# Home Builder's Guide to Coastal Construction

## Technical Fact Sheet Series

*FEMA P-499 / December 2010*

FEMA

# Coastal Construction Fact Sheet Series

**HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION** Technical Fact Sheet No. G.1

GUIDE G

## Introduction

FEMA has produced a series of 37 fact sheets that provide technical guidance and recommendations concerning the construction of ***coastal residential buildings***. The fact sheets present information aimed at improving the performance of buildings subject to flood and wind forces in coastal environments. The fact sheets make extensive use of photographs and drawings to illustrate National Flood Insurance Program (NFIP) regulatory requirements, the proper siting of coastal buildings, and recommended design and construction practices, including structural connections, the building envelope, utilities, and accessory structures. In addition, many of the fact sheets include lists of additional resources that provide more information about the topics discussed.

**Note:** The fact sheets have been divided into 10 different categories, which represent various building components or aspects of the construction process. Fact sheets are numbered first by the category and then followed by a number to represent the fact sheet within the category. Future updates to the guide will include fact sheets using these categories and will allow the user to add new fact sheets within the category without requiring the entire guide to be reprinted. Revisions to individual sheets will include a letter behind the numbers to represent each successive update.

## Available Fact Sheets

The following 37 fact sheets are also available on the FEMA website (www.fema.gov) as Adobe® Portable Document Format (PDF) files and as plain text (.txt) files. You must have Adobe® Reader to view the PDF files. The latest version of Adobe Reader is recommended. Download the free Reader from www.adobe.com.

## Category 1 – General


Coastal Building Successes and Failures

**Fact Sheet No. 1.1, Coastal Building Successes and Failures –** Explains how coastal construction requirements differ from those for inland construction, and discusses the characteristics that make for a successful coastal residential building. Includes design and construction recommendations for achieving building success.


Summary of Coastal Construction Requirements and Recommendations

**Fact Sheet No. 1.2, Summary of Coastal Construction Requirements and Recommendations for Flood Effects –** Summarizes recommendations for exceeding NFIP regulatory requirements for new construction and for repairs, remodeling, and additions. Topics include building foundations, enclosures below the Base Flood Elevation (BFE), use of nonstructural fill, use of space below the BFE, utilities, certification requirements, and repairs, remodeling, and additions. Cross-references to related fact sheets are provided.


Using a Digital Flood Insurance Rate Map (DFIRM)

**Fact Sheet No. 1.3, Using a Digital Flood Insurance Rate Map (DFIRM) –** Explains the purpose of Flood Insurance Rate Maps (FIRMs) and Digital Flood Insurance Rate Maps (DFIRMs); highlights features that are important to coastal builders, including flood zones and flood elevations; and explains how to obtain FIRMs, DFIRMs, and Flood Insurance Studies (FISs).


Lowest Floor Elevation

**Fact Sheet No. 1.4, Lowest Floor Elevation –** Defines "lowest floor," discusses benefits of exceeding the NFIP minimum building elevation requirements, identifies common construction practices that are violations of NFIP regulations, which result in significantly higher flood insurance premiums; and discusses the NFIP Elevation Certificate. Also includes a copy of the certificate.

**Fact Sheet No. 1.5, V Zone Design Certification –** Explains the certification requirements for structural design and methods of construction in V Zones. Also includes a copy of a sample certificate and explains how to complete it.

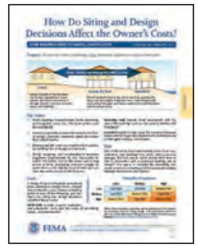
**Fact Sheet No. 1.6, Designing for Flood Levels Above the BFE –** Recommends design and construction practices that reduce the likelihood of flood damage in the event that flood levels exceed the BFE. It includes illustrations of appropriate construction practices and information on the insurance benefits of building above the BFE.

**Fact Sheet No. 1.7, Coastal Building Materials –** Provides guidance and best practices on the selection of building materials used for coastal construction. Flood, wind, corrosion, and decay resistance are discussed, including protection recommendations.

**Fact Sheet No. 1.8, Non-Traditional Building Materials and Systems –** Provides guidance on alternative building materials and techniques and their application in coastal environments. It includes discussions of Engineered Wood Products, Structural Insulated Panels, Insulating Concrete Forms, Prefabricated Shear Walls and Moment Frames, Sprayed Closed-Cell Foam Insulation, Advanced Wall Framing, and Modular Houses.

**Fact Sheet No. 1.9, Moisture Barrier Systems –** Describes the moisture barrier system, explains how typical wall moisture barrier systems work, and discusses common problems associated with moisture barrier systems.

## Category 2 – Planning



**Fact Sheet No. 2.1, How Do Siting and Design Decisions Affect the Owner's Costs?–** Discusses effects of planning, siting, and design decisions on coastal home costs. Topics include initial, operating, and long-term costs; risk determination; and the effect on costs of meeting and exceeding code and NFIP design and construction requirements.

**Fact Sheet No. 2.2, Selecting a Lot and Siting the Building–** Presents guidance concerning lot selection and building siting considerations for coastal residential buildings. Topics include factors that constrain siting decisions, coastal setback lines, common siting problems, and suggestions for builders, designers, and owners.

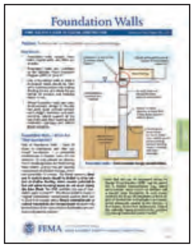
## Category 3 – Foundations

**Fact Sheet No. 3.1, Foundations in Coastal Areas–** Explains foundation design criteria and describes foundation types suitable for coastal environments. Also addresses foundations for high-elevation coastal areas (e.g., bluff areas).

**Fact Sheet No. 3.2, Pile Design and Installation–** Presents basic information about pile design and installation, including pile types, sizes and lengths, layout, installation methods, bracing, field cutting, connections, and verifying capacities.

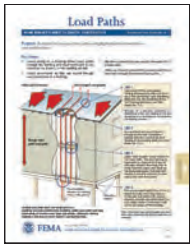
**Fact Sheet No. 3.3, Wood Pile-to-Beam Connections –** Illustrates typical wood-pile-to-beam connections; presents basic construction guidance for various connection methods, including connections for misaligned piles; and illustrates pile bracing connection techniques.


**Fact Sheet No. 3.4, Reinforced Masonry Pier Construction–** Provides an alternative to piles in V Zones and A Zones in coastal areas where soil properties preclude pile installation, but the need for an “open foundation system” still exists. Includes recommendations for good masonry practices in coastal environments.

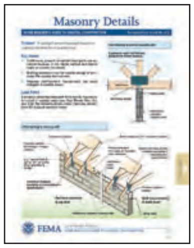



**Fact Sheet No. 3.5, Foundation Walls–** Discusses and illustrates the use of foundation walls in coastal buildings. Topics include footing embedment, wall height, materials and workmanship, lateral support, flood openings and ventilation requirements, and interior grade elevations for crawlspaces.

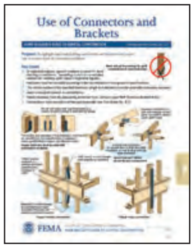
## Category 4 – Load Paths




**Fact Sheet No. 4.1, Load Paths–** Illustrates the concept of load paths and highlights important connections in a typical wind uplift load path.



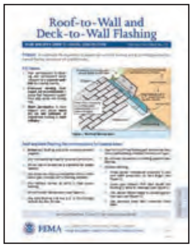

**Fact Sheet No. 4.2, Masonry Details –** Illustrates important roof-to-wall and wall-to-foundation connection details for masonry construction in coastal areas. Topics include load paths, building materials, and reinforcement.




**Fact Sheet No. 4.3, Use of Connectors and Brackets–** Illustrates important building connections and the proper use of connection hardware throughout a building.

## Category 5 – Wall Systems


**Fact Sheet No. 5.1, Housewrap–** Explains the function of housewrap, examines its attributes, and addresses common problems associated with its use. Topics include housewrap vs. building paper and housewrap installation.




**Fact Sheet No. 5.2, Roof-to-Wall and Deck-to-Wall Flashing–** Emphasizes the importance of proper roof and deck flashing, and presents typical and enhanced flashing techniques for coastal homes.


**Fact Sheet No. 5.3, Siding Installation in High-Wind Regions–** Provides basic design and installation tips for various types of siding for high-wind regions, including vinyl, wood, and fiber cement and discusses sustainable design issues.


**Fact Sheet No. 5.4, Attachment of Brick Veneer in High-Wind Regions–** Provides recommended practices for installing brick veneer that will enhance wind resistance in high wind regions. Examples of proper installations and brick veneer tie spacings are provided.

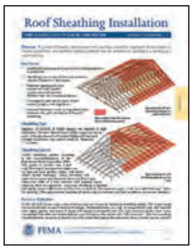
## Category 6 - Openings


**Fact Sheet No. 6.1, Window and Door Installation–** Presents flashing detail concepts for window and door openings that provide adequate resistance to water intrusion in coastal environments, do not depend solely on sealants, are integral with secondary weather barriers (e.g., housewrap), and are adequately attached to the wall. Topics include the American Society for Testing and Materials (ASTM) Standard E 2112 and specific considerations concerning pan flashings, Exterior Insulation Finishing Systems, frame anchoring, shutters, and weatherstripping.


Protection of Openings– Shutters and Glazing

**Fact Sheet No. 6.2, Protection of Openings – Shutters and Glazing–** Presents information about the selection and installation of storm shutters and impact-resistant glazing and other types of opening protection in windborne debris regions. Shutter types addressed include temporary plywood panels; temporary manufactured panels; permanent, manual closing; and permanent, motor-driven.

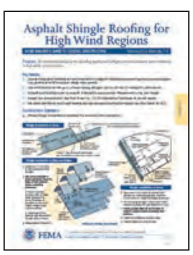
## Category 7 - Roofing


Roof Sheathing Installation

**Fact Sheet No. 7.1, Roof Sheathing Installation–** Presents information about proper roof sheathing installation and its importance in coastal construction; also discusses fastening methods that will enhance the durability of a building in a high-wind area. Topics include sheathing types and layout methods for gable-end and hip roofs, fastener selection and spacing, the treatment of ridge vents and ladder framing, and common sheathing attachment mistakes.


Roof Underlayment for Asphalt Shingle Roofs

**Fact Sheet No. 7.2, Roof Underlayment for Asphalt Shingle Roofs–** Presents recommended practices for the use of roofing underlayment as an enhanced secondary water barrier in coastal environments. Optional installation methods are illustrated.


Asphalt Shingle Roofing for High Wind Regions

**Fact Sheet No. 7.3, Asphalt Shingle Roofing for High-Wind Regions–** Recommends practices for installing asphalt roof shingles that will enhance the wind resistance of roof coverings in high-wind, coastal regions. Issues include installation at hips, eaves, and ridges; shingle characteristics; weathering and durability; and wind resistance.


Tile Roofing for High Wind Regions

**Fact Sheet No. 7.4, Tile Roofing for High-Wind Areas–** Presents design and construction guidance for tile roofing attachment methods. Topics include uplift loads, uplift resistance, special considerations concerning tile attachment at hips and ridges, tile installation on critical and essential buildings, and quality control.


Minimizing Water Intrusion Through Roof Vents in High-Wind Regions

**Fact Sheet No. 7.5, Minimizing Water Intrusion through Roof Vents in High-Wind Regions–** Describes practices for minimizing water intrusion through roof vent systems, which can lead to interior damage and mold growth in high-wind regions. Topics include soffit vents, ridge vents, gable end vents, off-ridge vents, gable rake vents, and turbines.


Metal Roof Systems in High-Wind Regions

**Fact Sheet No. 7.6, Metal Roof Systems in High-Wind Regions–** Presents design and installation guidance for metal roofing systems that will enhance wind-resistance in high-wind regions. Discussions on sustainable design options are included.

## Category 8 - Attachments


Enclosures and Breakaway Walls

**Fact Sheet No. 8.1, Enclosures and Breakaway Walls–** Discusses requirements and recommendations for enclosures and breakaway walls for their use below the BFE. It includes a diagram of a compliant wall system and examples of systems that have either resulted in increased damages or increased flood insurance premiums.


Decks, Pools, and Accessory Structures

**Fact Sheet No. 8.2, Decks, Pools, and Accessory Structures–** Summarizes NFIP requirements, general guidelines, and recommendations concerning the construction and installation of decks, access stairs and elevators, swimming pools, and accessory buildings under or near coastal residential buildings.


Protecting Utilities

**Fact Sheet No. 8.3, Protecting Utilities–** Identifies the special considerations that must be made when installing utility equipment, such as fuel, sewage, and water/sewage lines in a coastal home, and presents recommendations for utility protection.

## Category 9 - Repairs


**Fact Sheet No. 9.1, Repairs, Remodeling, Additions, and Retrofitting - Flood–** Outlines NFIP requirements for repairs, remodeling, and additions, and discusses opportunities for retrofitting in coastal flood hazard areas. Also presents recommendations for exceeding the minimum NFIP requirements. Definitions of “substantial damage” and “substantial improvement” are included.


**Fact Sheet No. 9.2, Repairs, Remodeling, Additions, and Retrofitting - Wind–** Outlines requirements and makes “best practice” recommendations for repairs, remodeling, and additions, and discusses opportunities for retrofitting in coastal high wind areas.

## Category G - Guide


**Fact Sheet No. G.1–** Technical Fact Sheet Guide


**Fact Sheet No. G.2, References and Resources–** Lists references that provide information relevant to topics covered by the *Home Builder’s Guide to Coastal Construction* technical fact sheets.

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

# Coastal Building Successes and Failures

**HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION** Technical Fact Sheet No. 1.1



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

## Is Coastal Construction That Different From Inland Construction?

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

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

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

## 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 1. Well-built but poorly sited building.***

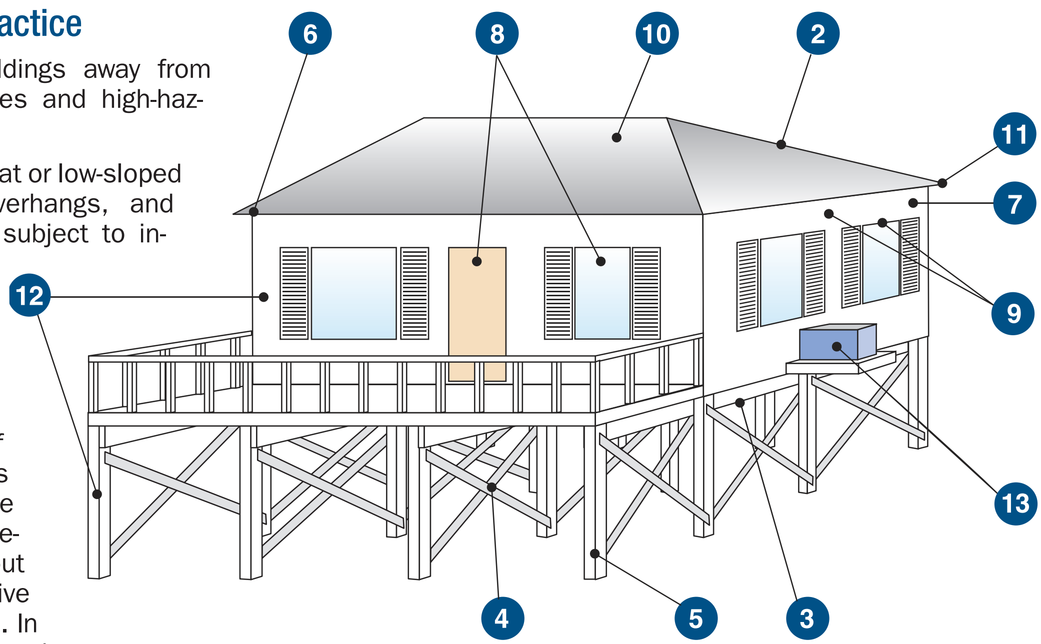
***Figure 2. Well-sited building that still sustained damage.***

## 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, choose 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.

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).

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

# Summary of Coastal Construction Requirements and Recommendations



**Purpose:** *To summarize recommendations for exceeding National Flood Insurance Program (NFIP) regulatory requirements concerning coastal construction.*

## Key Issues

- *New construction** in coastal flood hazard areas (V Zone and A Zone) should be designed using the engineering standards (ASCE 24 and ASCE 7) or the International Residential Code (IRC), as applicable. Best practices must exceed the minimum NFIP requirements and must meet, or exceed, all community zoning and building code requirements. *Repairs, remodeling, and additions* must always meet NFIP and building code requirements for the part of the structure impacted. Should these costs exceed 50 percent of the fair market value of the structure, the entire building must be brought to local floodplain management and building code compliance.

- Engineering standards ASCE 24-05 and ASCE 7-10 are *more stringent in V Zones than in A Zones*, to protect against the increased flood, wave, flood-borne debris, and erosion hazards typical of V Zones.

- ***For added protection, it is strongly recommended that buildings in flood zones that are subject to breaking waves between 1.5 and 3 feet as well as erosion and scour be designed and constructed to V Zone standards.*** These coastal areas, mapped as A Zones, may be subject to damaging waves and erosion and are often referred to as "Coastal A Zones." Buildings in these areas are typically constructed to the minimum NFIP A Zone requirements and have at least a 1-percent-annual-chance of sustaining major damage or being destroyed. This regulatory standard is known as the *base flood*.

