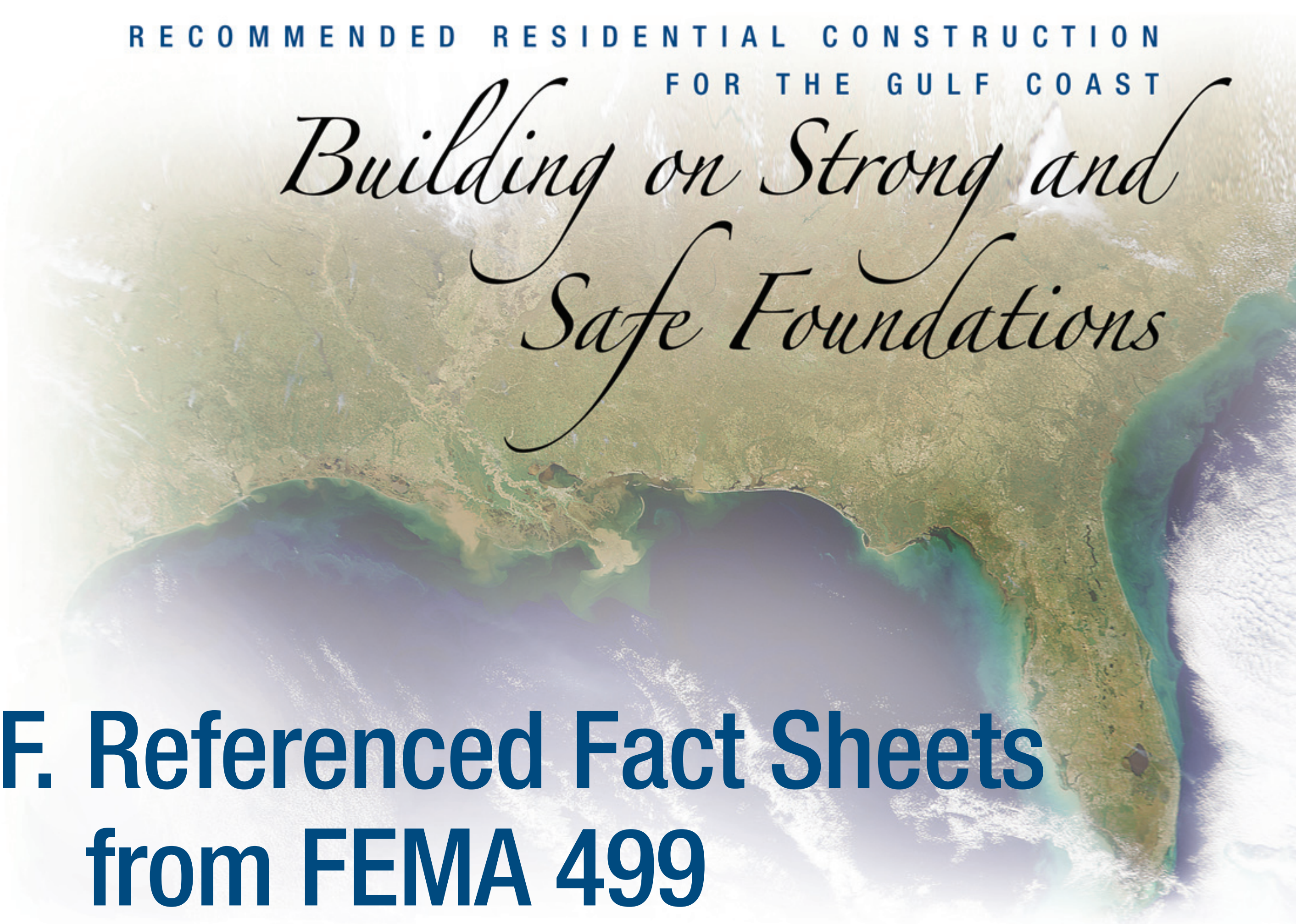
Building on Strong and Safe Foundations



F. Referenced Fact Sheets from FEMA 499

Fact Sheet No.	Title
1	Coastal Building Successes and Failures
2	Summary of Coastal Construction Requirements and Recommendations
4	Lowest Floor Elevation
5	V-Zone Design and Construction Certification
6	How Do Siting and Design Decisions Affect the Owner's Costs?
7	Selecting a Lot and Siting the Building
8	Coastal Building Materials
9	Moisture Barrier Systems
11	Foundations in Coastal Areas
12	Pile Installation

13	Wood-Pile-to-Beam Connections
14	Reinforced Masonry Pier Construction
15	Foundation Walls
16	Masonry Details
26	Shutter Alternatives
27	Enclosures and Breakaway Walls
29	Protecting Utilities

Coastal Building Successes and Failures

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?

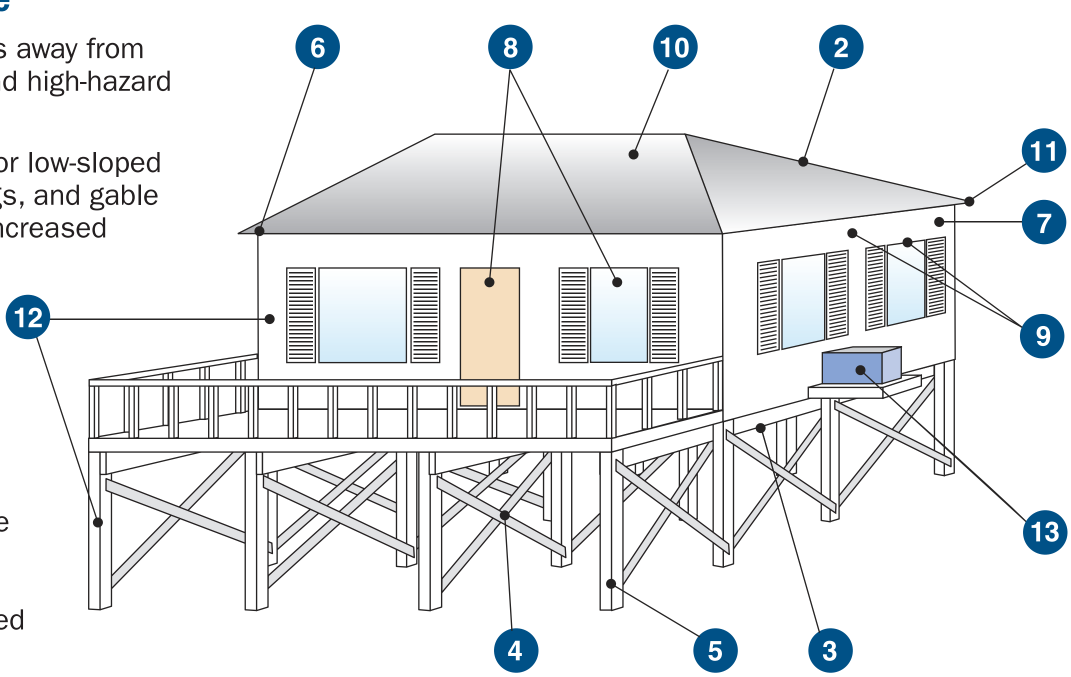
In coastal areas, a building can be considered a success only if it is capable of resisting damage from coastal hazards and coastal processes over a period of decades. This statement does not imply that a coastal residential building will remain undamaged over its intended lifetime. It means that the 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 Zones in Coastal Areas: 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 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)**		
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.

Lowest Floor Elevation

FEMA

NAHB RESEARCH CENTER

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:

Coastal A

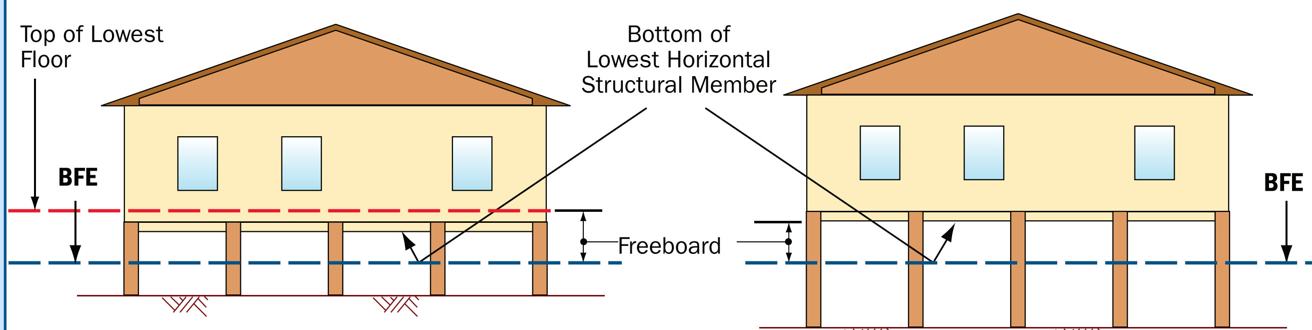
A Zones in Coastal Areas:

Subject to Breaking Waves and Erosion During the Base Flood
Lowest Horizontal Structural Member Above BFE (Freeboard)

V

V Zones:

Bottom of Lowest Horizontal Structural Member Above BFE (Freeboard)



A-Zone Building (Open Foundation)

V-Zone Building (Open Foundation)

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

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

FEMA

NAHB RESEARCH CENTER

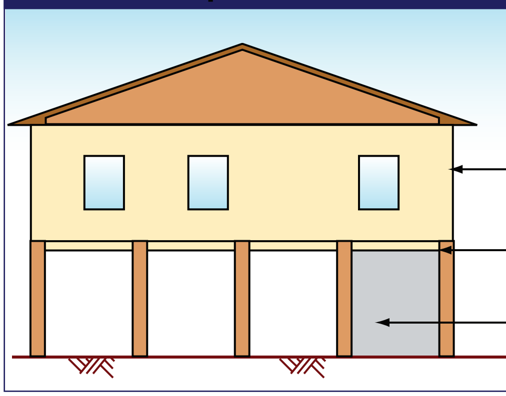
HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 5*

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.***

Required Certifications in V Zones



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.

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?

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 building 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.

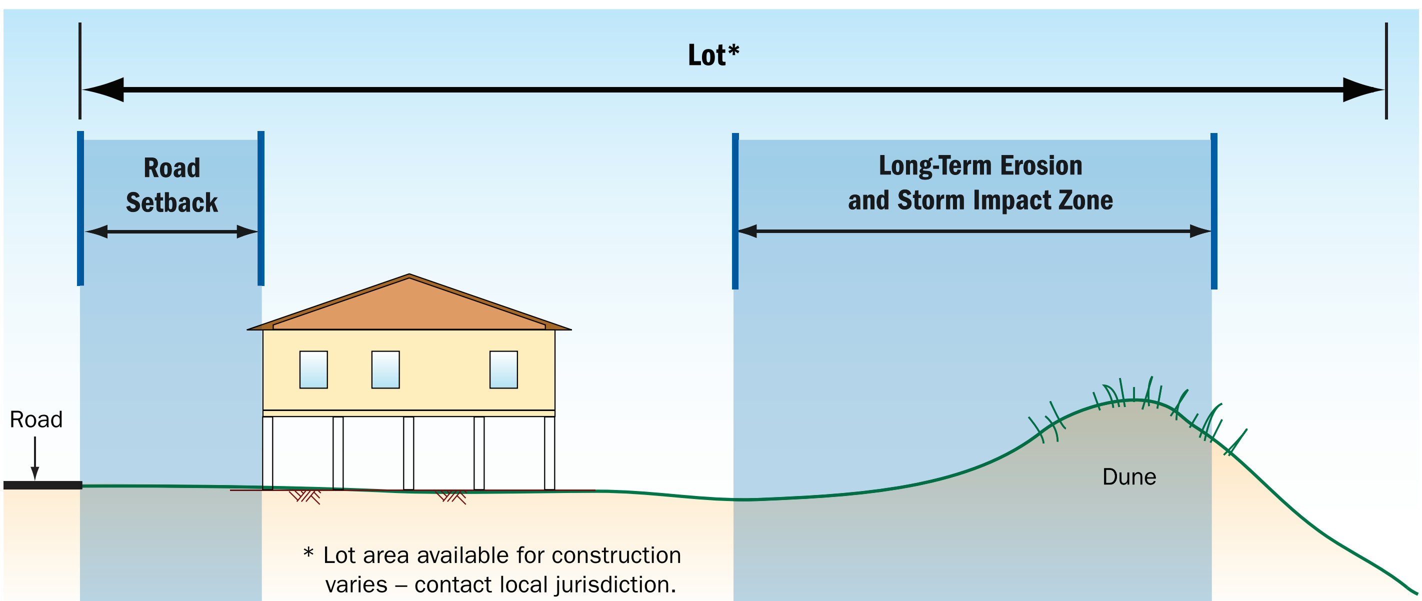
- Storms can cause short-term erosion that far exceeds setbacks based on long-term averages.
- Erosion rates vary over time, and erosion could surpass the setback distance in just a few years' time. The rate variability must also be known to determine the probability of undermining over a given time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

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 8*

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.

