storage of material –** Keep stored materials covered and off the ground.
- **Proper batching –** Mortar and grout must be properly batched to yield the required strength.
- **Good workmanship –** Head and bed joints must be well mortared and well tooled. Concave joints and V-joints provide the best moisture protection (see detail above). All block walls should be laid with full mortar coverage on horizontal and vertical face shells. Block should be laid using a “double butter” technique for spreading mortar head joints. This practice provides for mortar-to-mortar contact as two blocks are laid together in the wall and prevents hairline cracking in the head joint.
- **Protection of work in progress –** Keep work in progress protected from rain. During inclement weather, the tops of unfinished walls should be covered at the end of the workday. The cover should extend 2 feet down both sides of the masonry and be securely held in place. Immediately after the completion of the walls, the wall cap should be installed to prevent excessive amounts of water from directly entering the masonry.

Reinforcement: Masonry must be reinforced according to the building plans. Coastal homes will typically require more reinforcing than inland homes. The following figure shows typical reinforcement requirements for a coastal home.



Masonry reinforcement.

Gable Ends: Because of their exposure, gable ends are more prone to damage than are hipped roofs unless the joint in conventional construction at the top of the endwall and the bottom of the gable is laterally supported for both inward and outward forces. The figure at right shows a construction method that uses continuous masonry from the floor to the roof diaphragm with a raked cast-in-place concrete bond beam or a cut masonry bond beam.

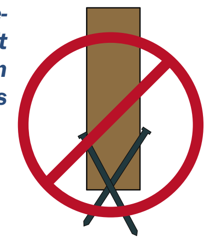


Continuous gable endwall reinforcement.

Use of Connectors and Brackets

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

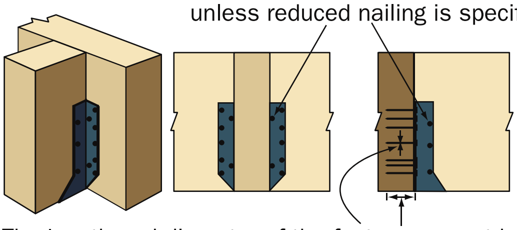
Purpose: To highlight important building connections and illustrate the proper use of various types of connection hardware.



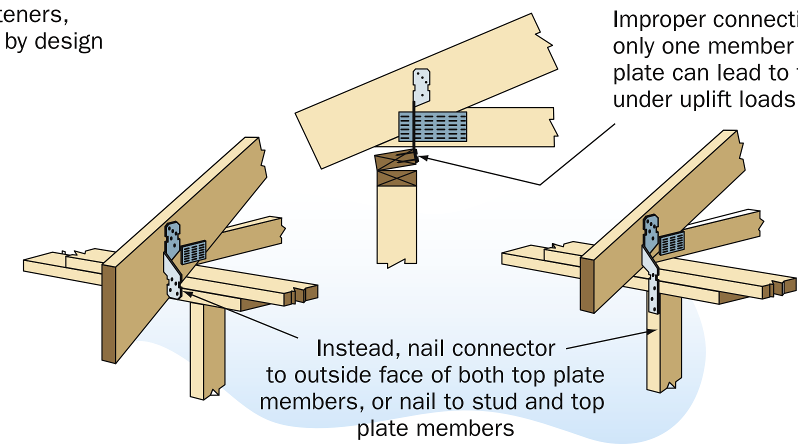
Never rely on toe-nailing for uplift connections in high-wind areas

Key Issues

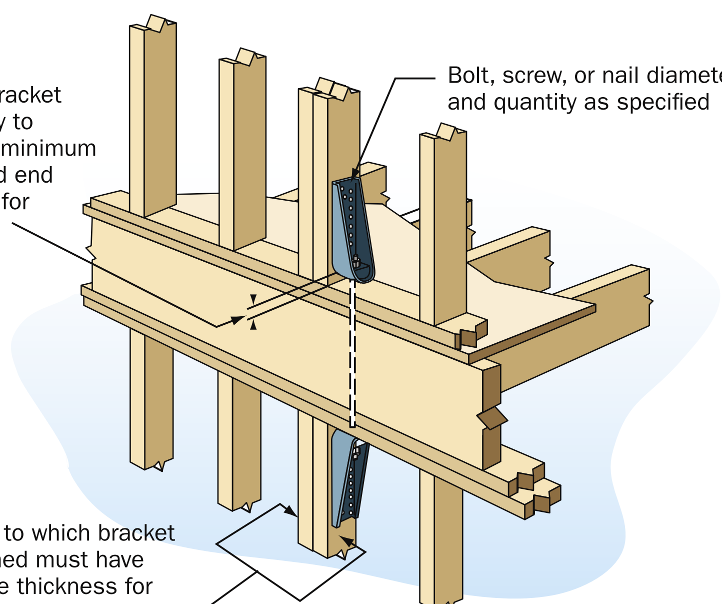
- In high-wind regions, special hardware is used for most framing connections. Toe-nailing is not an acceptable method for resisting uplift loads in high-wind regions.
- Hardware must be installed according to the manufacturer's or engineer's specifications.
- The correct number of the specified fasteners (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).



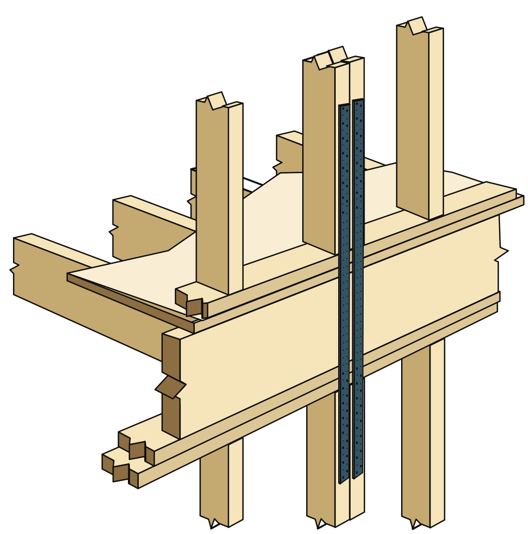
Proper fasteners must be used with connection hardware.



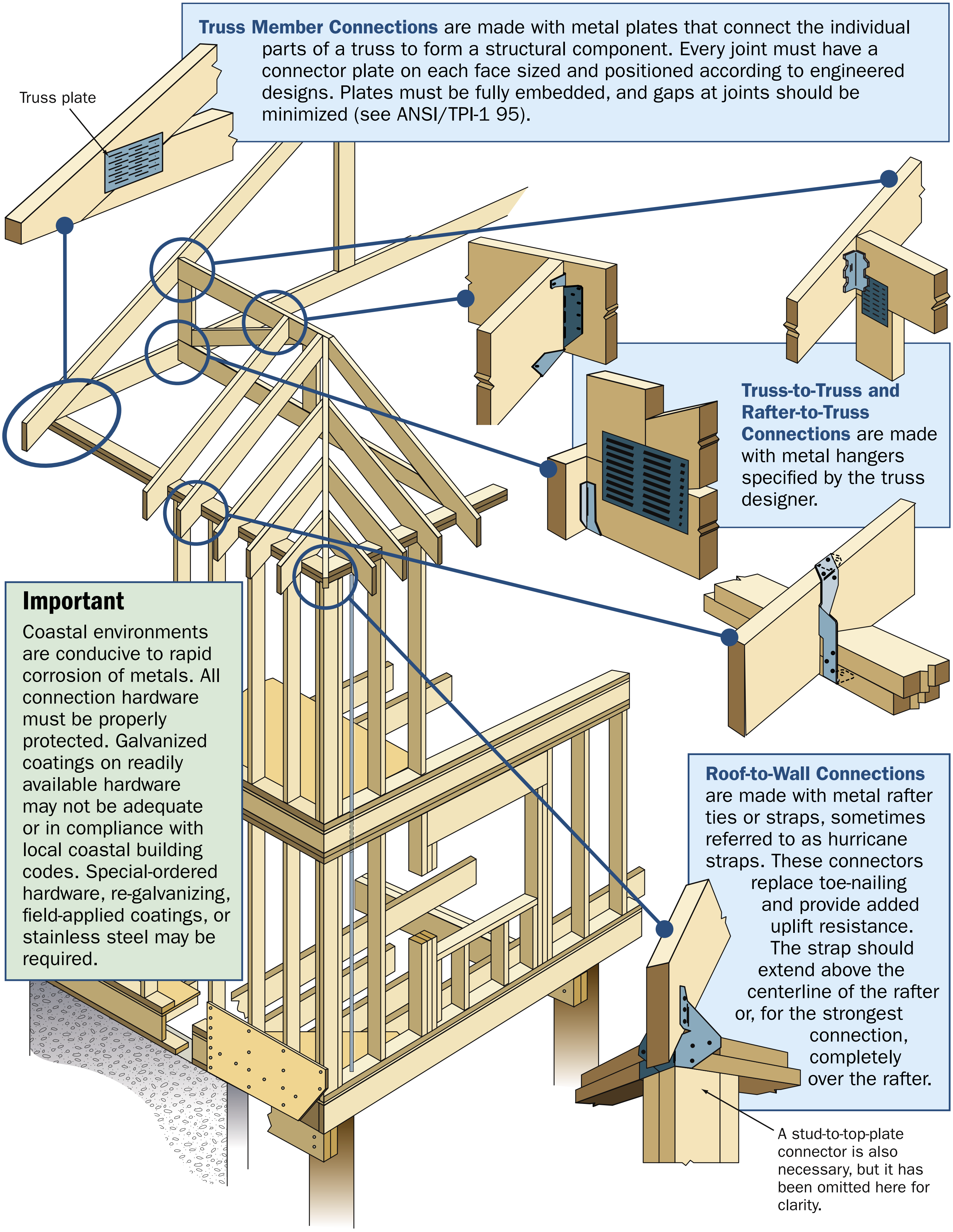
Avoid load path failure at roof-to-wall connections.



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).

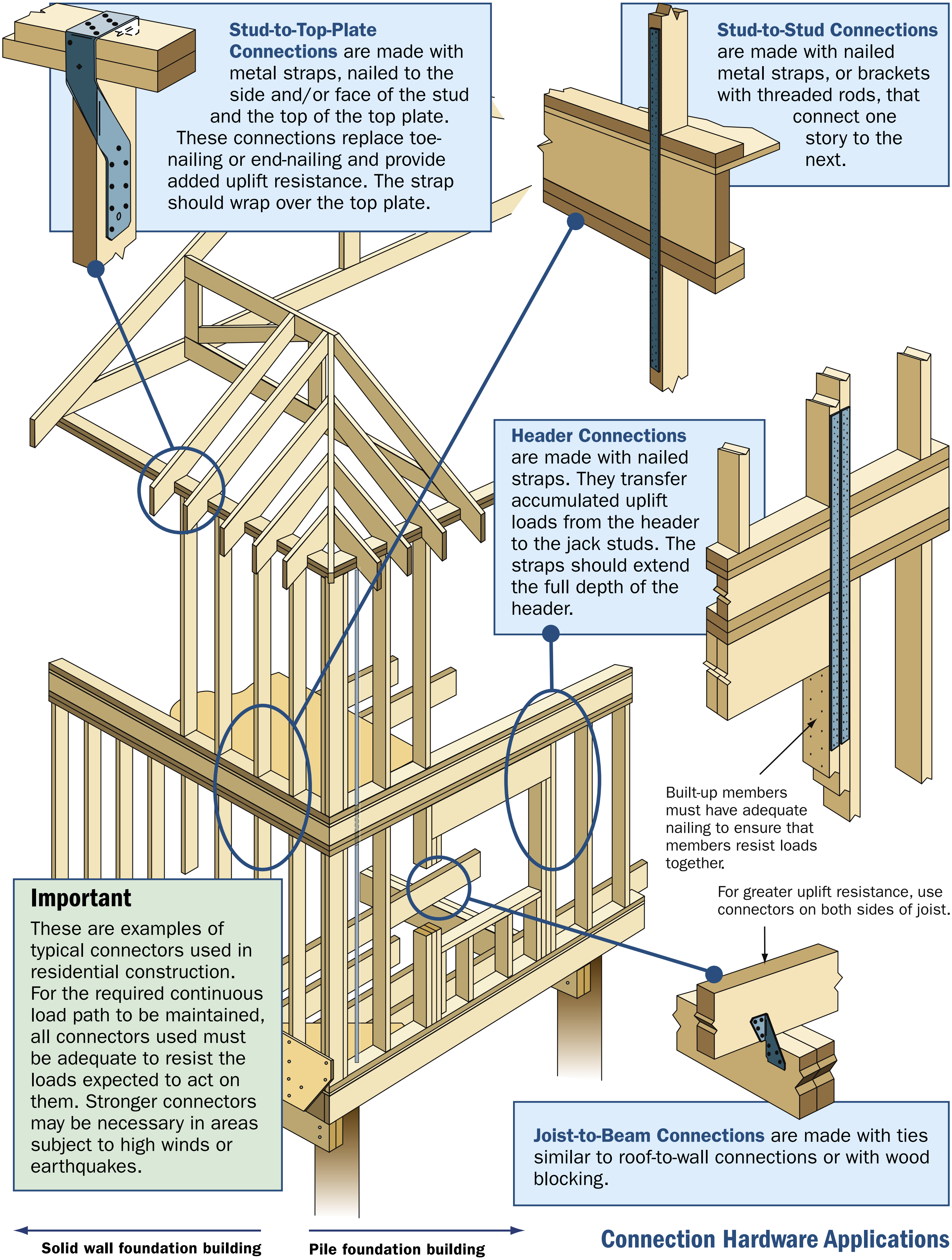
Truss-to-Truss and Rafter-to-Truss Connections are made with metal hangers specified by the truss designer.

