North Carolina Coastal Federation NOAA Marine Debris Program

Award Number NA19NOS9990033

Recommendations for Improved Marine Construction to reduce damage, losses, and marine debris resulting from storms in North Carolina

Project Title: North Carolina Hurricane Florence Marine Debris Clean-up

Project Period: September 1, 2019 – August 31, 2021

Publication Authors: Kerri Allen, Ana Zivanovic-Nenadovic, Tracy Skrabal, Ted Wilgis, Kelsey Albert

Publication Date: September 1, 2021

North Carolina Coastal Federation, a 501(c)(3) non-profit organization, founded in 1982, that engages the community in protecting and restoring the health and productivity of the N.C. coast.

North Carolina Hurricane Florence Marine Debris Clean-up
Recommendations for Improved Marine Construction to reduce damage, losses, and marine debris resulting from storms in North Carolina

I. Introduction and Background

After Hurricane Florence, aerial and visual observations of damage to waterfront structures, primarily docks and piers, revealed extensive and significant damage. Treated lumber, floats, polystyrene and other debris from these structures was deposited in the public trust waters, wetlands and dredge spoil islands along the central and southern portion of North Carolina's coast (Appendix A). The amount and extent of debris was unprecedented in recent history.

Recognizing the extent and impacts of the debris to the coastal environment and economy of fishing and tourism, the North Carolina General Assembly awarded funding in 2019 through the North Carolina Department of Environmental Quality to the North Carolina Coastal Federation to remove debris from public trust waters that fall outside the scope of traditional cleanup programs. The project focused on consumer and heavy wooden debris from damaged docks and piers that had washed up after the storm (Appendix B). The debris was collected primarily by hand by small crews of fishermen/women using skiffs (Appendix C). A total of 204 tons of debris was picked up in Onslow and Carteret counties over seven months, along with three abandoned and derelict vessels (Appendix D).

Thanks to additional funding provided by the National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program in 2019 (Appendix E), the removal work was extended to include Pender and New Hanover Counties. An additional 115 tons of debris was collected from these areas over six months.

Then in late 2019, the North Carolina Division of Coastal Management (DCM) provided matching funds and received funding from the USDA Natural Resources Conservation Service Emergency Watershed Protection Program to remove debris and abandoned and derelict vessels (ADVs) from the central and southern coastal areas. DCM contracted with the federation to implement the project. Between July 1, 2020 and July 31, 2021, a total of 569 tons of debris and 21 ADVs have been removed from the public trust waters of these regions, including several state parks and coastal reserves.

Roughly 85% of debris removed has been from storm-damaged residential docks and piers (Appendix F). In addition to continuing removal efforts, this project serves to provide a case study on large-scale marine debris removal for distribution by NOAA for other regions. These cleanup efforts will support the development of recommendations for state-wide standards and model local ordinances for more storm resilient marine construction and will also increase education and outreach on marine debris in the estuarine environment.

A. Characterization of debris: Post-Florence surveys
   1. Using NOAA's aerial imagery acquired post-Florence (September 2018), federation staff completed an assessment of storm damaged piers and structures along the Central and Southeast coasts. Large storm debris fields were also identified throughout the regions:

Area	Estimated Total Docks	Visibily Damaged Docks	Percentage Damaged
Harkers Island	143	103	72%
Taylors Creek, Beaufort	159	37	23%
Bogue Sound (Mainland, AB bridge to El bridge)	417	290	70%
Bogue Sound (Island, AB bridge to El bridge)	638	440	69%
Cedar Point (El bridge to twin bridges)	100	56	56%
Swansboro (twin bridges to Hammocks Beach State Park)	96	60	63%
New River, Sneads Ferry, Chadwick Bay	192	110	57%
Topsail Island (New River Inlet to Topsail Inlet)	608	205	34%
Corcus Ferry Road to Figure 8 Bridge	225	109	48%
Figure 8 Bridge to Masonboro Inlet (Wrightsville Beach)	600	260	43%
Masonboro Inlet to Snows Cut	320	175	55%
Snows Cut to Carolina Beach	338	158	47%

   2. In early 2019, LDSI Inc. gathered information and performed a survey by boat of debris and abandoned and derelict vessels visible along the Atlantic Intracoastal Waterway from Core Sound to the Cape Fear River. Debris and vessels recorded through this survey can be found in their waterway debris mapping tool.
   3. Marine debris recovered
      a) Marine debris included household trash, plastic, bottles, cans, foam pieces, fishing gear, tires, building supplies, pressure treated wood, decking, and boards and pilings (Appendix G).
      b) In order to maintain habitat quality and not cause disturbance to the surrounding marsh vegetation, crew members hauled out wood by hand to piles that the contractor could reach with heavy equipment from the waterway (Appendix H).

B. Primary question: how can we reduce the amount of residential dock and pier debris left in public trust waters after storm events?

II. Existing statutes, rules, ordinances

A. A preliminary review of existing statutes, rules, and ordinances revealed:
   1. While commercial docks and piers have building code requirements in N.C., residential docks and piers are exempt from the state building code (Chapter 36).
   2. Coastal municipalities in N.C. are prohibited by state law (§143-151.8) from adopting any building code standards other than state codes (not considered a major life and safety issue).
      a) Regulations on docks, however, are generally prescribed by DCM and local zoning ordinances, which likewise can be more stringent than State requirements (Appendix I).
   3. Most municipalities require local building permits, in addition to DCM permits, but these permits only evaluate whether or not a dock/pier can be built, location in waterway/AEC, length/width, etc.

4. Once constructed, the structure can be inspected, but since it is exempt from the building code, there is nothing for local staff to inspect other than whether it exists or not. This one-time inspection is not always conducted, and is primarily for tax/property records.

B. North Carolina State Building Code
   1. Section 3601.2 (1) *Docks, piers, gangways and catwalks, other than residential and farm docks and piers exempted from this chapter in the exceptions below, shall be designed by a registered design professional.*

      Exceptions: The following structures are exempt from the requirements of this chapter:
      (5) *Piers and docks associated with one- and two-family dwelling meeting the exceptions of the North Carolina Residential Code.*
   2. Section R327 from the North Carolina Residential Code exempts residential docks from Chapter 36 of the state building code and specifies size requirements, heights, number of boat slips, roof area, etc. (Appendix J).

C. Division of Coastal Management
   1. See tables outlining structure requirements, retrieved from CAMA Handbook for Coastal Development. Requirements do not address building materials or methods.

D. Office of the State Fire Marshal (OSFM)
   1. OSFM goes further into the pier and dock permit requirements as applied to Section R327. As noted, pier and dock structures meeting all of the limitations of the exception of Section R327.1 are not subject to any other minimum code requirements. If the structure exceeds the limitations of the exception, then compliance with Chapter 36 of the NC Building Code is required.

E. Telephone interviews were conducted with contractors, engineers, land use planners, inspectors, regulatory staff, agency staff and scientists. Below are highlights and common themes regarding existing statutes, rules and ordinances (full summaries can be found in Appendix K).
   1. Contractors and engineers:
      a) In general, building codes have been drifting away from damage reduction approaches and moving towards life-safety issues. The building code council is not beyond looking at damage reduction, but so much is local site-selection driven that standard design change is not really feasible.
      b) The existing code is decent, but often not enforced; local building inspectors either lack training or do not care as much about water dependent structures as they do homes. Including required maintenance/inspections of waterfront structures in N.C. code would be a major improvement.
      c) Previous versions of code attempted to set design limits where they thought professional design might be an advantage, but ended up overdesigning residential structures that did not

need it. Requirements were not significantly improving residential docks/piers; the last round of amendments removed the requirement for residential docks and piers to be designed by a licensed Professional Engineer.

d) Most important thing from a contractor's perspective is vibrating the pilings sufficiently. This makes a huge difference; when they're washed in, the hole is blown out and it takes a long time for the sediment to build back up and does not fill in as well. By vibrating the pilings, the seal is tight; they recommend a 10-foot minimum - it all revolves around a solid foundation. It is also important to build with good quality hardware (especially for saltwater) and lumber.

e) Most newer docks are built fairly well, the problem is typically with older docks that are band-aided/pieced together year after year, storm after storm. An area to focus on is follow-up in dock repair, especially after storms. There are so many emergency permits issued, with few to quality check the work; some contractors purposely build something they know will not last to keep themselves in business. It is recommended property owners look for builders with at least 10 years of experience, avoid pop up contractors, do their homework and vet the builder. Maintenance and repair are key.

f) Importance of site-specific engineering: many builders have no idea what goes into wave and wind criteria. The problem is not how to design, but how to have a *functional* water-dependent use.

g) All about confidence and how much risk the property owner is willing to take. It comes down to how much money you want to put into it - do you want a frame with strong pilings that stay in place, but the boards will wash out? Do you just want to rebuild each time? Do you want a structure that will be partially damaged, totally damaged, with a specific storm height? Recommended careful consideration into how we characterize the narrative, suggested focusing on the cost of rebuilding (market debris reduction as secondary benefit).

h) Factors preventing property owners from building more durable structures: expense, not knowing better, and timeframe - everyone wants it built now.

2. Planning and local government staff:

   a) Up until 2017, residential docks and piers located in VE flood hazard zones had to be engineered by a registered design professional (same as current commercial docks and piers requirements). Once the residential building code was amended in 2017, this was no longer required. Building code has recently been weakened, but most government staff maintain that requiring an engineer to design structures is unnecessary; the same effect can be achieved by focusing on materials and techniques.

   b) No local governments interviewed addressed building materials in local codes (Appendix L). Pending DCM approval, drawings must be approved by local building inspector's office.
   c) Some jurisdictions may have more restrictive standards; in general, law and administrative code prevents local jurisdictions from developing standards that exceed state level BUT local zoning departments can impose additional zoning restrictions (building departments cannot).
      (1) Because of this, local building department staff think a zoning ordinance is the best path forward, but planners are often cautious of ordinance changes, preferring to see changes made through DCM.