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

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.

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).

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 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)

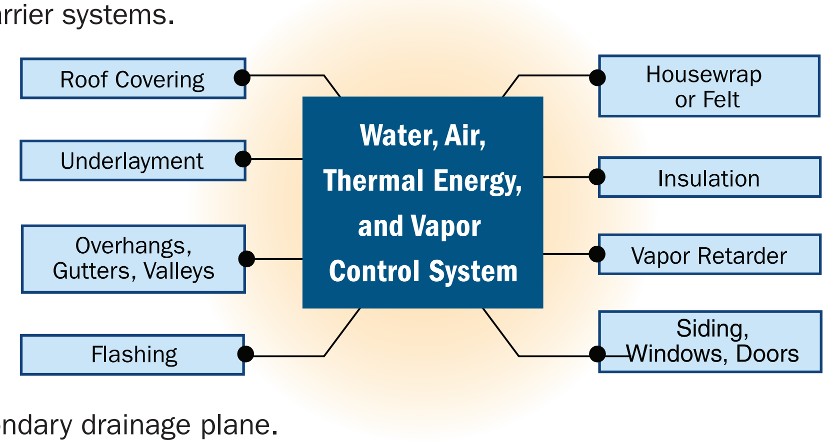
International Code Council Evaluation Service, Inc. Protocol for Testing the Flood Resistance of Materials. (http://www.icc-es.org/index.shtml)

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.

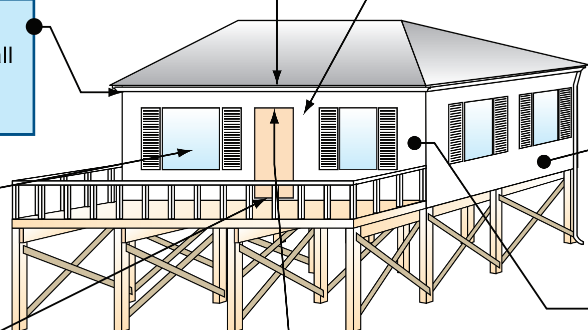
Locations and Causes of Common Water Intrusion Problems

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

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

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

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



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

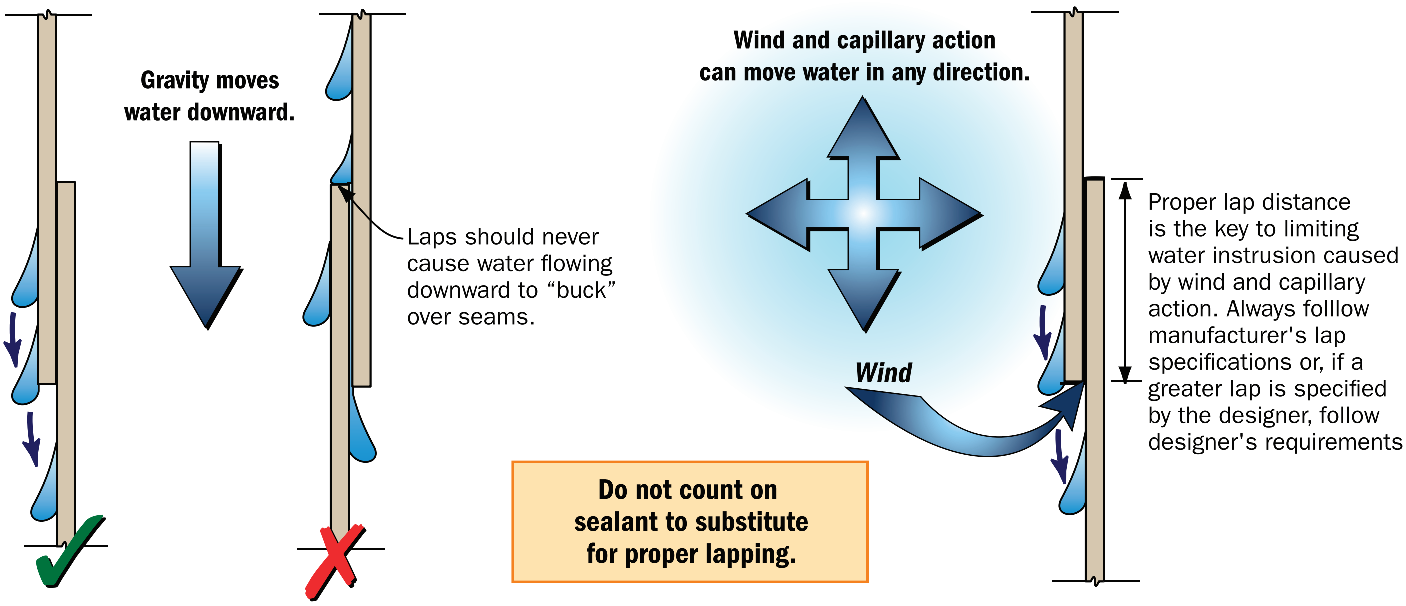
No housewrap or building paper used, or improperly lapped – Virtually all siding leaks. Use housewrap or building paper to shed water. Properly lap material so water flows without bucking seams. Water must be allowed to drain out of walls.

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

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.

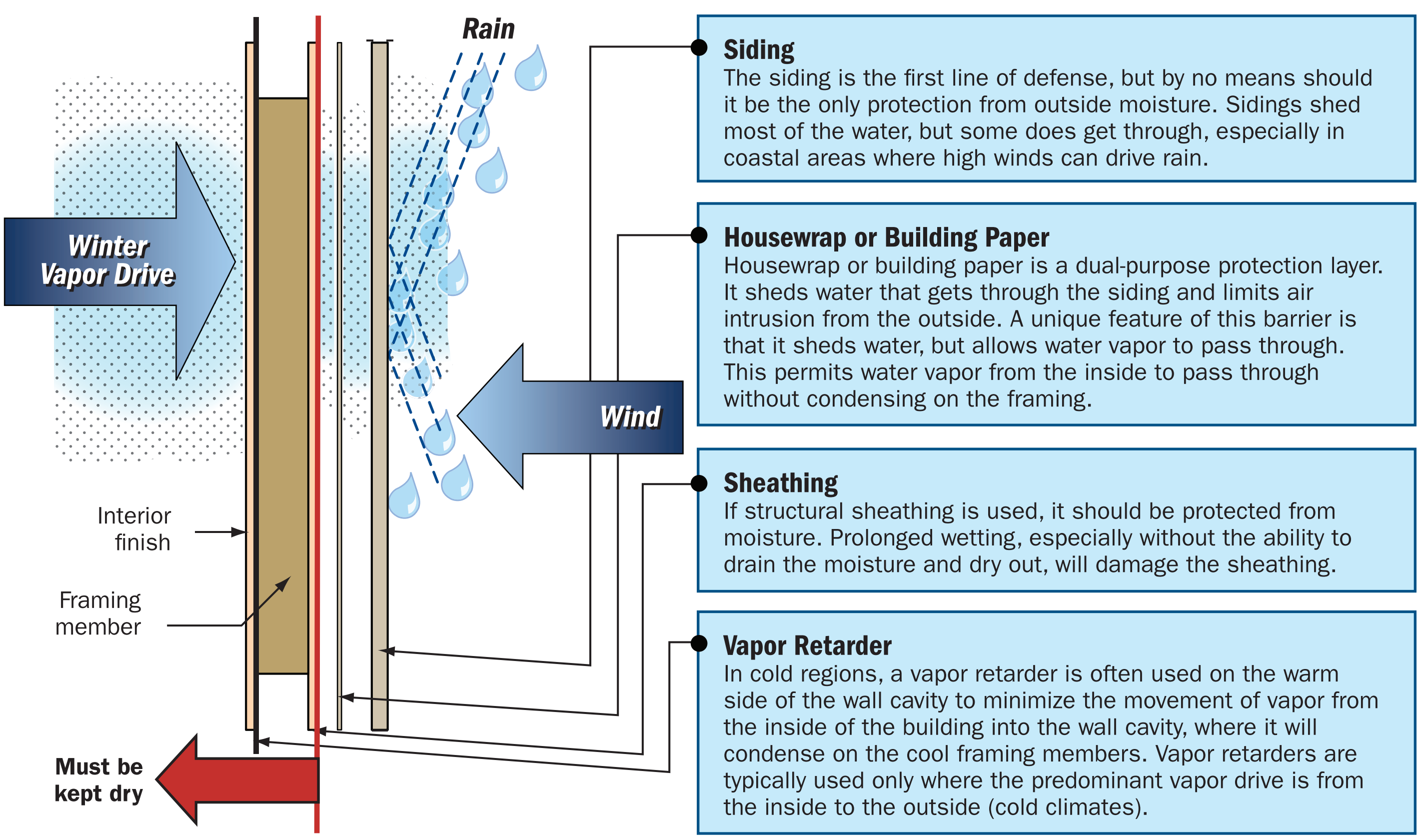
The location of water entry is often difficult to see, and the damage to substrate and structural members behind the exterior wall cladding frequently cannot be detected by visual inspection.

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



Foundations in Coastal Areas

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION FEMA 499/August 2005 *Technical Fact Sheet No. 11*

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.)
- 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).

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

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.

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.

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

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.

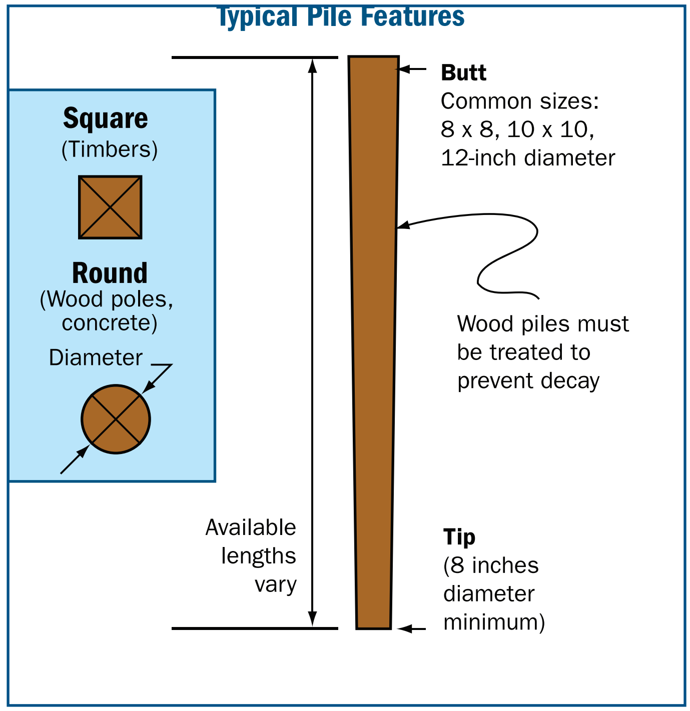
Pile Installation

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.)