- Buildings constructed to minimum NFIP A Zone standards and subject solely to shallow flooding (i.e., not subject to breaking waves greater than 1.5 feet or erosion) are still subject to flood damage and should be built with a first floor elevation above the BFE (usually at least one foot or greater), which is referred to as "freeboard."

- Following the recommendations in the following table will result in less damage to the building and may reduce 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*** refers to structures for which construction began on or after the effective date of adoption of the community's floodplain management ordinance. Substantial improvements, repairs of substantially damaged buildings, and some enclosures must meet the same floodplain management ordinance and building code requirements as new construction where such ordinances and codes have been adopted by the community.

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

| | Coastal Construction Requirements and Recommendations | | | |
|---|---|---|---|---|
| | V Zone | Coastal A Zone | A Zone | Additional Resources |
| **Foundation** | | | | |
| **Structural Fill**<br>**NFIP 60.3(e)(6)** | **Prohibited** | **Requirement:** Compaction where used; protect against scour and erosion. | **Requirement:** Compaction where used; protect against scour and erosion. | **IBC:** 1804.4, App. G 401.1, App. G 401.2<br>**IRC:** R322.3.2<br>**ASCE:** ASCE 24 Sec. 2.4<br>**Other:** FEMA TB #5 |
| **Solid Foundation Walls [see Fact Sheet Nos. 3.1, 3.5]**<br>**NFIP 60.3(c)(3)** | **Prohibited** | **Requirement:** Flood vents must be installed to equalize pressures (see Fact Sheets Nos. 3.5 and 8.1).<br>**Recommendation:** An open foundation system should be used. | **Requirement:** Where used, the walls must allow floodwaters to pass between or through the walls using flood openings (see Fact Sheets Nos. 3.5 and 8.1). | **IBC:** 1612.5.1<br>**IRC:** R322.2.3<br>**ASCE:** ASCE 24 Sec. 2.5, ASCE 7 Sec. 5.4.4.2<br>**Other:** FEMA TB #5, FEMA 550 |
| **Open Foundation [see Fact Sheet No. 3.1]**<br>**NFIP 60.3(e)(5) and 60.3(c)(5)** | **Recommendation:** Site new construction landward of the long-term erosion setback and landward of the area subject to erosion during the 1% coastal flood event.<br>**Requirement:** All new construction shall be landward of the reach of the mean high tide; alteration of sand dunes and mangrove stands that increases the potential of flood damage is prohibited. | **Recommendation:** Open foundations are recommended in Coastal A Zones. | **Recommendation:** Open foundations are recommended in A Zones. | **IBC:** 1803.5.5<br>**IRC:** R322.3.3<br>**ASCE:** ASCE 7 Sec. 5.4.4.1, ASCE 24 Sec 4.5.5<br>**Other:** FEMA TB #5 |
| **Lowest Floor Elevation (not in a V Zone) [see Fact Sheet No. 1.5]**<br>**NFIP 60.3(c)** | **Not Applicable** | **Recommendation:** Elevate the bottom of the lowest horizontal structural member at, or above, BFE.<br>**Requirement:** Top of floor must be at or above BFE. | **Requirement:** Top of floor must be at or above BFE. | **IBC:** 1603.1.7, 1612.5<br>**IRC:** R105.3.1.1, R322.2.1, R322.1.5<br>**ASCE:** ASCE 24 Sec. 1.5.2, ASCE 24 Sec. 2.5, ASCE 24 Ch. 5, ASCE 24 Ch. 7<br>**Other:** FEMA TB #5 |
| **Bottom Lowest Horizontal Structural Member [see Fact Sheet No. 1.4]**<br>**NFIP 60.3(e)(4)** | **Requirement:** Bottom of the lowest horizontal structural member of the first floor must be at, or above, the BFE (see Fact Sheet No. 1.5). | **Recommendation:** Follow the V Zone building elevation requirement. | **Recommendation:** The minimum recommendation is to follow the Coastal A Zone requirements. Users should consider following V Zone recommendations for the lowest horizontal structural member elevation to further minimize the risk of flood damage. | **IBC:** 1603.1.7, 1605.2.2, 1605.3.1.2, 1612.4, 1612.5.2<br>**IRC:** R322.3.2<br>**ASCE:** ASCE 24 Sec. 4.4, ASCE 24 Sec. 2.5, ASCE 24 Ch. 5<br>**Other:** FEMA 55, FEMA TB #8, FEMA TB #5 |

| | Coastal Construction Requirements and Recommendations | | | |
|---|---|---|---|---|
| | **V Zone** | **Coastal A Zone** | **A Zone** | **Additional Resources** |
| **Foundation** | | | | |
| **Orientation of Lowest Horizontal Structural Member** | **Requirement:** Elevate the bottom of the lowest horizontal structural member at, or above, BFE. | **Recommendation:** If the orientation of the lowest horizontal structural member is parallel to the expected direction of waves, elevate the bottom of the member to or above BFE; If the orientation of the lowest horizontal structural member is perpendicular to the expected direction of waves, elevate the bottom of the member to BFE plus one foot. Diagonal bracing for decks, stairways, balconies and other attached structures should also be elevated at, or above, the BFE. | **Recommendation:** Follow the Coastal A Zone recommendation. | **IBC:** see ASCE 24<br>**IRC:** R322.3.2<br>**ASCE:** ASCE 24 Sec 4.4<br>**Other:** FEMA TB #5 |
| **Freeboard [see Fact Sheet Nos. 1.1, 1.4]** | **Requirement:** No NFIP requirement, but freeboard is required by IRC and ASCE. | **Recommendation:** Freeboard is recommended in Coastal A Zones.<br>**Note:** Per ASCE 24-05 one foot of freeboard required for Risk Category II structures. | **Recommendation:** Freeboard is recommended in A Zones.<br>**Note:** One foot above BFE is required per IRC R322.2.1 Item #2 for Coastal A Zones. | **IBC:** see ASCE 24<br>**IRC:** R322.2.1, R322.3.2<br>**ASCE:** ASCE 24 Sec. 2.3 |
| **Enclosures Below the BFE (not in a V Zone)** | **Not Applicable** | **Recommendation:** If an enclosure is constructed, use breakaway walls, open lattice, or screening (as required in V Zones).<br>**Requirement:** If an area is fully enclosed, the enclosure walls must be equipped with openings to equalize hydrostatic pressure; the size, location, and covering of openings governed by regulatory requirements. | **Recommendation:** If an enclosure is constructed, use breakaway walls, open lattice, or screening (as required in V Zones).<br>**Requirement:** If an area is fully enclosed, the enclosure walls must be equipped with openings to equalize hydrostatic pressure; the size, location, and covering of openings governed by regulatory requirements. | **IBC:** 1203.3.2, 1403.5, 1612.4, 1612.5.1<br>**IRC:** R322.2.2, R408.7<br>**ASCE:** ASCE 24 Sec. 2.6, ASCE 24 Sec 4.6<br>**Other:** FEMA TB #1 |
| **Enclosures Below the BFE (not in V Zones) [see Fact Sheet No. 8.1]**<br>**NFIP 60.3(c)(5)** | **Prohibited,** except for breakaway walls, open wood lattice, and screening. | **Not Applicable** | **Not Applicable** | **IBC:** 1403.5, 1403.6, 1612.4, 1612.5.2<br>**IRC:** R322.3.2, R322.3.4, R322.3.5<br>**ASCE:** ASCE 24 Sec. 4.6, ASCE 7 Sec. C5.3.3<br>**Other:** FEMA 55, FEMA TB #5, FEMA TB #9 |

| | Coastal Construction Requirements and Recommendations | | | |
|---|---|---|---|---|
| | V Zone | Coastal A Zone | A Zone | Additional Resources |
| **Foundation** | | | | |
| Non Structural Fill | **Requirement:** Allowed for minor landscaping and site drainage as long as the fill does not interfere with free passage of flood waters and debris beneath the building, or cause changes in flow direction during coastal storms that could result in damage to buildings. | **Recommendation:** Follow the V Zone fill requirement. | **Recommendation:** Follow the V Zone fill requirement. | **IBC:** 803.11.1<br>**IRC:** R322.14.2, R322.3.2<br>**ASCE:** ASCE 24 Sec 1.5.4, 45.4<br>**Other:** FEMA TB #5 |
| Use of Space Below BFE [see Fact Sheet No. 8.1] | **Requirement:** Allowed only for parking, building access, and storage | **Requirement:** Allowed only for parking, building access, and storage | **Requirement:** Allowed only for parking, building access, and storage | **IBC:** 1107.7.5, G105.7 (5), 801.5, G103.5, G103.8<br>**IRC:** R309.3, R322.1, R322.1.2, R322.1.3, R322.1.4, R322.1.4.1, R322.2.1, R322.2.2, R322.3.2, R322.3.5<br>**ASCE:** ASCE 24 1.5.2, 2.6, 2.6.1, 2.6.2.1, 2.6.2.2, 4.6, 4.6.1, 4.6.2 |
| **Utilities** | | | | |
| Sanitary Sewer<br>NFIP 60.3(a)(6)(i) and 60.3(a)(6)(ii) | | | | **IBC:** 1403.6, App. G 401.3<br>**IRC:** R322.1.7, R P2602.2, R P3001.3, R P3101.5<br>**ASCE:** ASCE 24 Sec. 7.3.4<br>**Other:** FEMA 348, FEMA TB #4 |
| Utilities [see Fact Sheet No. 8.3]<br>NFIP 60.3(a)(3) (iv) | **Requirement:** 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 unless flood proofed to the extent practicable. | **Requirement:** Electrical, heating, ventilation, plumbing, and air-conditioning equipment and other service facilities to be designed and/or located as to prevent water from entering or accumulating within the components during periods of flooding.<br>**Recommendation:** Follow the V Zone utility recommendation | **Requirement:** Electrical, heating, ventilation, plumbing, and air-conditioning equipment and other service facilities to be designed and/or located as to prevent water from entering or accumulating within the components during periods of flooding. | **IBC:** 1403.6, 1612.4, App. G 701<br>**IRC:** R322.1.6, IFGC 301.11, R G2404.7, R P2601.3, R P2602.2, R M1301.1.1, R M1401.5, R M1601.4.9, R M1701.2, R M2001.4, R M2201.6<br>**ASCE:** ASCE 24 Ch. 7<br>**Other:** FEMA 348, FEMA TB #4 |
| **Certification** | | | | |
| Permits<br>NFIP 60.3(b)(1) | **Requirement:** V Zone certificate, Breakaway Wall certificate, and Elevation Certificate. | **Requirement:** Elevation Certificate. | **Requirement:** Elevation Certificate. | **IBC:** App. G 101.3, App. G 103, App. G 104<br>**IRC:** R104.2, R105, App. E, App. J<br>**ASCE:** ASCE 24 Sec. 4.6, ASCE 7 Sec. C5.3.3<br>**Other:** FEMA EMI IS-9 |

| | Coastal Construction Requirements and Recommendations | | | |
|---|---|---|---|---|
| | V Zone | Coastal A Zone | A Zone | Additional Resources |
| **Certification** | | | | |
| **Elevation**<br><br>**NFIP 60.3(b)(5)(i) and 60.3(e)(2)** | **Requirement:** The lowest horizontal structural member must be at, or above, BFE; 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. 1.4,1.5, 8.3) | **Recommendation:** Follow the V Zone building elevation requirement.<br><br>**Requirement:** Top of lowest floor must be at, or above, BFE; 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. 1.4 8.3) | **Recommendation:** The minimum recommendation is to follow the Coastal A Zone requirements. Users should consider following V Zone recommendations for the lowest horizontal structural member elevation to further minimize the risk of flood damage.<br><br>**Requirement:** Top of the lowest floor must be at, or above, BFE; 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. 1.4, 8.3) | **IBC:** 110.3.3,1603.1.7, 1612.5<br><br>**IRC:** R106.1.3, R322.1.2, R322.1.5, R322.2.1<br><br>**ASCE:** ASCE 24 Sec. 1.5.1, 1.5.2, 4.4 |
| **Structure** | **Requirement:** Registered engineer or architect must certify that the design and methods of construction are in accordance with an accepted standard of practice for meeting design requirements described under General Requirement (see Fact Sheet No. 1.5) | **Recommendation:** Follow the V Zone requirement. | **Recommendation:** Follow the V Zone requirement. | **IBC:** 1604.1,1604.2, 1604.3<br><br>**IRC:** R301.1, R301.1.3,R301.2<br><br>**ASCE:** ASCE 7 Sec. 1.3.1.3.3 |

| | Coastal Construction Requirements and Recommendations | | | |
|---|---|---|---|---|
| | V Zone | Coastal A Zone | A Zone | Additional Resources |
| **Certification** | | | | |
| Breakaway Walls [see Fact Sheet Nos. 1.5, 8.1] (also see Enclosures Below BFE)<br><br>NFIP 60.3(e)(5) | **Requirement:** Walls must be designed to break free under larger of the following allowable stress design loads: (1) design wind load, (2) design seismic load, or (3) 10 psf, acting perpendicular to the plane of the wall; if loading intended to cause collapse exceeds 20 psf using allowable stress design, the breakaway wall design shall 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. | **Recommendation:** Breakaway walls are recommended with an open foundation in lieu of solid walls; if breakaway walls are used and enclose an area, flood openings are required (see Fact Sheet Nos. 3.1, 3.5). | | **IBC:** 1612.5 (2.3)<br>**IRC:** R322.3.4<br>**ASCE:** ASCE 24 Sec. 4.6.1, 4.6.2, 2.6.1.1, ASCE 7 Sec. 5.3.3<br>**Other:** FEMA TB #5, FEMA TB #9 |
| Openings in Below-BFE Walls [see Fact Sheet Nos. 3.1, 3.5] (also see Enclosures Below BFE)<br><br>NFIP 60.3(c)(5) | **Not Applicable** | **Requirement:** Unless the number and size of the openings meet regulatory requirements, a registered engineer or architect must certify that the openings are designed to automatically equalize hydrostatic forces on the walls by allowing automatic entry and exit of flood waters. | **Requirement:** Unless the number and size of the openings meet regulatory requirements, a registered engineer or architect must certify that the openings are designed to automatically equalize hydrostatic forces on the walls by allowing automatic entry and exit of flood waters. | **IBC:** 1203.4.12, G1001.4<br>**IRC:** R322.2.2<br>**ASCE:** ASCE 24 Sec. 2.6.1, 2.6.2.1, 2.6.2.2<br>**Other:** FEMA TB #1 |
| **Repairs, Remodeling, and Additions [See Fact Sheet No. 9.1]** | | | | |
| Substantial Improvements and Repairs of Substantial Damage<br><br>NFIP 60.3(e)(5) and 60.3(c)(5) | **Requirement:** Must meet current NFIP requirements concerning new construction in V Zones except for siting landward of mean high tide (see Fact Sheet Nos. 1.4, 1.5, 2.2, 3.1, 3.5, 8.1, 8.3). | **Recommendation:** Follow the V Zone requirement for building elevation and open foundations.<br>**Requirement:** Must meet current NFIP requirements concerning new construction in A Zones (see Fact Sheet Nos. 1.4, 3.1, 3.5, 8.1, 8.3). | **Recommendation:** Elevate bottom of lowest horizontal structural member to or above BFE.<br>**Requirement:** Must meet current NFIP requirements concerning new construction in A Zones (see Fact Sheet Nos. 1.1, 3.1, 3.5, 8.1, 8.3) | **IBC:** 1612.1, 1612.2, 3403.2, 3404.2, 3405.2, 3405.3, 3405.4<br>**IRC:** R322.1.6, R322.3.1<br>**ASCE:** ASCE 24 Sec. 4.3, ASCE 7 Sec. 1.6<br>**Other:** FEMA P-758 |

| | Coastal Construction Requirements and Recommendations | | | |
|---|---|---|---|---|
| | V Zone | Coastal A Zone | A Zone | Additional Resources |
| Repairs, Remodeling, and Additions [See Fact Sheet No. 9.1] | | | | |
| **Lateral Additions That Constitute Substantial Improvement**<br><br>**NFIP 60.3(e)(5)** | **Requirement:** Both the addition and the existing building must meet current NFIP requirements concerning new construction in V Zones (see Fact Sheet Nos. 1.4, 1.5, 2.2, 3.1, 3.5, 8.1, 8.3). | **Recommendation:** Follow V Zone requirement for building elevation and open foundations for the addition and the existing building.<br>**Requirement:** Only additions must meet current NFIP requirements concerning new construction in A Zones (see Fact Sheet Nos. 1.4, 1.5, 3.1, 3.5, 8.1, 8.3), 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 the existing building it too must meet current NFIP requirements for new construction in A Zones. | **Recommendation:** Elevate bottom of lowest structural member of the addition to or above BFE (same for the existing building if it is elevated).<br>**Requirement:** Only additions must meet current NFIP requirements concerning new construction in A Zones (see Fact Sheet Nos. 1.4, 2.2, 3.1, 3.5, 8.1, 8.3), 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 the existing building it too must meet current NFIP requirements for new construction in A Zones. | **IBC:** 3403.2, 3412.2.3, 3405.3<br>**IRC:** R322.3.1<br>**ASCE:** ASCE 7 Sec. 1.6<br>**Other:** FEMA TB #1, FEMA TB #5, FEMA TB #9, FEMA 550 |
| **Lateral Additions That Do Not Constitute Substantial Improvement**<br><br>**NFIP 60.3(e)(5) and 60.3(c)(5)** | **Recommendation:** Make addition compliant with current NFIP requirements for V Zone construction.<br>**Requirements:** Post-FIRM existing building – the addition must meet NFIP requirements in effect at time the building was originally constructed. Pre-FIRM existing building – NFIP requirements concerning new construction are not triggered (see Fact Sheet Nos. 1d, 1e, 2b, 3a, 3e, 8a, 8c) | **Recommendation:** Follow V Zone requirement for building elevation and open foundations for the addition and the existing building.<br>**Requirements:** Post-FIRM existing building – the addition must meet NFIP requirements in effect at the time the building was originally constructed (see Fact Sheet Nos. 1d, 1e, 2b, 3a, 3e, 8a, 8c). Pre-FIRM existing building -- NFIP requirements concerning new construction are not triggered. | **Recommendation:** Elevate bottom of lowest horizontal structural member to or above BFE (same for existing building if it is elevated) (see Fact Sheet No. 1d)<br>**Requirements:** Post-FIRM existing building – the addition must meet NFIP requirements in effect at the time the building was originally constructed (see Fact Sheet Nos. 1d, 1e, 2b, 3a, 3e, 8a, 8c). Pre-FIRM existing building -- NFIP requirements concerning new construction are not triggered. | **BC:** 3403.2, 3412.2.3, 3405.3<br>**IRC:** R322.3.1<br>**ASCE:** ASCE 7 Sec. 1.6<br>**Other:** FEMA TB #1, FEMA TB #5, FEMA TB #9, FEMA 550 |