3. Agency staff:
   a) DCM does not address building code issues at all; they simply permit the structures. Local governments have building code guidelines and are addressed in the building permits. Property owners often ask about structure recommendations, but since they are a public agency, DCM is very wary of promoting any kind of technique, method, etc. Instead, speak in general terms, listing pros and cons for different techniques. They recommend property owners only get what they need - for example, just because they can have up to 2,000 square feet doesn't mean they should.
   b) DCM does not think it is likely they would incorporate any requirements into the General Permit, the extensive vetting and very high threshold required to prove the recommendations are in everyone's best interest would likely prohibit anything from being adopted coastwide. Could see DCM providing BMP's to property owners as a resource, without official endorsement. As for implementation, they think focusing on strong public outreach is important, as well as drafting ordinances that local governments could adopt.
   c) Department of Public Safety - have not found any additional construction standards beyond what is recommended in the N.C. NFIP Model ordinance, FEMA Technical Bulletins, N.C. Building Code, or ASCE 24. All of which require construction which remains in place or breaks apart during the occurrence of the base flood and demonstrates no harmful diversion of flood waters or wave runup and wave reflection that would increase damage to adjacent buildings and structures.
   d) N.C. Residential Code makes exceptions for smaller docks associated with single-family homes. Only larger docks have to comply with any code requirements. We may want to ask the OSFM whether code changes would be warranted.

III. Additional questions/recommendations raised during fact-finding

A. How to address 'cutoff debris' (post-construction debris intentionally left in public waters by contractor/builder)? Removal crews found large amounts during clean-up.
   1. In N.C., there are no specific DCM rules addressing this type of debris.
   2. In Florida, they recognize that construction of structures over coastal waters raises numerous issues related to debris that might enter the water. Florida's Joint Coastal Permit (JCP) carries the following construction requirement – "*During pier construction, there shall be no construction debris discarded into the Gulf of Mexico (or Atlantic Ocean).*"
   3. Dock maintenance: removal crews reported numerous residential structures that are still standing, but are in tremendous disrepair. How can we prevent these structures from becoming debris after the next storm event?
      a) DCM: no CRC rule or statutory language that requires owners to maintain docks or authorizes DCM to take any action when a structure deteriorates.
      b) USACE: keeping docks, piers, boathouses, etc. maintained in good condition is a standard federal requirement but the Corps is unable to enforce due to limited resources.
         (1) SE dock disrepair inventory (South Wings Imagery)
         (2) South Wings flew and took aerial photos over the project area, imagery helped guide target areas for cleanup, as well as helped establish a complete picture of the scope of structures in disrepair.

B. Construction impacts: what are the impacts on the environment *during* construction?
   1. Do we want to take into consideration or evaluate damage done while building structures (equipment, cranes, etc.)? How long-lasting are these impacts? Do 'better practices' have more severe impacts? Are these addressed by DCM/Corps?

C. Is there a path for requiring/incentivizing personal removal of structure debris following storm events?
   1. In Florida, in anticipation of such conditions that would cause design breakaway features to become dislodged as well as any other pier damage, JCP's routinely require the following specific permit condition: "*The permittee shall expeditiously recover any breakaway debris, such as pier deck sections or railing, dislodged from the pier following the impact of major storms.*"
   2. The State of Georgia (interview with Buck Bennett) has been successful in requiring private property removal of damaged/lost marine debris/ADV's using the violation notice and enforcement process associated with GA's *Coastal Marshes Protection Act.*

IV. Discussion and recommendation for policy changes (rules, regulations, ordinances)

The focus of the policy team was to find policy solutions to require stricter design and construction standards for residential docks and piers in the coastal area. To better understand the possible solutions, it is relevant to understand the current regulatory context surrounding these structures.

Regulatory Context

North Carolina State Building Code

Construction of residential docks and piers in North Carolina has been exempted from the State Building Code since 2012 (Appendix M). Section 3601.2 (1) states:

> *"Docks, piers, gangways and catwalks, other than residential and farm docks and piers exempted from this chapter in the exceptions below, shall be designed by a registered design professional.*
> *Exceptions: The following structures are exempt from the requirements of this chapter: (5) Piers and docks associated with one- and two-family dwelling meeting the exceptions of the North Carolina Residential Code."*

Furthermore, state law prohibits local governments from adopting any building codes stricter than those prescribed by the General Statute §143-138(e):

> *"Except as otherwise provided in this section, the North Carolina State Building Code shall apply throughout the State, from the time of its adoption…."*

However, the section continues to specify:

> *"However, any political subdivision of the State may adopt […] floodplain management regulations within its jurisdiction. […] No such code or regulations, other than floodplain management regulations […] shall be effective until they have been officially approved by the Building Code Council as providing adequate minimum standards to preserve and protect health and safety. Local floodplain regulations may regulate all types and uses of buildings or structures located in flood hazard areas identified by local, State, and federal agencies, and include provisions governing substantial improvements, substantial damage, cumulative substantial improvements, lowest floor elevation, protection of mechanical and electrical systems, foundation construction, anchorage, acceptable flood resistant materials, and other measures the political subdivision deems necessary considering the characteristics of its flood hazards and vulnerability."*

North Carolina Residential Code

Following the state building code residential docks and piers structures are exempted from the Residential Building Code. Section R327 from the North Carolina Residential Code exempts residential docks from Chapter 36 of the state building code and specifies size requirements, heights, number of boat slips, roof area.

Coastal Area Management Act (CAMA)
The N.C. Division of Coastal Management requires CAMA general permit for construction of residential docks and piers as regulated by 15A NCAC 07H.0208 (b)(6). These standards relate to size and dimensions of structures, access to riparian property, but do not require any design and constructions specification or prescribe the use of specific materials.

CAMA development handbook provides more detailed structural recommendations but maintains its regulatory extent on the length and size of structures.

Proposed Policy Solutions
With this regulatory framework in mind, the policy team explored various policy avenues for mandating design and construction requirements for residential docks and piers. Considered solutions addressed: 1) stronger construction and design; and 2) post-storm marine debris problems caused by poorly designed residential docks.

The first set of solutions for mandating stronger design and construction standards:

1. Reinstate the design and structural requirements in the State Building Code.
   Since 2013, the residential North Carolina State Building Code has been updated every six years. Prior to this, the updates were required every three years. The exemption for residential docks first appears in the 2012 Code update, with 2009 being the last year that included the structures in the building code. In our effort to understand the reasons behind the exemption, we communicated with multiple State Building Code Council members and discovered that during the 2012 Code update the Agency received an overwhelming number of public comments requesting the exemption. However, the vast majority of the public comments originated in inland communities where smaller docks over backyard ponds and streams are common. Thus, residential docks and piers across the state were exempted from the Code.

   Prior to the exemption the 2009 State Building Code stated:

   "The design of piers, bulkheads and waterway structures is essential for the protection of life and property without causing adverse effects to the shoreline. These structures by their very natures result in some modification of physical environment and therefore require minimum design standards."

   The Code went on to specify minimum standards for foundations, design forces, structural integrity, material selection and utilization and construction techniques (Appendix N).

   Further communications with the Council member indicate that the Agency is working on reviewing the exemption and reinstating the residential docks standards in the code and considering implementing certain criteria to differentiate among different types, sizes and geographical locations of residential docks and piers.

The group recommends that at a minimum, these previous construction standards be reinstated in the 20 coastal counties as defined by the Coastal Area Management Act. Given the increased frequency and intensity of storms, the risk of marine debris posed by residential docks and piers in these areas is high not only to private properties but also to public trust waters, recreational areas and ecologically-important coastal wetlands and other coastal habitats.

2. <u>Amend rules and laws to allow residential docks to be defined as potential flood hazard and included in flood plain ordinance</u>.
During storm surge and flood periods residential docks get detached and, as free flowing debris, pose a hazard to life and property and become an important safety issue. As such, residential docks can be defined as coastal hazards.

By statutory authorization the North Carolina legislature delegated to local governments the responsibility to adopt regulations design to propose the public health, safety and general welfare. Under this authority local governments develop floodplain ordinances defining flood prone areas subject to periodic inundations which result in loss of life, property, health and safety hazards, disruption of commerce, all of which adversely affect the public safety, and general welfare.

As noted above, the General Statute also allows local governments to impose stricter building codes than those prescribed by the State Code through the floodplain ordinance. However, given that the current flood plain ordinance does not apply to structures built over water, the policy group recommends two ways to address the residential docks:

a) Consider residential docks as site-specific development that affects free-of-obstruction requirements for certain practices in the coastal zone. 44 CFR 60.3(e)(5) states, in part:

   "… that all new construction and substantial improvements within Zones V1-30, VE, and V on the community's FIRM have the space below the lowest floor either **free of obstruction** or constructed with non-supporting breakaway walls, open wood lattice-work, or insect screening intended to collapse under wind and water loads without causing collapse, displacement, or other structural damage to the elevated portion of the building or supporting foundation system..."

   The NFIP interprets the **free-of-obstruction** requirements to apply to certain site development practices that prevent the free flow of coastal flood water and waves under or around buildings or increase flood loads on nearby buildings. Construction elements outside the perimeter (footprint) of and not attached to a coastal building (e.g., bulkheads, retaining walls, decks, swimming pools, accessory structures) and site development practices (e.g., addition of fill) may alter the physical characteristics of flooding or significantly increase wave or flood forces affecting nearby buildings. As part of the design certification process for a building in Zone V, the registered design professional must consider the effects these elements and practices will have on the building and on nearby buildings.

As such, the design and construction standards and practices of residential docks would have to be taken into consideration with new construction and substantial improvements.

b) Amend the floodplain ordinances to include residential docks built over water under their purview. Under the federal law, once FEMA provides a community with the flood hazard information upon which floodplain management regulations are based, the community is required to adopt floodplain management ordinances. The coastal floodplain ordinances currently do not apply to structures built over water. The policy group recommends exploring avenues to amend the rules and regulations governing flood ordinance coverage to include residential docks.

Funded by the Natural Resources Conservation Service Emergency Watershed Protection program and in partnership with the Division of Coastal Management, the Coastal Federation performed coastal marine debris cleanups from Hurricane Florence and Dorian. The crews started in August 2020 and found that *85% of the debris came from destroyed docks during past storms*. Large part of this debris was identified to have come from improper dock construction discards. This included pressure treated wood, railing, pilings and dock construction material. Thus, the following recommendations focus specifically on *prevention of marine debris* caused by dock construction.

1. <u>Amend CAMA general permit for construction of residential docks and piers</u>
   Currently, an upland disposal of dock construction material is a norm, rather than an explicit written requirement in the 15A NCAC 07H.0208 (b)(6). The policy team recommends the general permit rule language be amended to explicitly include the requirement for upland disposal of docks and piers construction material.