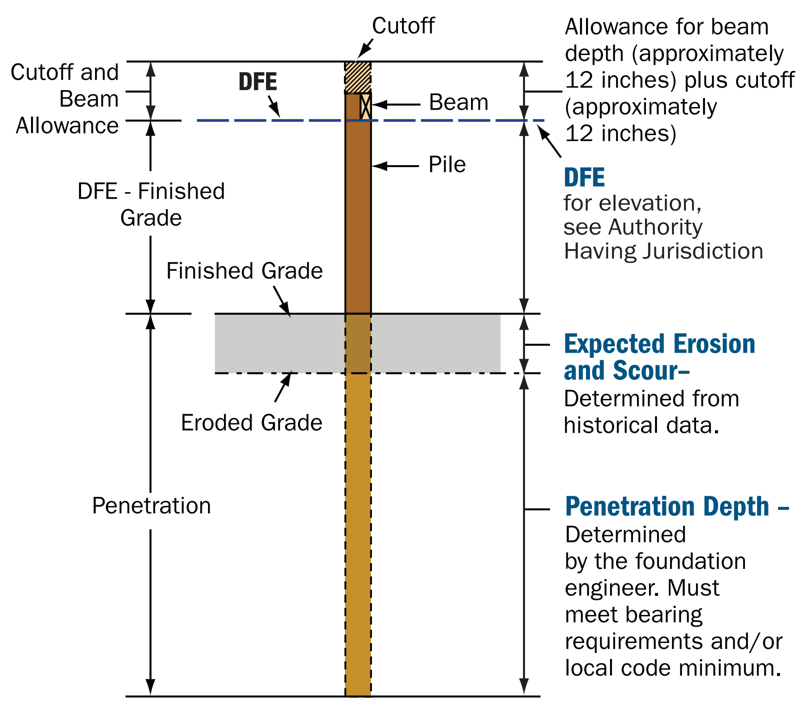


Pile Types

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

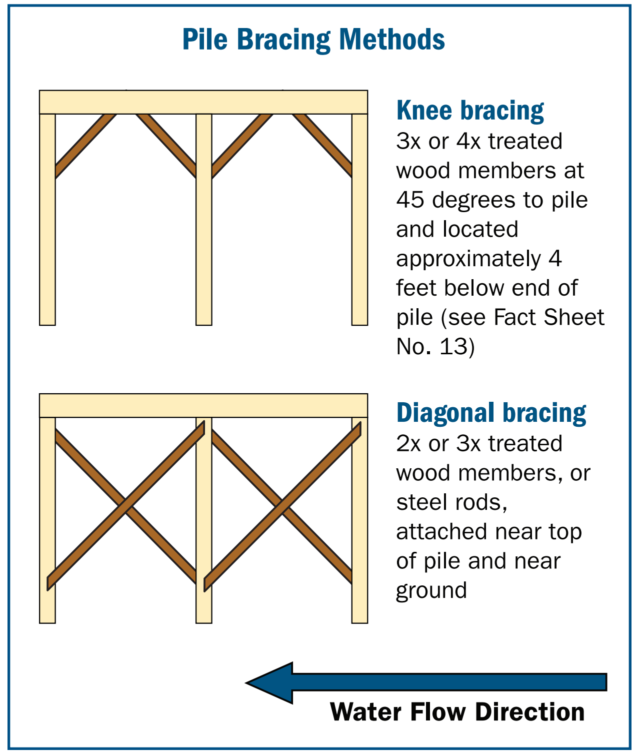
The pile layout is determined by the foundation engineer. Accurate placement and correction of misaligned piles is important. Pile placement should not result in more than 50 percent of the pile cross-section being cut for girder or other connections. Verify proper pile locations on drawings before construction 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

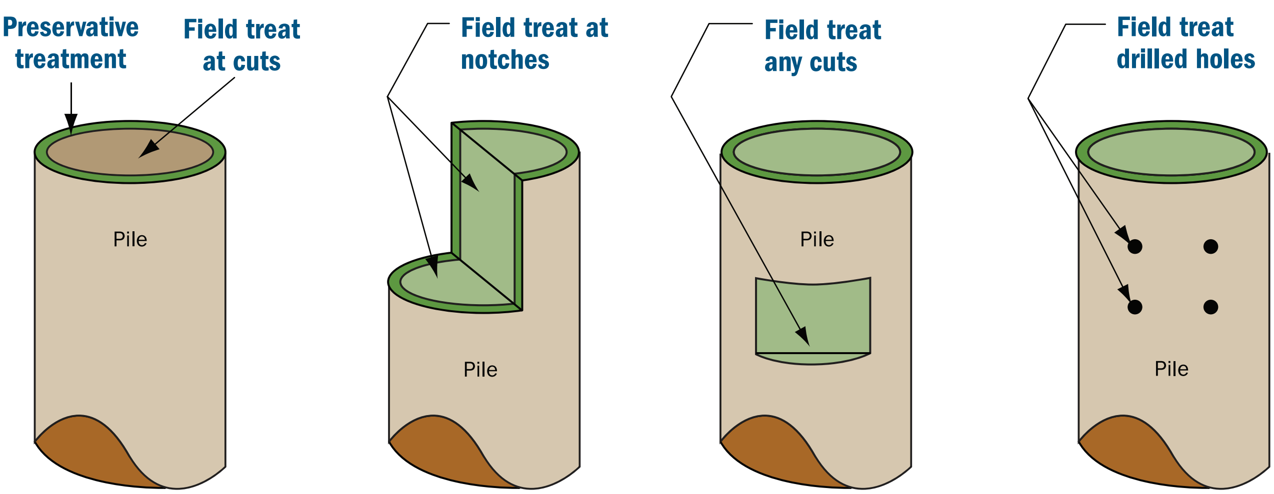
Piles can be driven, augured, or jetted into place. The installation method will vary with soil conditions, bearing requirements, equipment available, and local practice. One common method is to initially jet the pile to a few feet short of required penetration, then complete the installation by driving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

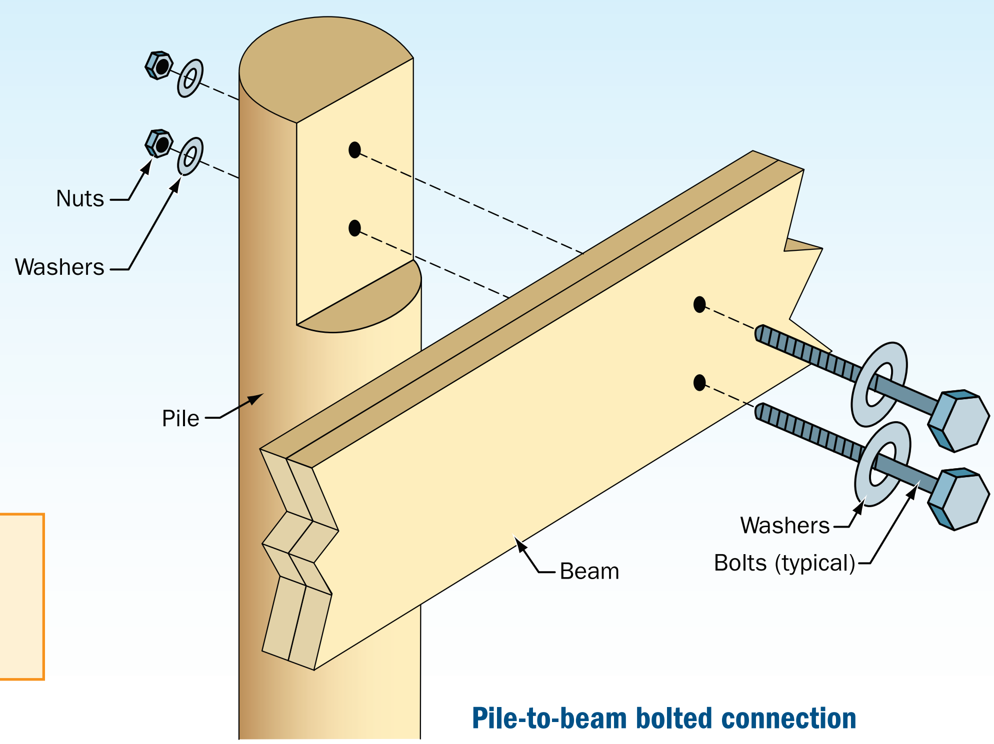
NOTE: The pile-to-beam connection is one of the most critical links in the structure. ***This connection must be designed by an engineer.*** See Fact Sheet No. 10 for "load path" information. The number of bolts and typical bolt placement dimensions shown are for illustrative purposes only. Connection 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:

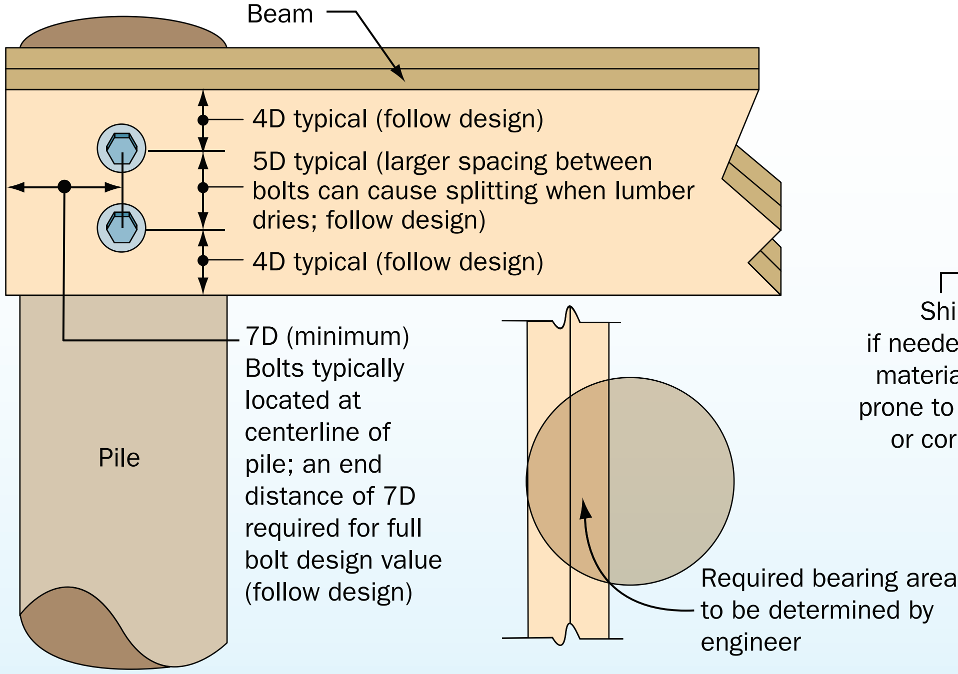
1. provide required ***bearing*** area for beam to rest on pile
2. provide required ***uplift*** (tension) resistance
3. maintain beam in an ***upright*** position
4. be capable of resisting ***lateral*** loads (wind and seismic)
5. be constructed with ***durable*** connectors and fasteners