Important

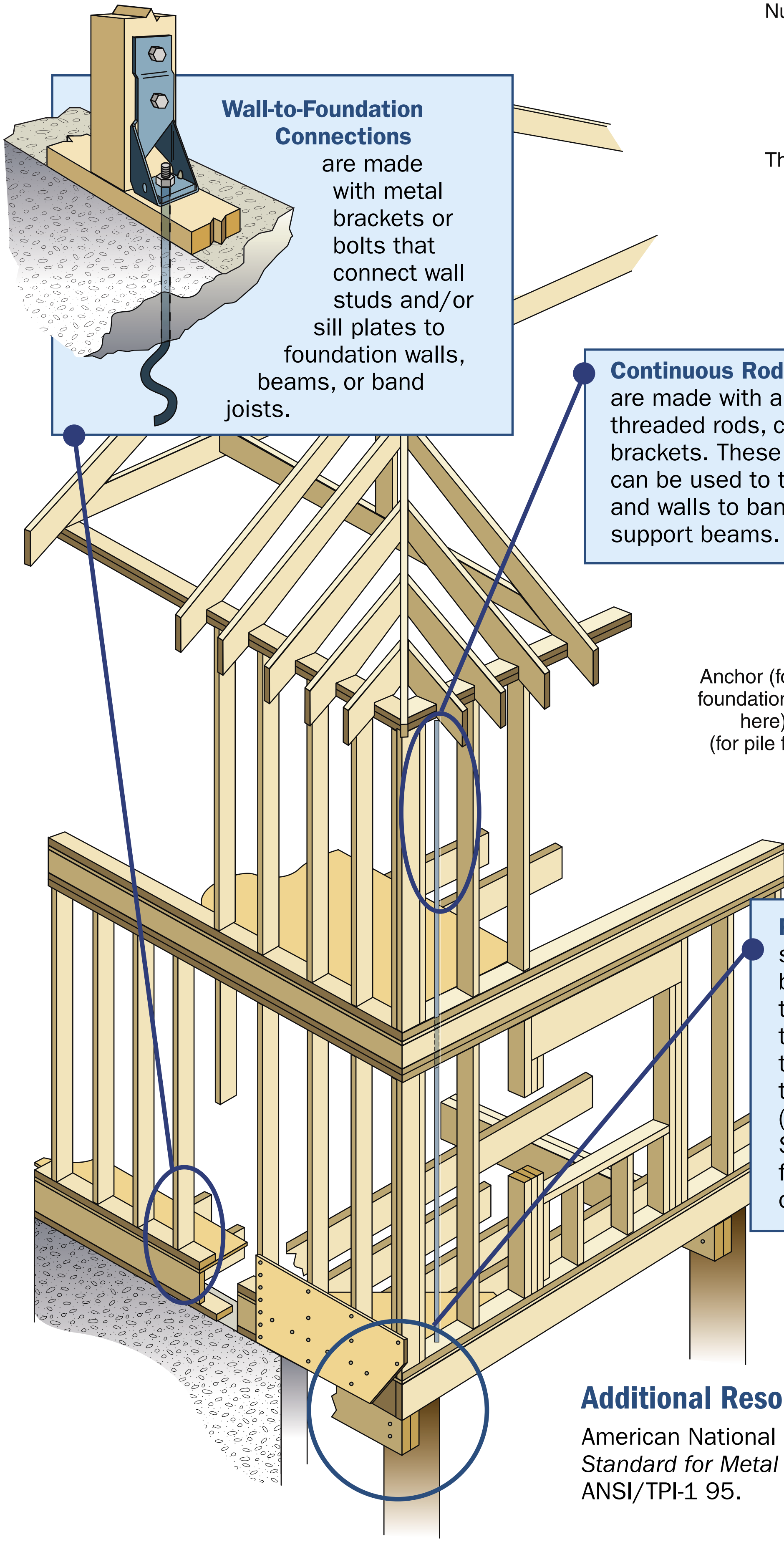
Coastal environments are conducive to rapid corrosion of metals. All connection hardware must be properly protected. Galvanized coatings on readily available hardware may not be adequate or in compliance with local coastal building codes. Special-ordered hardware, re-galvanizing, field-applied coatings,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

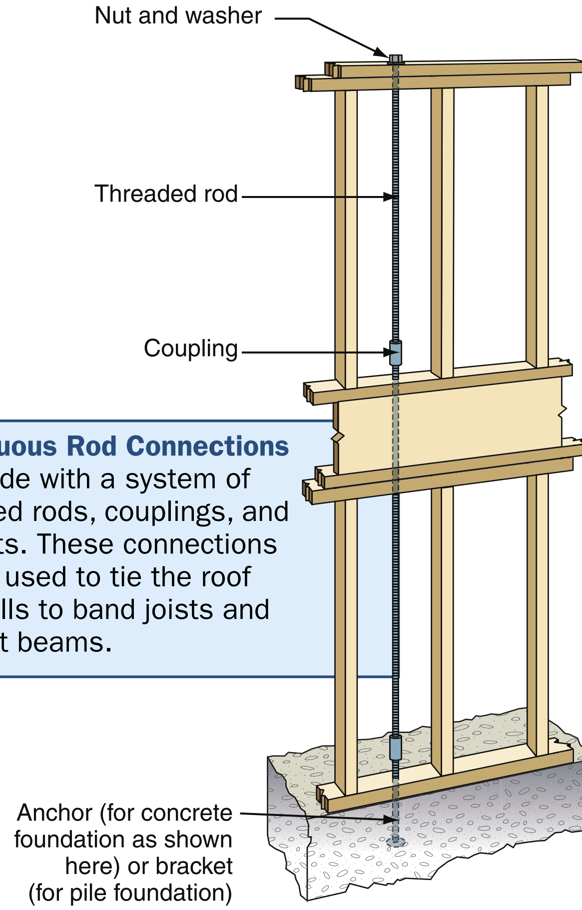
Connection Hardware Applications



Connection Hardware Applications

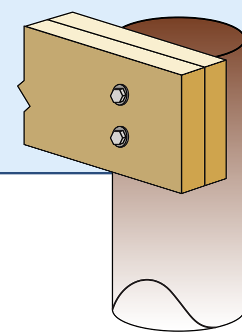


Wall-to-Foundation Connections are made with metal brackets or bolts that connect wall studs and/or sill plates to foundation walls, beams, or band joists.



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.

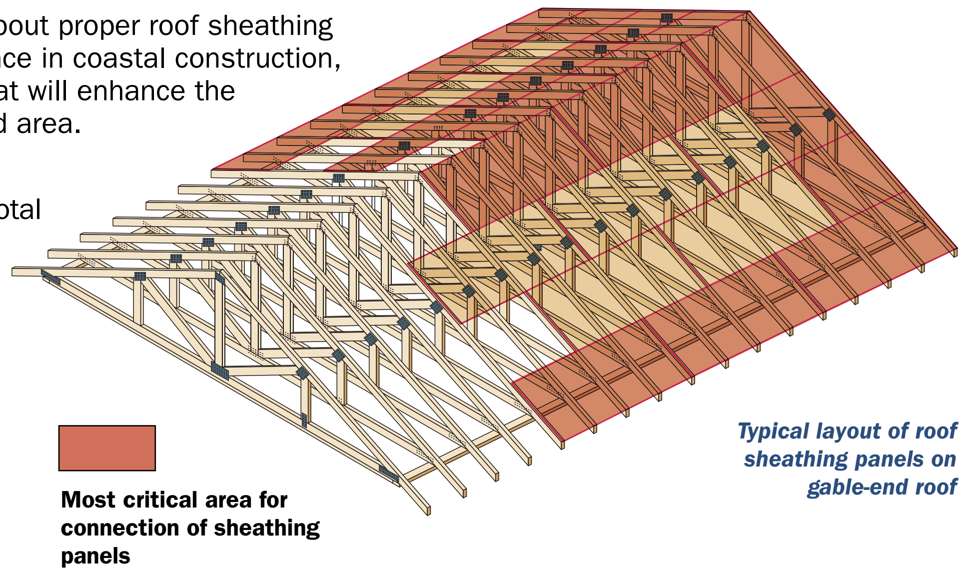
Connection Hardware Applications

Roof Sheathing Installation

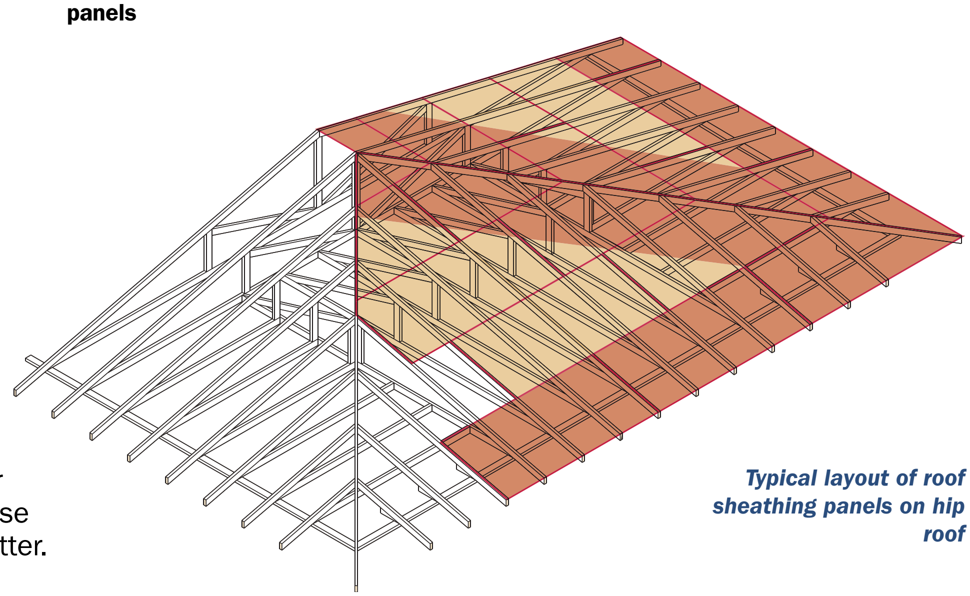
Purpose: To provide information about proper roof sheathing installation, emphasize its importance in coastal construction, and illustrate fastening methods that will enhance the durability of a building in a high-wind area.

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.



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

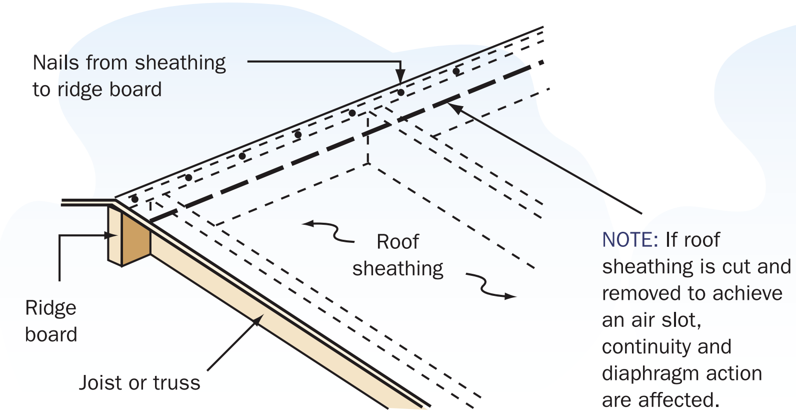
An 8d nail (2.5 inches long) is the minimum size nail to use for fastening sheathing panels. Full round heads are recommended to avoid head pull-through. Deformed-shank (i.e., ring- or screw-shank) nails are required near ridges, gables, and eaves in areas with design wind speeds over 110 mph (3-second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

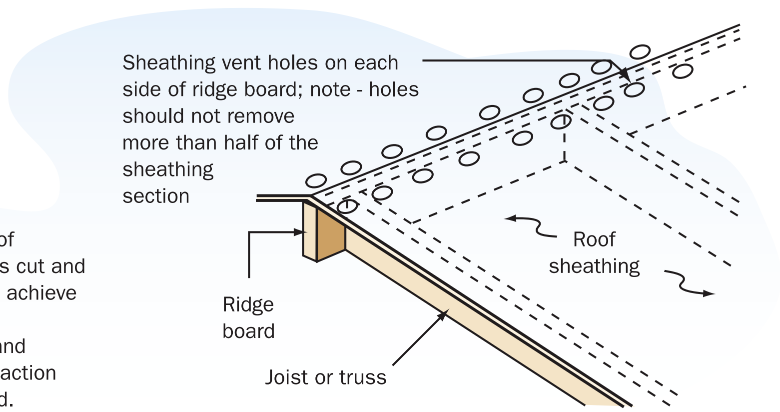
It is ***extremely important*** to have proper fastener spacing on **all** panels. Loss of just one panel in a windstorm can lead to total building failure. Drawings should be checked to verify the required spacing; closer spacing may be required at corners, edges, and ridges. Visually inspect work after 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.