| | Coastal Construction Requirements and Recommendations | | | |
|---|---|---|---|---|
| | V Zone | Coastal A Zone | A Zone | Additional Resources |
| **Repairs, Remodeling, and Additions [See Fact Sheet No. 9.1]** | | | | |
| **Vertical Additions That Constitute Substantial Improvement**<br><br>**NFIP 60.3(e)(5) and 60.3(c)(5)** | **Requirement:** Entire building must meet current NFIP requirements concerning new construction in V Zones (see Fact Sheet Nos. 1d, 1e, 2b, 3a, 3e, 8a, 8c). | **Recommendation:** Follow V Zone requirements for building elevation and open foundations.<br>**Requirement:** Entire building must meet current NFIP requirements concerning new construction in A Zones (see Fact Sheet Nos. 1d, 1e, 2b, 3a, 3e, 8a, 8c). | **Recommendation:** Elevate bottom of lowest horizontal structural member to or above BFE (same for existing building if it is elevated) (see Fact Sheet No. 1d).<br>**Requirements:** Post-FIRM existing building – the addition must meet NFIP requirements in effect at the time the building was originally constructed (see Fact Sheet Nos. 1d, 1e, 2b, 3a, 3e, 8a, 8c). Pre-FIRM existing building -- NFIP requirements concerning new construction are not triggered. | **IBC:** 3405.3.1, 3405.4, 3405.5<br>**IRC:** N/A<br>**ASCE:** N/A |
| **Vertical Additions That Do Not Constitute Substantial Improvement**<br><br>**NFIP 60.3(e)(5) and 60.3(c)(5)** | **Recommendation:** Make the addition compliant with current NFIP requirements for V Zone construction.<br>**Requirements:** Post-FIRM existing building – the addition must meet NFIP requirements in effect at the time the building was originally constructed. Pre-FIRM existing building -- NFIP requirements concerning new construction are not triggered (see Fact Sheet Nos. 1.4, 1.5, 2.2, 3.1, 3.5, 8.1, 8.3). | **Recommendation:** Follow the V Zone requirement for building elevation and open foundations for the existing building.<br>**Requirements:** Post-FIRM existing building – the addition must meet NFIP requirements in effect at the time the building was originally constructed (see Fact Sheet Nos. 1.4, 1.5, 2.2, 3.1, 3.5, 8.1, 8.3). Pre-FIRM existing building -- NFIP requirements concerning new construction are not triggered. | **Recommendation:** Elevate bottom of lowest horizontal structural member at, or above, BFE (same for the existing building if it is elevated) (see Fact Sheet No. 1.4).<br>**Requirements:** Post-FIRM existing building – the addition must meet NFIP requirements in effect at the time the building was originally constructed (see Fact Sheet Nos. 1.4, 1.5, 2.2, 3.1, 3.5, 8.1, 8.3). Pre-FIRM existing building -- NFIP requirements concerning new construction are not triggered. | **IBC:** 3405.3.1, 3405.4, 3405.5<br>**IRC:** N/A<br>**ASCE:** N/A |

| | Coastal Construction Requirements and Recommendations | | | |
|---|---|---|---|---|
| | **V Zone** | **Coastal A Zone** | **A Zone** | **Additional Resources** |
| **Repairs, Remodeling, and Additions [See Fact Sheet No. 9.1]** | | | | |
| **Elevating on New Foundation**<br><br>**NFIP 60.3(e)(5) and 60.3(c)(5)** | **Requirement:** New foundation must meet current NFIP requirements concerning new construction in V Zones; the building must be properly connected and anchored to the new foundation.<br>**Note:** Repairing a foundation that does not constitute a substantial improvement does not require current compliance, but compliance to the year of construction. | **Recommendation:** Follow the V Zone requirement for building elevation and open foundations.<br>**Requirement:** New foundation must meet current NFIP requirements concerning new construction in A Zones; the building must be properly connected and anchored to the new foundation. | **Recommendation:** Elevated bottom of lowest horizontal structural member to or above BFE (see Fact Sheet No. 1d).<br>**Requirement:** New foundation must meet current NFIP requirements concerning new construction in A Zones; the building must be properly connected and anchored to the new foundation. | **IBC:** 1808.1, 1808.2, 1808.3, 1808.6, 1808.6.1<br>**IRC:** R401.1, R401.2, R401.3, R401.4, R401.4.1<br>**ASCE:** ASCE 24 Sec. 1.5.3, 1.5.3.1, 1.5.3.2, 1.5.3.3, ASCE 7 Sec. 1.6<br>**Other:** FEMA 550, FEMA TB #1, FEMA TB #5 |
| **Enclosures Below Buildings–When Enclosure Constitutes a Substantial Improvement**<br><br>**NFIP 60.3(e)(5) and 60.3(c)(5)** | **Requirement:** Both the enclosure and the existing building must meet current NFIP requirements for new construction in V Zones (see Fact Sheets Nos. 1.4, 1.5, 2.2, 3.1, 8.1, 8.3). | **Recommendation:** Follow the V Zone requirement for building elevation and open foundations.<br>**Requirement:** Both the enclosure and the existing building must meet current NFIP requirements for new construction in A Zones (see Fact Sheets Nos. 1.4, 1.5, 2.2, 3.1, 8.1, 8.3). | **Recommendation:** Elevated bottom of lowest horizontal structural member at, or above, BFE (see Fact Sheet No. 1.4).<br>**Requirement:** Both the enclosure and the existing building must meet current NFIP requirements for new construction in A Zones (see Fact Sheets Nos. 1.4, 1.5, 2.2, 3.1, 8.1, 8.3). | **IBC:** 1612.1, 3404.2<br>**IRC:** R322.1, R322.1.8, R322.3.5<br>**ASCE:** ASCE 24 Sec. 4.6, ASCE 7 Sec. 1.6<br>**Other:** FEMA TB #5, FEMA TB #9 |
| **Enclosures Below Buildings–When Enclosure Does Not Constitutes a Substantial Improvement**<br><br>**NFIP 60.3(e)(5) and 60.3(c)(5)** | **Recommendation:** Make the enclosure compliant with current NFIP requirements for new V Zone construction.<br>**Requirement:** Post-FIRM existing building – the enclosure must meet NFIP requirements in effect at the time the building was originally constructed. Pre-FIRM existing building -- NFIP requirements concerning new construction are not triggered (see Fact Sheet No. 8.1). | **Recommendation:** Construct only breakaway enclosures; install flood openings in the enclosure; do not convert the enclosed space to habitable use.<br>**Requirement:** Post-FIRM existing building -- the enclosure must meet NFIP requirements in effect at the time the building was originally constructed. Pre-FIRM existing building -- NFIP requirements concerning new construction are not triggered (see Fact Sheet Nos. 3.5, 8.1). | **Recommendation:** Install flood openings in the enclosure; do not convert the enclosed space to habitable use.<br>**Requirement:** Post-FIRM existing building – the enclosure must meet NFIP requirements in effect at the time the building was originally constructed. Pre-FIRM existing building -- NFIP requirements concerning new construction are not triggered (see Fact Sheet Nos. 3.5, 8.1). | **IBC:** 1612.1, 3404.2<br>**IRC:** N/A<br>**ASCE:** ASCE 24 Sec. 4.6<br>**Other:** FEMA TB #1, FEMA TB #5, FEMA TB #9 |

| | Coastal Construction Requirements and Recommendations | | | |
|---|---|---|---|---|
| | V Zone | Coastal A Zone | A Zone | Additional Resources |
| **Repairs, Remodeling, and Additions [See Fact Sheet No. 9.1]** | | | | |
| Reconstruction of Destroyed or Razed Building<br><br>NFIP 60.3(e)(5) and 60.3(c)(5) | **Requirement:** Where the entire building is destroyed, damaged, or purposefully demolished or razed, the replacement building must meet current NFIP requirements concerning new construction in V Zones, even if it is built on the foundation from the original building (see Fact Sheet Nos. 1.4, 1.5, 9.1). | **Recommendation:** Follow the V Zone requirement for building elevation and open foundations.<br><br>**Requirement:** Where the entire building is destroyed, damaged, or purposefully demolished or razed, the replacement building must meet current NFIP requirements concerning new construction in A Zones, even if it is built on the foundation from the original building (see Fact Sheet Nos. 1.4, 9.1). | **Requirement:** Where the entire building is destroyed, damaged, or purposefully demolished or razed, the replacement building must meet current NFIP requirements concerning new construction in A Zones, even if it is built on the foundation from the original building (see Fact Sheet Nos. 1.4, 9.1). | **IBC:** 1810.1.2, 105.1, K103.1<br>**IRC:** R105.1, AJ501.3, AJ501.4, AJ501.5.1, AJ501.5, AJ501.5.1, AJ501.5.2, AJ501.5.3, AJ501.5.3.1, AJ501.5.3.2, AJ501.5.3.3, AJ501.5.3.4 AJ501.5.3.5, AJ501.6, AJ501.7, AJ501.8, AJ501.8.1, AJ501.8.2, AJ501.8.3<br>**ASCE:** N/A<br>**Other:** FEMA 550 |
| Moving Existing Building<br><br>NFIP 60.3(e)(5) and 60.3(c)(5) | **Requirement:** Where the existing building is moved to new location or site, the relocated building must meet current NFIP requirements concerning construction in V Zones (see Fact Sheet Nos. 1.4, 1.5, 9.1). | **Recommendation:** Follow the V Zone requirement for building elevation and open foundations.<br><br>**Requirement:** Where the existing building is moved to new location or site, the relocated building must meet current NFIP requirements concerning construction in A Zones (see Fact Sheet Nos. 1.4, 9.1). | **Recommendation:** Elevate bottom of lowest horizontal structural member at, or above, BFE (see Fact Sheet No. 1.4).<br><br>**Requirement:** Where the existing building is moved to new location or site, the relocated building must meet current NFIP requirements concerning construction in A Zones (see Fact Sheet Nos. 1.4, 9.1). | **IBC:** 3410.1<br>**IRC:** AE102.6<br>**ASCE:** ASCE 7 Sec. 1.6<br>**Other:** FEMA 550 |
| **Manufactured Housing** | | | | |
| General | | | | **IRC:** R322.1.9, App. AE101<br>**ASCE:** Not Applicable<br>**Other:** FEMA 85 |

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

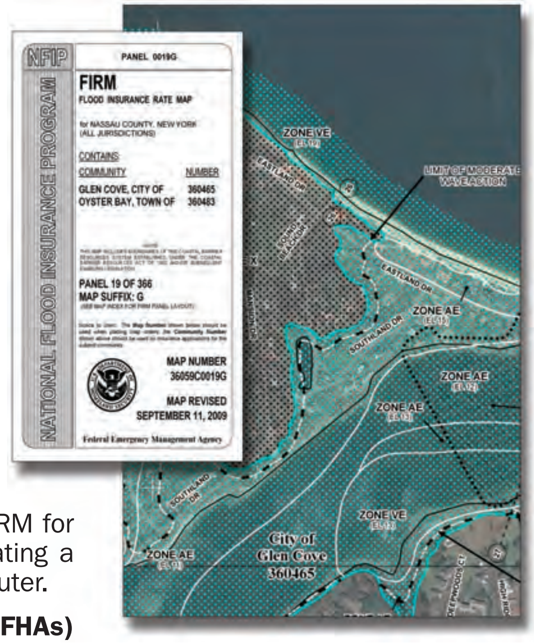
# Using a Digital Flood Insurance Rate Map (DFIRM)





**Purpose:** *To explain the purpose of Flood Insurance Rate Maps (FIRMs), Digital Flood Insurance Rate Maps (DFIRMs), highlight features that are important to coastal builders, and explain how to obtain FIRMs, DFIRMs, and Flood Insurance Studies (FISs).*

## What Is a FIRM?




Flood-prone areas are studied by engineers and hydrologists that specialize in analysis of streams, rivers, tidal shorelines, and their adjacent floodplain or coastal area. These published studies, known as the community's **FIS**, provide detailed information on the study area that facilitates the creation of flood maps. FISs are usually produced for the highest risk streams, most rivers, and almost all coastal reaches.

FEMA has mapped flood hazards for nearly 20,000 communities in the United States, most commonly on FIRMs. Most of the nation's FIRMs were converted during the past five years through the Map Modernization Program into a digital product that depicts flood-prone areas for a community. These are known as **Digital Flood Insurance Rate Maps**, or **DFIRMs**.

Effective October 1, 2009, FEMA discontinued the distribution of paper maps. Paper FIRMs were replaced with DFIRMs. The FIRM for your specific site can be viewed online and reproduced by creating a printable **FIRMette**[1] that can be downloaded to a personal computer.

DFIRMs show the delineation of the **Special Flood Hazard Areas (SFHAs)** – land areas subject to inundation by a flood that has a 1-percent probability of being equaled or exceeded in any given year (hence, the terms "1-percent-annual-chance flood" and "100-year flood"). SFHAs are shaded on the DFIRM and are divided into different flood zones, depending on the nature and severity of the flood hazard. DFIRM datasets have been provided to your local community and are available for viewing at the local National Flood Insurance Program (NFIP) coordinator's office.

### FIRMs and DFIRMs Are Used By:

- **Communities**, to regulate new construction* (e.g., foundation type, lowest floor elevation, use of the enclosed areas below the lowest floor).
- **Designers and Builders**, to determine flood hazards and plan new construction per community ordinance and code requirements.
- **Lenders**, to determine whether flood insurance is required for federally backed mortgages.
- **Insurance Agents**, to establish flood insurance premiums.
- **Land surveyors and engineers**, to complete National Flood Insurance Program (NFIP) elevation certificates (see Fact Sheet No. 1.4, *Lowest Floor Elevation*).

* Note that new construction may include some additions, improvements, repairs, and reconstruction. Consult the community about substantial improvement and substantial damage requirements.

1 FIRMettes are user-selected portions of flood maps available through the FEMA Map Service Center.

1 GENERAL

## Why Are FIRMs and DFIRMs Important?

- FIRMs and DFIRMs show the boundaries of modeled flood hazard areas in a community.
- SFHAs shown on the maps are used to set flood insurance rates and premiums.
- The 1-percent-annual-chance flood elevations and flood depths shown on FIRMs and DFIRMs are the minimum regulatory elevations on which community floodplain management ordinances and building codes are based.
- The information shown on these maps can affect the design and construction of new buildings and infrastructure, the improvement and repair of existing buildings, and additions to existing buildings (see Fact Sheet Nos. 1.2, *Summary of Coastal Construction Requirements and Recommendations for Flood Effects*, and 8.3, *Protecting Utilities*).

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

- ***BFEs*** are typically shown on DFIRMs for riverine flood zones (Zone A, AE, AO, and AH) and coastal flood zones (Zone V and VE). ***The BFE is the predicted elevation of flood waters and wave effects during the 1-percent-annual-chance flood (also known as the base flood).*** The BFE is referenced to the vertical datum shown on the DFIRM. Most have been updated to the 1988 North American Vertical Datum.
- The minimum ***lowest floor elevation and the foundation type and design*** for new construction* are determined by the BFE and flood zone, as required in the community's floodplain management ordinance and building code (see Fact Sheet Nos. 1.4, *Lowest Floor Elevation*, and 3.1, *Foundations in Coastal Areas*). This ordinance, along with the most current DFIRM and FIS, are adopted by resolution to meet NFIP participation requirements. Use of these tools supports community planning, zoning, and building inspection programs that require specific structure design and new construction* in high-hazard coastal floodplains.

Some communities have adopted higher standards for coastal construction (e.g., lowest floor elevations above the BFE [freeboard], restrictions on foundation types, and enclosures in Zone A). *Builders should consult their local jurisdiction for details.*

* Note that new construction may include some additions, improvements, repairs, and reconstruction. Consult the community about substantial improvement and substantial damage requirements.