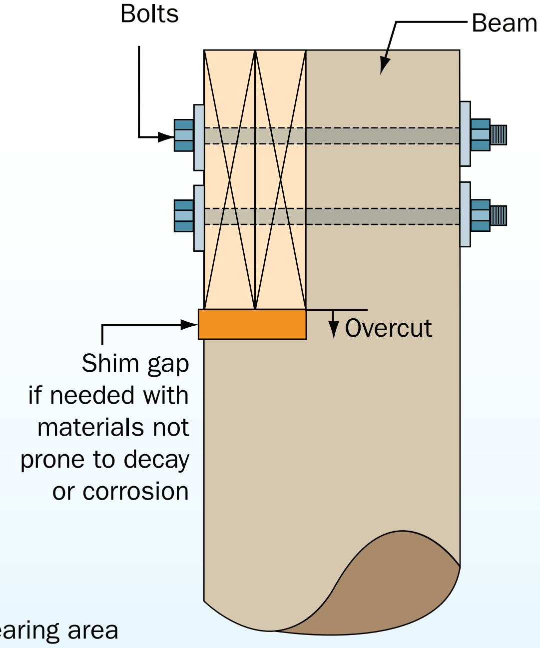
Pile-to-beam bolted connection

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

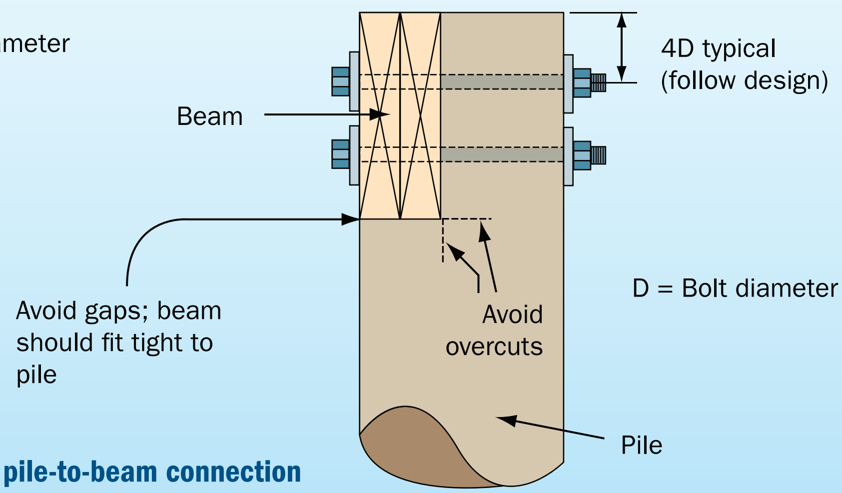
Bolt end and edge distance on beam



D = Bolt diameter



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

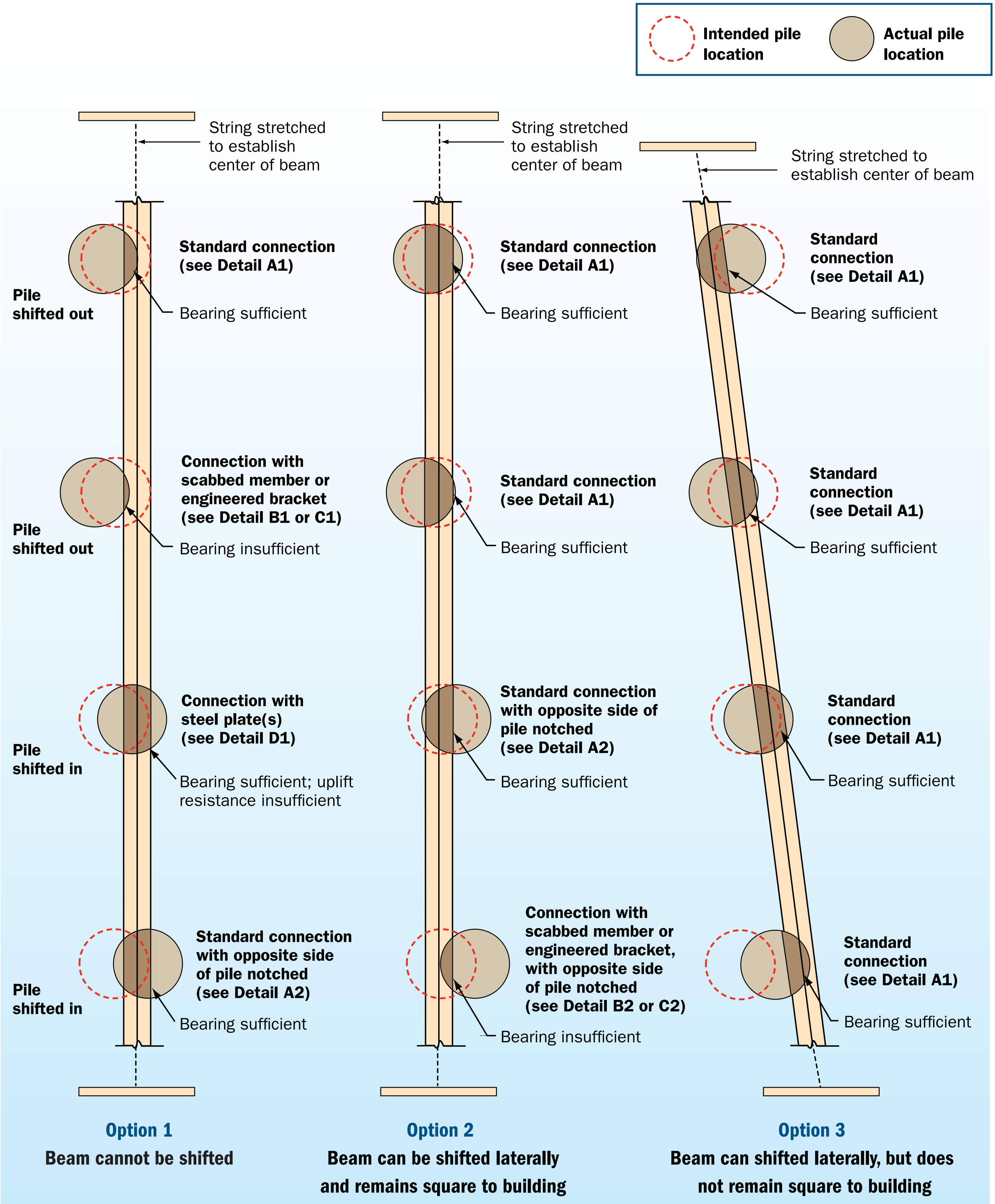
Option 2 (see page 3) – beam can be shifted laterally and remains square to building

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

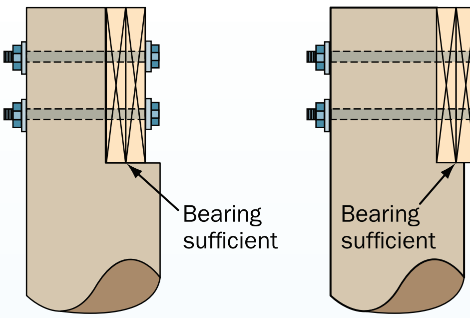


Note: Pile-to-beam connections must be designed by an engineer.

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

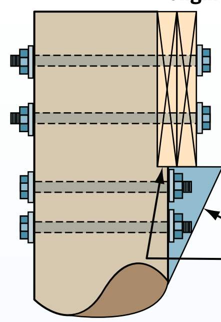
1. The ability to construct the pile-to-beam connections designed by the engineer is directly dependent on the accuracy of pile installation and alignment.
2. Misaligned piles will require the contractor to modify pile-to-beam connections in the field.
3. Badly misaligned piles will require removal and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

Detail A1 **Standard connection**



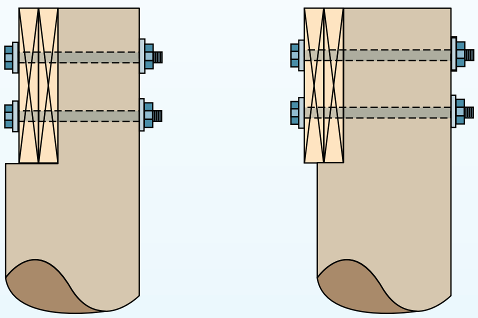
If bearing area under beam is sufficient, a standard bolted connection can be used; if bearing area is insufficient, install scabbed member (Detail B1/B2) or engineered bracket Detail (C1/C2)

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

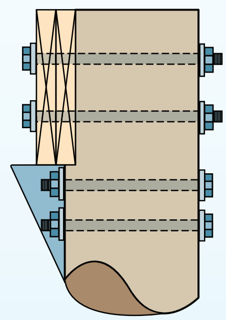


If bearing area under beam is insufficient, install engineered bracket; connection to be designed by an engineer

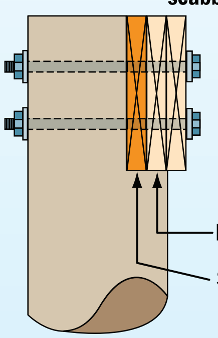
Detail A2 **Standard connection with pile notched on opposite side to avoid overnotching**



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

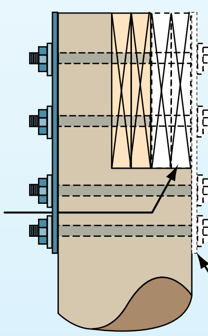


Detail B1 **Insufficient bearing – scabbed member for bearing**



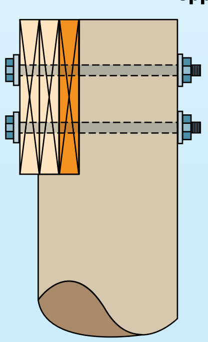
If bearing area under beam is insufficient, deepen notch and install scabbed member to achieve bearing; do not overnotch

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

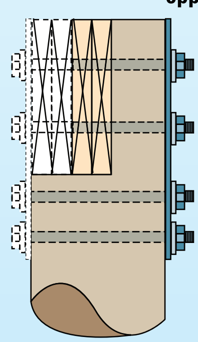


Notch side of pile that leaves the greatest pile section; use 1/4" or thicker galvanized steel plate(s) to satisfy uplift resistance requirements; connection to be designed by an engineer

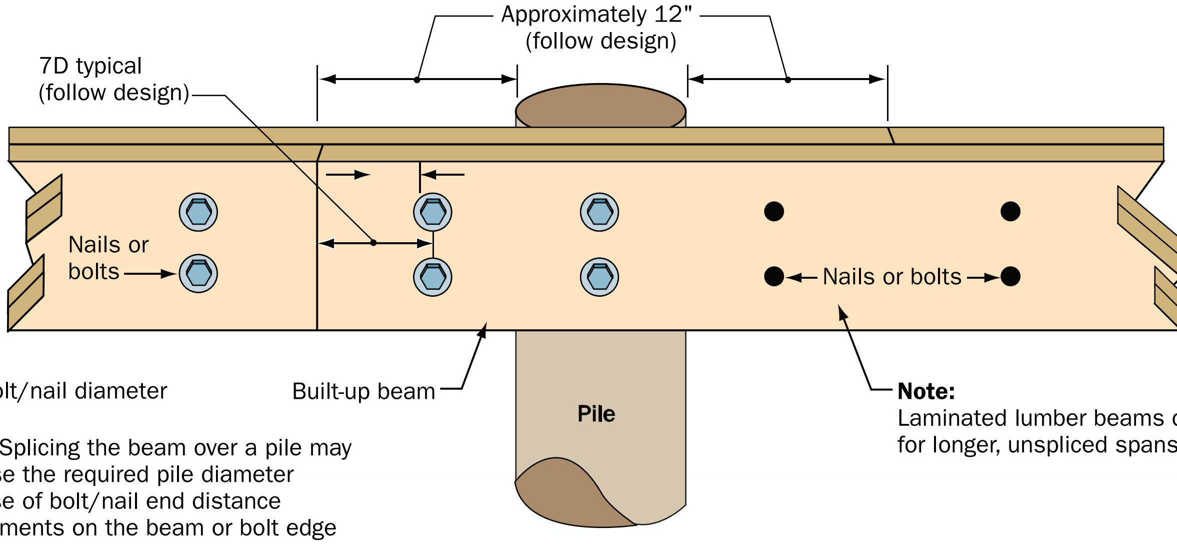
Detail B2 **Scabbed member with pile notched on opposite side to avoid overnotching**



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.

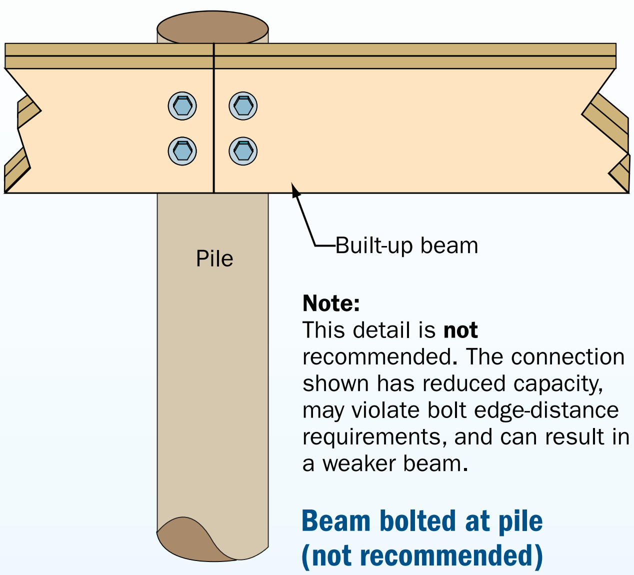


D = Bolt/nail diameter

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.

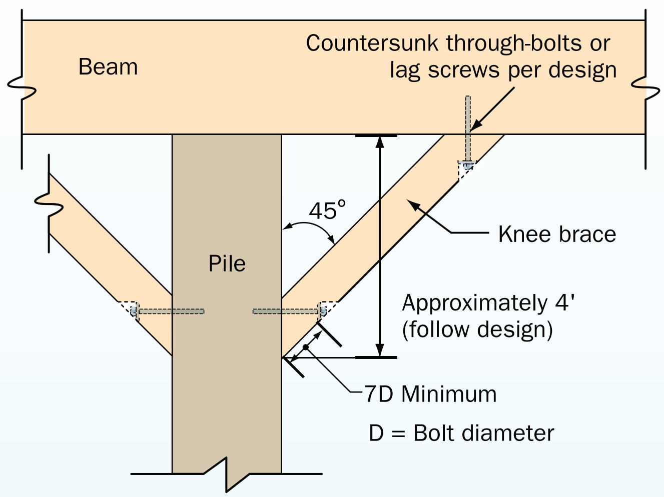
Note:
Laminated lumber beams can be used for longer, unspliced spans.