2. <u>Adopt policies and ordinances to require encapsulation of polystyrene docks</u>
   Select states, cities, towns, and agencies across the United States have adopted policies, ordinances, or voluntary initiatives to regulate unencapsulated polystyrene docks. As discussed at length during our technical group discussion, unencapsulated dock floats are a significant, long-lasting, and damaging source of polystyrene (foam) pollution.

   These floats are highly unstable, and susceptible to damage and complete losses during coastal storms. Once damaged and broken apart, unencapsulated polystyrene spreads (from small beads and fragments to full sized floats) throughout our coastal and aquatic ecosystems (Rozalia Dock Foam Study, in Draft, 2021) (Appendix O). When consumed by marine creatures, these foam beads/fragments can block airways or digestive tracts, and prohibit animals from absorbing nutrients (Rozalia, Rittmaster, 2018). Polystyrene contains chemicals such as benzene, styrene, and ethylene, which can leach into water and can pose significant health risks (Rozalia, Georgia Forever, 2019). Additional toxins can easily bind with polystyrene's molecular structure. As a result, these become polystyrene concentrates and magnifies these toxins within marine mammals. This toxicity moves up the food chain, affecting entire ecosystems and eventually humans (Rozalia, Marcy & Johnson, 2009).

Throughout NC's coastal and estuarine environment, the presence of this very specific marine debris is ubiquitous, and has been found in every single location surveyed by federation staff and the marine debris removal crews. The vast majority of these beads and fragments cannot be removed by current removal efforts, and are non-biodegradable, thus increasing the cumulative effect of this material in these regions.

In sharp contrast, the encapsulation process melts the hard plastic onto the polystyrene and hardens it. When damaged during storms, the encapsulated float seeps the foam interior contained rather than allowing its dispersal into the environment. Encapsulated docks last significantly longer, require far less maintenance than unencapsulated docks pose. They prevent toxin magnification, save the lives of marine animals, and ensure a healthy and aesthetic ecosystem (Rozalia).

Unencapsualted floats (left) shed polystyrene particles and break apart in the marine environment, as opposed to encapsulated (right) which do not.

Examples of different approaches to regulation of unencapsulated docks across the country can be found in Appendix P.

The policy team recommends that well-defined requirements for dock encapsulation be included in the set of standard recommendations proposed to the State Building Code as suggested in the first recommendation. In addition, we recommend that local governments implement ordinances that require dock encapsulation. The City of Wilmington adopted an ordinance incentivizing land-owners to implement dock encapsulation in exchange for a larger dock area (Appendix Q).

Summary of Policy Recommendations

1. Reinstate the residential dock and piers construction and design standards to the State Building Code proposing the integration of the new standards developed by the Technical Team of this work group (including dock encapsulation). The team recommends higher dock construction standards in 20 coastal counties as defined by CAMA.
2. Amend rules and laws to allow residential docks to be defined as potential flood hazard and included in flood plain ordinance.
3. Amend CAMA general permit for construction of residential docks and piers.
4. Adopt policies and ordinances to require encapsulation of polystyrene docks.

Sources:
2018 NORTH CAROLINA STATE BUILDING CODE
143-138. North Carolina State Building Code
Section R327
1 SUBCHAPTER 7H - STATE GUIDELINES FOR AREAS OF ENVIRONMENTAL CONCERN
SECTION .0100 - INTRODUCTION AND GENERAL COMMENTS 15A NCAC
CAMA Handbook for Development in Coastal North Carolina How to Use This Guide
Introduction About This Guide
GENERAL ASSEMBLY OF NORTH CAROLINA SESSION 2013 SESSION LAW 2013-118
HOUSE BILL 120 AN ACT TO REQUIRE APPROVAL FROM THE NORTH CA
NC DEQ: CAMA Counties

V. Discussion and recommendations for development and dissemination of Best Management Practices (BMPs) for removal and disposal of hurricane marine debris

As described above, an unprecedented amount of debris was spread out and deposited throughout the public trust marshes, tidal creeks, sounds, embayments and islands of the central and southern coastal region of North Carolina. Determining the amount, extent and removal method(s) of the debris was a new challenge. Federal and state agencies, whose resources were already stretched very thin by the storm response, relied on visual surveys by boat along major waterways and aerial photographs to estimate the degree of the debris. Areas with higher population densities, significant waterfront development and significant cultural resources (parks, reserves) were prioritized. However, as determined later by the field crews of contracted fishermen/women, it was very difficult to get an accurate sense of the scale and extent of the debris just from visual surveys. Much of the debris had been floated by the storm surge and blown by the wind far up into the wetlands and into the interiors of marsh and dredge spoil islands. Not until the field crews began scouring these areas with small skiffs and walking through the wetlands and across the islands, did the true extent of the debris fields become apparent.

Due to the geography and shallow water of the estuaries, creeks and waters of the central and southern coast, along with the spread of the debris, figuring out how to find, collect and remove the debris was a challenge. Mobilizing a fleet of marine contractors with barges and excavators was not possible or feasible for the vast majority of debris. Many contractors were in high demand to repair and replace the lost and damaged waterfront structures. Also, the water was too shallow and the habitat too sensitive for large vessels and heavy equipment. Based on earlier success employing fishermen/women to retrieve lost fishing gear, the federation turned again to local fishing communities to pull together small (3-4 people) field crews using skiffs (19-22' long) to navigate the shallow, ever changing waters and habitats of the coast. Using their knowledge of tides, where currents and surges go and the local areas, the field crews quickly found the debris. Each crew of 3-4 people have averaged collecting one ton/2,000lbs of debris each day.

The issue of the vast amount of debris is certainly linked to the damaging forces of sustained storm surges and wind. However, as described in this report a significant amount of debris was generated due to poor construction, lack of maintenance (funding, enforcement) and very little storm preparedness. Crews found stacks of new lumber with the tags still attached from construction sites. Whole sections of pier decking lifted off pilings due to inadequate attachment (Appendix R). Sections of docks with piling attached were pulled out of the bottom due to the shallow depth of pilings.

This section provides guidance, resources and "lessons learned" from the large-scale cleanup of hurricane marine debris ongoing since early 2019. While the collection and removal of debris has been very successful, due to the hard work of the field crews, there would be a lot less debris to recover if the guidelines and recommendations in this report are adopted, followed and enforced.

Post- Storm Debris Identification, Assessment and Removal Practices

- After a significant storm event, using aerial imagery is a great help in assessing the potential scope, scale, type, and amount of debris. NOAA rapidly produces imagery for areas affected by storms:
    - https://storms.ngs.noaa.gov/storms/isaias/index.html#8/35.661/-76.191
    - https://storms.ngs.noaa.gov/storms/florence/index.html#18/34.63577/-77.19929
- Waterway surveys by boat are useful, but often greatly underestimates the amount of debris deposited in the marsh, behind berms of spoil islands and hidden in marsh hammocks.
- Surveying by drone can be useful, but has limited applications.
- Communicating with local residents and sending out small crews of people familiar with the local environment to conduct focused searches of sample areas can yield good results.

Coordination with Regulatory Agencies, Resource Managers and Local Officials

- Work with state and federal regulatory agencies to receive State and National Environmental Policy Act (SEPA and NEPA) clearances for project activities.
- Provide debris collection crews with the written regulatory guidance and NOAA Marine Debris BMPs (Appendix S), and offer training to crews to ensure compliance.
- Notify local, state, and federal agencies of debris collection activities when the field crews are active in their respective areas.

Recruiting and Setting up Debris Collection Crew

- Local fishermen/women have proven to be excellent and resourceful. Sometimes have to compete or be flexible during commercial seasons.
- Field crews are made up of Boat Owner/Operator; Field Crew Supervisor; (2) Field Crew Members.
- Initiate contact with potential crew supervisor and/or Captain.
- Describe the pay, requirements, and expectations of the job for each crew member.
- Ensure the Captain has the proper vessel to support the requirements of the job.
- Ensure the Crew Supervisor has the necessary equipment and skills to handle their job expectations.
- Meet and interview the crew to ensure proper knowledge of equipment, navigation, location, etc. is present.

- Establish clear and concise communication and exchange of information with the Crew Supervisor.
- Provide the crew with all necessary documentation, forms, etc. for the contract.
- Make sure the Crew Supervisor is aware of the format, frequency, and expectations of paperwork (debris logs, hour logs, etc.).
- Provide gear and explanation for the use of gear (sharp kit, oil spill kit, sleds, etc.) to the crew. Also, explain what gear may be required by the crew to provide if needed.
- Make sure the Crew Supervisor is supplied with the proper maps and outline the scope of the project.
- Ensure the Captain is committed to finding a place to store his vessel during the duration of the contract or is capable of shuttling his vessel to and from the location of the contract.
- Provide the Crew Supervisor with the contact information and locations necessary to facilitate the delivery, setup, and servicing of the dumpster.
- Accompany the crew at least one day out on the water to answer questions, give guidance, and examples of how to perform the requirements of the contract.
- Instruct the crew on proper dumpster loading etiquette and site maintenance expectations.
- Instruct the crew on proper environmental etiquette in order to minimize impact to the environment and surrounding areas.
- Continue communication throughout the course of the contract for questions, concerns, or necessary guidance.

Debris Collection

Typical size skiff used for debris collection (left); crews using a 4-wheel ATV and small trailer to collect debris from ocean front beach (center); and utilizing debris sleds (right) to minimize environmental impacts of removal.

Recovery and collection of debris methods vary according to the type of debris, waterbody and habitats. Often it is initially thought that barges with excavators will be most effective. However, in shallow, tidal estuaries with changing conditions, small boat crews operating by hand and with hand tools are often most effective. Small crews also seem to minimize the negative impacts to the surrounding environment.

- Shallow draft barges with excavators or landing type barges with skid-steers are useful to pick up large debris along maintained channels. They can also be useful for picking up stockpiled debris placed by small crews. If operating in an area with little to no land access to host a debris dumpster or offload debris, a barge can serve as a mobile debris collection platform for the small crews.
- On oceanfront beaches crews may be able to use a 4-wheel ATV with a small trailer to collect and haul debris to access sites. Coordination with resource and regulatory agencies must occur to ensure protection of bird and turtle nesting sites.
- Small crews made up of 4 individuals working with 21 - 24’ long shallow draft skiffs/bateaus are very effective and efficient. Larger crews tend to lead to less production and wait times.
- Crews should be outfitted with (See attached gear list):
    - Gear: debris sleds, trash bags, trash grabbers, wrecking bars, chainsaw, logging picks, heavy duty rope/line, small spill kit, medical/sharps container w/red bags and bucket, marsh mats, 5-gallon buckets, shrimp baskets, heavy duty garden carts for hauling debris to dumpster
    - Safety/Visibility: Safety glasses, gloves, first aid kit, orange work vests (best with organization logo), boat flags labelled with *Marine Debris Collection*
- Provide crews with high visibility t-shirts, safety vests, hard hats (if needed) and boat flags with project information and or logo to make the public aware of their activities for safety and educational purposes.