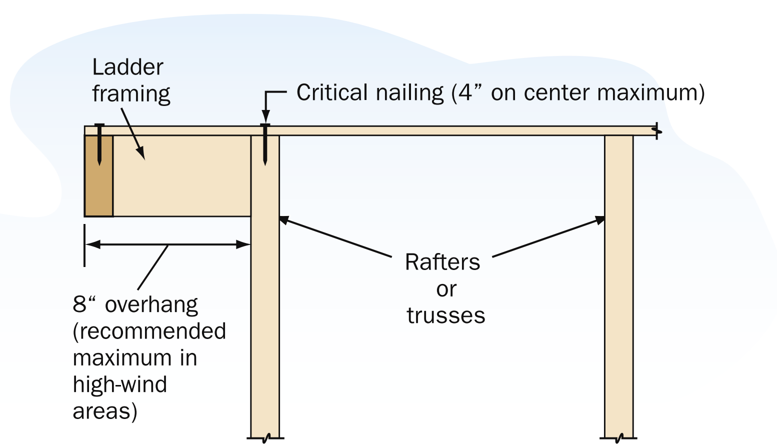
Method for maintaining a continuous load path at the roof ridge by nailing roof sheathing.



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

Ladder Framing at Gable Ends

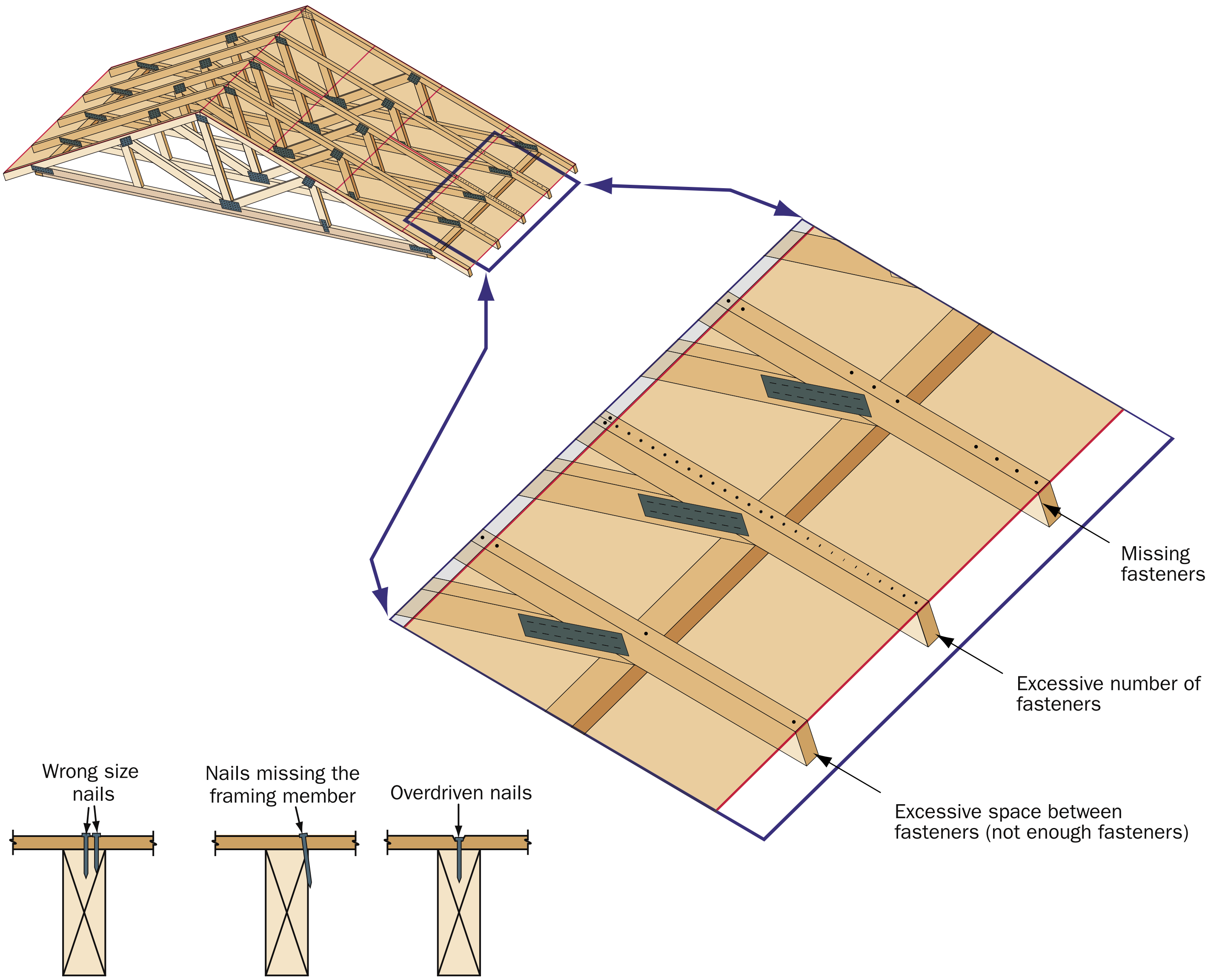
Use extra care when attaching a ladder-framed extension to a gable end. Many homes have been severely damaged by coastal storms because of inadequate connections between the roof sheathing and the gable truss. The critical fasteners occur at the gable-framing member, not necessarily at the edge of the 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

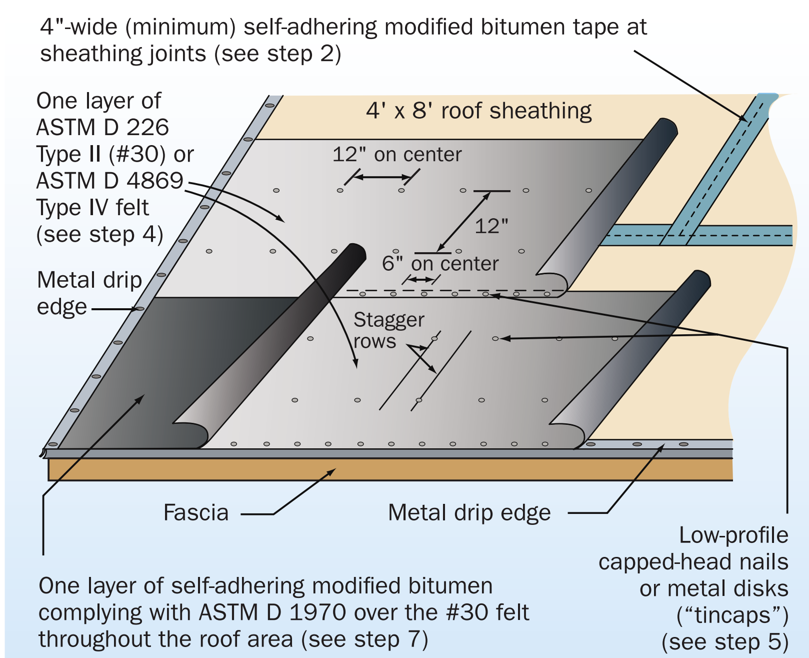
> **Note:** This fact sheet provides general guidelines and recommended enhancements for improving upon typical practice. It is advisable to ***consult local building requirements*** for type and installation of underlayment, particularly if specific enhanced underlayment practices are required locally.

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).

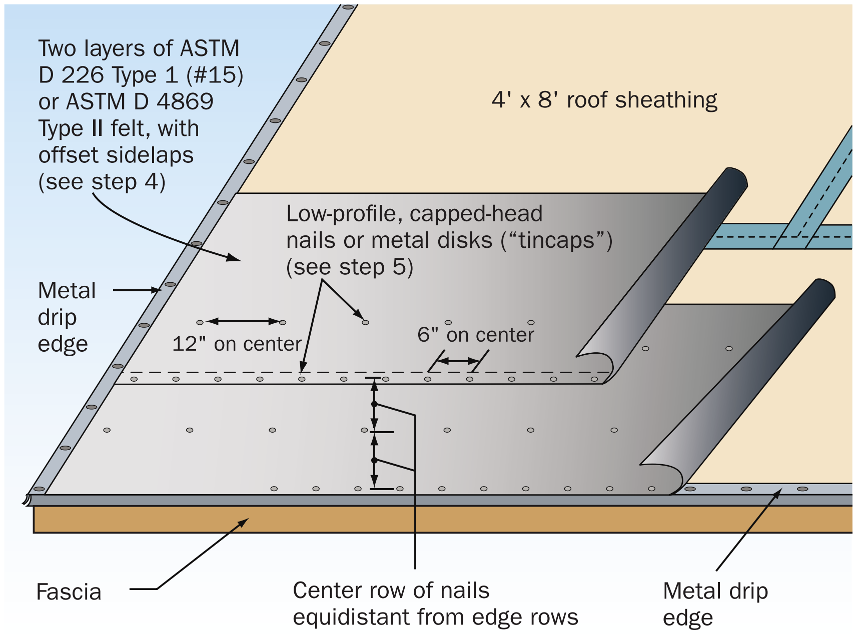
Installation Sequence – Option 1[1]

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.



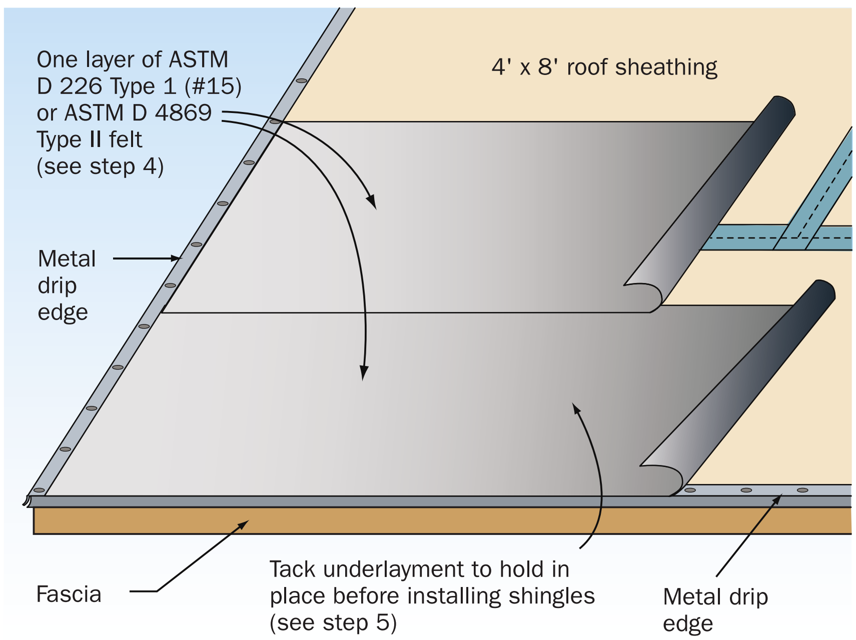
Installation Sequence – Option 2[1]

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.