Lapped splice (built-up beam)



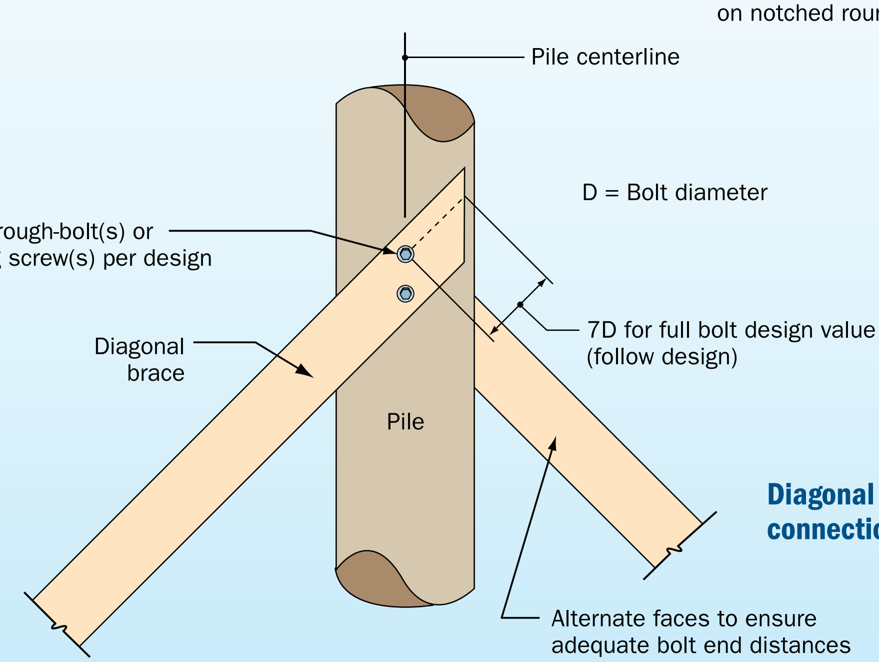
Note:
This detail is **not** recommended. The connection shown has reduced capacity, may violate bolt edge-distance requirements, and can result in a weaker beam.

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

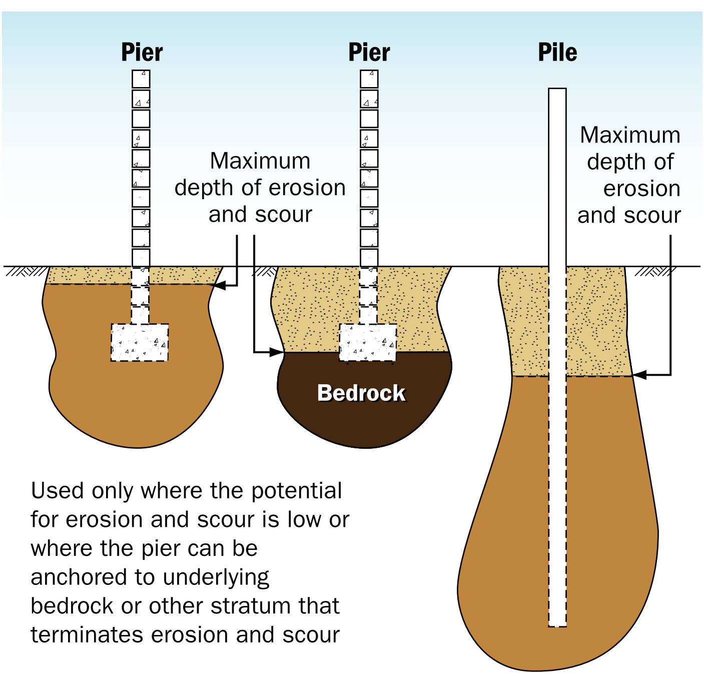
NAHB RESEARCH CENTER

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

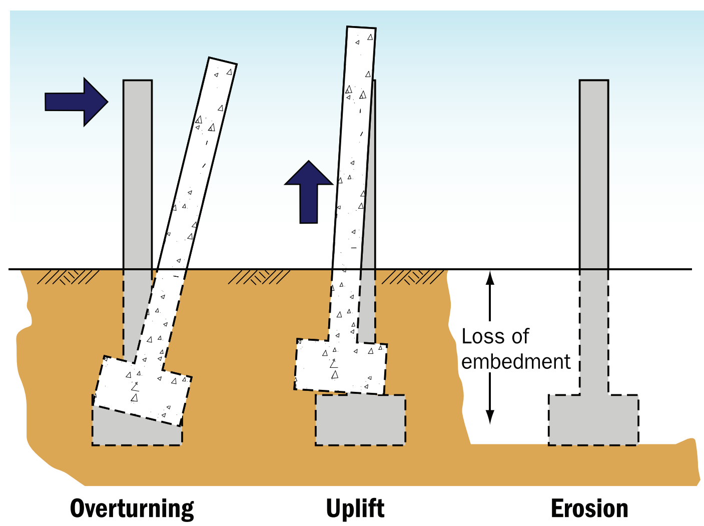
- The footing must be designed for the soil conditions present. Pier foundations are generally not recommended in V zones or in A zones in coastal areas.
- The connection between the pier and its footing must be properly designed and constructed to resist separation of the pier from the footing and rotation 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



Used only where the potential for erosion and scour is low or where the pier can be anchored to underlying bedrock or other stratum that terminates erosion and scour

Used where the potential for erosion and scour is high



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.

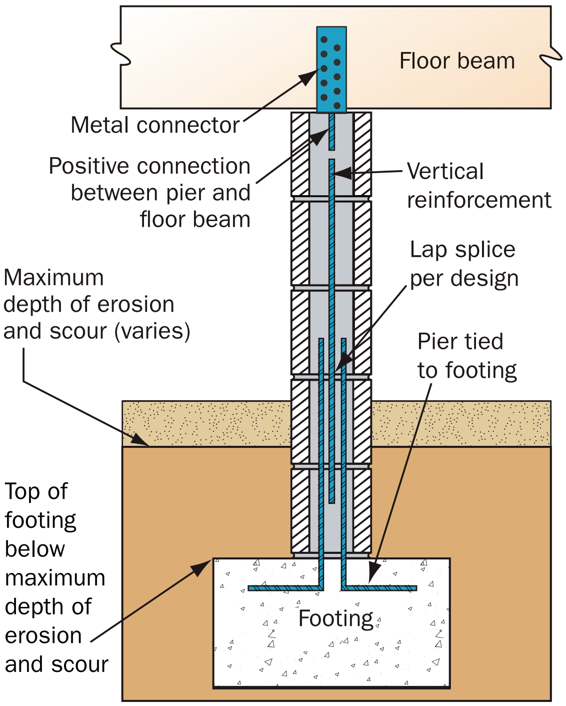
The small footings on the piers in this photograph did not prevent these piers from overturning during Hurricane Iniki.

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.

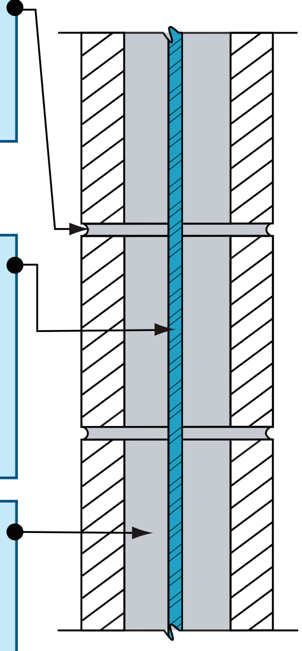
Recommendations for Masonry Piers in Coastal Regions



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*

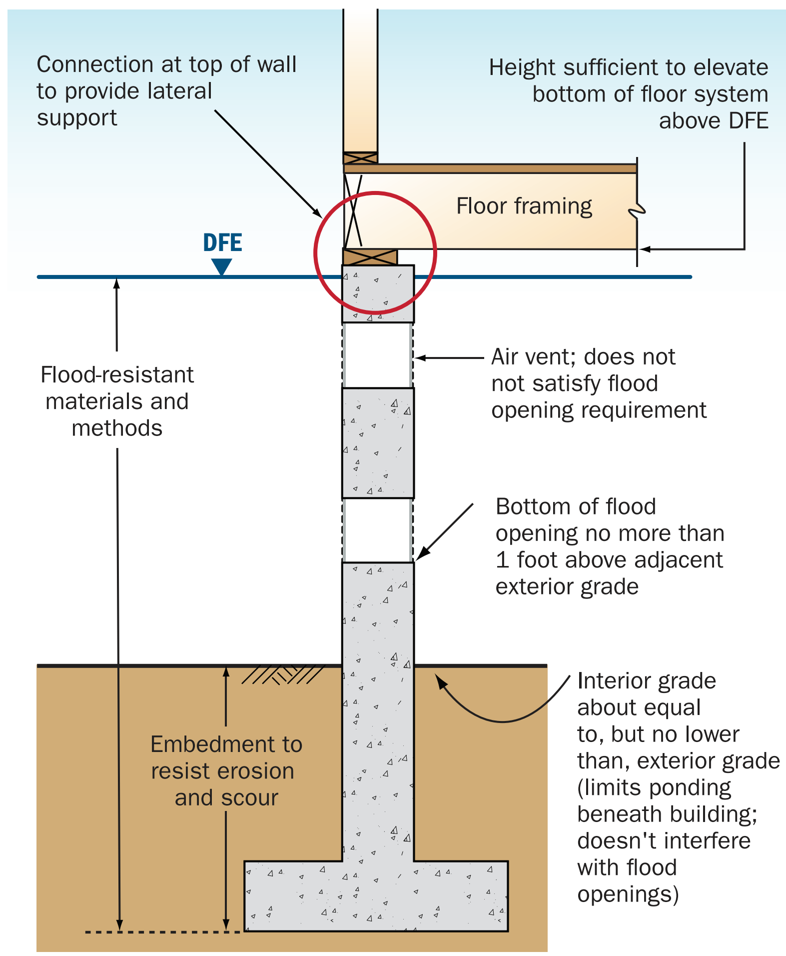
Purpose: To discuss the use of foundation walls in coastal buildings.

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.

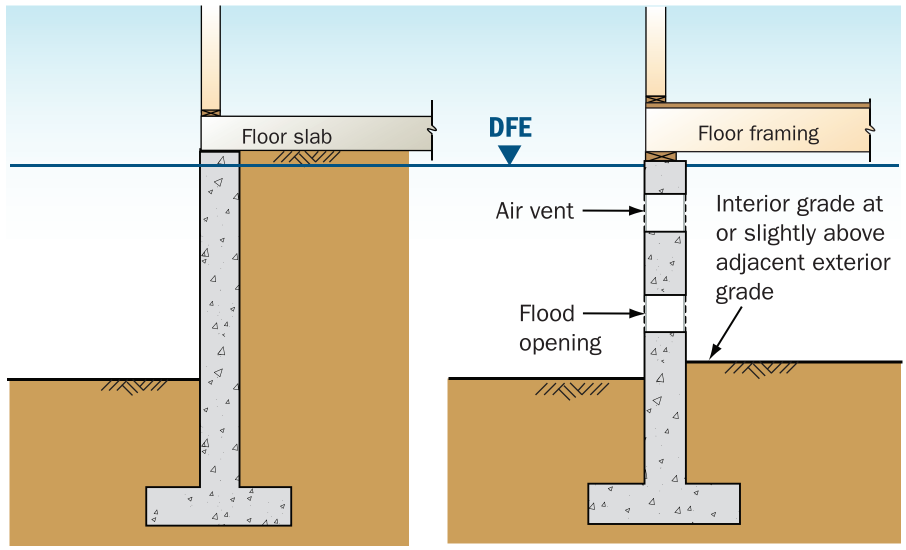
Design Considerations for Foundation Walls

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).

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.