## Flood Hazard Zones in Coastal Areas

(See the sample DFIRM that follows)

**Zone V:** Areas closest to the shoreline including the Primary Frontal Dune (PFD), subject to storm wave action, high-velocity flow, and erosion during 100-year storm events. Elevations are not provided.

**Zone VE:** Base Flood Elevations (BFEs) are provided on the DFIRM and an additional hazard can be present associated with storm waves greater than 3 feet and including the PFD. BFEs are derived from detailed analyses shown in the FIS.

**Zone A:** Areas subject to flooding during the 1-percent-annual-chance flood. Flood conditions are less severe than in Zone V and MOWAs due to lower wave forces. Because detailed analysis has not been performed, BFEs and flood depths are not provided.

**Zone AE:** Depicts BFEs on the DFIRM. Further details are provided in the FIS on areas where hydrology and hydraulic modeling was performed to determine flood hazard risk.

**Area of Moderate Wave Action (MOWA):** Area landward of Zone V, or landward of an open coast without a mapped Zone V. During base flood conditions, the potential wave height in this area is between 1.5 and 3 feet above the 1-percent-annual-chance stillwater flood depth. While this area is not specifically labeled on the DFIRM panel, this is the area between the LiMWA and the VE/AE zone boundary. In many codes and standards it is referred to as the "Coastal A Zone."

**Zone AO:** Areas subject to shallow flooding or sheet flow during the 1-percent-annual-chance flood. If they appear on a coastal DFIRM they will most likely be found on the landward slopes of shoreline dunes and overtopped structures. Flood depths, rather than BFEs, are shown for Zone AO.

**Zone AH:** Areas subject to inundation by 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between 1 foot and 3 feet.

**Zone X:** Areas with a lower probability of flooding (<1%); these areas are generally not regulated through community floodplain management ordinances and building codes due to their lower predicted risk of flooding.

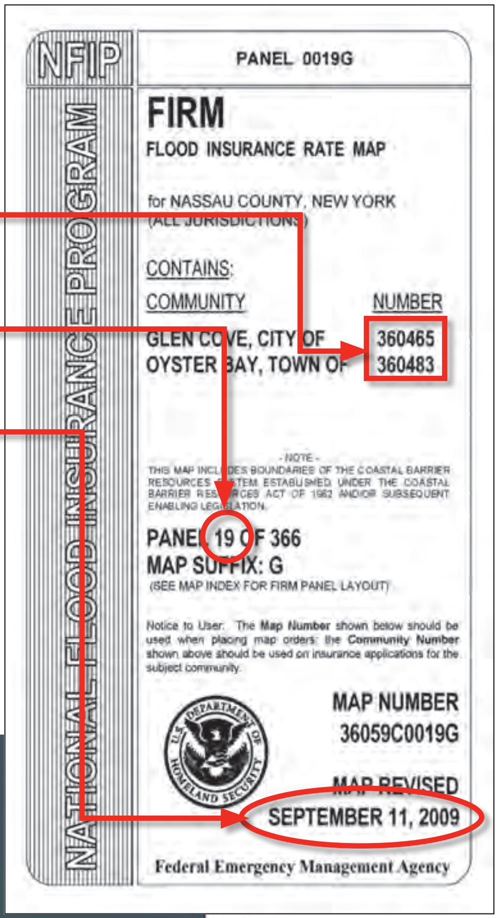
## Sample DFIRM

This map is a portion of the DFIRM for the Town of Oyster Bay and the City of Glen Cove in Nassau County, New York. Several important things to note are highlighted:

***The community identification number is 360465 for Glen Cove and 360483 for Oyster Bay.***

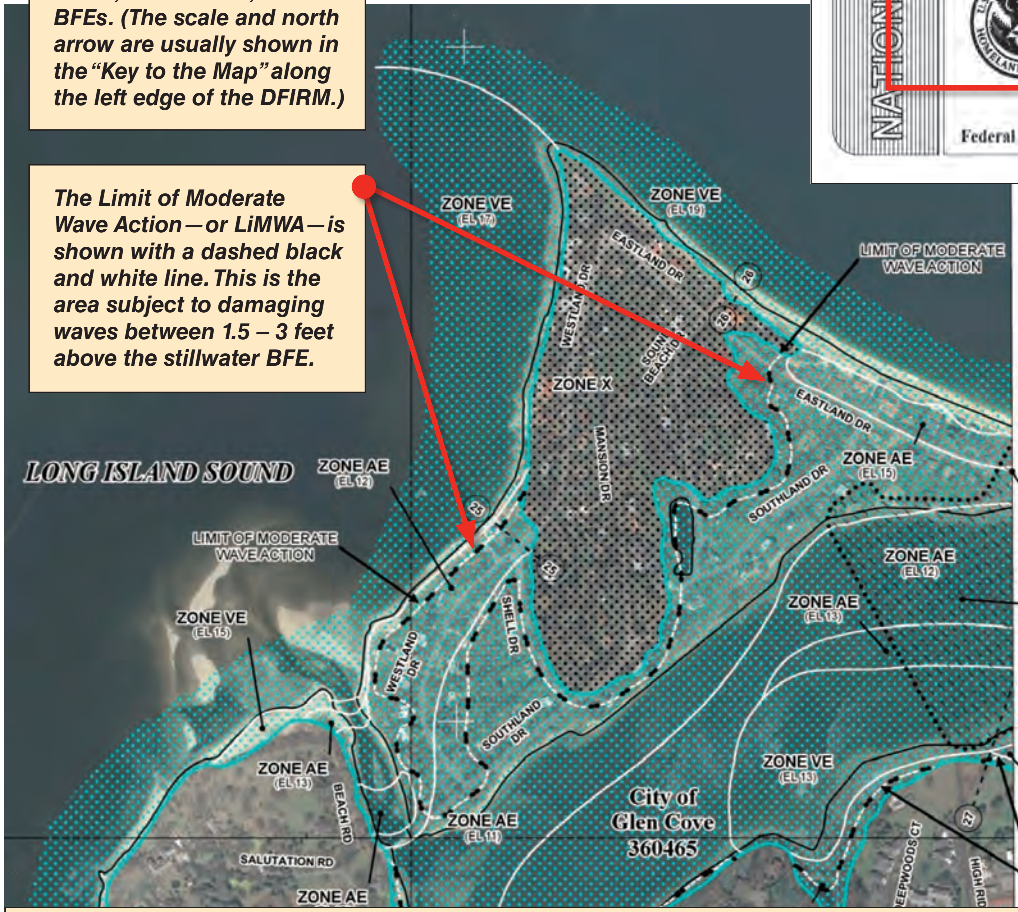
***The panel number is 19. Note that an Index Map is available showing all DFIRM panels for all communities within Nassau County.***

***The effective date of the DFIRM is September 11, 2009.***




***The map scale is shown along with shorelines, roads, flood zones, and BFEs. (The scale and north arrow are usually shown in the "Key to the Map" along the left edge of the DFIRM.)***

***The Limit of Moderate Wave Action—or LiMWA—is shown with a dashed black and white line. This is the area subject to damaging waves between 1.5 – 3 feet above the stillwater BFE.***




***BFEs across the DFIRM section shown range from 11 to 19 feet. The datum (not shown in this sample) is the 1988 North American Vertical Datum.***

***Area designated as a Coastal Barrier Resource System.***

***Zone X has a less than 1-percent chance of flooding; therefore, floodplain ordinance and most flood-related building code requirements are not in effect for this area. However, use of the building standards described in these fact sheets is recommended due to the area's proximity to coastal waters and wind.***

1 GENERAL

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

- Many DFIRMs are digital conversions of FIRMs produced during the past few years without improved analysis of flood hazards. While some corrections were made, the maps may not accurately represent coastal flood hazards. Sections 7.8 and 7.9 of FEMA's *Coastal Construction Manual* (FEMA-55, 2005) describe how coastal flood hazards are mapped and how to determine whether coastal FIRMs reflect present-day flood hazards.
- DFIRMs do not incorporate the effects of long-term shoreline erosion. This information should be obtained from other sources.
- Recent post-storm investigations and studies have shown flood forces and damage in Areas of Moderate Water Action (MOWAs) or Coastal A Zones can be very similar to those in Zone V. Some communities have adopted DFIRMs that show MOWAs as a white line on the DFIRM that depicts the LiMWA. Although DFIRMs (and minimum NFIP building standards) do not differentiate between Zone A in coastal areas and Zone A in riverine areas, *builders should consider using Zone V foundation and elevation standards for new construction in the MOWA. These flood zones are depicted as white boundaries on DFIRMs where communities are encouraging use of Zone V standards in MOWAs.*
- Many communities and states require that the lowest floor elevations are above the BFE, offering an additional level of protection known as ***Freeboard***. The term used to describe the higher elevation level is **Design Flood Elevation (DFE)**.
- Many property owners have voluntarily constructed their buildings with the lowest floor several feet above the BFE because of the potential for flood waters to exceed the BFE and enter the building. Flood insurance is not available in areas designated as being in the Coastal Barrier Resource System (CBRS). Only structures constructed prior to the designation of the area as being in the CBRS are allowed to purchase federal flood insurance.

## Where Can I Get FIRMs, DFIRMs, Flood Studies, and Other Information?

**Community floodplain administrator.** The community's DFIRMs and its local floodplain management regulations, should be on file and available for viewing at the office of the community floodplain administrator.

**FEMA's Map Information eXchange, or FMIX.** This service center serves as a one-stop shop for a variety of information, products, services, and tools that support the National Flood Insurance Program. To contact a FEMA Map Specialist, please call 1-877-FEMAMAP (1-877-336-2627) or email FEMAMapSpecialist@riskmapcds.com. DFIRMs and FISs can be accessed at www.msc.fema.gov. Index sheets and specific FIRM panels can be viewed online at the FEMA Map Service Center website by entering either a parcel address or the specific DFIRM panel number, if known. A user-selected portion of flood maps (called a FIRMette) such as the previous sample can be created, saved, and printed. An effective tutorial on interpretation and use of the old FIRM product is available at www.FloodSmart.gov. While not specific to the newer DFIRM platform, the tutorial defines basic flood hazard map terminology and will be helpful to those less experienced with using flood hazard maps.

Information regarding FIRMs, DFIRMs, FISs, and related products can also be obtained from FEMA through FMIX at:

1-877-FEMAMAP (1-877-336-2627)

Or

FEMAMapSpecialist@riskmap.cds.com

# Lowest Floor Elevation



**Purpose:** *To describe the benefits of exceeding the National Flood Insurance Program (NFIP) minimum elevation requirements; to identify common construction practices that violate NFIP regulations, which result in significantly higher flood insurance premiums; and to discuss the NFIP Elevation Certificate.*



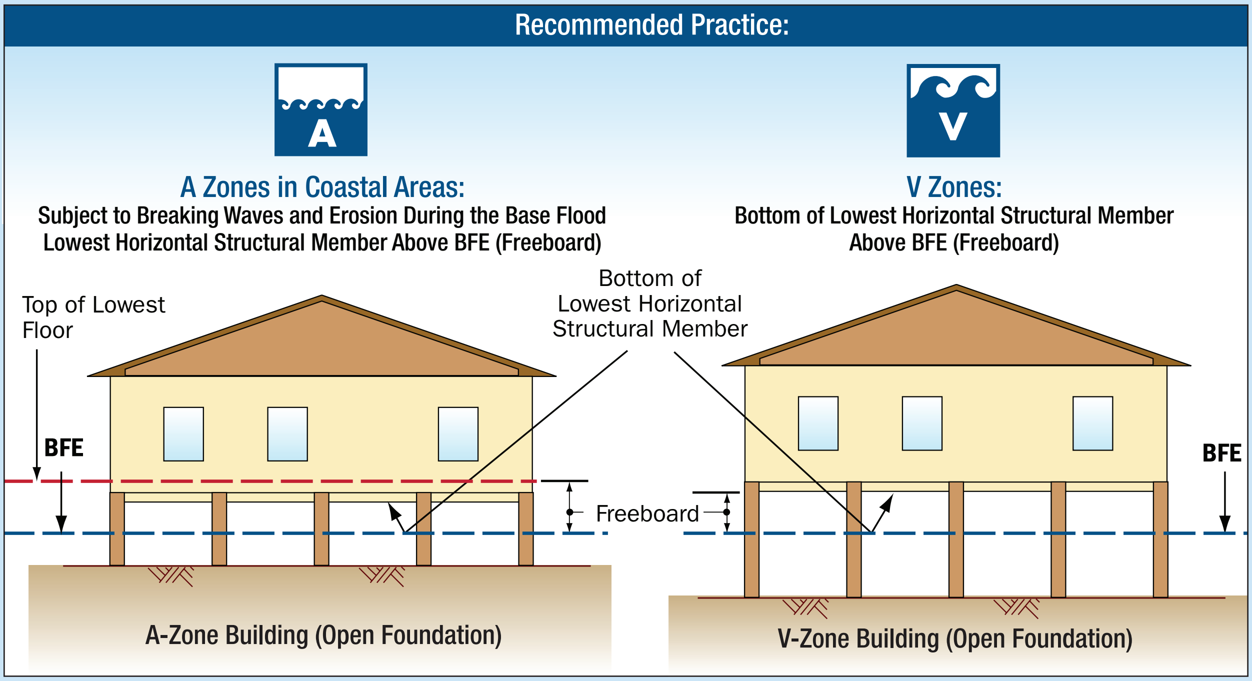
## Why Is the Lowest Floor Elevation Important?

In riverine and other inland areas, experience has shown that if the lowest floors of buildings are not elevated above the flood level, these buildings and their contents will be damaged or destroyed. 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 V Zones or Coastal A Zones, 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 Coastal A Zones, it is recommended that the elevation requirements of ASCE 24 (that exceed the minimum elevation requirements of the NFIP) be followed:

- The bottom of the lowest horizontal structural member of a building in the V Zone is elevated 1 foot or more above the Base Flood Elevation (BFE) (i.e., add freeboard).
- The lowest horizontal structural member of a building in the A Zone in coastal areas is elevated 1 foot or more above the BFE (i.e., add freeboard).




* NFIP minimum elevation requirements: A Zones – elevate top of lowest floor to or above BFE; V Zones – elevate bottom of lowest horizontal structural member to or above BFE. In both V Zones and A Zones, many people have decided to elevate a full story to provide below-building parking, far exceeding the elevation requirement. See Fact Sheet No. 1.2 for more information about NFIP minimum requirements in A Zones and V Zones.

1 GENERAL

## 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 **vehicle parking, building access, or storage**, the floor of that area is considered the lowest floor. Such prohibited use will violate NFIP requirements, resulting in drastically increased flood insurance premiums.
- Note that **any below-BFE finished areas**, including foyers, will violate NFIP requirements, may sustain unreimbursable flood damage, and make the building subject to increased 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. Basements are prohibited from being constructed in V Zones and A Zones unless the basement is elevated to or above the flood elevation or a basement exception has been granted.
- Walls of enclosed areas below the BFE must meet special requirements in coastal areas (see Fact Sheet No. 8.1, *Enclosures and Breakaway Walls*; TB 5, *Free-of-Obstruction Requirements* (2008); and TB 9, *Design and Construction Guidance for Breakaway Walls Below Elevated Coastal Buildings* (2008)). **However, it should be emphasized that in no instance are basements recommended in Coastal A Zones**.

## Construction Practices and the Lowest Floor

Constructing the lowest floor at the correct elevation is critical. Failure to do so can result in a building being built below the BFE. As a result, construction work can be stopped, certificates of occupancy can be withheld, and correcting the problem can be expensive and time-consuming. Here are some helpful tips to consider when constructing the lowest floor:

- After the piles have been installed and the lowest horizontal structural supporting members have been installed, have a licensed professional engineer, architect, or surveyor validate the intended elevation of the lowest floor before the piles are cut off. This should be noted on the Elevation Certificate.
- Alternatively, after the piers or columns have been constructed, the intended elevation of the lowest floor should be validated during an inspection by the licensed professional and noted on the Elevation Certificate prior to installation of the lowest horizontal structural supporting members.

Do not modify building plans to create habitable space below the intended lowest floor. Doing so will put the building in violation of floodplain management ordinances and building code requirements. Also, this space cannot be converted to living space after the certificate of occupancy is awarded.

## FEMA Elevation Certificate

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

A licensed surveyor, engineer, or architect must complete, seal, and submit the Elevation Certificate to the community code official. Not placing the lowest supporting horizontal members and the first floor of a building at the proper elevation in a coastal area can be extremely costly and difficult to correct. Following the carpenter's adage to measure twice, but cut once, the elevation of the building must be checked at several key stages of construction. 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 final certificate must be submitted **upon completion of all construction prior to issuance of the certificate of occupancy**.

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

- Name and address of property owner.
- NFIP flood zone and elevation from a Digital Flood Insurance Rate Map (DFIRM) and/or Flood Insurance Study (FIS).
- GPS coordinates.
- Adjacent grade elevation.
- Lowest horizontal structural supporting member elevation.
- Elevation of certain floors in the building.
- Lowest elevation of utility equipment/machinery.

The Elevation Certificate provided in this fact sheet expires March 31, 2012. Updated versions can be found at http://www.fema.gov/business/nfip/forms.shtm. The Elevation Certificate and instructions are available on FEMA's website: http://www.fema.gov/pdf/nfip/elvcert.pdf.