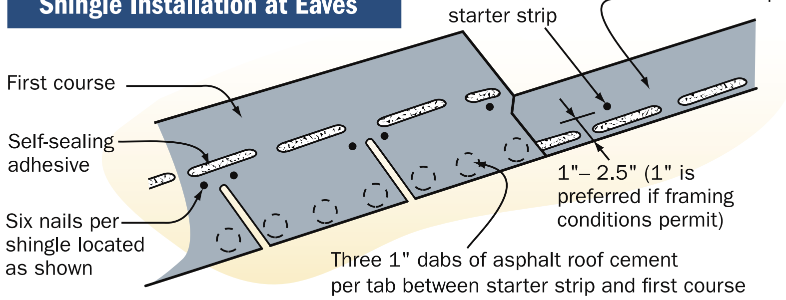
Key Issues

- 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

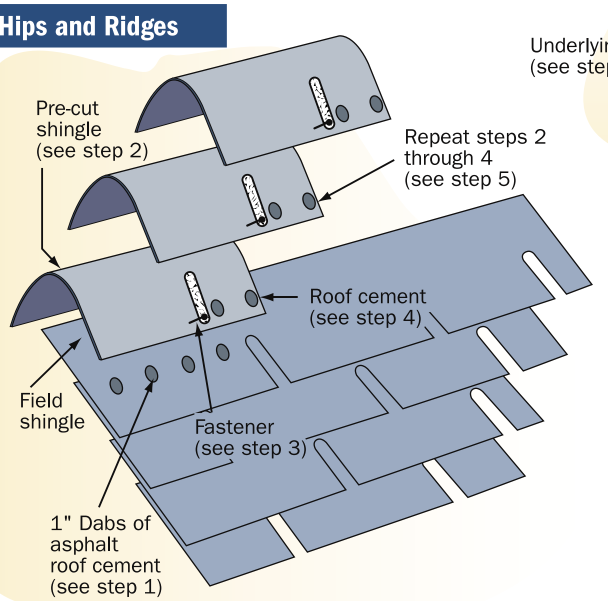
1 Follow shingle installation procedures for enhanced wind resistance.

Shingle Installation at Eaves

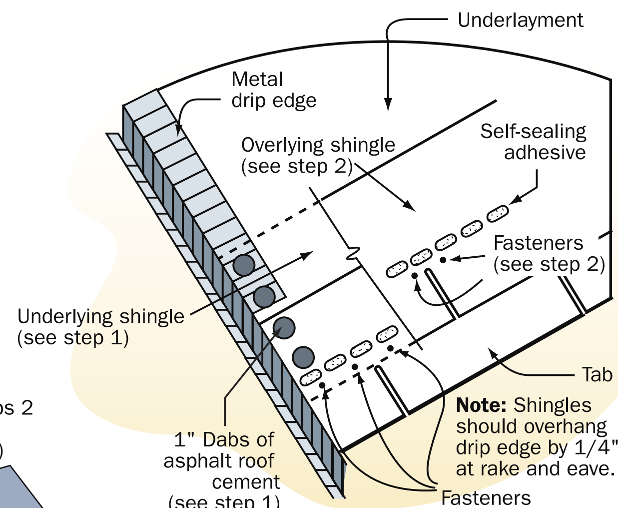


Shingle Installation at Hips and Ridges

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

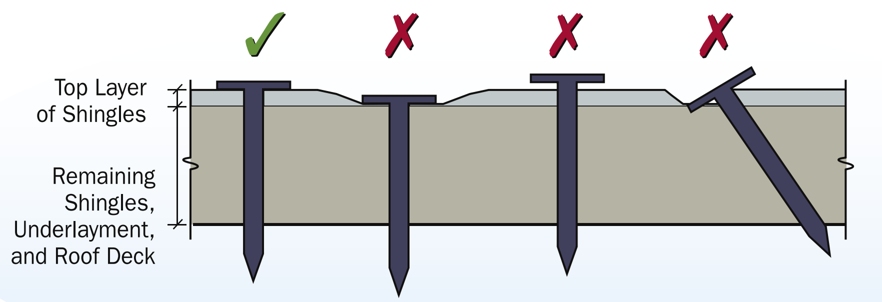
1. Design wind speed based on 3-second peak gust.
2. ASTM D 3462 specifies a minimum fastener pull-through resistance of 20 lb at 73° F. If a higher resistance is desired, it must be specified.

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.

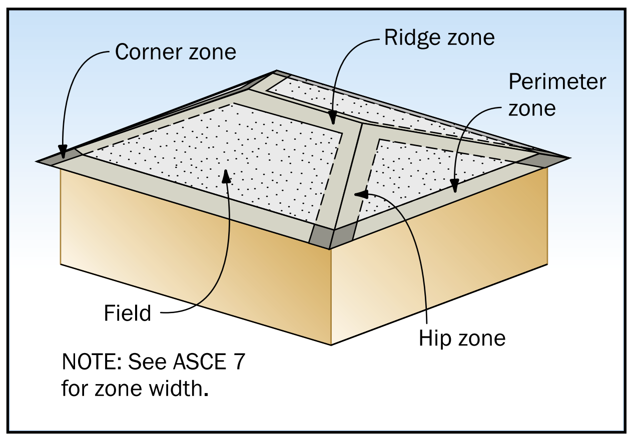


***Figure 1* For critical and essential facilities, clip all tiles in the corner, ridge, perimeter, and hip zones.**

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.)

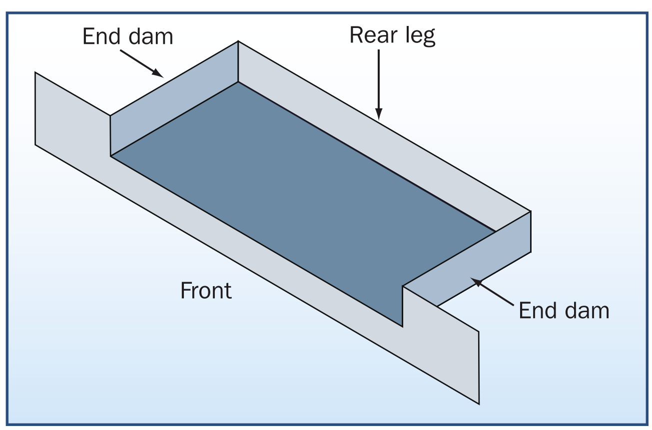


Figure 1 Pan flashing.

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.

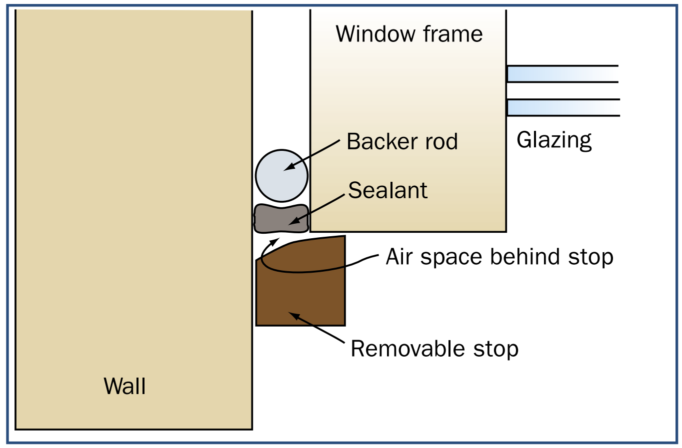


Figure 2
Protection of sealant with a stop.

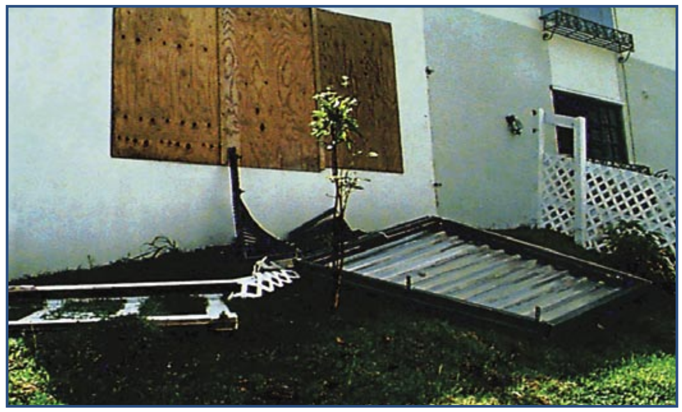


Figure 3
Hurricane Georges in Puerto Rico. The window lying on the ground was protected by a shutter. However, the shutter was attached to the window frame. The window frame fasteners were over-stressed and the entire assembly failed. Attachment of the shutter directly to the wall framing is a more reliable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

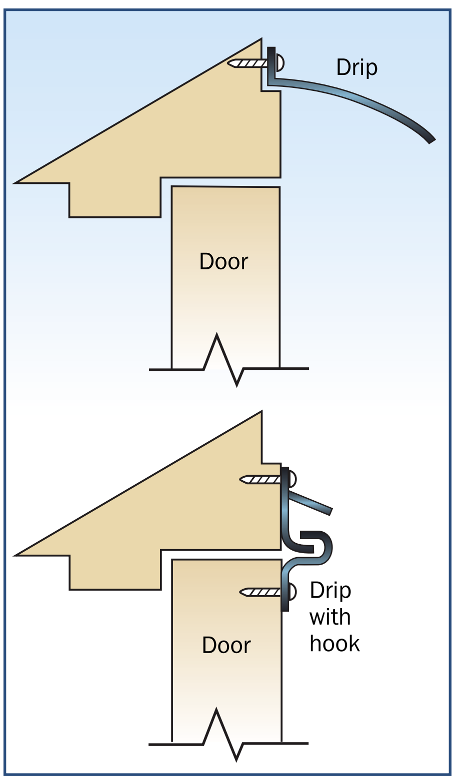


Figure 4
Drip at door head and drip with hook at head

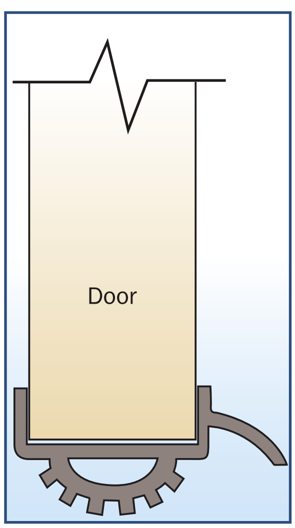


Figure 5
Door shoe with drip and vinyl seal.

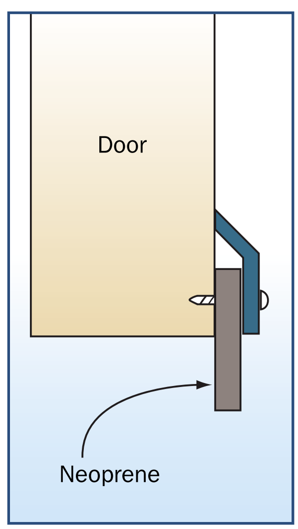


Figure 6
Neoprene door bottom sweep.

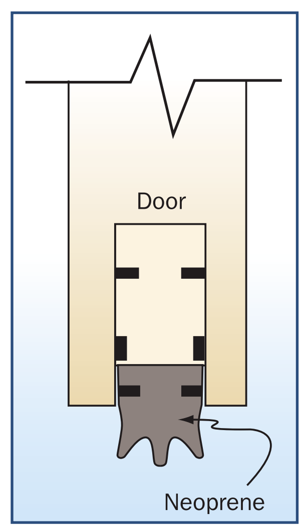


Figure 7
Automatic door bottom.

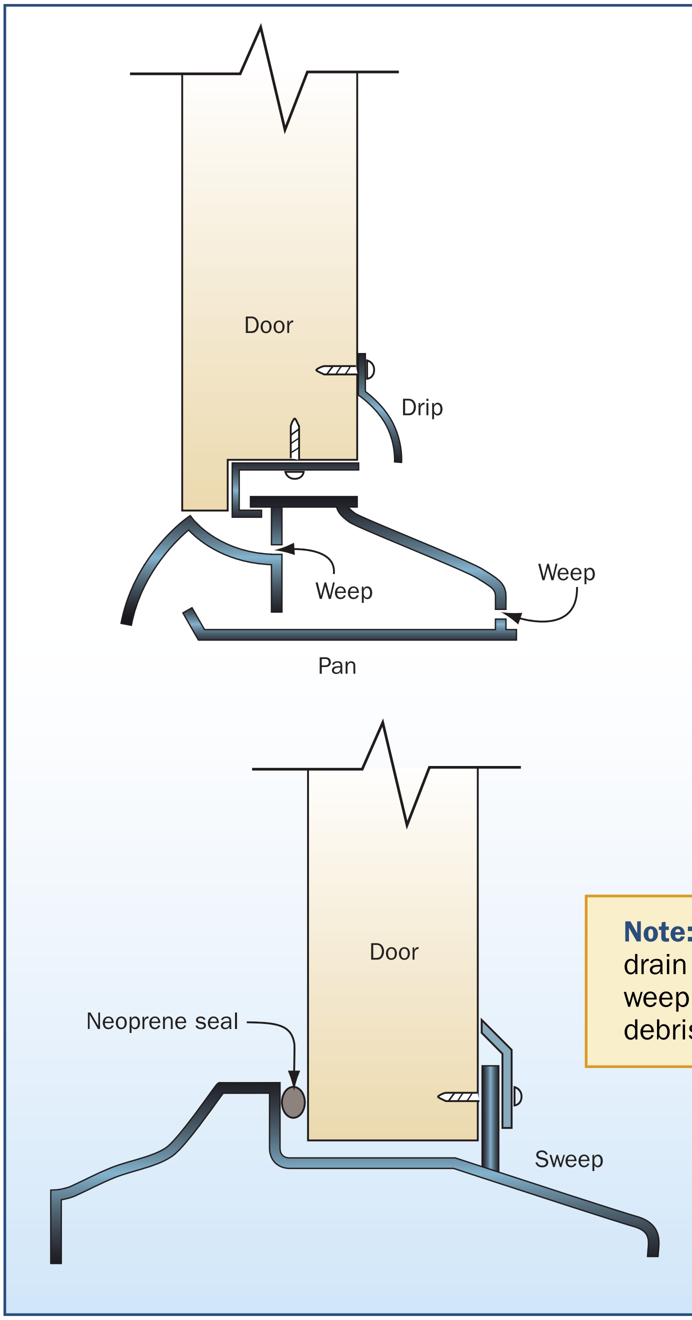


Figure 8 Thresholds.