Floor slab atop backfilled stemwall foundation

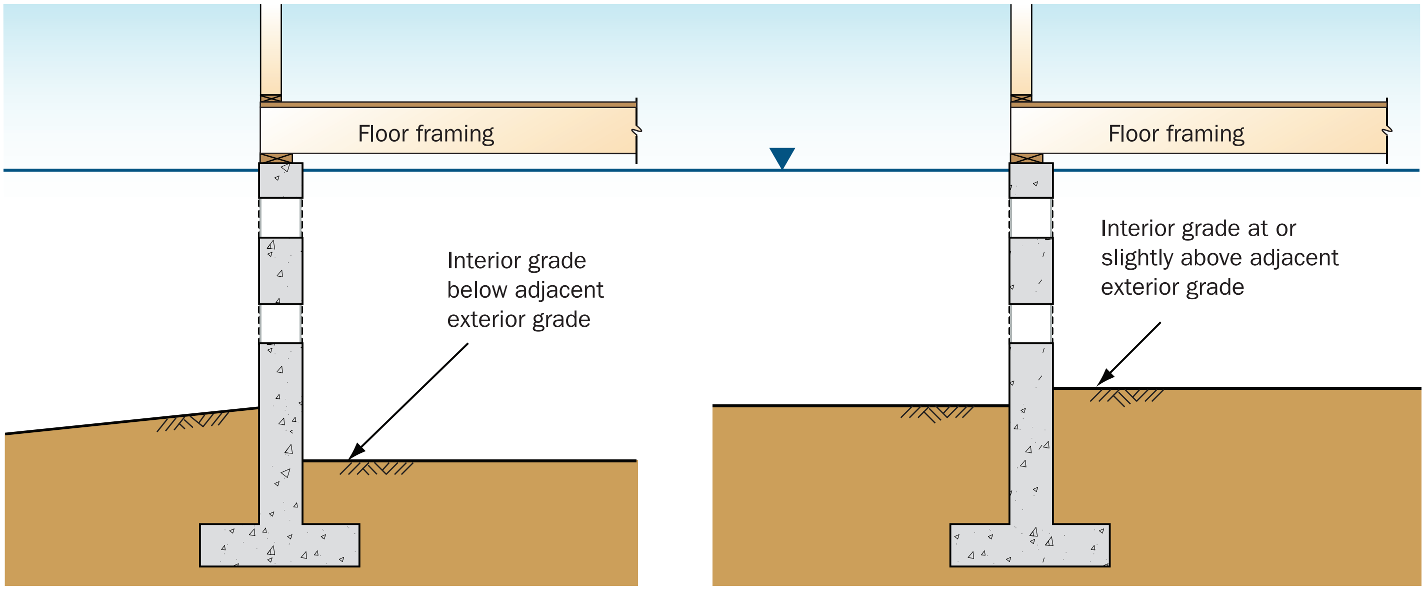
Floor joist system and crawlspace

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

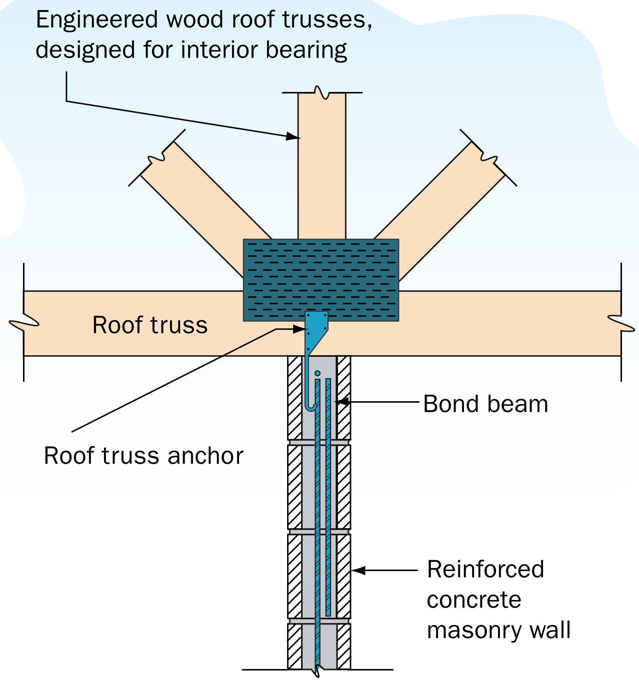
Purpose: To highlight several important details for masonry construction in coastal areas.

Key Issues

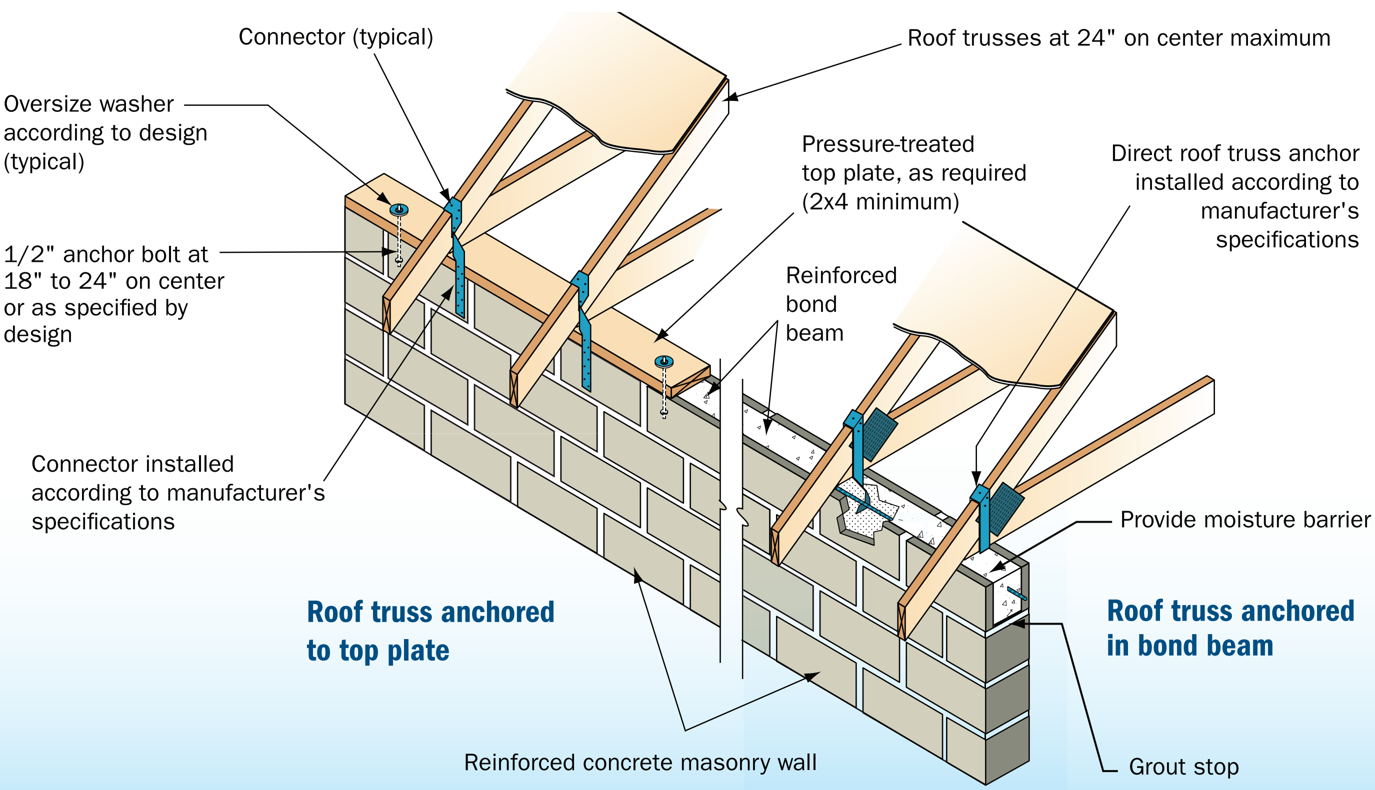
- Continuous, properly connected load paths are essential because of the higher vertical and lateral loads on coastal structures.
- Building materials must be durable enough to withstand the coastal environment.
- Masonry reinforcement requirements are more stringent in coastal areas.

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.

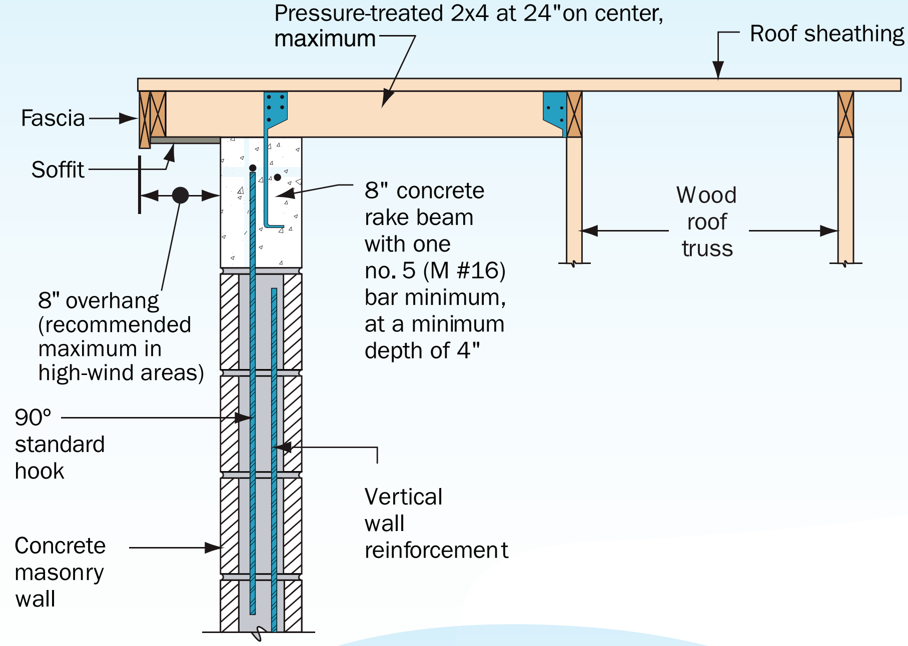


Roof framing to interior masonry wall

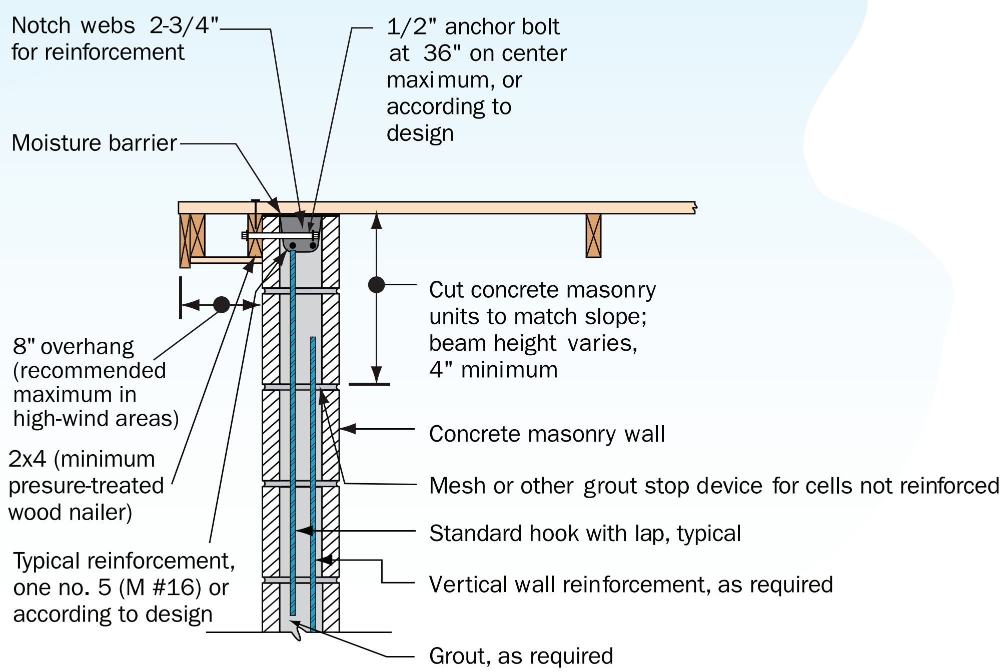


Roof framing to masonry wall.

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



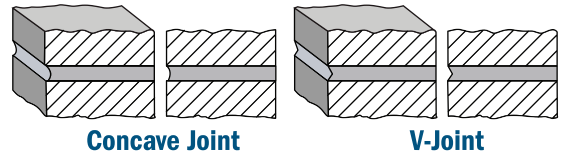
Gable end wall – cut masonry rake beam with ladder-type overhang



Gable endwall connection.

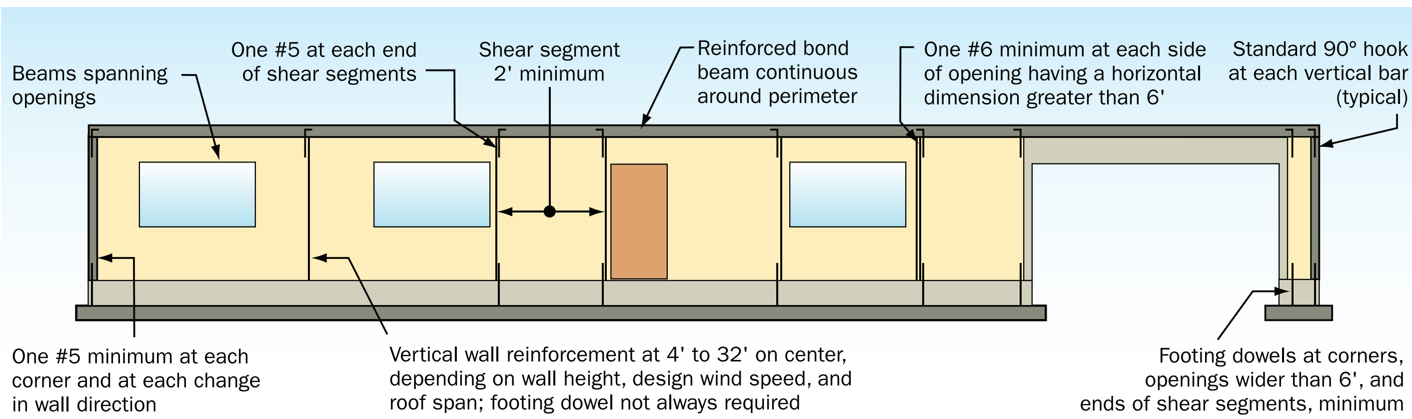
Durability – High winds and salt-laden air can damage masonry construction. The entry of moisture into large cracks can lead to corrosion of the reinforcement and subsequent cracking and spalling. Moisture resistance is highly dependent on the materials and quality of construction.