# V Zone Design and Construction Certification





**Purpose:** *To explain the certification requirements for structural design and methods of 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 proposed methods of construction** (a similar documentation requirement appears in the 2009 IRC, Section R322.3.6). It is recommended that the design professional use ASCE 24 and ASCE 7 as appropriate engineering standards.

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

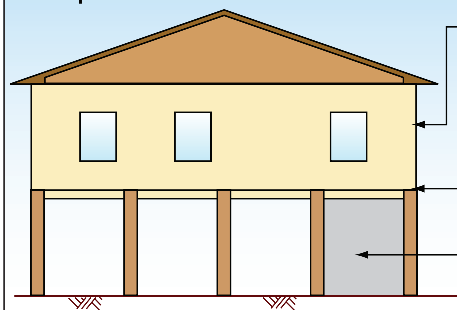
1. A **registered professional engineer or architect shall develop or review the structural design, specifications, and plans** for the construction.
2. A **registered professional engineer or architect shall certify that the design and methods of construction** to be used are in accordance with accepted standards of practice in meeting these 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).
- 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. ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures,* provides guidelines on different load combinations, which include flood and wind loads.

## Completing the V Zone Design Certificate

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. It is intended to show one way that a jurisdiction may require that the certification and supporting information be provided. In this example, the certification statement can address both design and proposed methods of construction and breakaway wall design.




### Other Certifications Required in V Zone

- Breakaway Wall Design, by a registered professional engineer or architect (see Fact Sheet No. 8.1, *Enclosures and Breakaway Walls*)
- "As Built" Lowest Floor Elevation, by a surveyor, engineer, or architect (see Fact Sheet No. 1.4, *Lowest Floor Elevation*)

**The V Zone Design 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., 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 and Fact Sheet No. 8.1, Enclosures and Breakaway Walls.)*

**Note:** The V Zone design certificate is not a substitute for the NFIP Elevation Certificate (see Fact Sheet No. 1.4, *Lowest Floor Elevation*), which is required to certify as-built elevations needed for flood insurance rating.

# V ZONE DESIGN CERTIFICATE

Name _______________________________ Policy Number *(Insurance Co. Use)* ____________________

Building Address or Other Description ______________________________________________

Permit No. ____________________ City ____________________ State ________ Zip Code __________

## SECTION I: Flood Insurance Rate Map (FIRM) Information

Community No. ________________ Panel No. ____________ Suffix _____ FIRM Date ______ FIRM Zone(s) __________

## SECTION II: Elevation Information Used for Design

*[**NOTE: This section documents the elevations/depths used or specified in the design – it does not document surveyed elevations and is not equivalent to the as-built elevations required to be submitted during or after construction.**]*

1. FIRM Base Flood Elevation (BFE)............................................ _____ feet*
2. Community's Design Flood Elevation (DFE) ............................ _____ feet*
3. Elevation of the Bottom of Lowest Horizontal Structural Member .......... _____ feet*
4. Elevation of Lowest Adjacent Grade ......................................... _____ feet*
5. Depth of Anticipated Scour/Erosion used for Foundation Design............ _____ feet
6. Embedment Depth of Pilings or Foundation Below Lowest Adjacent Grade..... _____ feet

* Indicate elevation datum used in 1-4: ❑ NGVD29 ❑ NAVD88 ❑ Other ______________________

## SECTION III: V Zone Design Certification Statement

I certify that: (1) I have developed or reviewed the structural design, plans, and specifications for construction of the above-referenced building and (2) that the design and methods of construction specified 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.
- 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 Design Certification Statement

***NOTE. This section must be certified by a registered engineer or architect when breakaway walls are designed to have a resistance of more than 20 psf (0.96 kN/m2) determined using allowable stress design]***

I certify that: (1) I have developed or reviewed the structural design, plans, and specifications for construction of breakaway walls to be constructed under the above-referenced building and (2) that the design and methods of construction specified to be used 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***.
- 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 (see Section III).

## SECTION V: Certification and Seal

This certification is to be signed and sealed by a registered professional engineer or architect authorized by law to certify structural designs. I certify the V Zone Design Certification Statement (Section III) and _____ the Breakaway Wall Design Certification Statement (Section IV, check if applicable).

Certifier's Name ____________________ License Number ________________

Title __________________________ Company Name ________________

Address ______________________________________________

City __________________________ State _____ Zip Code ____________

Signature ________________ Date ________ Telephone ____________

Place Seal Here

# Designing for Flood Levels Above the BFE





**Purpose:** *To recommend design and construction practices that reduce the likelihood of flood damage in the event that flood levels exceed the Base Flood Elevation (BFE).*

## Key Issues

- BFEs are established at a flood level, including wave effects, that has a 1-percent chance of being equaled or exceeded in any given year, also known as the 100-year flood or base flood. Floods more severe and less frequent than the 1-percent flood can occur in any year.
- Flood levels during some recent storms have exceeded BFEs depicted on the Flood Insurance Rate Maps (FIRMs), sometimes by several feet. In many communities, flooding extended inland, well beyond the 100-year floodplain (Special Flood Hazard Area [SFHA]) shown on the FIRM (see Figure 1).
- Flood damage increases rapidly once the elevation of the flood extends above the lowest floor of a building, especially in areas subject to coastal waves. In V Zones, a coastal flood with a wave crest 3 to 4 feet above the bottom of the floor beam (approximately 1 to 2 feet above the walking surface of the floor) will be sufficient to substantially damage or destroy most light-frame residential and commercial construction (see Figure 2).
- There are design and construction practices that can eliminate or minimize damage to buildings when flood levels exceed the BFE. **The most common approach is to add freeboard to the design (i.e., to elevate the building higher than required by the FIRM).** This practice is outlined in American Society of Civil Engineers (ASCE) 24-05, *Flood Resistant Design and Construction*.
- There are other benefits of designing for flood levels above the BFE: reduced building damage and maintenance, longer building life, reduced flood insurance premiums, reduced period of time in which the building occupants may need to be displaced in the event of a flood disaster (and need for temporary shelter and assistance), reduced job loss, and increased retention of tax base.
- The cost of adding freeboard at the time of home construction is modest, and reduced flood insurance premiums will usually recover the freeboard cost in a few years' time.

***Figure 1. Bridge City, Texas, homes were flooded during Hurricane Ike, even though they were constructed outside the SFHA and in Zone B. The flood level was approximately 4' above the closest BFE.***

***Figure 2. Bolivar Peninsula, Texas, V Zone house constructed with the lowest floor (bottom of floor beam) at the BFE (dashed line). The estimated wave crest level during Hurricane Ike (solid line) was 3' to 4' above the BFE at this location.***

## How High Above the BFE Should a Building be Elevated?

Ultimately, the building elevation will depend on several factors, all of which must be considered before a final determination is made:

- **The accuracy of the BFE shown on the FIRM:** If the BFE is suspect, it is probably best to elevate 3 or more feet above the BFE; if the BFE is deemed accurate, it may only be necessary to elevate a couple of feet above the BFE.
- **If historical high water levels are above the BFE,** the historical high water levels should be considered in building elevation decisions.
- **Availability of preliminary Digital Flood Insurance Rate Maps (DFIRMs):** As new Flood Insurance Studies (FISs) are completed, preliminary DFIRMs will be produced and available for use, even before they are officially adopted by those communities.
- **Future conditions:** Since the FIRM reflects conditions at the time of the FIS, some owners or jurisdictions may wish to consider future conditions (such as sea level rise, subsidence, wetland loss, shoreline erosion, increased storm frequency/intensity, and levee settlement/failure) when they decide how high to elevate.
- **State or local requirements:** The state or local jurisdiction may require a minimum freeboard through its floodplain management requirements or building code.
- **Building code requirements:** The International Building Code (IBC) requires buildings be designed and constructed in accordance with ASCE 24. ASCE 24 requires between 0 and 2 feet of freeboard, depending on the building importance and the edition of ASCE 24 referenced.[1] The 2009 International Residential Code (IRC) requires 1 foot of freeboard in V Zones and in Coastal A Zones.
- **Building owner tolerance for damage, displacement, and downtime:** Some building owners may wish to avoid building damage and disruption, and may choose to elevate far above the BFE.

In V Zones and A Zones, FEMA 499 recommends considering elevation of residential structures to the 500-year flood elevation, or to the requirements of ASCE 24-05, whichever is higher.

1 The 1998 edition of ASCE 24 is referenced by the 2003 edition of the IBC, and requires between 0 and 1 foot of freeboard. The 2005 edition of ASCE 24 is referenced by the 2006 and 2009 editions of the IBC, and require between 0 and 2 feet of freeboard.

If the 500-year stillwater elevation (feet North American Vertical Datum of 1988 [NAVD] or feet National Geodetic Vertical Datum of 1929 [NGVD]) is not available, a rule of thumb can be used to approximate it as 1.25 times the 100-year stillwater elevation (feet NAVD or feet NGVD).

The 500-year wave crest elevation ***can*** be approximated as 1.25 times the BFE.

## Flood Insurance Rate Maps and Flood Risk

Hurricanes Ivan (2004), Katrina (2005), Rita (2005), and Ike (2008) have demonstrated that constructing a building to the minimum National Flood Insurance Program (NFIP) requirements—or constructing a building outside the SFHA shown on the FIRMs—is no guarantee that the building will not be damaged by flooding.

This is due to two factors: 1) flooding more severe than the base flood occurs, and 2) some FIRMs, particularly older FIRMs, may no longer depict the true base flood level and SFHA boundary.

Even if the FIRM predicted flood levels perfectly, buildings constructed to the elevations shown on the FIRM will offer protection only against the 1-percent-annual-chance flood level (BFE). Some coastal storms will result in flood levels that exceed the BFE, and buildings constructed to the minimum elevation could sustain flood damage. The black line in Figure 3 shows the probability that the level of the flood will exceed the 100-year flood level during time periods between 1 year and 100 years; there is an 18 percent chance that the 100-year flood level will be exceeded in 20 years, a 39 percent chance it will be exceeded in 50 years, and a 51 percent chance it will be exceeded in 70 years. As the time period increases, the likelihood that the 100-year flood will be exceeded also increases.

Figure 3 also shows the probabilities that floods of other severities will be exceeded. For example, taking a 30-year time period where there is a 26 percent chance that the 100-year flood level will be exceeded and a 6 percent chance that a flood more severe than the 500-year flood will occur.

### Elevation Recommendation

FEMA 499 recommends new and reconstructed residential buildings be elevated above the effective BFEs with freeboard equal to that specified in ASCE 24-05, plus 3 feet. When new DFIRMs are available and adopted, 499 additionally recommends new and reconstructed residential buildings be elevated to or above the freeboard elevation specified by ASCE 24-05.

FIRMs depict the limits of flooding, flood elevations, and flood zones during the base flood. As seen in Figure 3, buildings elevated only to the BFEs shown on the FIRMs have a significant chance of being flooded over a period of decades. Users should also be aware that the flood limits, flood elevations, and flood zones shown on the FIRM reflect ground elevations, development, and flood conditions at the time of the FIS.[2]

**FIRMs do not account for the following:**

- Shoreline erosion, wetland loss, subsidence, and relative sea level rise
- Upland development or topographic changes
- Degradation or settlement of levees and floodwalls
- Changes in storm climatology (frequency and severity)
- The effects of multiple storm events

Thus, what was once an accurate depiction of the 100-year floodplain and flood elevations may no longer be so.

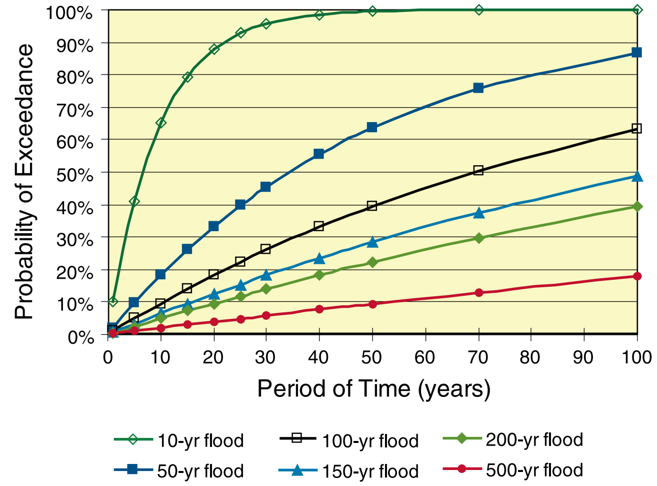



*Figure 3. Probability that a flood will exceed the n-year flood level over a given period of time.*

(Note: this analysis assumes no shoreline erosion, and no increase in sea level or storm frequency/severity over time.)

## Consequences of Flood Levels Exceeding the BFE

Buildings are designed to *resist* most environmental hazards (e.g., wind, seismic, snow, etc.), but are generally designed to *avoid* flooding by elevating the building above the anticipated flood elevation. The difference in design approach is a result of the sudden onset of damage when a flood exceeds the lowest floor elevation of a building. Unlike wind—where exposure to a wind speed slightly above the design speed does not generally lead to severe building damage—occurrence of a flood level even a few inches above the lowest floor elevation generally leads to significant flood damage. Therefore, the recommendation is to add freeboard.

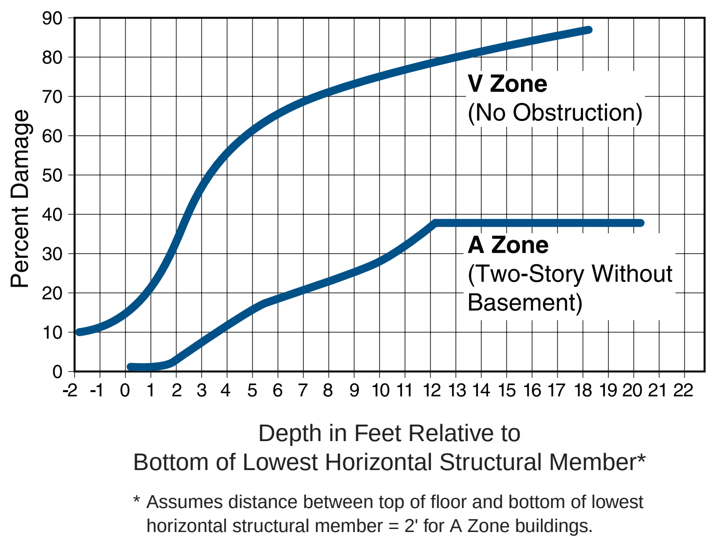



*Figure 4. Flood depth versus building damage curves for V Zones and riverine A Zones.*

(SOURCE: FEMA 55, *COASTAL CONSTRUCTION MANUAL*).

This is especially true in cases where waves accompany coastal flooding. Figure 4 illustrates the expected flood damage (expressed as a percent of a building's pre-damage market value) versus flood depth above the bottom of the lowest horizontal structural member supporting the lowest floor (e.g., bottom of the floor beam), for a building in a V Zone and for a building in a riverine A Zone.[3]

2 Sections 7.8.1.3 and 7.9 of FEMA's *Coastal Construction Manual* (FEMA 55, 2000 edition) provide guidance on evaluating a FIRM to determine whether it still provides an accurate depiction of base flood conditions, or whether it is obsolete.

3 Since the normal floor reference for A Zone buildings is the top of the lowest floor, the A Zone curve was shifted for comparison with the V Zone curve.

One striking difference between the two curves is that a flood depth in the V Zone (wave crest elevation) 3 to 4 feet above the bottom of the floor beam (or approximately 1 to 2 feet above the top of the floor) is sufficient to cause substantial (>50 percent) damage to a building. In contrast, A Zone riverine flooding (without waves and high velocity) can submerge a structure without causing substantial damage. This difference in building damage is a direct result of the energy contained in coastal waves striking buildings—this type of damage was identified in Texas and Louisiana following Hurricane Ike (see Figure 5).

In cases where buildings are situated behind levees, a levee failure can result in rapid flooding of the area. Buildings near a levee breach may be exposed to high velocity flows, and damages to those buildings will likely be characterized by the V Zone damage curve in Figure 4. Damages to buildings farther away from the breach will be a result of inundation by floodwaters, and will likely resemble the A Zone curve in Figure 4.



***Figure 5. Hurricane Ike damage to buildings. The upper left and upper right photos are of buildings that were close to the Gulf of Mexico shoreline and subjected to storm surge and large waves above the lowest floor. The lower left photo is of a building close to Galveston Bay shoreline and subjected to storm surge and small waves. The lower right photo is of a Cameron Parish, Louisiana, school that was approximately 1.3 miles from the Gulf shoreline, but subjected to storm surge and small waves.***

## General Recommendations

The goal of this fact sheet is to provide methods to minimize damage to buildings in the event that coastal flood levels rise above the BFE. Achieving this goal will require implementation of one or more of the following general recommendations:

- In all areas where flooding is a concern, inside and outside the SFHA, elevate the lowest floor so that the bottom of the lowest horizontal structural member is at or above the Design Flood Elevation (DFE). Do not place the top of the lowest floor at the DFE, since this guarantees flood damage to wood floor systems, floor coverings, and lower walls during the design flood, and may lead to mold growth and contamination damage (see Figure 6).
- In V Zones and A Zones, use a DFE that results in freeboard (elevate the lowest floor above the BFE) (see Figure 7).
- In V Zones and A Zones, calculate design loads and conditions (hydrostatic loads, hydrodynamic loads, wave loads, floating debris loads, and erosion and scour) under the assumption that the flood level will exceed the BFE.