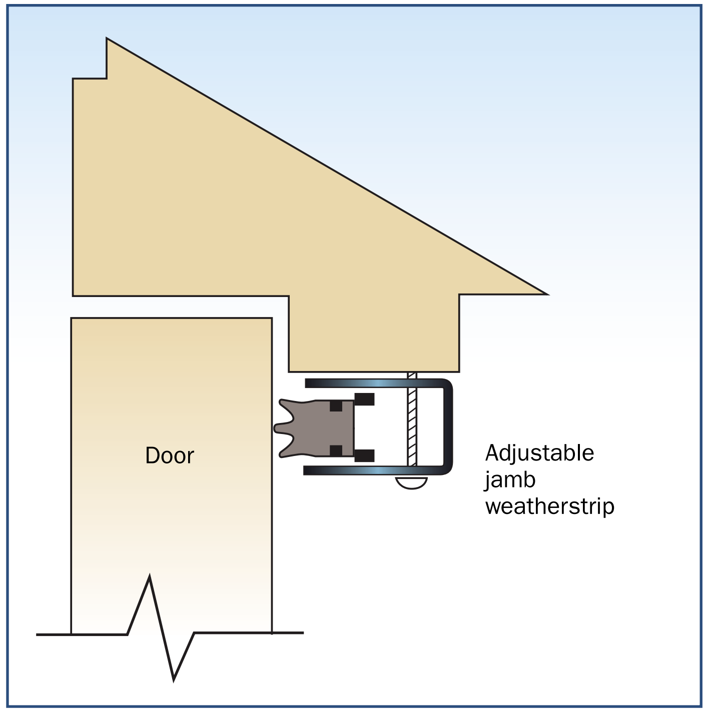


Figure 9
Adjustable jamb/head weatherstripping.

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

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

FEMA | U.S. Department of Homeland Security | U.S. Department of Housing and Urban Development | NAHB Research Center

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.

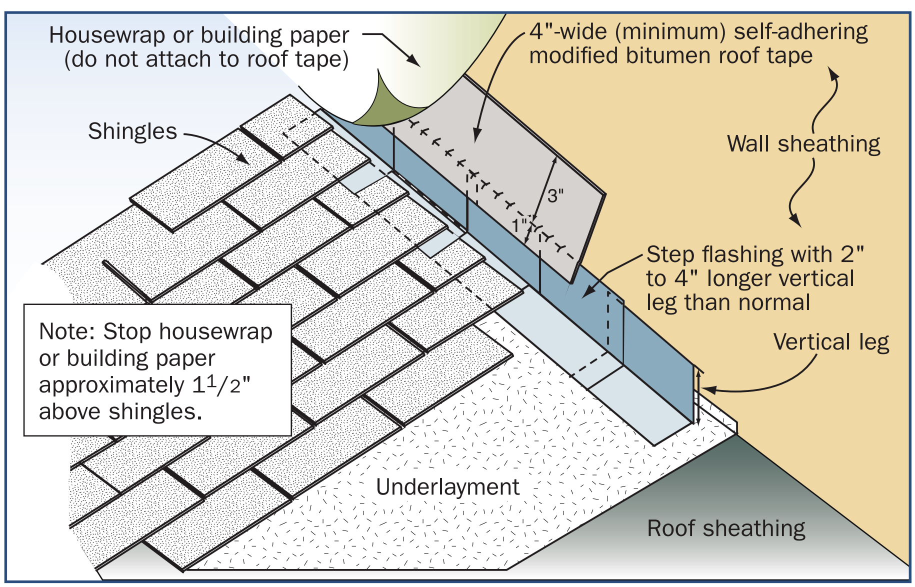


Figure 1
Roof/wall flashing detail.

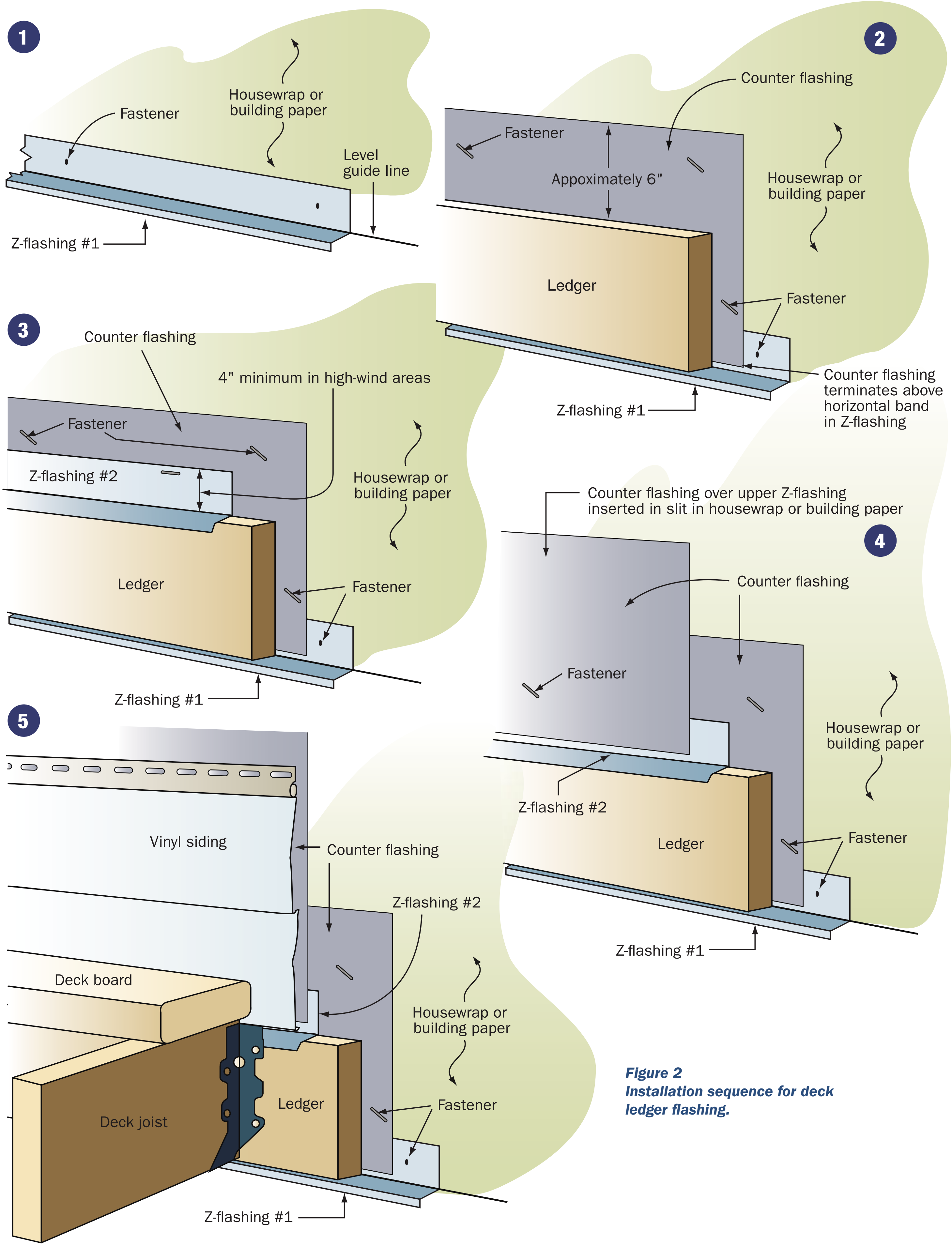


Figure 2
Installation sequence for deck ledger flashing.

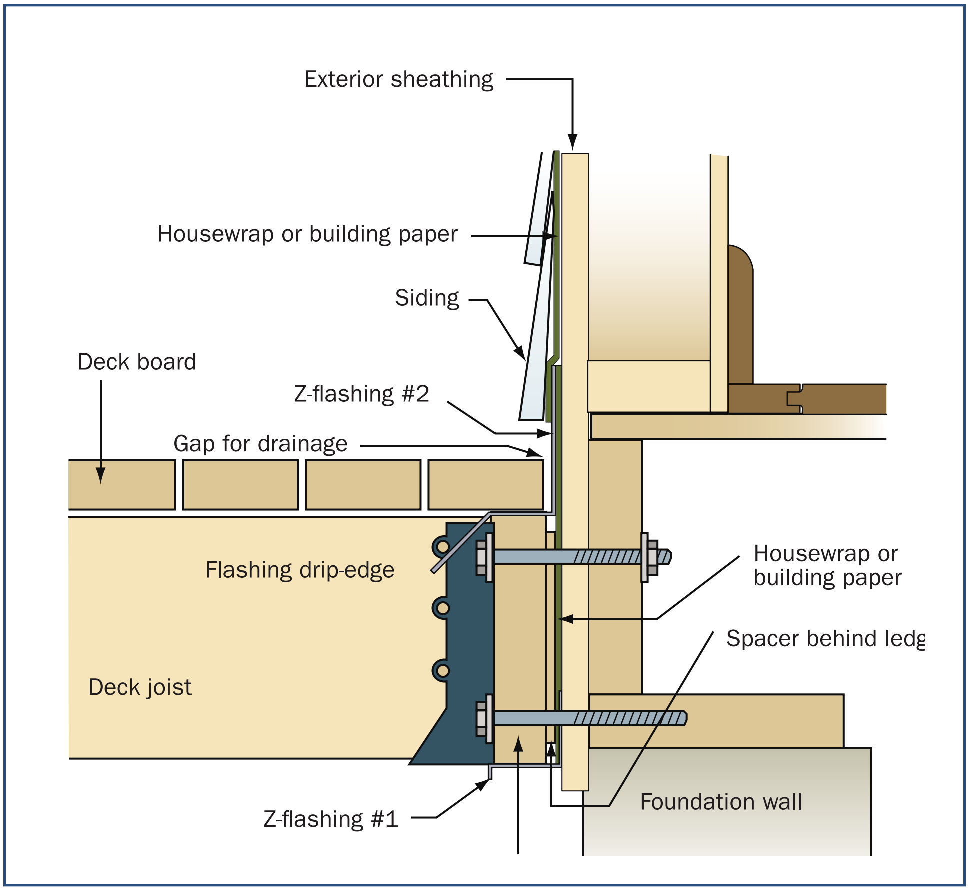


Figure 3
Deck ledger flashing.

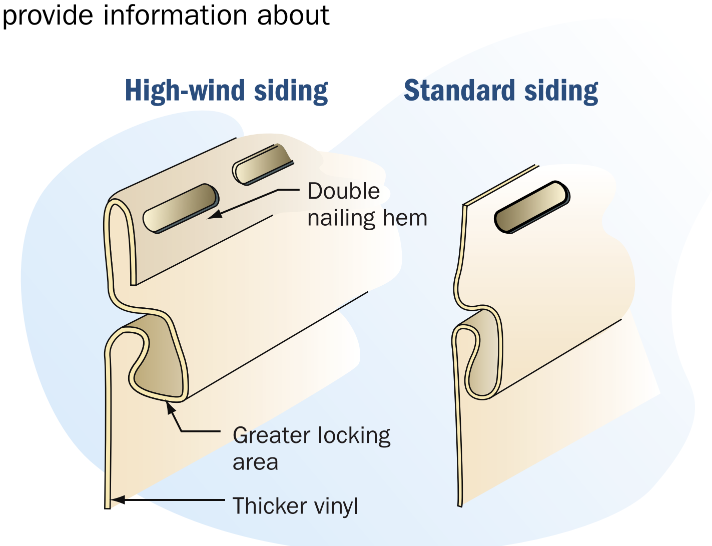
Siding Installation and Connectors

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.