Quality depends on:



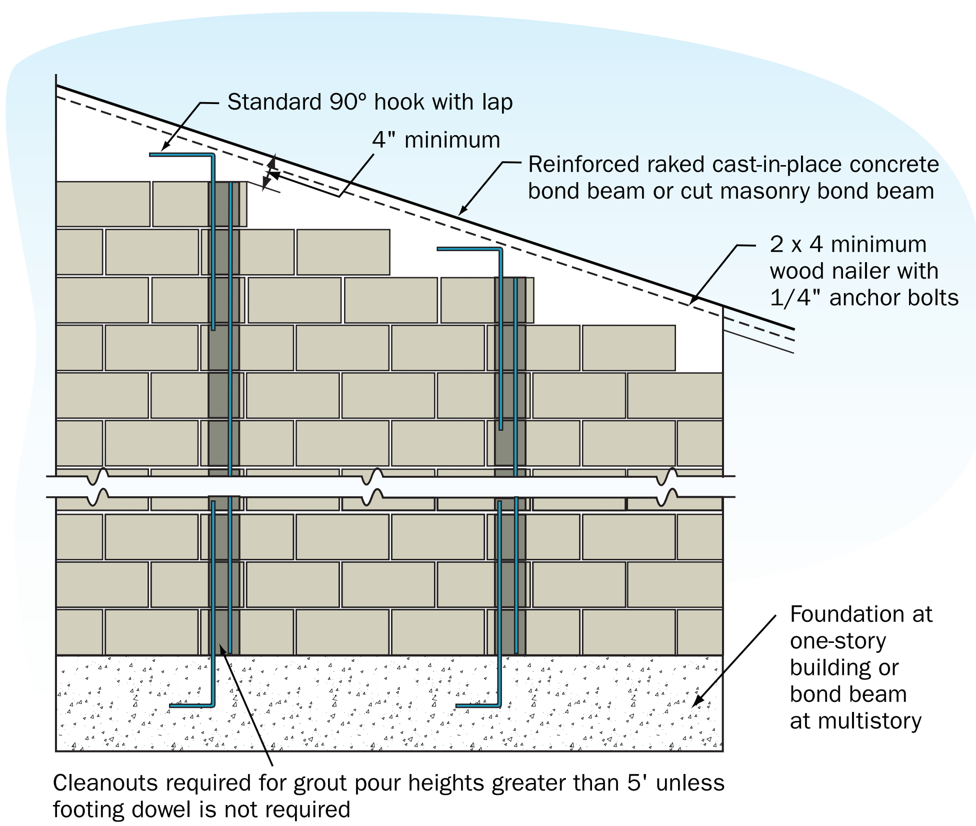
- **Proper storage of material –** Keep stored materials covered and off the ground.
- **Proper batching –** Mortar and grout must be properly batched to yield the required strength.
- **Good workmanship –** Head and bed joints must be well mortared and well tooled. Concave joints and V-joints provide 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.

Shutter Alternatives

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

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

Plywood panels are a cost-effective means of protection.

Why Are Storm Shutters Needed?

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

Temporary, manufactured metal panel shutter. The shutter is installed in a track permanently mounted above and below the window frame. The shutter is placed in the track and secured with wing nuts to studs mounted on the track. This type of shutter is effective and quickly installed, and the wing nut and stud system provides a secure anchoring method.

Where Are Storm Shutters Required and Recommended?

Model building codes, which incorporate wind provisions from ASCE 7 (1998 edition and later), ***require*** that buildings within the most hazardous portion of the ***hurricane-prone region***, called the ***windborne debris region*** (see page 4 of this fact sheet), either (1) be equipped with shutters or impact-resistant glazing and designed as enclosed structures, or (2) be designed as partially enclosed structures (as if the windows and doors are broken out). Designing a partially enclosed structure typically requires upgrading structural components and connections, but will not provide protection to the interior of the building. Designers and owners should assume that a total loss of the building interior and contents will occur in partially enclosed structures.

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

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

windborne debris regions, as opposed to designing a partially enclosed structure. The *Home Builder's Guide to Coastal Construction* also recommends giving strong consideration to the use of opening protection in all hurricane-prone areas where the basic wind speed is 100 mph (3-second peak gust) or greater, even though the model building codes do not require it. Designers should check with the jurisdiction to determine whether state or local requirements for opening protection exceed those of the model code.

What Types of Shutters Are Available?

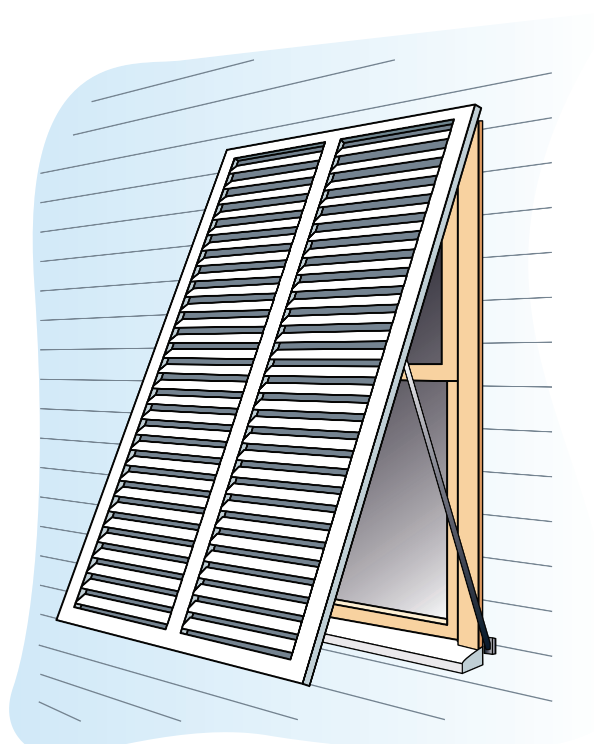
A wide variety of shutter types are available, from the very expensive motor-driven, roll-up type, to the less expensive temporary plywood panels (see photograph on page 1 of this fact sheet). Designers can refer to Miami-Dade County, Florida, which has established a product approval mechanism for shutters and other building materials to ensure they are rated for particular wind and windborne debris loads (see Additional Resources on page 5 of this fact sheet).

Shutter Type	Cost	Advantages	Disadvantages
Temporary plywood panels	Low	Inexpensive	Must be installed and taken down every time they are needed; must be adequately anchored to prevent blow-off; difficult to install on upper levels
Temporary manufactured panels	Low/Medium	Easily installed on lower levels	Must be installed and taken down every time they are needed; difficult to install on upper levels
Permanent, manual-closing	Medium/High	Always in place Ready to be closed	Must be closed manually from the outside; difficult to access on upper levels
Permanent, motor-driven	High	Easily opened and closed from the inside	Expensive

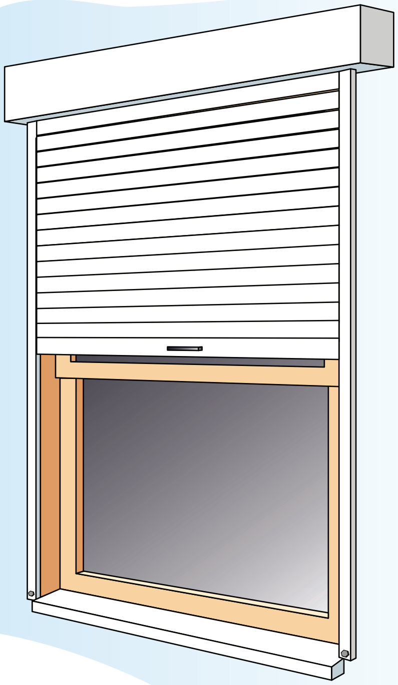
Shutter Styles

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

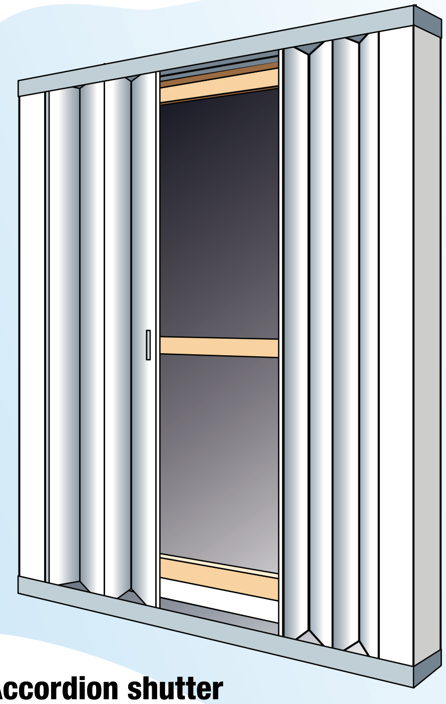
Colonial shutters



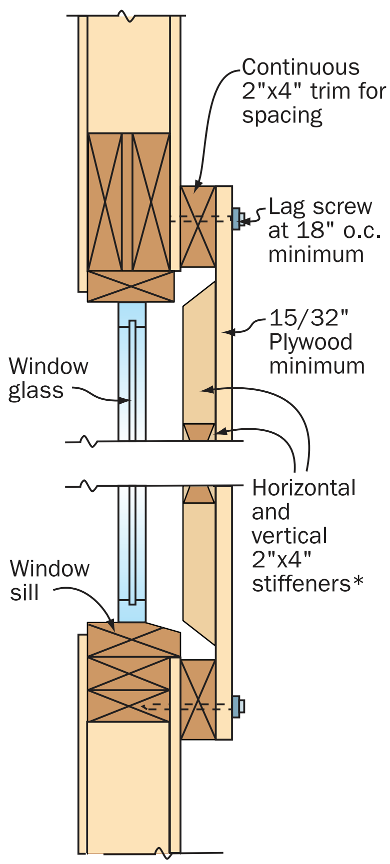
Bahama shutter



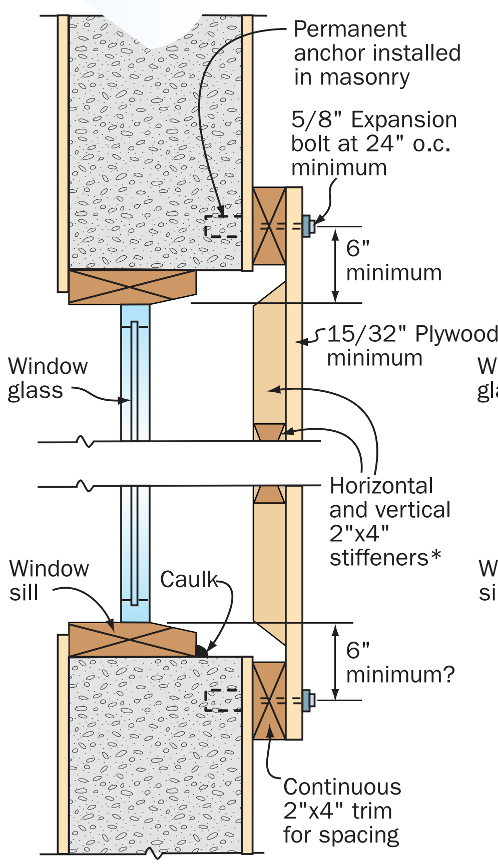
Roll-up shutter



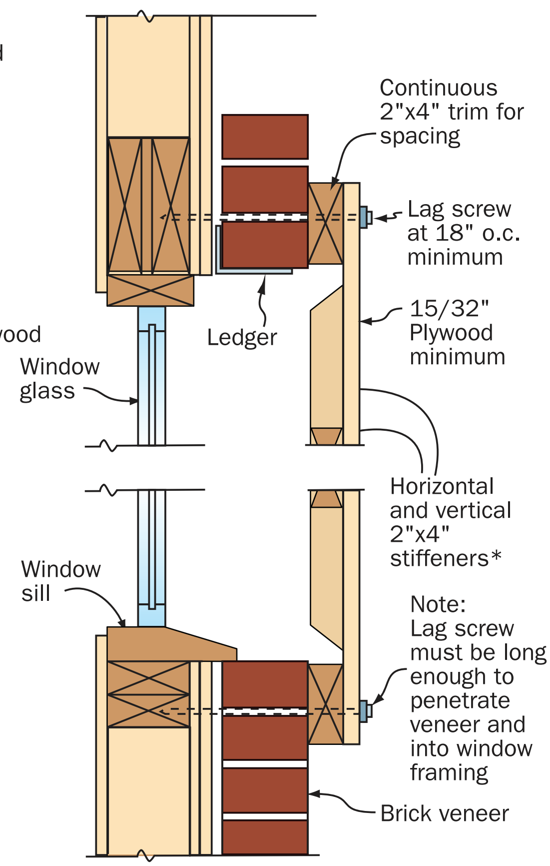
Accordion shutter



Wood Stud Wall



Masonry Wall



Wood Stud Wall With Brick Veneer

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

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

Are There Special Requirements for Shutters in Coastal Areas?