*Figure 6. Mold and biological/chemical contamination are also concerns when flood levels rise above the lowest floor. Contamination may result in the building being irreparable or, at least, make the cleanup, restoration, and repairs more expensive and time-consuming.*

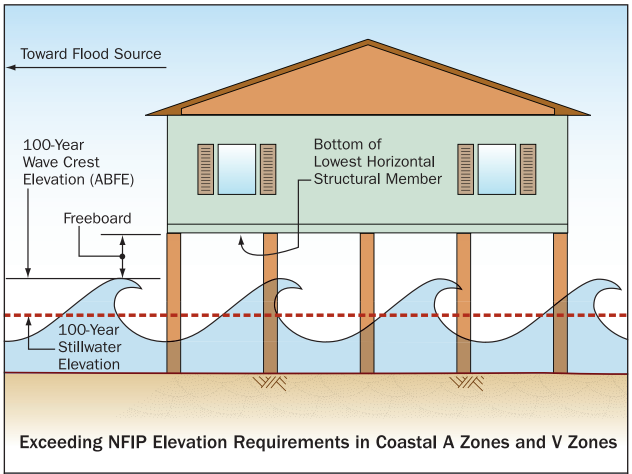



*Figure 7. Recommended construction in Coastal A Zone and V Zone.*

- In an A Zone subject to moderate waves (1.5 to 3.0 feet high) and/or erosion (i.e., Coastal A Zone), use a pile or column foundation (see Figure 7).
- Outside the SFHA (in Zone B, Zone C, and Zone X), adopt flood-resistant design and construction practices if historical evidence or a review of the available flood data shows the building could be damaged by a flood more severe than the base flood (see Figure 8).
- Design and construct buildings in accordance with the latest model building code (e.g., IRC or IBC), ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures* and ASCE 24-05, *Standard for Flood Resistant Design and Construction* as applicable.
- Use the pre-engineered foundations, as applicable, which are shown in FEMA 550, *Recommended Residential Construction for the Gulf Coast: Building on Strong and Safe Foundations.*
- Use strong connections between the foundation and the elevated building to prevent the building from floating or washing off the foundation, in the event that flood levels do rise above the lowest floor.
- Where additional freeboard is prohibited or not provided use flood damage-resistant building materials and methods above the lowest floor. For example, consider using drainable, dryable interior wall assemblies (see Figure 9). This allows interior walls to be opened up and dried after a flood above the lowest floor, minimizing damage to the structure.

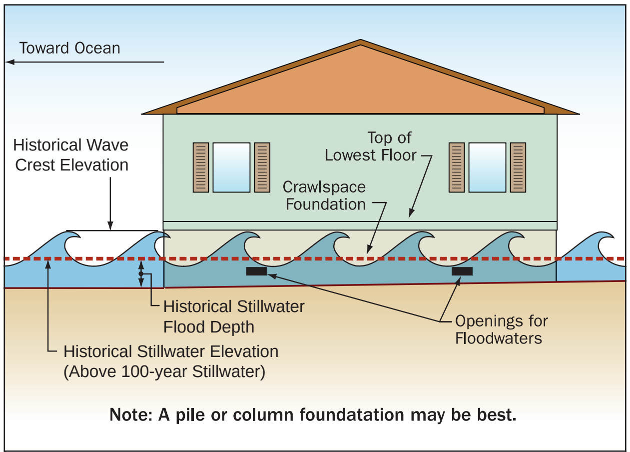



*Figure 8. Recommended construction in Zone B, Zone C, and Zone X.*

- New and replacement manufactured homes should be installed in accordance with the provisions of the 2009 edition of the National Fire Protection Association (NFPA) 225, *Model Manufactured Home Installation Standard*. The standard provides flood, wind, and seismic-resistant installation procedures. It also calls for elevating manufactured homes in A Zones with the bottom of the main chassis frame beam at or above the BFE, not with the top of the floor at the BFE. FEMA P-85, *Protecting Manufactured Homes from Floods and Other Hazards* provides additional guidance on proper manufactured home siting and installation.

*Figure 9. Recommended wet floodproofing techniques for interior wall construction. The following flood damage-resistant materials and methods will prevent wicking and limit flood damage:*

*1) construct walls with horizontal gaps in wallboard;*

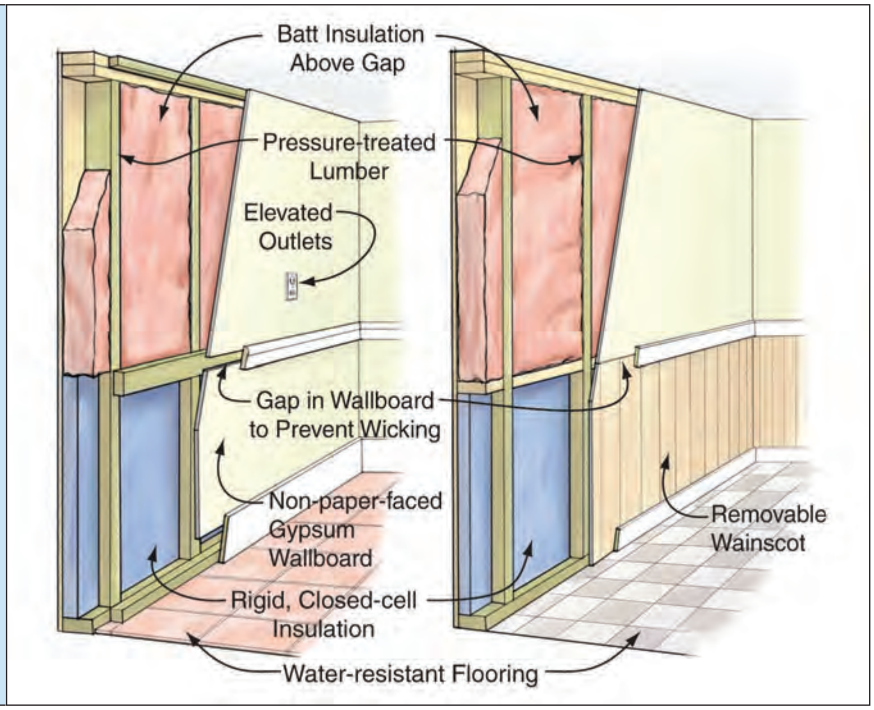
*2) use non-paper-faced gypsum wallboard below gap, painted with latex paint;*

*3) use rigid, closed-cell insulation in lower portion of walls;*

*4) use water-resistant flooring with waterproof adhesive; and*

*5) use pressure treated wood framing*

(SOURCE: LSU AGCENTER AND COASTAL CONTRACTOR MAGAZINE).



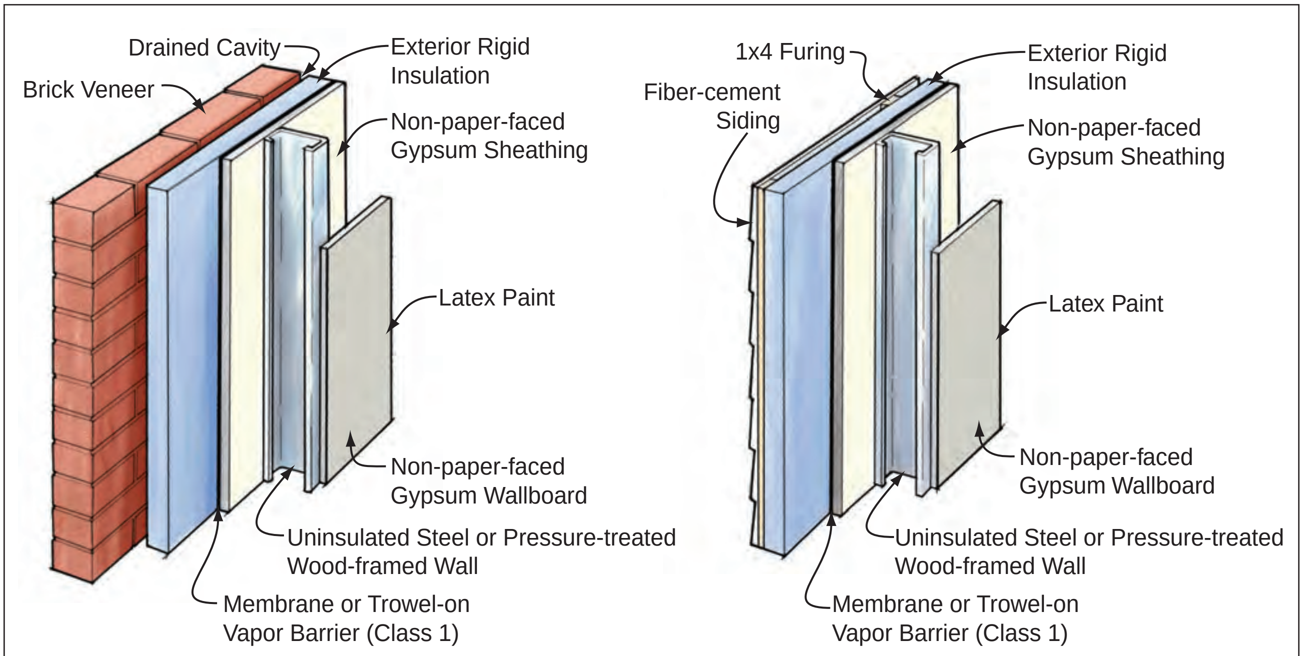




*Figure 10. Recommended flood-resistant exterior cavity wall construction. The following materials and methods will limit flood damage to exterior cavity walls:*

*1) use brick veneer or fiber-cement siding, with non-paper-faced gypsum sheathing (vinyl siding is also flood-resistant but is less resistant to wind damage);*

*2) provide cavity for drainage;*

*3) use rigid, closed-cell insulation;*

*4) use steel or pressure-treated wood studs and framing; and*

*5) use non-paper-faced gypsum wallboard painted with latex paint*

(SOURCE: COASTAL CONTRACTOR MAGAZINE AND BUILDING SCIENCE CORPORATION).

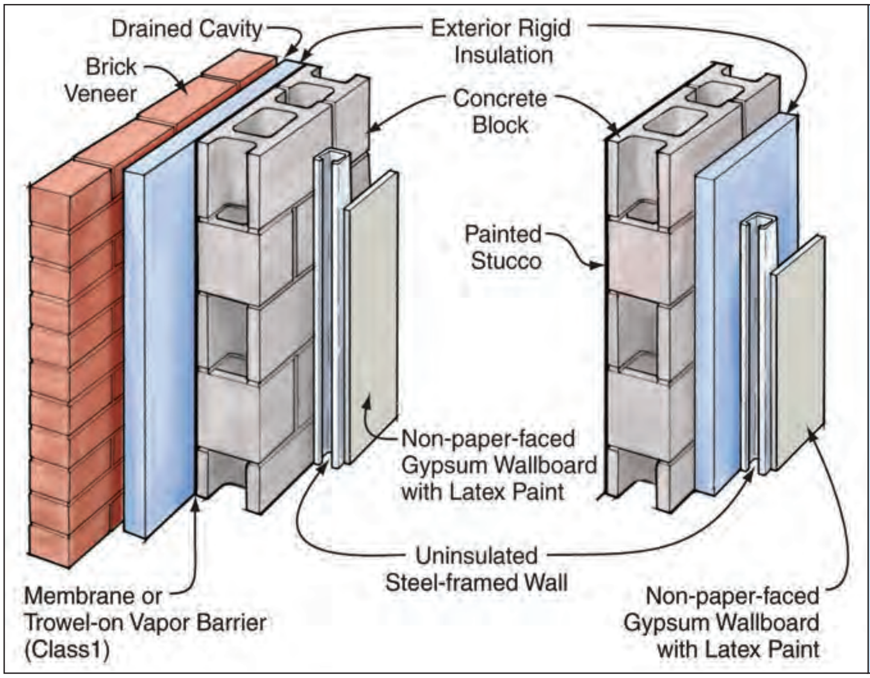



***Figure 11. Recommended flood-resistant exterior mass wall construction. The following materials and methods will limit flood damage to exterior mass walls:***

***1) use concrete masonry with stucco or brick veneer (provide drainage cavity if brick veneer is used);***

***2) use rigid, closed-cell insulation;***

***3) use steel framing; and 4) use non-paper-faced gypsum wallboard painted with latex paint***

(Source: Coastal Contractor Magazine and Building Science Corporation).

GENERAL 1

## Other Considerations

As previously stated, in addition to reduced building damage, there are other reasons to design for flood levels above the BFE:

- Reduced building maintenance and longer building life.
- Reduced flood insurance premiums.
- Reduced displacement and dislocation of building occupants after floods (and need for temporary shelter and assistance).

Until flooded, many homeowners and communities do not think about these benefits. However, one of the most persuasive (to homeowners) arguments for elevating homes above the BFE is the reduction in annual flood insurance premiums. In most cases, flood premiums can be cut in half by elevating a home 2 feet above the BFE, saving several hundred dollars per year in A Zones, and $2,000 or more per year in V Zones. In V Zones, savings increase with added freeboard.

A comprehensive study of freeboard (American Institutes for Research, 2006) demonstrated that adding freeboard at the time of house construction is cost-effective. Reduced flood damage yields a benefit-cost ratio greater than 1 over a wide range of scenarios, and flood insurance premium reductions make adding freeboard even more beneficial to the homeowner. Reduced flood insurance premiums will pay for the cost of incorporating freeboard in a house in a V Zone in 1 to 3 years; for a house in an A Zone, the payback period is approximately 6 years.

## Flood Insurance Premium Reductions Can Be Significant

| Example 1: V Zone building, supported on piles or piers, no below-BFE enclosure or obstruction. $250,000 building coverage, $100,000 contents coverage. | | Example 2: A Zone building, slab or crawlspace foundation (no basement). $200,000 building coverage, $75,000 contents coverage. | |
|---|---|---|---|
| Floor Elevation Above BFE | Reduction in Annual Flood Premium* | Floor Elevation Above BFE | Reduction in Annual Flood Premium* |
| 1 foot | 25% | 1 foot | 39% |
| 2 feet | 50% | 2 feet | 48% |
| 3 feet | 62% | 3 feet | 48% |
| 4 feet | 67% | 4 feet | 48% |

* Compared to flood premium with lowest floor at BFE

## Additional Resources and References


American Institutes for Research. 2006. *Evaluation of the National Flood Insurance Program's Building Standards*, (http://www.fema.gov/library/viewRecord.do?id=2592)

ASCE. 2005. *Minimum Design Loads for Buildings and Other Structures*. ASCE 7-05.

ASCE. 2005. *Standard for Flood Resistant Design and Construction*. ASCE 24-05.

Coastal Contractor Magazine. July 2006. Low Country Rx: *Wet Floodproofing. Drainable, dryable assemblies made with water-tolerant materials help speed recovery from deeper than-expected floods*, by Ted Cushman, (http://www.coastalcontractor.net/cgi-bin/issue.pl?issue=9)

FEMA. 2000. *Coastal Construction Manual*. FEMA 55. (ordering information at: http://www.fema.gov/pdf/plan/prevent/nhp/nhp_fema55.pdf)

FEMA. 2009. *Mitigation Assessment Team Report, Hurricane Ike in Texas and Louisiana: Building Performance Observations, Recommendations, and Technical Guidance*. FEMA P-757. (available at: http://www.fema.gov/library/viewRecord.do?id=3577)

FEMA. 2009. *Protecting Manufactured Homes from Floods and Other Hazards*. FEMA P-85, (http://www.fema.gov/library/viewRecord.do?fromSearch=fromsearch&id=1577)

FEMA. 2010. *Recommended Residential Construction for the Gulf Coast, Building on Strong and Safe Foundations.* FEMA 550, (http://www.fema.gov/library/viewRecord.do?id=1853)

LSU AgCenter. 1999. *Wet Floodproofing. Reducing Damage from Floods*. Publication 2771, (http://www.lsuagcenter.com/NR/rdonlyres/B2B6CDEC-2B58-472E-BBD9-0BDEB0B29C4A/26120/pub2771Wet6.pdf)

NFPA. 2009. *Model Manufactured Home Installation Standard*. NFPA 225, (http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=225&cookie_test=1)

# Coastal Building Materials

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION　　Technical Fact Sheet No. 1.7

GENERAL 1

**Purpose:** *To provide guidance and best practices on selecting building materials to use for coastal construction.*

## Key Issues

This fact sheet will cover special considerations that must be made when selecting building materials for a coastal building. The harsh environment requires that more substantial building materials be used and more care taken when using these materials in order to ensure durability, hazard resistance, and reduce maintenance. The materials discussed can be used when dealing with both flood and wind hazards. Other factors such as corrosion and decay resistance will also be covered. Although proper design is a key element it will be for naught if the proper materials are not selected. This fact sheet is also intended to provide the reader an idea of what the best practice should be when selecting a material for a coastal building. The following are some key considerations when screening materials.

***Select building materials that can endure periodic flooding.***

- Materials and construction methods in a coastal environment should be resistant to ***flood and wind damage, wind-driven rain, corrosion, moisture, and decay (due to sunlight, aging, insects, chemicals, temperature, or other factors).***
- Ease of installation or the ability to properly install the material should be a major consideration for the selection of materials.
- 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 Sheets Nos. 9.1, *Repairs, Remodeling, Additions and Retrofitting – Flood* and 9.2, *Repairs, Remodeling, Additions and Retrofitting – Wind*).