Crews working by hand to collect polystyrene pieces from unencapsulated floating docks (left) and examples of larger floats that are found in large numbers (center, left).

Debris Disposal

- Utilizing existing public boat ramps and access areas for staging debris dumpsters and loading works well and is preferred versus using a community, private or business access.
- State/local agencies and governments that manage boat ramps may provide a Special Use Permit, with conditions, to enable dumpster staging and debris offloading.
- Locations for dumpster placement must be accessible during all tides and also accessible for debris drop-off by the crew. There must be constant access to the dumpster for removal by the dumpster company.
- Recycling is difficult due to debris contamination. If possible, it is helpful to have a yard where reusable wood can be stored and offered to the public. Would need two dumpsters at each collecting site, one for reusable wood/ recyclable metal and the other for debris for landfill.
- 40-yard dumpsters are best, as they fill up quickly. Crews average 1 ton of debris collection/day, with a 40 yd dumpster being filled once a week on average.
- Using local waste hauling companies if possible.
- Municipal landfills will sometimes offer discounts, waive fees or provide in-kind equipment assistance with debris removal.
- Check with local landfills to see if debris needs to be sorted.
- Use traffic cones and signage to educate the public about the project and to discourage illegal dumping in the dumpster.
- Ensure weight tickets are provided and recorded for every dumpster that is emptied.

Full copies of crew SOP's, equipment estimates, member agreements, contractor agreements, signage, liability waivers, and case-study photos may be found in Appendix T.

40-yard dumpsters at removal sites. Constant access to dumpsters, a reliable removal schedule and good working relationships with local government staff are key in getting debris removed in a timely manner.

VI. Design/Construction Recommendations for Long-Term Resiliency and Prevention of Hurricane Marine Debris from Marine Construction

Introduction and Background

North Carolina is not alone when it comes to incomplete standards surrounding the construction of residential docks and piers. Upon researching other coastal states that may be prone to hurricanes, the vast majority of coastal states have similar policies to North Carolina - permit requirements and size limitations, but no standards directly related to construction. There are a number of reasons for this, including: difficulties and lack of consensus on the most effective construction standards (especially for hurricane prone areas); wide variability of factors and considerations across coastal regions; lack of expertise and resources for monitoring and enforcement; lack of education for consumers and construction professionals; market forces that can drive marine construction towards low bid, substandard construction materials and practices; lack of political support for strengthening construction standards. Nevertheless, there are numerous examples and models for resilient construction of docks, piers, and effective programs that have resulted in reduction of marine debris from damages and losses of docks, piers, etc., particularly during hurricanes and coastal storm events that are frequent along North Carolina's coastal region.

Considerations before building marine structures

Property owners and professionals need to consider a number of factors when determining marine construction needs. Overall, it is important to understand the use needs, specific site conditions, history of energy and weather conditions for the site, qualifications of the marine professional, and funding/insurance options. There are various design options and material choices. Where to locate the structures is another important factor. Understanding the tides, storm exposure, and/or bottom conditions can help determine the best location and type of dock for a given waterfront area and ensure the longevity of the structure, especially in marine and storm- prone areas. Each different docking system offers benefits and potential risks. It is critical to understand uses as well as current and historic site conditions, typical and storm energy forces, future risks, and historic damage/maintenance issues.

When choosing a design and location for a dock/pier/etc. the first step is to ask a few questions about your particular location and needs:

- What is the depth of the water and condition at the bottom?
- Should the structure(s) be permanent, adjustable or removable?
- How many boats will the dock need to accommodate at once? What about other types of watercraft, such as kayaks, canoes, paddleboards, etc.?
- Will the water level rise and fall drastically, potentially limiting the dock's usage?
- Will the dock be exposed to any ice during the winter if the surface freezes?

- What are the surface conditions of the water? Are you in an area that's prone to heavy boat traffic or frequent storms?
- What are the historic wave heights/wind energy/current velocities/storm surge for this shoreline and property?
- What is the history of damage/losses/maintenance issues for any structures at this or nearby properties?
- What is your budget? How much are you willing to put into constructing and maintaining the dock?
- Is insurance a factor in building your structures, and can you obtain a policy with rate incentives for more durable/resilient construction techniques and materials?

Considerations in Selecting a Marine Contractor

Over 85% of the marine debris removed from North Carolina's estuaries between 2019-2021 is the result of damaged and/or lost docks, piers, boat houses, etc. Many examples of damaged and/or lost structures are the direct result of substandard marine construction techniques, including lack of expertise/experience, poor construction, substandard materials, and cutting corners on both construction methods and materials.

The qualifications, experience and proof of resilient, durable, and long-standing marine construction, are extremely important factors in selecting a marine contractor. As with the selection of any contractor, property owners should be proactive in vetting and selecting a marine contractor. (Appendix U) Selecting a contractor solely based on the bid price is often not the best option, if one does not take into account the type of construction and potential for longevity. This is especially true for marine construction within coastal North Carolina, given North Carolina's long history and increasing risks of coastal storms, hurricanes, heavy boat traffic, and other marine conditions affecting the lifetime of marine structures.

Although an added up-front cost to property owners, it is advisable to hire a marine engineer for design guidance, especially within areas which are susceptible to storm energy, surges in water elevation, and significant wave, boat wake, or current conditions.

Below are some recommendations that property owners should consider before contacting a marine contractor and during their vetting and selection processes:

- Obtain and read educational materials concerning the type of marine construction project to be performed.
    - One or more options which could apply to the situation should be identified and design techniques based on proven engineering principles and construction practices for such projects should be studied.
    - Publications addressing a variety of marine construction projects are available from Sea Grant and the U.S. Army Corps of Engineers.
    - Write down as much as possible about what is intended to be accomplished by the project. The present situation should be outlined, the problem to be

solved should be stated, and preferences for type of construction and final appearance should be described.

- Potential contractors should be given as clear a picture of the project as can be provided, as well as needs and uses for the structure.
    - It is best to allow contractors to propose a range of feasible designs from which the client can choose a final project.
    - Important information that can be presented to the contractor includes: the exact location of the project; a description of the problem to be solved; specific site conditions (best gathered during a site evaluation); site conditions and history of tide, wave, storms and current conditions, changes to the shoreline, etc.; the general composition of shoreline sediments (i.e., sand, clay, cobbles); any restrictions that would preclude needed equipment access to the construction site; and/or a rough description of the client's needs and proposed uses for the structure.
- What type of licensing and certifications do you have?
    - It is always better and safer to work with licensed and certified marine contractors. This may not be needed for smaller, residential settings, but may be worth considering.
- Does the contractor carry a Commercial Marine Liability Insurance Policy and a USL&H Endorsement on their Workman's Comp. Policy?
    - This may not be needed for smaller, residential settings, but may be worth asking.
- Are you experienced in marine construction in this area?
    - It is important that a contractor has experience in constructing marine structures. At the same time, you need someone who is especially experienced in building structures in your area. it is not enough if they know how to build structures. They should know and understand the challenges related to the location of your land, soil conditions, the historic energy and storm forces for the area, and design options to meet these forces.
- What design do I need for my uses?
    - When you have narrowed down your choice to a few experienced marine contractors, you may begin to discuss designs. Make sure to discuss your needs and uses for the structure. Ask them for suggestions for the ideal and most functional design and discuss the specific materials with lifetime estimates and any guarantees they would offer for their design in the event of damage and/or failure.
- What equipment will you be using?
    - Big projects require bigger equipment. You need to know that the contractor has access to the right equipment for the job, which equipment they will be using, how it will move through your space, etc.
- Do you have any references or testimonials?
    - Visiting existing structures at your project site is a good way to find local marine contractors and ask about their work.

    - Existing structure types that serve a similar purpose to a property owner's uses should be inspected and discussed with the structures' owners regarding the company that did the construction.
        - Questions to ask include: did the contractor have the proper equipment to successfully complete the project; were there any unusual problems during or subsequent to construction; how long has the project been in existence; and, is the owner satisfied with the way it has performed?
    - If the structures' owners are pleased with their structure, they will most likely be happy to share that information. Do not make the mistake of not checking references. Sometimes even the most experienced, licensed, and certified marine contractor who seems to be the most qualified person for the job may be unresponsive to needs, have a poor work ethic, hire inexperienced crews, etc.
- What is their reputation in the community?

<u>Sources:</u>
[Seven Questions to Ask Before Hiring a Marine Contractor, Thaler Contracting]
[Five Questions to Ask Your Contractor, Farrell Marine]
[Selecting a Marine Contractor - New York Sea Grant]

<u>Recommendations and Discussion of Marine Construction Best Management Practices</u>

Below are discussions of key factors, examples, and resources that can improve the resiliency and lifetime of marine structures in North Carolina. Recommendations for improving the resiliency of marine construction include consideration of materials and construction techniques. These include, but are not limited to, the following:

Recommendations for marine construction materials

<u>Support pilings and decking/docking materials</u>

A key factor in marine construction is selection of the materials. Types of structure materials that are commonly used for residential docks and piers include wood, concrete, polymer, recycled plastic/vinyl, and steel. When determining the best type of dock piling, you should consider the water conditions that your dock will have to withstand as well as the overall weight and load of the dock. A great deal of information may be obtained through an internet search. Some basic information about marine construction materials with some recommendations are included below:

Wooden Docking/Pilings

Historically, wood has been used to construct a large variety of marine structures within North Carolina and elsewhere. Untreated wood is not recommended for the coastal zone because it will soon decay if it comes in direct contact with seawater. In marine applications, timber is attacked by marine borers, insects, fungus, and rot. Marine plants, algae, crustaceans, and marine worms attach to treated timber piles, however, these do not appear to harm the strength characteristics of the wood. Typically, timber elements that are directly subject to the marine environment are then pressure-treated with some infused protective treatment (more information on this is provided below). Treated to withstand sea and brackish water, pressure-treated timber maintains its relative strength and lasts longer than untreated timber.