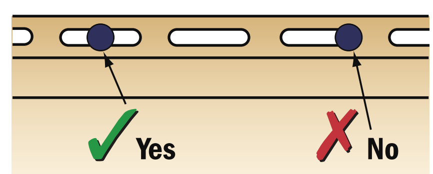


Features of typical high-wind siding and standard siding.

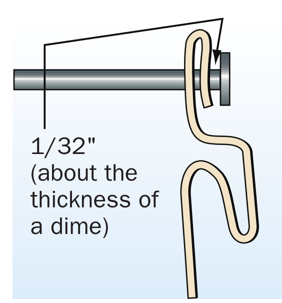
Vinyl Siding

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.



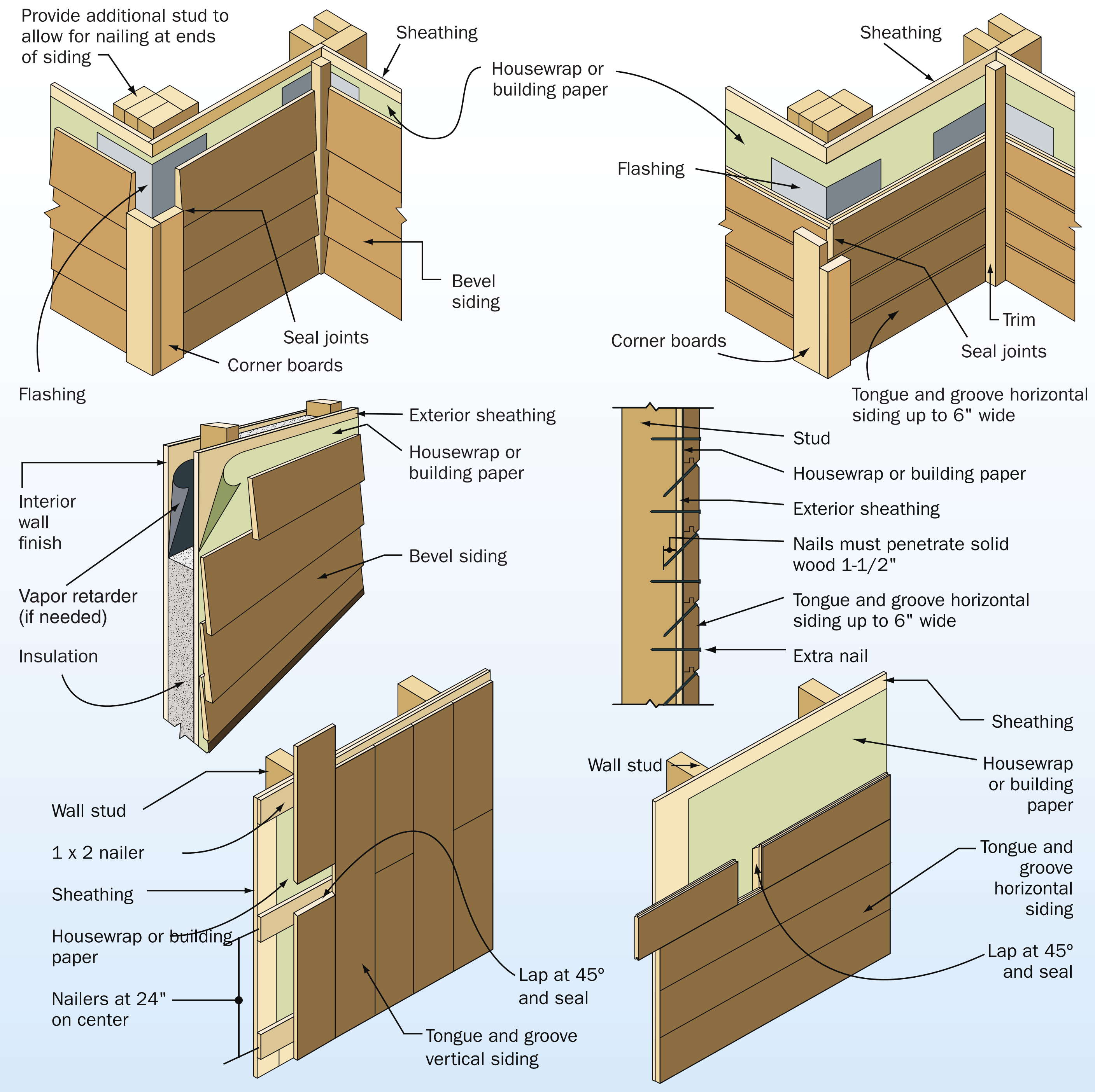
Proper and improper fastener locations.



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

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

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.

Plywood panels are a cost-effective means of protection.

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.

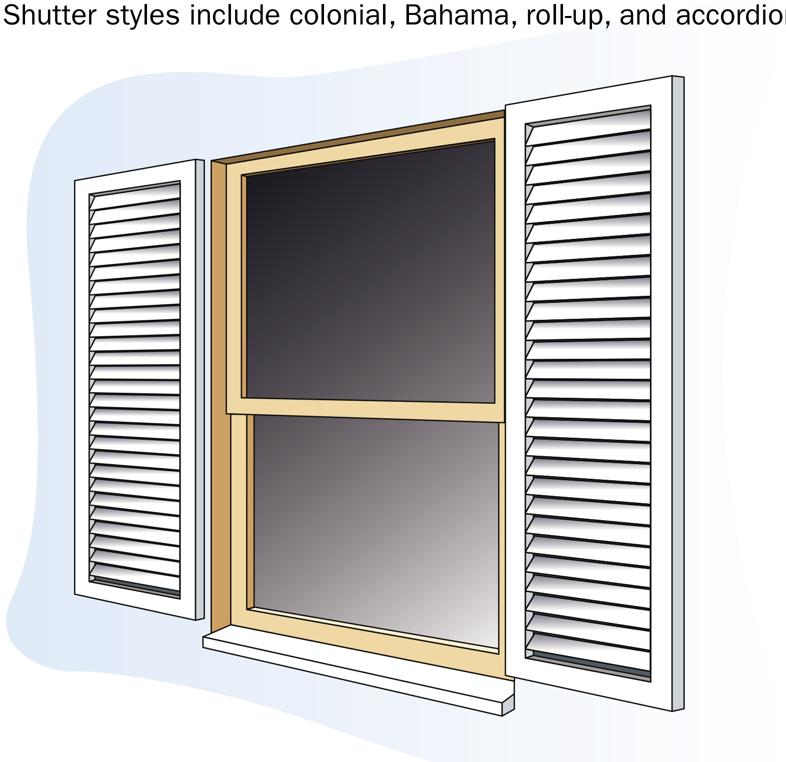
What Types of Shutters Are Available?

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).

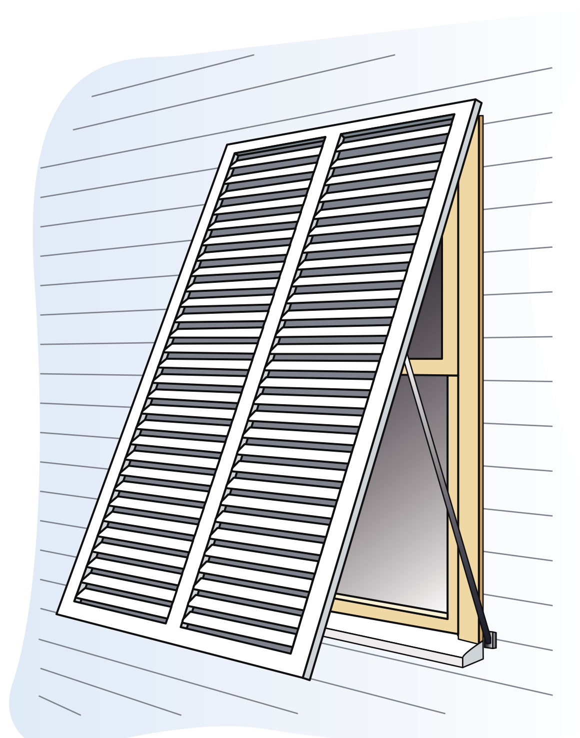
Shutter Type	Cost	Advantages	Disadvantages
Temporary plywood panels	Low	Inexpensive	Must be installed and taken down every time they are needed; must be adequately anchored to prevent blow-off; difficult to install on upper levels
Temporary manufactured panels	Low/Medium	Easily installed on lower levels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

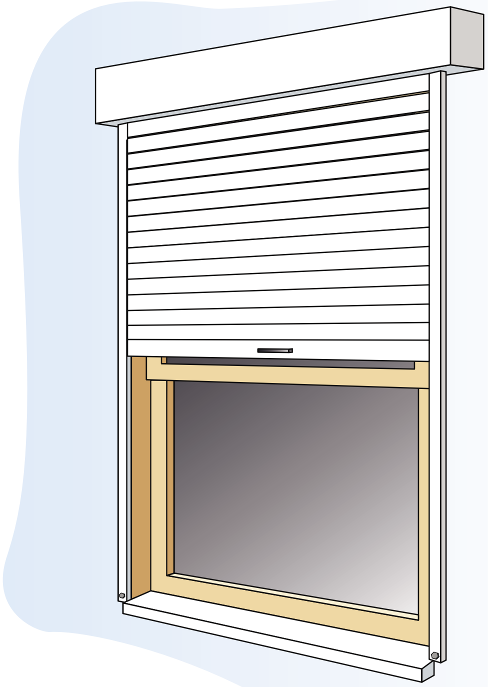
Shutter styles include colonial, Bahama, roll-up, and accordion.