The durability of a coastal home relies on the types of materials and details used to construct it. For flood-related information, see NFIP Technical Bulletin 2, *Flood Damage-Resistant Material Requirements for Buildings Located in the Special Flood Hazard Areas in accordance with the National Flood Insurance Program* 8/08. For other natural hazards, see the *Institute for Business and Home Safety Fortified…for Safer Living® Builder's Guide*.

## Flood-Resistant Materials

Flooding accounts for a large percentage of the damage caused by a coastal storm, which is why building materials must be flood damage-resistant. The NFIP defines a ***flood damage-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 cost of cosmetic repair should be less than the cost of replacing building materials. Although flood-resistant materials typically refer to areas below the BFE, they may be appropriate in areas above the BFE in order to limit the amount of damage caused by wind-driven rain. **All building materials below the BFE must be flood damage-resistant,** regardless of expected or historic flood duration.

Section 60.3(a)(ii) of the National Flood Insurance Program (NFIP) regulations requires that all new construction and substantial improvements in flood-prone areas be constructed with materials below the Base Flood Elevation (BFE) that are resistant to flood damage. (See Fact Sheet No. 9a for a definition of "substantial improvement.")

**The following are examples of flood-resistant materials:**

- **Lumber:** Preservative-treated or naturally durable wood as defined in the International Building Code. Naturally durable wood includes the heartwood of redwood, cedar, black locust, and black walnut.
- **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 5,000 psi minimum and a water-cement ratio not higher than 0.40—such mixes are usually nominally more expensive and rarely add significant cost to the project (consult ACI 318-02, Building Code Requirements for *Structural Concrete and Commentary* by the American Concrete Institute). Reinforcing steel used in concrete or masonry construction in coastal areas should not be left exposed to moisture and should not be stored on bare ground. The reinforcing steel should be free from rust and clearances should be maintained as shown on the design drawings.
- **Masonry:** Reinforced and fully grouted. If left unfilled, then masonry block cells can create a reservoir that can hold water and can make the masonry difficult to clean following a flood.
- **Structural Steel:** Coated to resist corrosion.
- **Insulation:** Plastics, synthetics, and closed-cell foam, or other types approved by the local building official.

**The following are examples of materials that are unacceptable below the BFE:**

- Normal, water-soluble adhesives specified for above-grade use or adhesives that are not resistant to alkali or acid in water, including groundwater seepage and vapor.
- Materials that contain paper-based materials, wood-based materials, or other organic materials that dissolve or deteriorate, lose structural integrity, or are adversely affected by water.
- Sheet-type floor coverings (e.g., linoleum, vinyl) or wall coverings (e.g., wallpaper) that restrict drying of the materials they cover.
- Materials that become dimensionally unstable when subject to wetting and drying.
- Materials that absorb water excessively or maintain a high moisture content after submergence.
- Wiring, outlets, and electrical components not designed to be flood resistant. It is important to locate any materials like these above the expected floodwater elevation. When this is not possible, it is important to allow for the isolation of these components.

Flood insurance will not pay a claim for damages to finish materials located in basements or in enclosed areas below the lowest floor of elevated buildings, even if such materials are considered to be flood damage-resistant. NFIP claims for damages below the BFE are limited to utilities and equipment, such as furnaces and water heaters.

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

| Location of Material Use | Name of Material |
|---|---|
| Piles and Posts | Preservative-treated round, tapered wood piles; square-cross section piles; or wood posts. |
| Piers | Reinforced concrete or concrete masonry units (CMU) (see the section "Flood-Resistant Materials" and Fact Sheet No. 3.4, *Reinforced Masonry Pier Construction*). |
| Foundation Walls | Reinforced concrete or CMU, or wood that is preservative-treated for foundation or marine use (see Fact Sheet No. 3.5, *Foundation Walls*). |
| Beams | Solid sawn timbers and glue-laminated timber products, either naturally durable wood or preservative-treated for above ground exposure; built-up members preservative-treated for ground contact. |
| Decking | Preservative-treated or naturally durable wood |
| Framing | Sawn lumber or manufactured lumber that is preservative-treated or naturally durable wood if in close proximity to the ground. |
| Exterior Sheathing | Plywood that is marine grade or preservative-treated, alkaline copper quaternary (ACQ) or copper azole (C-A) |
| Subflooring | Plywood that is marine grade or preservative treated, alkaline copper quaternary (ACQ) or copper azole (C-A). (Although providing additional freeboard is recommended, as a redundant hazard mitigation measure, a flood-resistant material can also be considered for the subflooring). |

| Location of Material Use | Name of Material |
|---|---|
| Siding | Vinyl siding, fiber cement siding, or heartwood of naturally durable species (see Fact Sheet No. 5.3, *Siding Installation in High-Wind Regions*). |
| 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, preservative-treated lumber or lumber from naturally durable wood. (Some tile types attached with ordinary mastic or thin set mortar may not be flood resistant and should be avoided. Verify with a manufacturer that a flooring material is flood-resistant.) |
| Walls and Ceilings | Cement board, brick, metal, cast stone in waterproof mortar, slate, porcelain, glass, glass block, clay tile, concrete, CMU, preservative-treated wood, naturally durable wood, marine grade plywood, or preservative-treated plywood. |
| Doors | Metal doors, either hollow, wood core, and foam-filled core should be evaluated after exposure to salt water flooding. Fiberglass, wood core doors may be another alternative to consider. |
| Insulation | Sprayed polyurethane foam (SPUF) or closed-cell plastic foams |
| Trim | Preservative-treated or naturally durable wood or artificial stone, steel, or rubber |



Although the materials listed are considered flood-resistant materials, some sidings and wall coverings may need to be removed from framing members following a flooding event in order to allow the system to properly dry. For more information on repair techniques after a flood, see FEMA 234, *Repairing Your Flooded Home* (08/92).

Many jurisdictions will provide a list of approved flood-resistant materials that can be used in their local coastal environments. Check these lists and include all proposed construction and materials in approved plans.

## Wind-Resistant Materials

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

**Examples:**

- Roof coverings rated for high winds (see Roofing Category, Fact Sheet Nos. 7.1–7.6)
- Double-hemmed vinyl siding (see Fact Sheet No. 5.3, *Siding Installation in High-Wind Regions*)
- Deformed-shank nails for sheathing attachments (see Fact Sheet No. 7.1, *Roof Sheathing Installation*)
- Wind-borne debris resistant glazing (see Fact Sheet No. 6.2, *Protection of Openings – Shutters and Glazing*)
- Reinforced garage doors
- Tie-down connectors used throughout structure (from roof framing to foundation — see Fact Sheet Nos. 4.1, *Load Paths* and 4.3, *Use of Connectors and Brackets*)
- Wider framing members (2x6 instead of 2x4)

As hurricanes in recent years have proven, even well-selected materials can fail if not installed properly. Proper installation requires attention to detail, following the manufacturer's recommended installation procedures, and proper maintenance. When selecting a material or building component it is important to consider the level of difficulty required to properly install the material. Improper installation of materials may expose the building's systems to wind loads that the systems were not designed to resist. Also, it is important to verify that any special requirements were followed and that specialized tools or adhesives were used. Even a building component that exceeds the design requirements can fail if it is installed incorrectly.

## Corrosion and Decay Resistance

Buildings in coastal environments are prone to damage from corrosion, moisture-related decay, and termite damage to building materials. Metal corrosion is most pronounced on coastal homes (within 3,000 feet of the ocean), but moisture-related decay and termite damage are prevalent throughout coastal areas.

## Corrosion-Resistant Metals

Preservative-treated wood used in a coastal environment often contains chemical preservatives such as Alkaline Copper Quat (ACQ), Copper Azole (CA-C), Dispersed or Micronized Copper (μCA-C), or Copper Naphthenate (CuN-W). The connectors and fasteners used in conjunction with these pressure-treated wood products should be properly selected and it should be verified that the connectors are compatible with the wood preservative. According to the 2009 International Residential Code (IRC) R317.3.1 and International Building Code (IBC) 2304.9.5.1 the fasteners should be compatible with the wood preservative per the manufacturer's recommendations. The fasteners shall be hot-dip zinc-coated galvanized steel, stainless steel, silicon bronze, or copper. If the manufacturer's recommendations are not available, then corrosion protection in accordance with ASTM A 653 type G185 for zinc-coated galvanized steel or equivalent is required. Exceptions to this rule may be noted in the building code.

***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. 3.3, Wood Pile-to-Beam Connections.)***

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* (see the "Additional Resources" section).

## Recommendations

- Use hot-dip galvanized steel or stainless steel hardware. Stainless steel hardware is acceptable in virtually all locations, but hot-dip galvanized hardware may not be appropriate in every location. Reinforcing steel should be protected from corrosion by sound materials (e.g., masonry, mortar, grout, concrete) and good workmanship (see Fact Sheet No. 4.2, *Masonry Details*). Use galvanized or epoxy-coated reinforcing steel in areas where the potential for corrosion is high (see Fact Sheet No. 3.4, *Reinforced Masonry Pier Construction*).
- It is important to verify that the connector plate and the fastener are the same type of metal. Avoid joining dissimilar metals, especially those with high galvanic potential (e.g., copper and steel) because they are more prone to corrosion.

- Metal-plate-connected trusses should not be exposed to the weather. Truss joints near vent openings are more susceptible to corrosion and may require increased corrosion protection. Verify the connectors used near any roof vent openings are stainless steel or a minimum of ASTM A 653 type G185 zinc-coated galvanized steel or equivalent.
- Due to the potential for galvanic corrosion, standard carbon-steel, aluminum, or electroplated fasteners and hardware are not recommended for direct contact with preservative-treated wood.
- The use of aluminum flashing with many types of treated wood should be avoided. Aluminum will corrode quickly when in contact with most wood preservatives. Copper flashing in many instances is the best choice although products such as vinyl flashing are becoming more common.

## Moisture Resistance

Moisture-resistant materials can greatly reduce maintenance and extend the life of a coastal home. However, such materials by themselves cannot prevent all moisture damage. Proper design and installation of moisture barriers (see Fact Sheet No. 1.9, *Moisture Barrier Systems*) are also required.

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

### Recommendations

- Control wood decay by separating wood from moisture, using preservative-treated wood, using naturally durable 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. Field treatment shall be done per M4-06 of the American Wood-Preservers' Association.
- 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 to the latest building codes.
- Cavity wall systems (two masonry wall systems separated by a continuous air space) should be avoided in flood-prone areas since they can fill with water, retain moisture, and be difficult to repair without a significant level of demolition.
- Consider the interior finishes for first floors where floodwaters exceeding the design event could cause significant damage (See Fact Sheet No. 1.6, *Designing for Flood Levels Above the BFE*). It is also important to consider that wind-driven rain can cause damage to interior finishes around door and window openings.

## 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, in Hawaii, and other tropical areas). Termites can be controlled by soil treatment, termite shields, and the use of termite-resistant materials.

### 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. 3.4, *Reinforced Masonry Pier Construction*).
- Use preservative-treated wood for foundations, sills, above-foundation elements, and floor framing.
- In areas with infestations of Formosan termites, wood products treated with insect-resistant chemicals or cold-formed steel framing are material options for providing protection against termite damage.

## Additional Resources

FEMA. NFIP Technical Bulletin 2-08, *Flood-Resistant Materials Requirements*. (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

FEMA. NFIP Technical Bulletin 8-96, *Corrosion Protection for Metal Connectors in Coastal Areas*. (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

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

American Wood Protection Association. (http://www.awpa.com)



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

# Non-Traditional Building Materials and Systems





**Purpose:** *To provide guidance on non-traditional building materials and techniques and their appropriate application in coastal environments.*

## Key Issues

- Determination of whether a material or system is appropriate for the site-specific hazards.
- Evaluation of whether new materials and construction systems should be resistant to flood and wind damage, wind-driven rain, corrosion, moisture, and decay.
- All coastal buildings will require maintenance and repairs (more so than inland construction). When considering using a non-traditional material or system, it is important to ask, "What are some considerations for various new materials and systems?"

***Figure 1. Construction of a modular home.***

Every year, new construction materials are introduced into the market. These building materials cover every part of the home from the foundation system to the roof system. New materials often offer a variety of benefits — a cost-effective solution, energy efficiency, aesthetics, ease of installation, or eco-friendly solutions.

This fact sheet will focus on providing information on building materials and systems that while not being considered traditional materials are not uncommon to the industry. The sheet is not intended to encourage any one material or system, but will provide information so that the user can make a more informed choice about whether something is an appropriate material or system for a given situation. While the fact sheet does not cover all materials, it provides readers with an idea of what criteria they may need to be mindful of when selecting materials and systems. While many are reasonable alternatives to traditional materials and systems, their uses should be carefully considered. The same factors used to consider the applicability of traditional building materials and systems should be used to determine whether new materials and systems are appropriate for use in a coastal environment. Some of these factors include overall hazard resistance for flood and wind, durability, maintenance, and repair requirements. Additionally, when considering a particular building component, it is important to consider the installation and constructability of the component. When selecting a material or a system for a coastal environment it is important to consider available information in addition to technical data from the manufacturer or supplier. Some examples of considerations are:

- Contact the local building official about the acceptability of the material or system.
- Review test results on the material or system's use in coastal environments.
- Review product code evaluation reports.
- Review field reports or a history of these materials or systems performing well in similar coastal environments, including experience in high winds and flooding.
- Review the manufacturer's installation and maintenance instructions.

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Not all materials and systems will be specifically addressed by local building code requirements. Some products or systems may be absent from the code and may require engineering calculations or studies in order to determine that they are appropriate for use in a particular area.

**NOTE:** When considering using new materials or systems, the application of load path connectors should be carefully evaluated. Connectors should be evaluated by testing to demonstrate adequate performance for their intended application. Installation of the connectors should be considered and the ease of installation should be a primary consideration. An improper installation of a connector can result in significant losses in strength.

## System Options

### Engineered Wood Products

A variety of Engineering Wood Products (EWPs) are recognized in the model building codes. Examples include wood structural panels such as plywood and oriented strand board (OSB) and products commonly used as columns and beams such as structural glued laminated timber (glulam) and structural composite lumber (SCL). Glulam is an engineered, stress-rated product of a timber laminating plant comprised of wood laminations of nominal 2 inches or less in thickness bonded together with adhesive. SCL refers to either laminated veneer lumber (LVL), laminated strand lumber (LSL), or oriented strand lumber (OSL), which are comprised of wood in various forms (e.g., veneer, veneer strands, or flaked strands) and structural adhesive. For floor systems, conventional sawn lumber joists and girders (either solid or built-up) are recognized as flood-resistant. If EWPs are used for floor framing they should be either flood-resistant or elevated to a height where they are not expected to be wetted.

#### Advantages:

- EWPs are available in dimensions (length, width, and thickness) that are economical or, in some instances, not possible with sawn lumber.
- Due to availability of larger sizes, EWPs are able to resist greater loads than sawn lumber.
- EWPs are manufactured in a dry condition and are more dimensionally stable than sawn lumber, which may warp and twist during drying.

Things to consider if building with EWPs:

- **Cost:** While EWPs can be used to offer greater spans and exceed the loading properties of conventional lumber, they cost more.
- **Availability:** Certain sizes of Glulam or SCL may be difficult to obtain. They may require special ordering and fabrication, which may not meet the project schedule for the building.
- **Installation:** Installation issues include conditions for storing materials, dimensional compatibility with other materials, and requirements for use of metal connectors and fasteners to ensure accordance with the manufacturer's installation instructions.

### Structural Insulated Panels (SIPs)

Structural Insulated Panels (SIPs) are manufactured panels made of a foam insulation core bonded between two structural facings. SIPs are commonly manufactured with OSB facings as discussed in the 2009 International Residential Code (IRC) Section R613.3.2, but are also available with steel, aluminum, or concrete facings. SIPs can be used for walls (see Figure 2), floors, and roofs, and are compatible with light-framed construction.

***Figure 2. Construction of a Structural Insulated Panel house.***

#### Advantages:

- SIPs offer an efficient construction method and quick assembly. Insulation is built-in, and wall openings and utility chases are precut by the manufacturer per the building plans, reducing on-site coordination and adjustments.
- They increase thermal resistance, reducing heat gain and loss from the building, which allows smaller HVAC equipment to be used in the building.

Things to consider if building with SIPs:

- Evaluate the design loading values of the SIP and verify that the product is appropriate for the wind loading requirements for the building location.
- SIPS are an engineered assembly. SIPS should not be used where they can be flooded unless the entire assembly has been tested for flood resistance. Many SIPs utilize OSB facings. Generally, SIPs should only be used above the base flood elevation (BFE) so that they maintain their structural integrity. Refer to IRC R322.1.8 for requirements for flood-resistant materials. Otherwise, if the SIP is exposed to water damage during flooding, the panel may need to be opened, allowed to dry out, and repaired or, in some instances, even replaced.
- As with conventional construction techniques, SIPs may sustain windborne debris damage. This may require cutting out a section of the SIPs and repairing it with either conventional framing techniques or a replacement SIP.
- The foam core of SIPs is inert and provides no food value to termites and other pests. However, pests may still nest within the foam. Always incorporate pest control methods into the design in conformance with local jurisdictional requirements. Some manufacturers sell pre-treated SIPs.
- Always use approved connectors and connection methods for panel-to-panel, panel-to-foundation, and panel-to-roof connections. For guidance on SIPs connections, refer to IRC R613.5. It is important to consider that not all connectors are compatible with SIPs and in some instances specific connectors may be required in order to maintain the load path.
- Follow manufacturer's installation instructions and product use requirements in the manufacturer's code evaluation report.