It is recommended to use hardwood pilings (such as greenheart) as a durable option for dock construction. Highly durable and resistant to marine borers – hardwood pilings address a major consideration in a dock piling material. Commercially available as untreated pilings, they are advertised as better than treated woods at standing up to the pressures of the job. This also has the added benefit of nothing nasty potentially leaching into the water.

Over time, most old timber pile construction will deteriorate in the marine environment. To avoid losses of the entire docking structure, existing older piers should be restored by the addition of replacement piles or by encapsulating the piles in concrete. Alternatively, piling sleeves may be heat shrunk onto wooden dock pilings before they are installed or retrofitted onto existing piles, creating a waterproof layer on the outside of the pile, which extends the strength and longevity of the dock piling.

Failed or damaged docks/piers/etc. very often require the use of undersized support pilings/posts during construction. In areas prone to heavy storm forces, strong currents, etc. the use of larger, more substantial round pilings (ie. 10”-12” diameter round pilings vs. 4” X 4” square pilings) is recommended for long-term stability.

Sources:
The Ultimate Guide to Dock Piling Materials - Decks & Docks Lumber Co.
Greenheart - Wood Species Guide

Aluminum Docks

Assembled with interlocking edges, aluminum decking planks create a lightweight, water-tight, and gapless seal. Some considerations include:

- Durability: Unlike wood that is susceptible to environmental impacts, aluminum is scratch- and weather-resistant. Aluminum socks are significantly lighter than wood, but when reinforced, may be stronger and more resilient to loads than comparable wood structures.
- Upkeep: Aluminum does not rust, but it will corrode. The corrosion process protects the aluminum from rusting. Though you do not have to worry about rust eating away the metal, you do have to worry about the structural integrity of the dock being compromised. A variety of protection methods are applied to aluminum and its alloys to enhance their corrosion resistance. Amongst the most common methods is anodizing. This is an electrolytic process which produces a hard, relatively thick film of aluminum oxide on the surface of the aluminum when the metal is made the

anode in a suitable electrolyte and current is passed through the circuit. Other protection methods include chemical conversion coatings and various paint finishes e.g. powder coating. Chemical pre-treatment prior to painting is essential. Sacrificial anodes, e.g. zinc, can be used to protect aluminum alloy structures when used in marine environments.

- Repairs: Because aluminum decking will not rot, attract damaging pests, or grow mold, repairs are usually minimal.
- Environmental Considerations: Though the mining process and refinement of ore requires a lot of energy, aluminum is heavily recycled. You can reuse uncontaminated aluminum almost indefinitely.
- Ability to Expand, Reconfigure, or Remove: Aluminum docks are typically manufactured in sections for installation, therefore, they can be added onto or reconfigured. While permanent structures like wood piling docks cannot be removed easily, aluminum docks can usually be folded and stored when not in use during the winter or seasons with heavy storms.
- Lifetime: The duration of an aluminum structure depends heavily on location and marine conditions. Aluminum frames may last from 30 to 50 years depending on conditions.

Sources:
Aluminum and Corrosion
EZ Dock

Plastic (New/Recycled or Composite) Docks

Those looking for a durable, innovative floating docking system should consider plastic decking. This type of dock material is easy to install and can cater to budgets of all kinds. It also represents a resilient option, with the durability and longevity of aluminum docks but without the higher price tag. Some considerations include:

- Durability: Plastic/composite docks are made of durable dock surface materials. In both freshwater and saltwater environments, polyethylene docks will not rot or splinter like wooden docks. The mobility of the relatively lightweight sections could allow for removal of some or all of the sections prior to hurricanes, extreme storm surges, etc. If a resin or plastic dock section is damaged, it can be easily replaced.
- Upkeep: Plastic docks are easy to maintain. Wooden docks require regular maintenance and aluminum docks require an attentive eye for rust, corrosion, or other unfavorable occurrences.
- Lifetime: Product marketing for plastic docks promote plastic docks for most low- to mid-category hurricanes. Warranties for plastic docks average about 50 years under normal conditions.

Flow-Through/Open Slatted Decking

A relatively new innovation involves plastic or heavy rubber coated flow-through decking, which is sold in varying sizes of decking modules. These products offer two benefits in coastal and storm prone areas:

- The open slatted or other open design allows water to easily flow through them, potentially reducing the pressure, lift, and potential failure of the structures during periods of extreme storm surges and waves associated with coastal storms and hurricanes, and
- The open structure allows for significant light penetration below the deck, preserving marsh and other coastal plants' growth, leading to greater stabilization of the shoreline during storms.

Flow-through plastic decking (photo courtesy of Ennett Marine Construction)

Steel Docking Structures

Steel dock pilings offer high load capacities and durable corrosion resistance. The corrosion resistance of steel dock pilings is an essential consideration in the use of steel piles/structures. When steel piles are used in seawater, they react chemically to form anodes and cathodes, resulting in the flow of electricity, which causes the corrosion of anodic areas of piles. Chemically active surface areas of underwater steel piles act as anodes and less chemically active surfaces act as cathodes. The degree of corrosion resistance is related to the overall steel wall thickness and the corrosion resistant coatings, which have been applied. By using steel dock pilings with a thick outer diameter wall and/or special coatings, you can be sure that steel dock pilings will offer durable support for years to come. Steel dock pilings offer great strength and can even be filled with concrete or other materials to increase the load capacity.

<u>Sources:</u>
[Dock Pilings | New & Used Structural Steel Pipe Pilings]
[Corrosion Protection Methods for Underwater Piles]

Concrete Docking/Pilings Construction

While no dock is maintenance free, many regard a concrete docking system as the strongest and lowest maintenance option among docking options. Individual concrete modules are often larger than those found on a waler connected dock. Many can be reinforced with steel or another material to improve its tensile strength. Other advantages of concrete include its resistance to decay, corrosion, and fire. When using concrete for pilings, it is important to make sure that any concrete pilings for sale have been allowed to fully cure for at least thirty days so that there is no leaching of chemicals from the piles into the water.

Concrete floating dock marinas are manufactured and assembled in modules. (Appendix V) Modular construction allows bending at the float connections to provide appropriate flexibility for a structure on the water subject to wave action. In addition, the manufacturing and installation of concrete floating docks is more manageable when floats are cast and transported in modules. A further benefit is that modules can be removed and replaced; in the unlikely event that this is necessary, individual modules can be disassembled and modified as needed.

It is reported that the port authorities in Georgia installed specially configured concrete panels at their public docks in order to foster a healthy community of marine organisms due to the lack of wooden components requiring chemical preservative treatment.

Concrete/timber docking with concrete encapsulated floats

Within industry options featuring innovative, resilient options, the Unifloat concrete floating dock system from Bellingham Marine utilizes a waler system to connect individual float modules together.

Sources:
[The Ultimate Guide to Dock Piling Materials - Decks & Docks Lumber Co.]
[Port docks playing host to marine life - News]

Walers

Walers are structural beams mounted flush to the deck of the Unifloat concrete floating dock from Bellingham Marine. They attach to the float by long rods threaded at the ends. Called "through rods," they span the width of the float and are held in place with washers and nuts. Walers can be made of a variety of structural materials depending on the engineering requirements of the marina. These include structural timbers, composite, steel, and other materials. The vast majority of Unifloat systems employ structural timbers although Bellingham Marine has built marinas with walers of other materials as appropriate to the project. The vital structural purpose of the walers is to connect the float modules in a manner that reduces damage and loss of structures during storms. In a Unifloat marina, no other connection method, such as hinges between floats, is necessary, or in fact desirable, as the waler system has proven itself under the harshest tests nature can deliver. Walers perform two other functions. First, they protect the concrete floating dock from impact by a docking boat. Second, they present a gentle surface to the hull of a boat using the moorage, especially when the walers are built of structural timbers and when combined with protective rub rails.

For comparison, NordiDock advertises a 50-foot section of NordiDock concrete dock 34,000lb in weight, and refers to photographic evidence in the wake of Hurricane Sandy, that concrete floating docks withstood the forces of the storm better than docks constructed from any other materials. Further, they state that new dock construction in the states of New Jersey, New York, Connecticut, and Massachusetts will need to take serious future storms into consideration*.
**Note: This fact has not been substantiated during this study.*

The patent for the original waler system (Usab's patent) describes the function of the walers as, "…to support the bolts or other fastening means, and to distribute the forces received therefrom throughout the structure." This is the stated benefit of the waler system: distributed loads.

To understand the importance of distributed loads, consider alternate float connection systems in use today. Typical systems employ heavy-duty hinged steel bolts or large stranded cables at the corners of the floats. There are two problems with these systems. First, the connection hardware can, and does, fail. It may weaken under repeated bending and attack from galvanic corrosion. Second, forces on the floats are not distributed, but are concentrated at the corners of the floats. Thus, enormous shear loads are focused where they can result in irreparable damage to the concrete body of the float.

Stress analysis of structures is a complicated science, but by reducing the analysis to its fundamentals we can compare the systems with clarity and understanding. The easy-to-follow example below demonstrates the advantage of distributed-load systems over point-loaded systems.

A practical example: Follow the Stresses

A large power boat is moored to a concrete floating dock in a storm. The boat's considerable "sail area," the currents in the marina, and the pulse of waves against the boat are all transmitted through its mooring lines into the floating concrete dock. These forces translate through the dock and are felt as shear forces at the module connections. In our example, the resultant shear force at the connection points between the floats is 10,000 pounds. In an actual marina during an actual storm, it could be more or less, but 10,000 lbs. gives us a round number to work with.

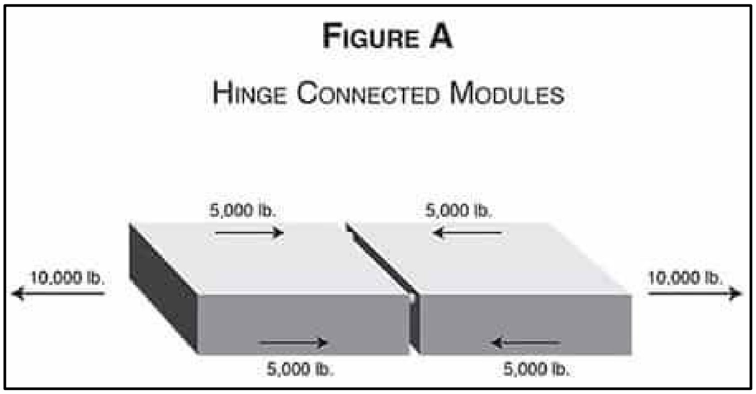


Figure A. Hinged Connection System

On the hinged or cable-connected system, the load is applied to the corners of the floats as a shear load of 5,000 lbs. applied equally to each of the four corners. The load is transferred through the hinge or cable to the concrete at the corners. The concrete structure must contend with a shear load of 5,000 lbs. at the vulnerable corners of the floats.