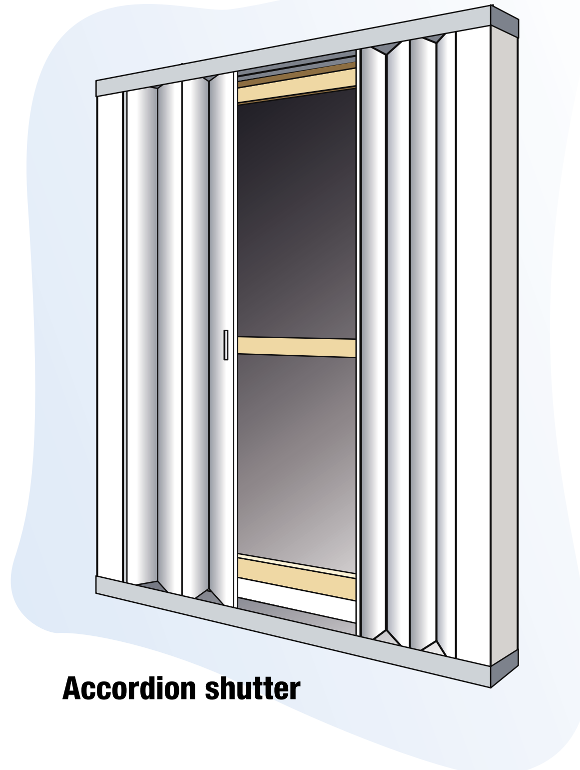
Colonial shutters



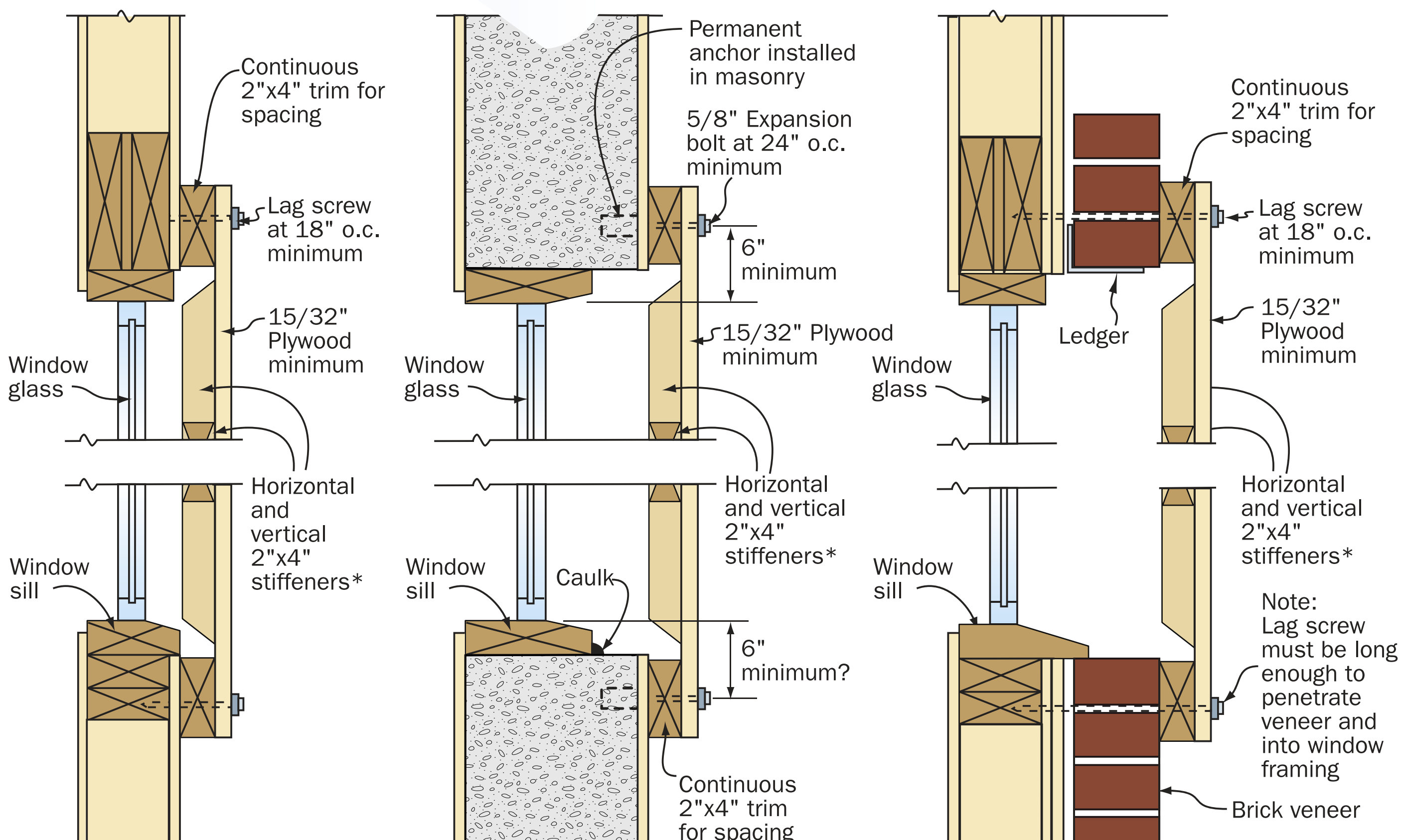
Bahama shutter



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.

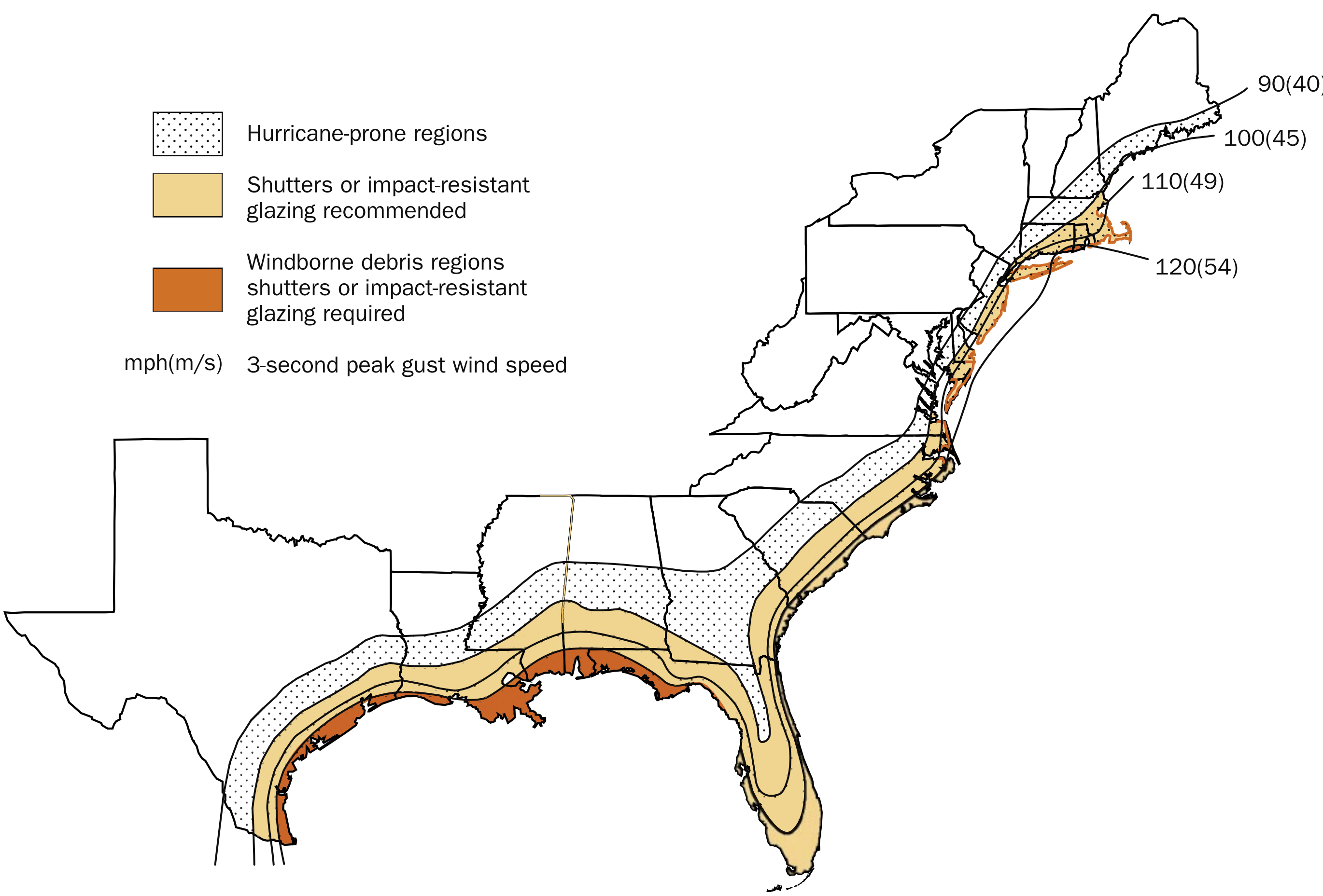
What Are "Hurricane-Prone Regions" "Windborne Debris Regions"?

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

FEMA

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.

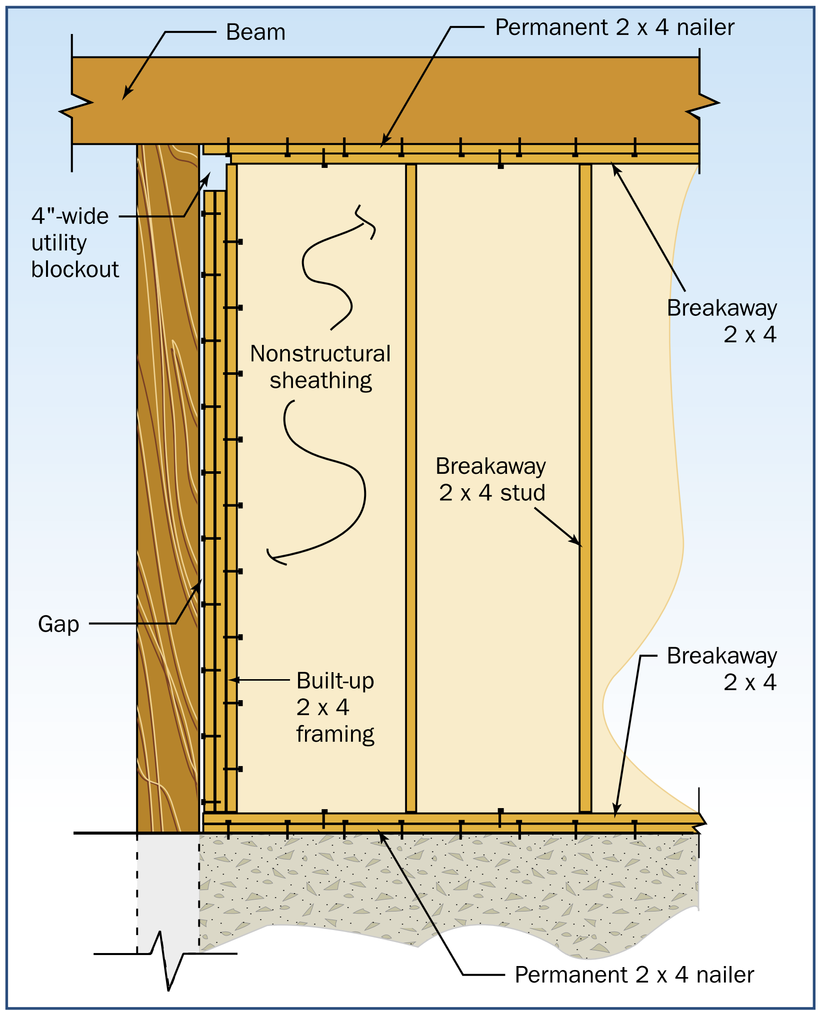
Enclosures can be divided into two types, ***breakaway*** and ***non-breakaway***.

- ***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

- 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.

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.

- 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.

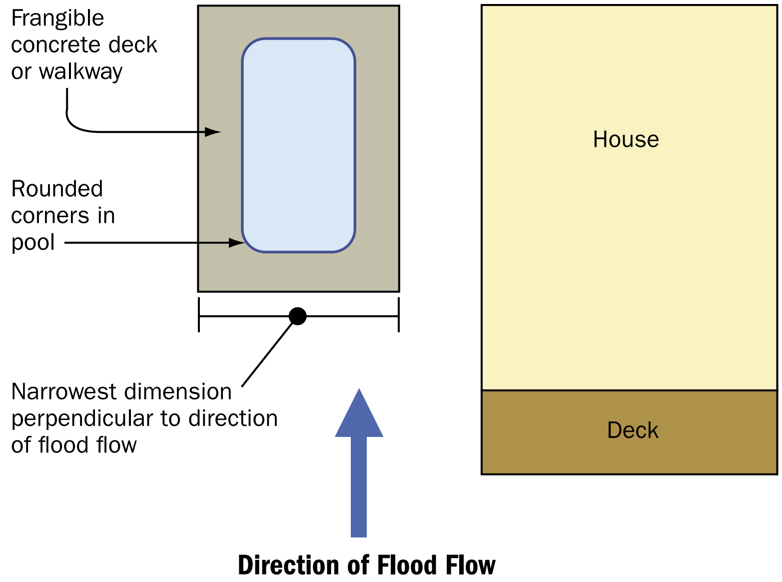
Large solid stairs such as these block flow under a building and are a violation of NFIP free-of-obstruction requirements.

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.

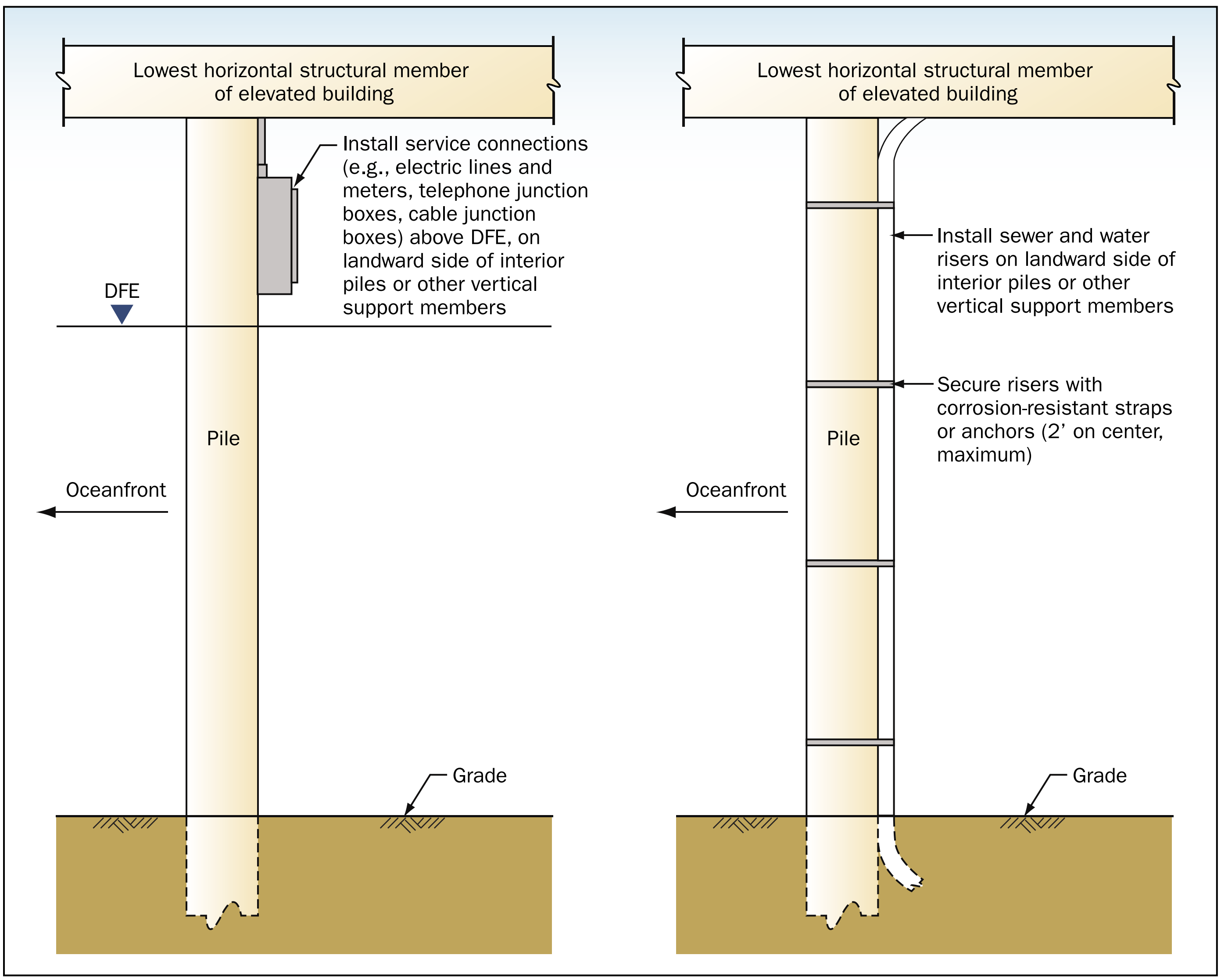
Utility Protection Recommendations

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)