***Figure 3. An example of ICF walls and reinforcing steel prior to placement of the concrete. The forms are left in place following placement of the concrete.***

## Insulating Concrete Forms (ICFs)

ICFs are made of molded expanded polystyrene (MEPS) foam and are used to form cast-in-place concrete walls (see Figure 3). Unlike conventional cast-in-place concrete construction, the ICFs are left in place after the concrete cures to provide insulation, an attachment surface for interior and exterior finishes, and space to run plumbing and electrical lines within the wall.

### Advantages:

- ICF provides improved energy efficiency and allows the use of smaller HVAC equipment than some other construction methods.
- The concrete and insulation walls are durable and require little maintenance.
- The combination of thick concrete walls and continuous insulation provide significant noise reduction over other construction methods.
- ICF provides good wind, windborne debris, and flood resistance.

Things to consider if building with ICFs:

- Special connectors may be required for the connection of the roof system, floor system, doors, and windows.
- For material and construction requirements for concrete walls, refer to IRC R611.
- Exterior foam must be protected from sunlight and physical damage by the application of an approved exterior wall covering. Refer to IRC 611.4 for requirements for stay-in-place concrete forms.
- ICF foam is inert and provides no food value to termites and other pests. However, pests may still nest within the foam. Always incorporate pest control methods into the design in conformance with requirements of the authority having jurisdiction.
- In some seismically active areas, constructing large, heavy structures on pile foundations can present significant design challenges. As with any

construction system, construction in areas subject to high erosion or scour could present design challenges due to the mass of an ICF structure.

- Foundation walls built with ICF (with appropriate openings) can be an appropriate foundation system in an A Zone. In V Zones, open foundation systems are required and in Coastal A Zones recommended. ICF and other solid foundation walls are not appropriate to be used in these areas.
- Follow manufacturer's installation instructions and product use requirements in the manufacturer's code evaluation report.

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## Prefabricated Shear Walls and Moment Frames

Many companies now offer prefabricated shear wall and moment frames that are pre-designed and available in standard sizes. The wall sections and moment frames (see Figure 4) are connected to the rest of the structural framing with bolted, screwed, or nailed connections. Sections are ordered and brought to the site on trucks as one piece or constructed with either bolted or proprietary connectors.

**Advantages:**

- Prefabricated shear walls are often designed to provide for quick installation and compatibility with other framing methods, where narrow wall solutions may not be practical with other framing options.
- Moment frames take the place of shear walls to allow large continuous spaces for windows and other wall openings. Much like the prefabricated shear walls they can be assembled quickly and incorporated into the house framing.

Things to consider if building with prefabricated shear walls and ordinary moment frames:

- Some systems may be limited in their application due to seismic or wind loading requirements.

***Figure 4. Installation of a prefabricated ordinary moment frame.***

- Verify that the members and connections used in the prefabricated sections are designed for the corrosive, moist coastal environment. Preservative-treated wood and galvanized or stainless steel connectors may be required for a coastal application.
- Not all prefabricated shear wall or moment frame systems will be allowed in all locations. It is important to consider that panel substitutions are subject to requirements of the applicable building code. Refer to IRC R602.10 for more information on wall bracing requirements.
- Maintaining the load path is important with any system. Because these systems provide lateral support for the structure, it is important to make sure that the load path will be transferred through the wall system and transferred down to the lower story of foundation and into the ground. Follow the manufacturer's installation instruction and product use requirements in the manufacturer's code evaluation report.

## Sprayed Closed-Cell Foam Insulation

Sprayed closed-cell foam polyurethane insulation is used to fill wall cavities in framed construction (see Figure 5). When sprayed, it expands and hardens forming a rigid air barrier and acting as a moisture retardant.

### Advantages:

- Sprayed closed-cell foam insulation expands to fill wall cavities, small holes, and gaps as it expands, producing a rigid barrier that results in reduced energy costs.
- It is quick to apply and may require less time to install than conventional batt insulation.
- It offers acceptable flood resistance, which is shown in NFIP Technical Bulletin 2-08, *Flood-Resistant Material Requirements for Buildings Located in Special Flood Hazard Areas* in accordance with the National Flood Insurance Program, Table 2.

Things to consider if building with sprayed closed-cell foam insulation:

- Tests have shown that sprayed foam insulation can improve the strength of structural framing systems and connections. However, structural framing systems and connections must be designed and constructed in accordance with all applicable building codes.
- While closed-cell foam is a flood-resistant material, it should be used in conjunction with preservative-treated, or naturally durable, wood or corrosion-resistant metal framing.

*Figure 5. An example of a wall cavity filled with sprayed closed-cell foam insulation.*

- Closed-cell foam should not be confused with other types of insulation. Some varieties of insulation on the market may be more cost-effective and more environmentally friendly; however, many of these products are not considered flood-resistant materials. Testing reports and provisions of the building code should be consulted for applicability in a coastal environment.
- Sprayed foam systems (such as those used in a wall system) create an assembly that when inundated by floodwaters may not be easily dried. For this reason, they are not appropriate to use below the BFE and are not considered flood-resistant material unless the entire assembly has been determined to be flood-resistant.

**NOTE:** Some framing materials such as prefabricated wood I-joists (e.g., a prefabricated I-joist constructed with sawn lumber or composite lumber flanges and plywood or OSB webs) should not be used below the BFE or where subject to flooding (see FEMA Technical Bulletin 2 *Flood-Damage Resistant Materials Requirements*).

## Methods

### Advanced Wall Framing

Advanced wall framing refers to methods designed to reduce the amount of lumber and construction waste generated during home construction. These methods include spacing wall studs up at 24 inches on center rather than 16 inches, and using smaller structural headers and single top plates on interior non-bearing walls.

#### Advantages:

- In most instances, the primary benefit of such techniques is the reduced lumber cost.
- The increased energy efficiency from the reduced number of wall studs and increased wall cavity space for insulation.

**Things to consider if using advanced wall framing techniques:**

- Not all wall framing techniques are applicable for hurricane-prone regions. The designer should carefully consider if this is an appropriate construction method for the area.
- Increasing wall stud spacing, even when using larger lumber sizes, can reduce the ability of a wall to resist transverse loads. For more information on designing framed walls to resist transverse loading, refer to IRC R602.10 or IBC 2305.

Construction crews may be unfamiliar with advanced wall framing techniques, which may increase construction time. Construction plans for advanced framing should be detailed enough for construction crews to recognize differences from conventional techniques, and additional training for construction crews may be required.

### Modular Houses

Modular houses provide an alternative construction method by constructing a traditional wood- or steel-framed house in sections in a manufacturing facility and then delivering the sections to a construction site where they are assembled onto a foundation (see Figure 1). The interior and exterior of the house are finished on site. These houses should not be confused with manufactured homes. Unlike

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manufactured homes, modular homes are required to meet the same building code requirements as houses constructed on site.

**Advantages:**

- Sections can be assembled in a controlled environment and construction time is less sensitive to poor weather conditions at the house site.
- Due to the sections being constructed at a manufacturing facility, materials use is often more efficient and fabrication is more efficient than site-built construction, resulting in reduced costs.

Things to consider if using modular houses:

- Proper installation of the house is important. Due to the sections of the house being constructed in another location, tight construction tolerances with the foundation are important in order for the sections to fit together properly.
- Modular homes are to be constructed to the same tolerances and locally enforced building codes as traditional site-built homes. The locally enforced building code where the house will be sited is the standard to which the modular house shall be constructed.
- The manufacturer needs to be aware of the location of the house and the materials that should be used in order to resist the site-specific hazards. Building component choices for flood, wind, and windborne debris-resistant materials should be identified prior to ordering the house and checked before installation begins.
- Extra care should be taken to verify that modular components are properly fastened to building foundations and load path connections are properly completed to transfer building loads from the roof to the foundation.

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

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# Moisture Barrier Systems





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

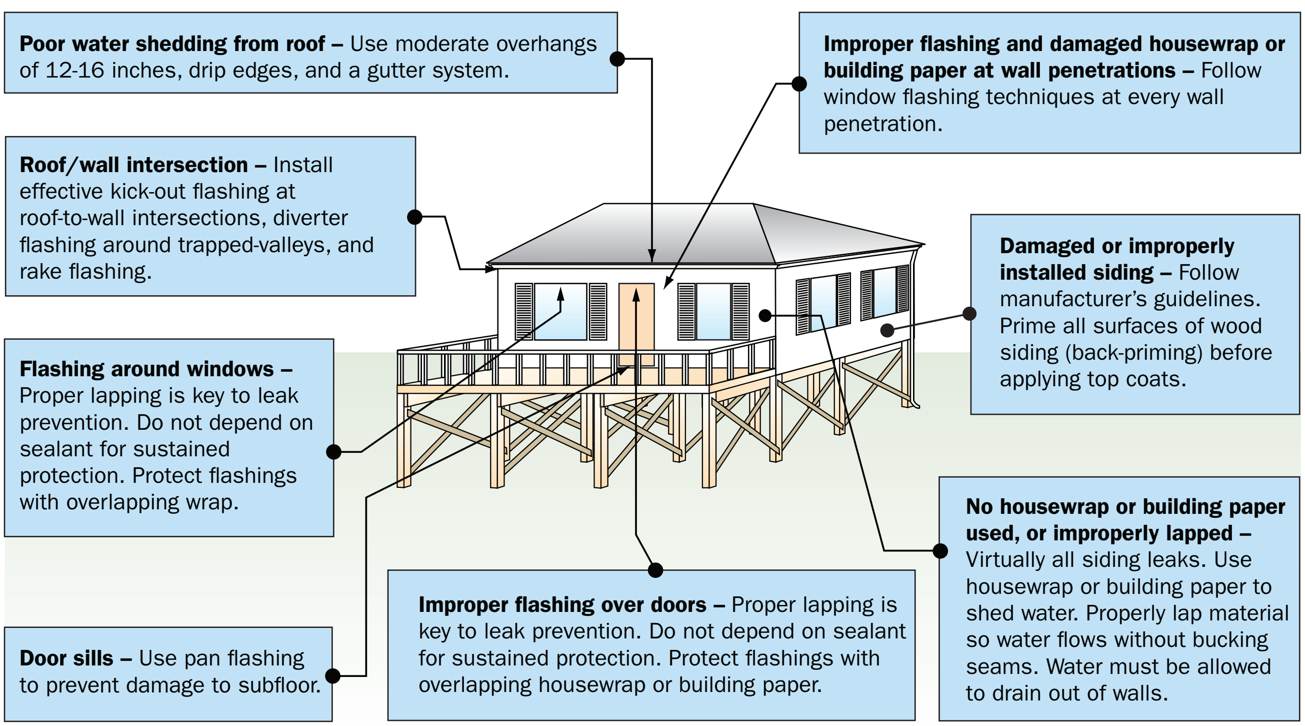
## Key Issues

- 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.

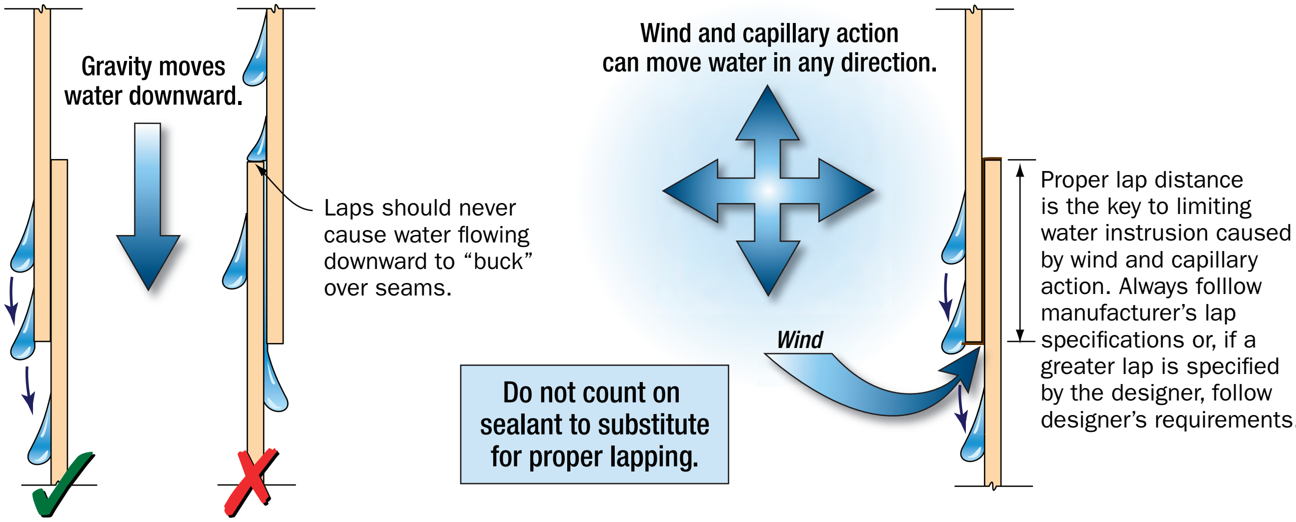
The purpose of the building envelope is to control the movement of water, air, thermal energy, and water vapor. The goal is to prevent water infiltration into the interior, limit long-term wetting of the building components, and control air and vapor movement through the envelope.

## Locations and Causes of Common Water Intrusion Problems



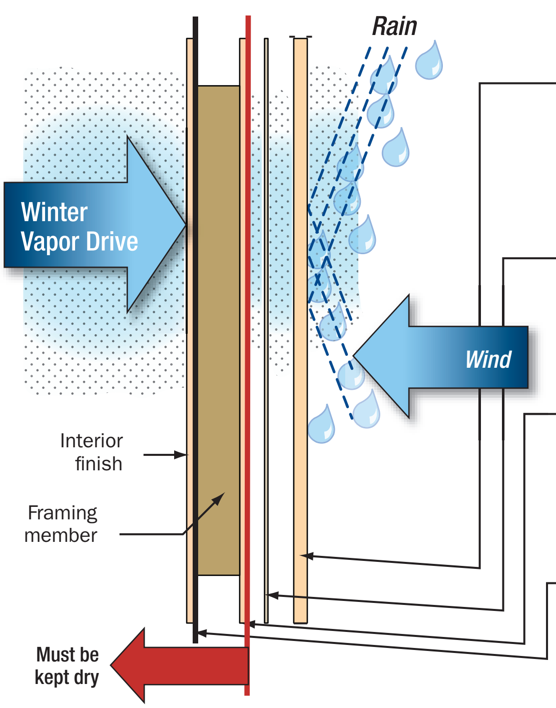
The location of water entry is often difficult to see, and the damage to substrate and structural members behind the exterior wall cladding frequently cannot be detected by visual inspection.

## Proper Lapping Is the Key…




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

## How a Redundant Moisture Barrier Works




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

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

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

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

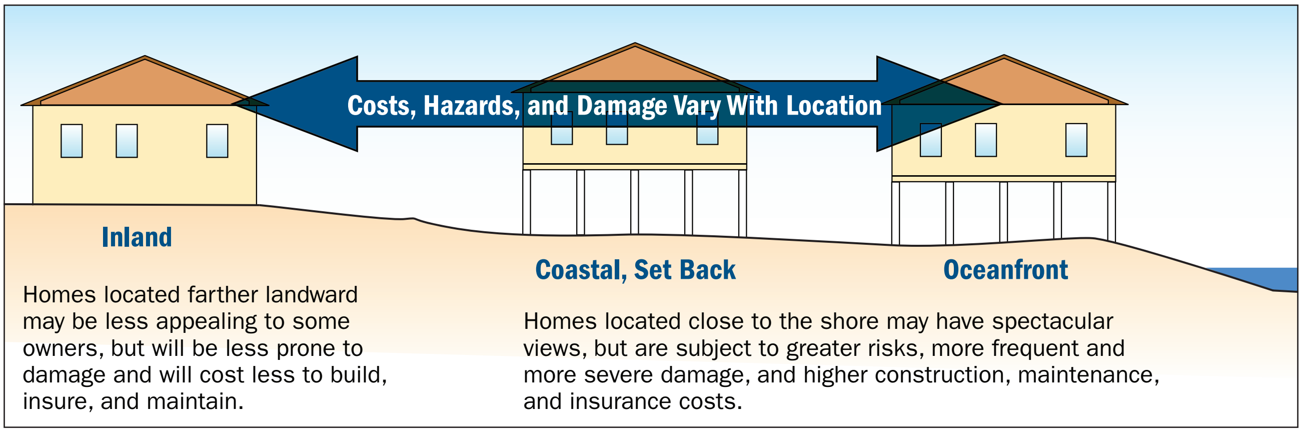
*Developed in association with the National Association of Home Builders Research Center*

# 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.[1]

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

## 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 $ Losses | Low | Medium | High |
|---|---|---|---|
| Low | Low Risk | Low Risk | Medium Risk |
| Medium | Low Risk | Medium Risk | High Risk |
| High | Medium Risk | High Risk | Extreme Risk |

[1]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).