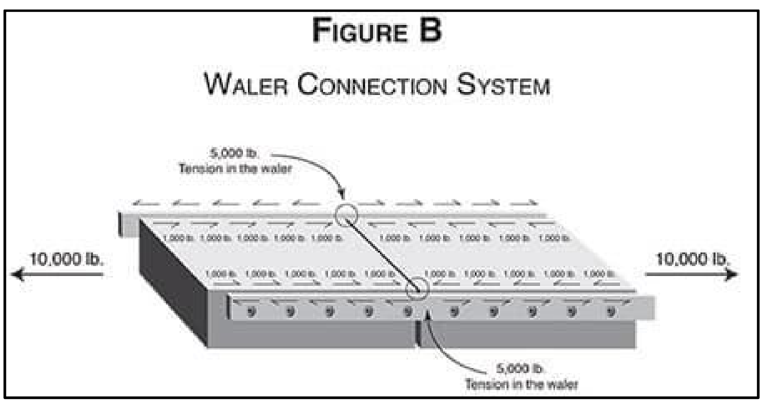


Figure B. Waler Connection System

By contrast, a Unifloat system with a typical complement of 10 through rods receives the same 10,000lb load. Unlike the hinged system, where loads are concentrated at the corners, the shear load is translated up and down the waler and distributed among all the through-rod entry/exit points. Each of the 20 entry/exit points in the concrete structure must contend with 1,000 lbs. of shear force. The waler system, with its distributed-load design, has reduced the load on the concrete structure by 80%.

Sources:
[Bellingham Marine]
[5 Reasons to choose a concrete floating dock]
[Understanding Walers: What is a Waler?]

A 2019 Industry Review of Trends in Marine Construction Materials

Regulation has pushed the need for fully encapsulated foam floats, particularly in Dade, Broward, and Palm Beach counties in Florida. New codes there prohibit exposed or coated foam; it must be in a polyethylene or concrete shell. "Foam beads on the water due to exposed foam will soon be a big cost for cleanup for marina owners," Ryder said.

He said that area is also experiencing an active storm cycle and more severe hurricanes in the last few years. Structural walers have gotten bigger, and float modules with more reinforcement and connection frames using heavier sections of steel are more common. Other dock builders are using newer and more innovative waler designs. Golden Marine Systems has changed from a wooden waler to an aluminum waler. "It's higher strength. It's sort of a hybrid system," said Mike Shanley of Golden Marine Systems, which manufactures aluminum and concrete docks.

Instead of waler-style concrete docks, SF Marinas is installing a lot of docks with single pass concrete structures. A single pass concrete structure is one solid structure that does not require bolted walers. The trends in dock material choices as builders see them often depend on the builder's capabilities. However, certain changes in material composition have influenced the market as well. Less effective lumber treatments have made timber less desirable for many applications. Those producing concrete systems are seeing very strong markets. Marintek, which manufactures concrete and aluminum systems, still does a considerable amount of work in aluminum. "Aluminum is less expensive than concrete, so that's a big attraction," Berry said. "It's much stronger and better looking and longer lasting than timber. It's the go between."

American Muscle Docks builds galvanized stainless steel, aluminum, and wooden docks. Some customers still choose wooden docks because it is the cheapest, said Luke Diserio of American Muscle Docks. "Aluminum has also come a long way. A lot of people are building heavier aluminum docks," Diserio said. Processing technology has made aluminum better and more suitable for saltwater, and American Muscle Docks has begun using aluminum in ocean environments where it wasn't before. MariCorps also produces a galvanized steel dock system, or a hybrid steel/concrete design, which allows a marina to put in a swimming pool in the docks. The trend for stainless steel docks, Ashby said, is from painted steel to galvanized.

Design trends are also influenced by many outside factors, such as weather, material availability, and technological advances.

Bellingham also uses fiberglass rods for its thru-rod system, which eliminates the use of 80 percent of the steel in the system and some maintenance costs.

Gael with Structurmarine explained how design choices can be influenced by the project cost versus understanding the total cost of ownership. Many owners are only looking at the initial price tag, not the total cost of ownership, which considers maintenance 30 years down the road.

<u>Sources:</u>
[Bigger and Stronger: Dock Builders Talk Trends in Design and Infrastructure]

<u>Floating Dock Materials</u>

Encapsulated floating dock floats

Expanded polystyrene foam is a common material to use as dock flotation because it is light and inexpensive. However, the environmental and social costs of this non-biodegradable material far outweigh its trivial benefits. When exposed to the elements, unencapsulated polystyrene will become brittle and crack, potentially crumbling into thousands of foam beads/fragments that destroy the aesthetic and health of shorelines and threaten aquatic ecosystems. (Appendix W) When consumed by marine creatures, these foam beads/fragments can block airways or digestive tracts, and even stop animals from absorbing nutrients (Rittmaster, 2018).

Furthermore, polystyrene contains chemicals such as benzene, styrene, and ethylene. In small quantities, these chemicals can leach into water (Georgian Bay Forever, 2019), and in larger quantities, can pose significant health risks. Also, other toxins can easily bind with polystyrene's molecular structure. As a result, dock foam often poisons marine animals, as polystyrene concentrates and magnifies these toxins. This toxicity moves up the food chain, affecting entire ecosystems and eventually humans. (Marcy & Johnson, 2009).

It is important to note that downstream disposal of polystyrene foam docks is not a viable solution. Materials Recovery Facilities do not make money from collecting dock foam, and therefore do not accept this type of pollution. Thus, encapsulating foam docks is an attractive alternative because doing so prevents foam dock pollution and eliminates the need for downstream cleanups. Economically, paying for encapsulated dock foam is initially more expensive than purchasing unencapsulated foam, but the investment quickly pays off. Encapsulated docks last significantly longer, require far less maintenance, and eliminate the potential risks unencapsulated docks pose. They prevent toxin magnification, save the lives of marine animals, and ensure a healthy and aesthetic ecosystem.

A variety of foam materials are used for floating docks. Most foams can be damaged by biofouling when submerged and by sunlight exposure, particularly after becoming post-storm debris. Air filled floats are not recommended or in some cases are prohibited as unreliable floatation. Encapsulating the foam reduces the likelihood of the decaying foam particles being released into the environment. A common construction practice is to partially or completely wrap the foam in a layer of filter fabric. How the filter fabric is installed likely affects the effectiveness of continued containment of the foam, if it becomes storm debris. More reliable containment is provided by partial or total encapsulation by hard, UV-resistant plastics. Biofouling is completely controlled. Foam deterioration and containment appears to be effective if fully encapsulated. Partial encapsulation (open top) can still release the foam when damaged by storms.

Hardware/Connectors - Connectors/Buffers

For energy prone areas, it is recommended to attach docking elements and supports with galvanized/hot dipped through bolts rather than lag bolts. The use of galvanized or stainless-steel hardware, including screws, bolts, nails, plates, cross-bracing, and anchors is recommended for marine environments, but ceramic coated is an option as well. Helix anchors should be tied down before a storm. For floating dock structures, the use of rubber buffer pads and/or rollers are recommended to reduce the damage to the support pilings over time, adding years to the life of the structures.


Pile supports/bumpers installed by Bellingham Marine

Marine Wood Grading/Moisture Content/Preservative Treatment

Preservative Treatment

Pressurized treatment of lumber, timbers, and piling is the most effective method of protecting wood designated for the marine environment. The pressure process allows deeper penetration of chemical components in the wood and closer control of retention levels. The choice of preservative depends on how and where wood will be used. There are three broad types of wood preservatives used in modern pressure-treating processes. Preservatives are forced into the wood's cells within a closed cylinder while under pressure. A "fixation" process bonds the preservative to the wood fiber, which results in a virtually insoluble bond that protects lumber products in service.

Several marine borers attack exposed heartwood in marine lumber typically used for docks and bulkheads. Once entering the heartwood as larvae, the borers can damage even fully preservative-treated lumber, weakening its structural capacity and shortening the useful life of the entire structure. Marine-use preservative treatment requirements are included in the North Carolina Building Codes. The preservative treatment requirement is well known through a national standard referenced in most codes. The heartwood lumber requirements (prior to treatment) are addressed in a footnote of the national standard which make them hard to find in writing and widely ignored in local practice. Enforcing the existing heartwood-exposure requirements would extend the structural lifetime of the material when installed in saltwater. On last check, with a few exceptions in North Carolina, most suppliers of marine-grade, preservative-treated lumber do not offer materials meeting the national heartwood standard. Meeting the standard requires more effort in sorting heartwood-free lumber prior to preservative treatment and raises the cost of production. Square pilings for dock and bulkhead construction almost always have exposed heartwood when sawn. They frequently do not meet the heartwood standard but can be individually encapsulated or avoided entirely in salt water exposures. Most round pilings can meet the requirements because the heartwood is fully surrounded by treatable sapwood. In general, heartwood is too dense to readily accept preservatives using typical pressure-treatment procedures and standards.