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

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

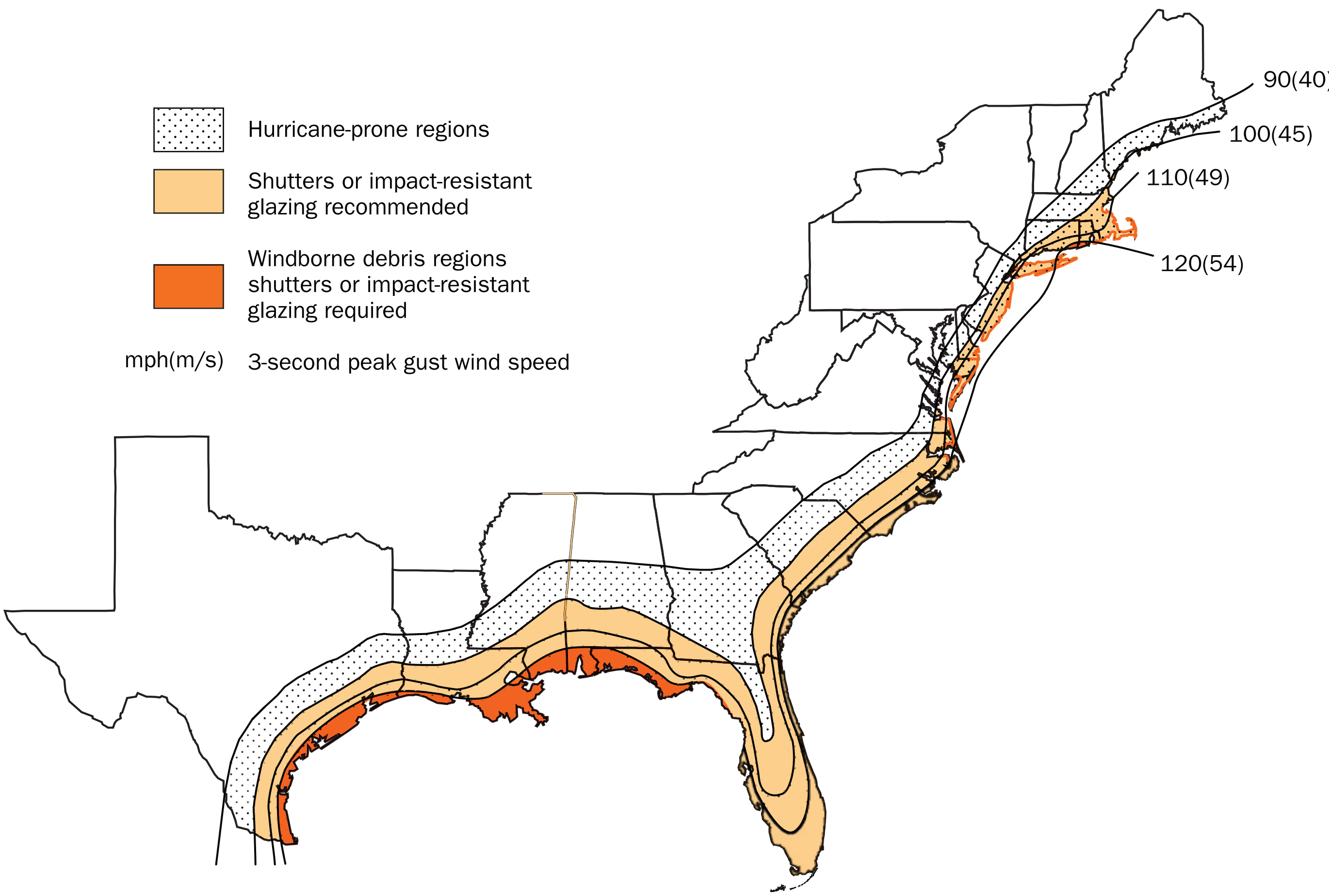
What Are "Hurricane-Prone Regions" "Windborne Debris Regions"?

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

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

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

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



Additional Resources

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

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

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

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

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

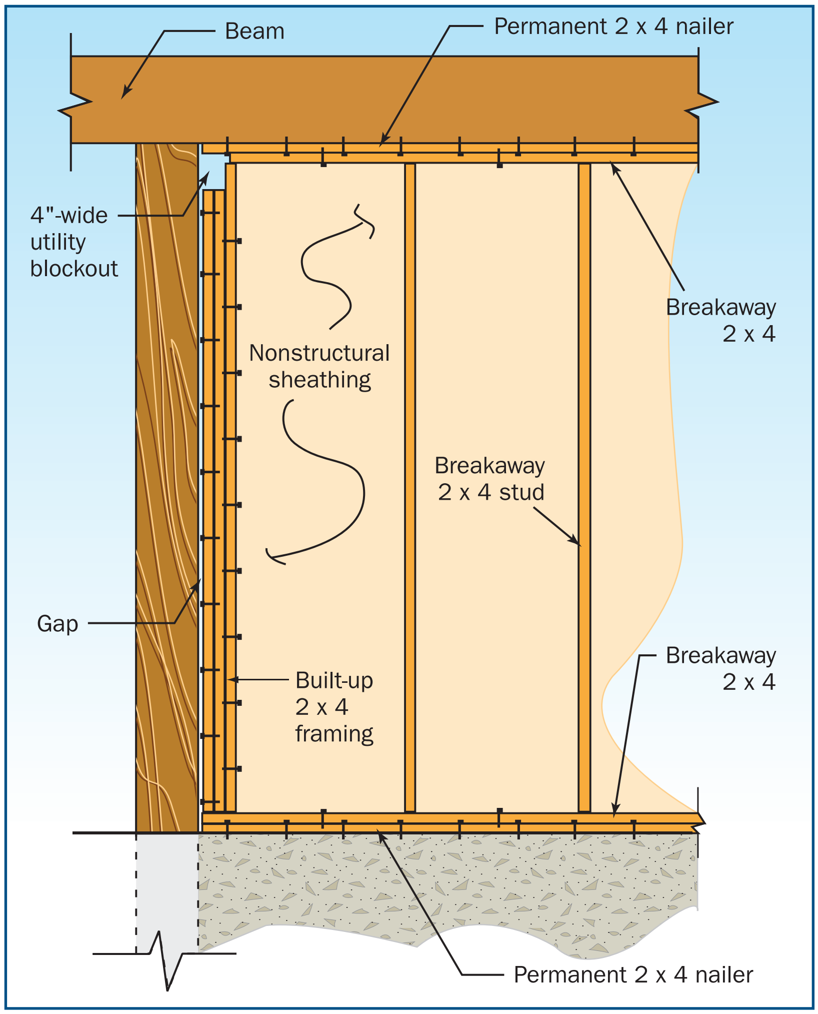
Enclosures can be divided into two types, ***breakaway*** and ***non-breakaway***.

- ***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.

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.

- 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.
- 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.

Enclosures and Breakaway Walls

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.

Protecting Utilities

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

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

Key Issues: Hazards, requirements, and recommendations

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

Coastal Hazards That Damage Utility Equipment

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

Electrical lines and box dislocated by hurricane forces.

Common Utility Damage in Coastal Areas

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

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

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

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

Basic Protection Methods

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

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

Elevation

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

Component Protection

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

NFIP Utility Protection Requirements

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

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

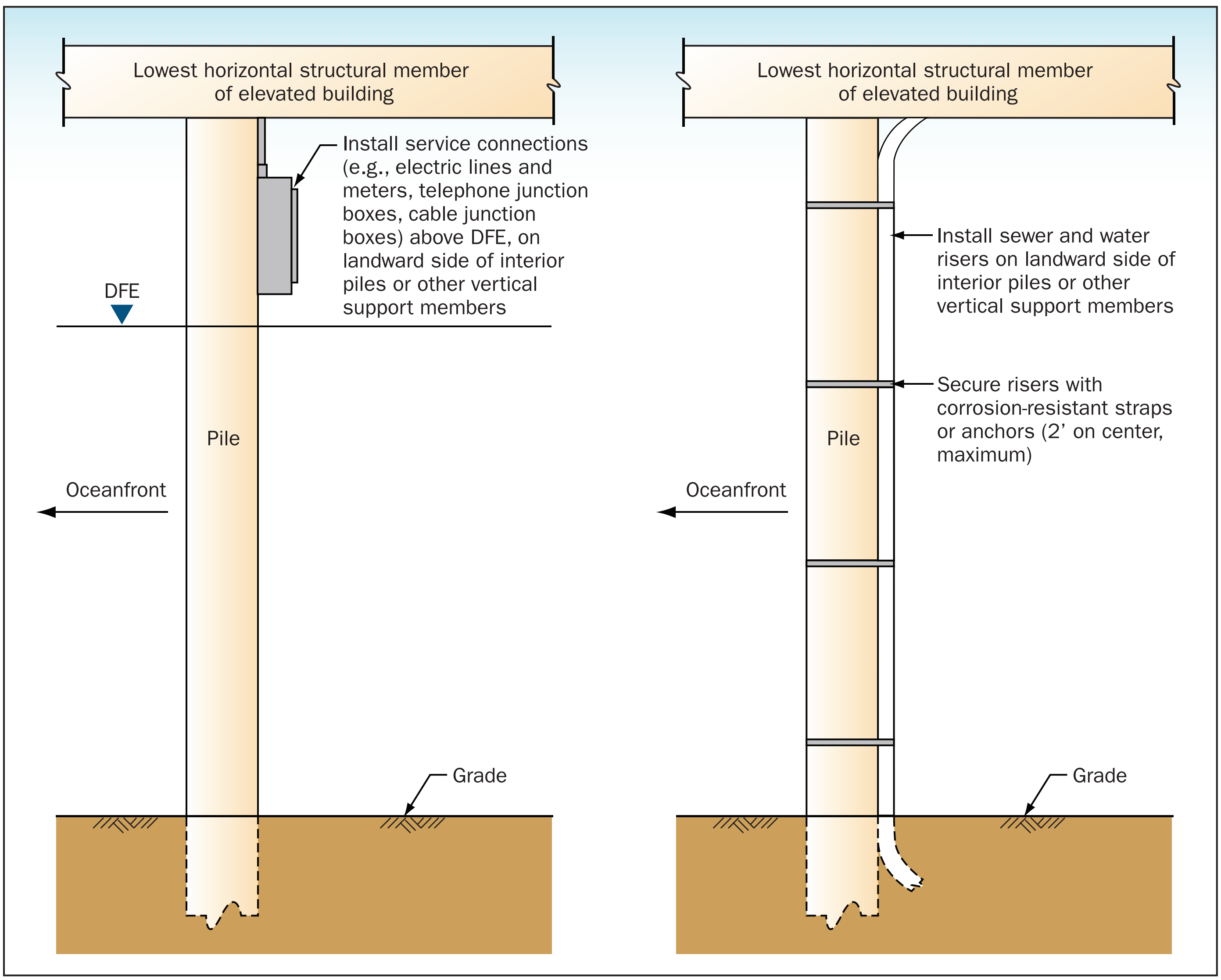
Utility Protection Recommendations

Electrical

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

Water/Sewage

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



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

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

HVAC

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

Elevated air conditioning compressors.

Fuel

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

Additional Resources

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

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

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