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Repairs, Remodeling, Additions, and Retrofitting

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).

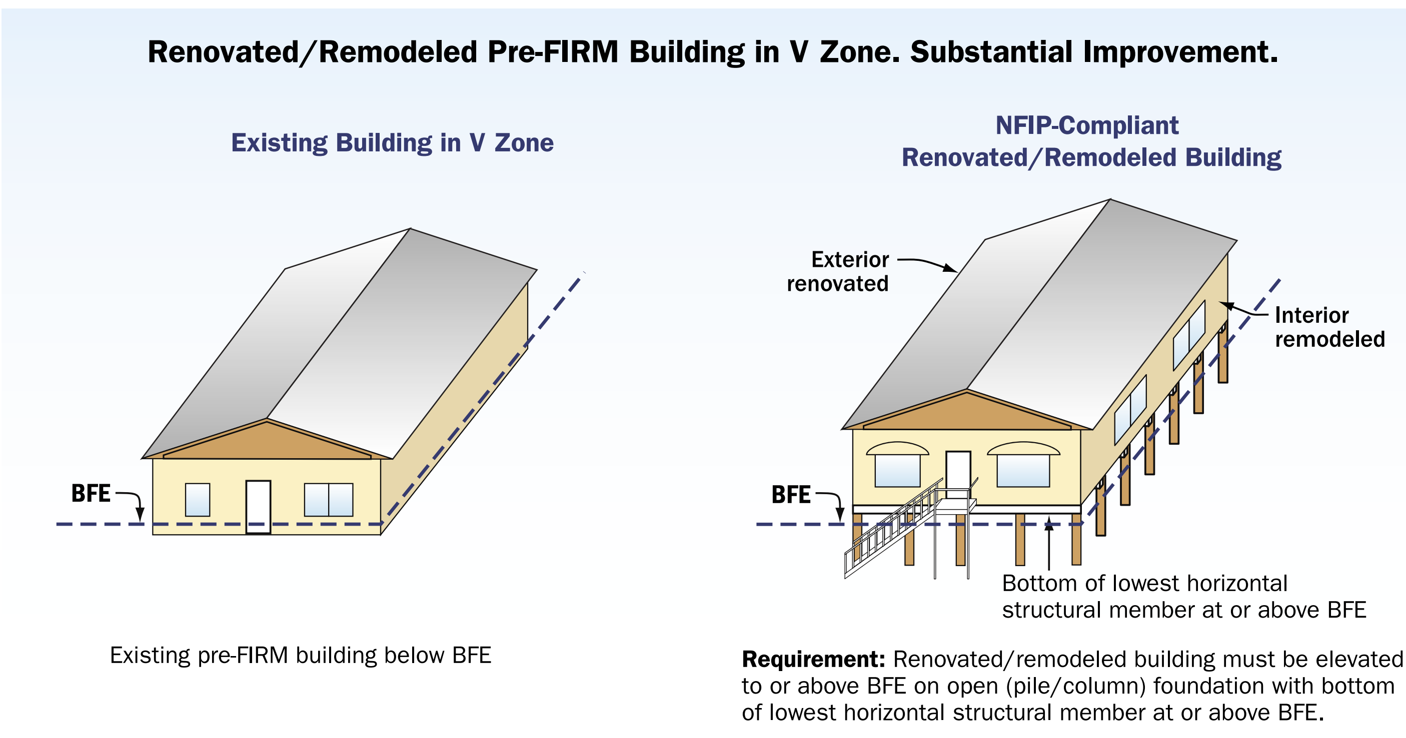

Figure 2 Substantial improvement: Renovated/remodeled building in a V zone.

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.***

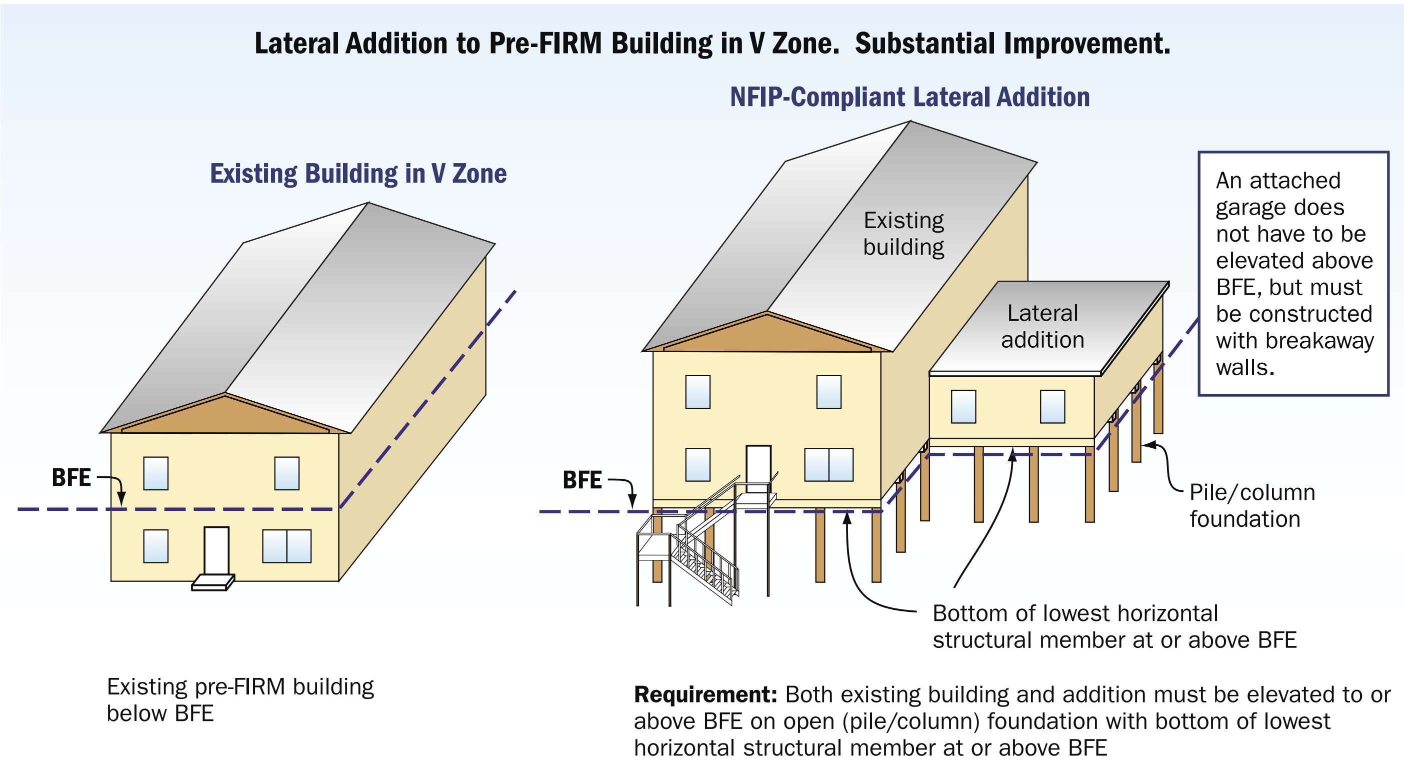

Figure 3 Substantial improvement: Lateral addition to a pre-FIRM building in a V zone.

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.

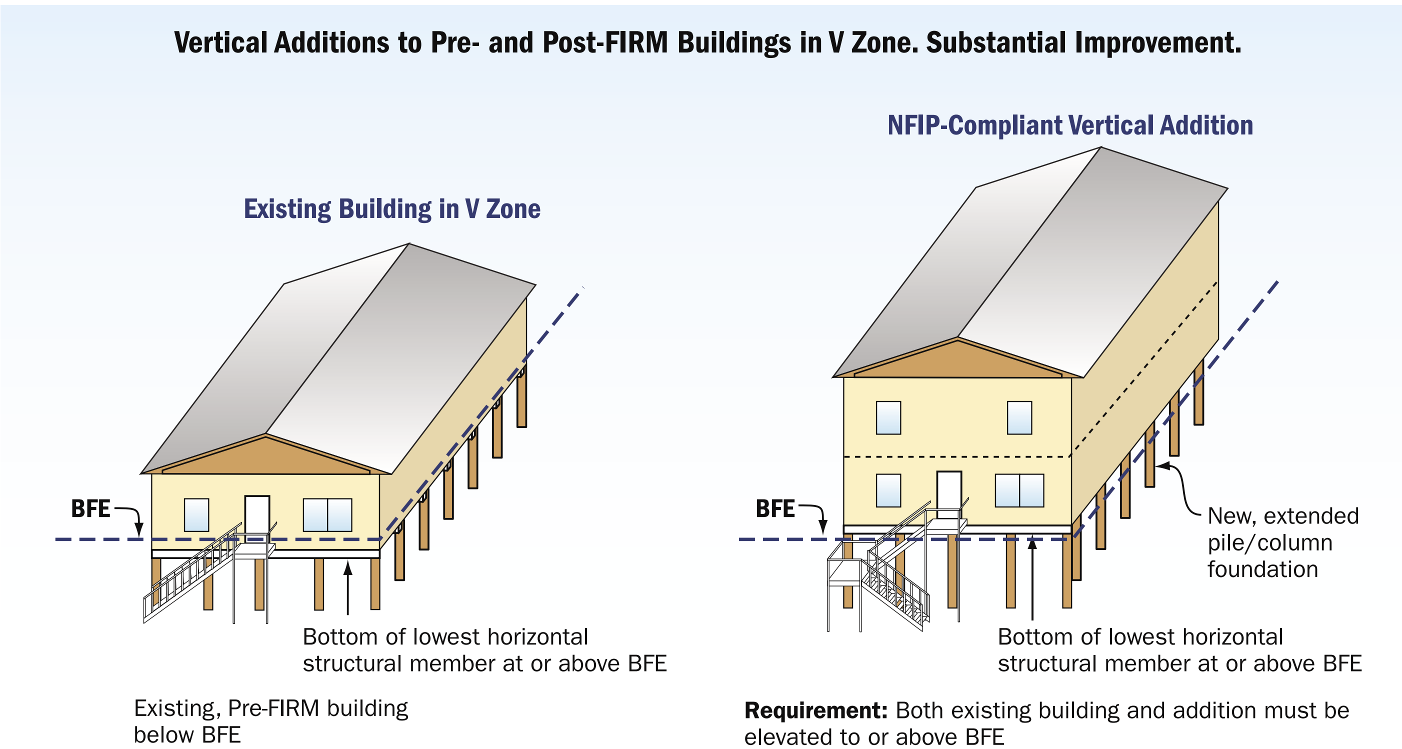

Figure 5 Substantial improvement: Vertical addition to a pre-FIRM building in a V zone.

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)

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

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Purpose: To list references that provide information relevant to topics covered by the *Home Builder's Guide to Coastal Construction* technical fact sheets.

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