Grade and Quality Marks

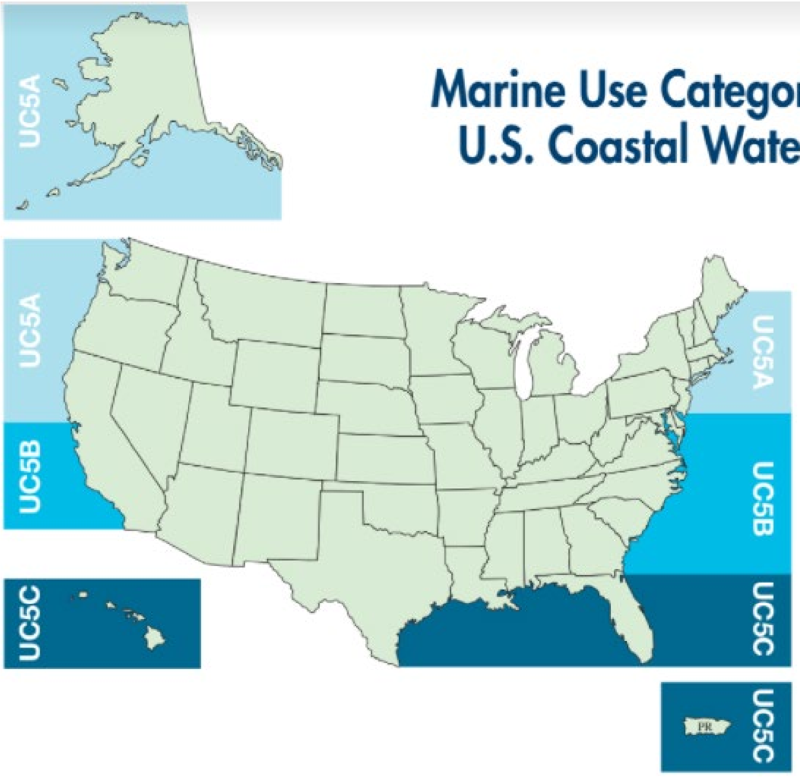
To protect the buyer and consumer, the industry has developed a system requiring ink-stamped grade marking of each piece of lumber under adequate quality control measures. This assures delivery of the grade specified for its intended use. Lumber grading and marking is monitored and inspected by agencies accredited by the American Lumber Standard Committee (ALSC). It is recommended that the buyer specify pressure-treated wood bearing ink-stamped quality marks and/or plastic end tags denoting the material was produced under supervision of an independent inspection agency accredited by the ALSC. Use of such marks by the producer pro- vides assurance that the preservative retention and penetration complies with American Wood Protection Association (AWPA) and/or Building Code specifications and that the preservative used is EPA approved and treated in compliance with federal law. Use of treated wood that does not bear an approved agency quality mark will not meet requirements of the International Code Council (ICC).

Moisture Content Requirements

Most of the in-service problems with heavy timbers and planking have been the result of inadequate drying practices prior to preservative treatment. Dimension lumber and decking used in marine applications should be kiln-dried or air-dried to 19% or less. Timbers (5x5 and larger), if specified to be kiln-dried, must be 20% or less and, if specified to be air-dried, must be 23% or less. These moisture content guidelines for untreated Southern Pine originate from the Southern Pine Inspection Bureau (SPIB).

A good resource for general guidance on quality, wood treatments, moisture content, etc. for various U.S. geographic use categories is the *Aquatic and Wetlands Structures, Design and Construction Guide*, which is compiled from various marine construction industry sources and standards (Appendix X). This resource should be a starting point for consideration and supplemented with local information regarding marine conditions, energy levels, and marine organisms.

Aquatic and Wetlands Structures, Design and Construction Guide, www.southernpine.com



Marine (salt water) Use Categories for U.S. Coastal Waters — Coastal zones and corresponding Use Categories for salt water marine exposure are shown here. Use Category requirements for particular zones are based on the presence of specific marine organisms. The degree of hazard posed by these organisms in a specific coastal zone will determine the appropriate preservative loading. This map is only a general guide and should be supplemented with local information where there is doubt concerning the nature of marine borer activity and selection of an appropriate preservative.

Recommendations for Construction Techniques

The resilience of marine construction results from both the material selected and the methods of construction. The following include recommendations for consideration in more resilient marine construction, with the goal of reducing marine debris from damaged/lost structures:

Driving vs. Vibrating in Pilings

A driven pile is a relatively long, slender column which offers support or resistance to forces and is made of material with a predetermined shape and size that can be physically inspected prior to and during installation. It is installed by impact hammering, vibrating, or pushing into the earth. Driven piles maintain their shape during installation, they do not bulge in soft soil conditions and are typically not susceptible to damage from the installation of subsequent piles. Many hollow-section piles can be visually inspected after installation to assure integrity. Most solid-section piles are uniform in section and can be dynamically inspected to verify integrity.

When conditions warrant, the pile driving process can be easily modeled prior to installation to determine adequate and economic equipment selection. Static or dynamic testing can confirm load carrying capacities of installed piles. Dynamic testing can easily confirm proper hammer performance and its effect on the pile. Many modern hammers have impact velocity measurement devices permanently installed, providing a very high level of quality control.

Piles are ideally suited for marine and other near shore applications. There are no special casings required and no delays related to the curing of concrete. Piles driven through water can be used immediately. Pile driving is relatively easy in many soils. Since the soil at the toe is in a compacted condition for displacement piles, end bearing can often carry a substantial load. There are no "soft bottom" soil conditions, so large settlements for end bearing piles are eliminated.

Driven piles displace and compact the soil. Other deep foundation options can require the removal of soil and considerable subsidence, which can undermine the support of adjacent structures and cause excessive deformations, both of which can result in structural problems.

“Pile jetting” is a technique that is frequently used in conjunction with, or separate from, pile driving equipment for pile placement. Pile jetting utilizes a carefully directed and pressurized flow of water to assist in pile placement. The application of a concentrated jet of water at the pile tip disturbs a ring of subgrade soils directly beneath it. The jetting technique liquefies the soils at the pile tip during pile placement, reducing the friction and interlocking between adjacent subgrade soil particles around the water jet. This greatly decreases the bearing capacity of the soils below the pile tip, causing the pile to descend toward its final tip elevation with much less soil resistance, largely under its own weight. In less frequent applications, compressed air jets are used instead of pressurized water jets with the same end result.

Placing long piles in dense soils may be a time-consuming endeavor with a traditional pile hammer and driving rig. Pile jetting offers significant time and cost savings over traditional pile driving, and where appropriate, jetting techniques could eliminate the need for a driving rig altogether. Pile jetting equipment usually consists of a crane with leads to place the piles, a jet pipe (or pipes) with connecting hoses, and a jet pump. Pile jetting can be used for most types of steel, wood, and concrete piles. Precast concrete piles may be fabricated with a jet-pipe already cast-in-place, if jetting is anticipated. Piles that are placed in uniform granular soils may be installed with a jet pipe placed through or near the center pile dimension. Other piles may have two water jet pipes fitted on either side to provide evenly distributed water jet coverage during placement. Design of the jet pipe outlet(s) and pump selection reflect the anticipated soil conditions and pile types.

The applied water pressure and flow rate through the jet pipe will directly influence the volume of subgrade soils affected. Too much flow and pressure may result in poor controllability and alignment of the pile being worked, or misalign and compromise adjacent piles. Too little water flow or pressure could make the jetting technique ineffective. The type of soils supporting the piles needs to be evaluated and understood. The jetting technique creates a localized soil disturbance wherever it is used. Laboratory tests have shown pile jetting can significantly reduce the lateral strength of placed piles since the technique can erode fine soil particles from the surrounding soil matrix. Pile jetting is most effective in granular soils without significant cohesion (interlocking). Water run-off from the pump discharge hose, including erosion and turbidity control issues, is another factor that needs to be planned in advance.

The most significant challenge may be that any negative impacts of pile jetting will be latent. In a typical pile driving project, a pile hammer of known weight and drop height is used. Noting the blow counts of the pile hammer over a specified pile length allows for a straightforward assessment of pile strength. Conversely, if a pile is jetted to its final tip elevation, its final strength capacity can be empirically estimated at best, but not specifically determined.

For these reasons, the more the effects of jetting become speculative, the less recommended the technique becomes. Project costs, a completed project's end use, and factors of safety will influence a decision to allow pile jetting, and to what extent. A less risky use of jetting would be through hard sandy soils above a firm bedrock layer that provides known bearing ability at the final pile tip elevation.

Sources:
Benefits of Driven Piles
Buildipedia.com: Home Improvement & AEC Professionals
Driven Piles vs. Jetted Piles - A Comparison

Piling Heights/Depths

No standard BMP exists for piling heights and/or depths, but it is a significant consideration for the long-term stability of any pile-supported marine structure. Regardless of piling materials (i.e. wood, concrete, steel), ensuring adequate piling depths below grade is a critical component of stability, especially in areas with less cohesive soils and/or areas of high wave energy, strong currents, and frequent tidal or storm surges. Equally important is the elevation of the pilings, which allow for a floating dock structure to rise and fall during normal tide ranges, as well as during extremely higher water levels associated with hurricanes and other coastal storms. One general rule of thumb for "average" coastal dock construction within North Carolina is to ensure that ~⅓ of a piling is driven below grade (i.e. 10' below grade for a 30' piling), and ~10'-12' of the piling is elevated above normal mean high water, to allow for extremely high storm surges. One innovative approach involves standard height pilings with a "telescoping "T" Bar" option to create extended pilings during periods of higher tides and storm surge conditions.


“Telescoping” encapsulated concrete pilings

Floating vs. Fixed docks

Though there are many varieties of docks, each of them can be placed in one of two categories: removable docks and permanent docks. Permanent docks are self-explanatory — they are installed securely into the ground and the structure is intended to remain there permanently. Removable docks are typically intended to be semi-permanent and can be expanded, reconfigured, or removed if necessary.

Fixed Docks

A fixed boat dock is a boat dock type that is fixed or stationary. Many dock owners prefer fixed boat docks due to the stability they offer. This is the primary difference between a floating boat dock and a fixed boat dock. A fixed dock may be the only way to safely reach a floating dock where water depth is adequate for boat mooring. Since floating docks rest on water; they are affected to a large extent by movement in the water. Waves can impact floating docks and cause them to have irregular movements on the water, just as a boat or other watercraft would. Therefore, if stability is the main criteria, fixed docks may be the better choice for areas that have strong tides or currents and a lot of wave action, such as high traffic areas. In addition, fixed docks can often provide support for more weight than a floating dock.
Sources:
Advantages of Owning a fixed Boat Dock

Floating Dock Construction

Floating docks are platforms, most often made of decking placed over airtight buoyant “float” structures that float on the water’s surface and support the dock. They are also available as pre-built sections that can be attached in a variety of configurations and shapes. Floating dock structures are versatile and rise or fall with the water level, helping them adapt to nearly any condition, including extreme fluctuations in water levels (surges) during hurricanes and other coastal storms. In addition, during severe weather or seasons in which the structure is not in use, floating docks can often be removed, stored, and put back in place when needed. This is extremely useful in hurricane or storm-prone areas. Additionally, boats secured to fixed docks often require constant monitoring and adjustment of the securing lines (especially during more significant tide changes and/or water fluctuations during storms. Finally, because floating docks rise and fall with water levels, any critical electrical systems attached to the dock surface will not be submerged.

There are numerous types of floating dock systems available in today's market - concrete, aluminum, steel, and wood are among the most popular. Not all "like" dock systems are created equal. There is great variability in quality, performance, engineering, and design within each type. The approach used in the design, how the system is engineered, and the quality of the materials are the greatest determinants of a dock system's overall performance. It is also important to note, not all types of systems are appropriate for all environments. Sites exposed to extreme weather and higher wave conditions may benefit from a heavier weight dock system.

Concrete docking (with concrete floats) and Encapsulated Floating Dock

- Install breakaway decking panels and increase deck spacing
    - Minimize what breaks and design *where* you want it to break. Often, designing breakaway panels or removing panels before a storm surge arrives can prevent more significant damage to and/or total loss of docks/piers. In addition, constructing docks with increased deck spacing and/or flow through materials can minimize damaging "lift" of the structures and damages during rising water and wave energy conditions.
- Build to withstand predicted wind loads based on past storm forces
    - Build docks to withstand at a minimum the erosion, scour, and loads accompanying a minimum of the 50-year storm event (or whatever storm event is represented at this site during the past decade. The evaluation should also include the historic tidal, current, surge and wave energies at this site.

- Increase deck height
    - In many coastal areas, adjusting deck level (for fixed docks/piers) for certain storm frequency. Building docks higher than expected breaking waves and storm surges/tides can reduce damage and losses of fixed docks.
- Reinforce bracing and/or anchoring for docks/piers
    - In higher energy and/or storm prone coastal areas, provide additional bracing of the construction elements. This reinforcement may include modifications to girders/connections to pilings.
    - In addition to reinforcing construction elements, adding support anchoring is recommended to reduce damage and losses of docking structures.
    - Incorporate stainless tie downs at support points and anchors to reduce lift of structure during storms. These often include stainless steel cable that goes around the entire dock structure at each support point (pylon and cross member section that makes contact with the seafloor) that is then affixed to an anchor under the mud. This adds additional strength and reduces the likelihood of the structure becoming dislodged or "washed out" during a storm event.


Reinforced bracing for floating dock joints completed by Bellingham Marine (left); Steel cable/helix anchor system on residential dock (right).

Protection Connectors From Corrosion

Connectors subject to exterior or marine use should always be either stainless steel or hot dip galvanized after fabrication. Depending on bolts alone to transfer gravity loads to the piles is not a prudent practice. Over time, even hot dip galvanized or stainless-steel bolts will corrode and require replacement. A better detail when the pile width is 2-inches or more than the girder would be to notch the girder into the side of the pile to provide direct bearing on the pile. The girder may then be bolted to the vertical protrusion of the notch to provide uplift resistance, lateral load resistance and torsional stability. Figure 4603.6 in the Residential Code is another possible means of connecting the girder to the pile and providing direct bearing for the girder when the girder is too wide to notch into the pile. However, the disadvantage to this connection is the connection has little resistance to lateral loads perpendicular to the connection plates. In addition, the girder and the pile must be the same width or the connection shimmed in order to install connection plates on both sides of the girder. Connections for girders bearing on top of the pile with a plate on only one side of the girder do not provide adequate torsional restraint to prevent the girder from rolling.

NC Department of Insurance, Office of the State Fire Marshal - Engineering Division; Engineered Wood Products and Connectors in Marine and Flood Zone Environments; Code: 2018 Residential Code Section: R322.1.8 and R4605.5 (Appendix Y)

Extended Runs for Gangways

For added resilience in high tide/surge areas, it is recommended to expand a traditional gangway (i.e. 24') to an extended length (i.e. 28') to maintain connection during super low and high tides and/or storm conditions (From: Bellingham Marine, personal communication).

<u>Additional Non-Construction Recommendations</u>

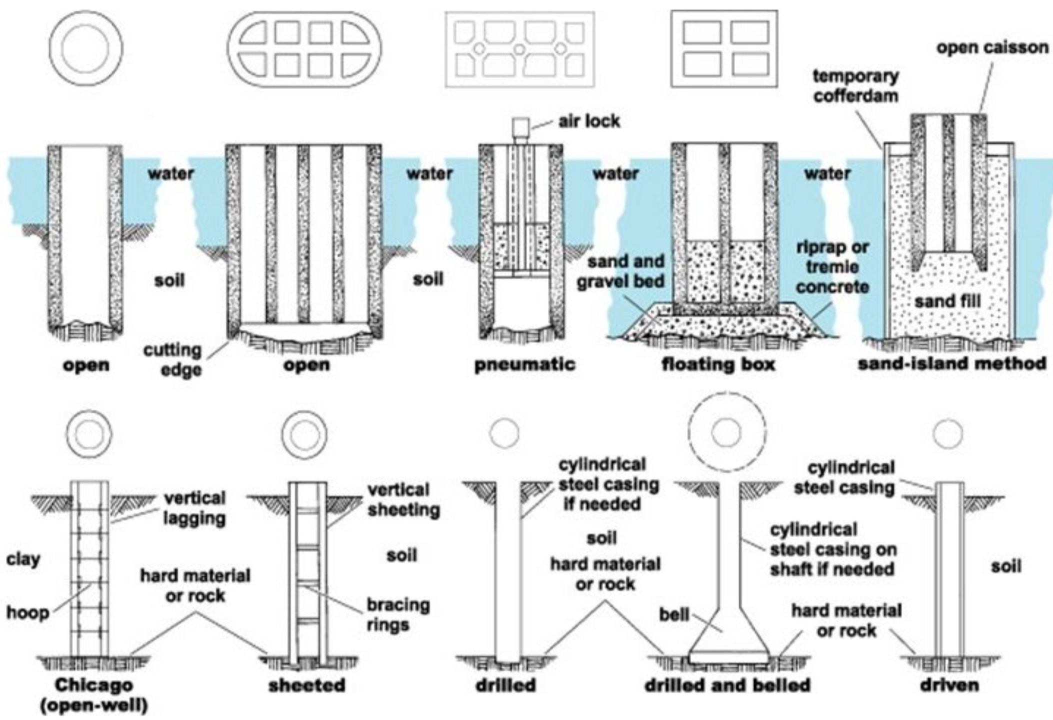
Creating Insurance Industry Incentives

One non-regulatory but effective strategy to increase the construction standards for marine construction (thereby reducing damage and/or losses of structures during storms) is through the insurance industry. One example of this program is the *Preferred Builder Credit Program,* offered through C.T. Lowndes & Co. in South Carolina. The company offers various levels of coverage/pricing for docks, piers, etc. based on the level of construction standards employed in the building. As incentives for better construction, the policy holder can qualify for better rates and policy coverage.

Promote, Fund, or Conduct Research on the Use of Modified Caissons to Strengthen Dock Pilings.

Caissons are rectangular or circular structures used in underwater construction work and can be sunk and filled with concrete to serve as a foundation in bridge construction. They often serve as the foundations for the large pilings that support the weight of bridges. If smaller, modified versions of these caissons could be made affordable to homeowners and were proven to improve the durability of residential docks and piers in storm events, they may have the potential to become widespread all along the coast.

A graphic depicting different types of caissons is included below:



Types of Caissons

Marine Contractors/Engineer Interview Results

To increase the body of local knowledge on the most resilient construction measures throughout coastal North Carolina, a preliminary questionnaire and list of marine contractors in eastern North Carolina was composed by the North Carolina Coastal Federation. Given time and funding opportunities, it would be useful to talk to contractors in different regions to determine their preferred methods of building docks and piers, if they have run into any unexpected problems, and to get their opinion on the topic of building marine structures to avoid damage and losses within our North Carolina waters. This will allow for more detailed information to be learned from marine contractors regarding their typical construction activities, standards, and best practices.

NCORR Resiliency Guide Recommendations

Limit new capital projects in high-risk areas. Where risky locations cannot be avoided, minimize risks through actions like elevating structures above the highest known or projected flood levels, designing for excess stormwater capacity, or building to fortified standards for wind. Consider climate change over the entire predicted lifespan of an asset, like a bridge or a wastewater treatment facility. Design and build – or upgrade – the asset to withstand future conditions.

Florida Department of Environmental Protection Fishing Pier Design Guidance

With the selection of a design storm event, it is important to determine the storm tide elevation across which the storm waves will propagate. Equally important as determining a design storm tide level is considering the beach and nearshore profile change caused by the erosion of the design storm event as well as the additional localized scour expected at the individual foundation piles. A geotechnical investigation with core borings is necessary for any pier construction in order to determine adequate pile penetration and breakout resistance resulting from the soil characteristics.

Pier construction techniques will likewise be important particularly when the dead loads of a construction crane need to be considered in the design of the foundation and structural members. Wind loads are specifically important for any canopies or concession buildings located on a pier. Pier decks and rails have additional design considerations.
With an acceptance of the risk, the initial question of any pier designer then settles on the storm magnitude for the selected site for pier construction. For what magnitude storm event should a pier be designed? In reality, this question is not addressed by normal building codes.

The 20-year return interval storm event is therefore the minimum design storm for which ocean and gulf fishing piers are required to be constructed in Florida. Public structures, including fishing piers, are typically designed for a 50-year life span. The probability of occurrence of a storm tide exceeding a certain elevation during a specified time period may be determined mathematically by a binomial theorem. Walton (1976) plots encounter probability versus encounter period for use in coastal construction economics of repair or replacement. The probability of occurrence for a minimum design event, a 20-year storm, during a 10-year period is about 42 percent. For a design life of 50 years, the encounter probability would be 94 percent. When considering the risk of an extreme event, the probability of having a 100-year storm during a 50-year design life would be about 40 percent.

Selection of a design storm event and associated storm tide level, leads to the determination of wave characteristics and erosion conditions for the site of a proposed fishing pier.

An important factor in designing a fishing pier's pile penetration is to determine the maximum expected localized scour around individual piles. The most important factors resulting in scour around fishing pier piles are the wave orbital velocity, the bottom current, and the diameter of the pile. Other important factors are the grain size of the bottom sediments and the shape of the pile (e.g. round, square, or octagonal). Niedoroda and Dalton (1986) provide a detailed description of the physical processes of scour around a vertical pile. Localized scour at vertical piles for fishing piers may be calculated by several methods; however, for most cases of combined waves and currents, the "rule of thumb" recommended by the Coastal Engineering Manual (USACE, 2008) is the maximum depth of scour at a vertical pile is equivalent to twice the diameter of the pile. This rule would be applicable to any shape pile commonly used in pier construction. For example, for either a two-foot square pile or for a two-foot diameter circular pile, the maximum localized scour would be expected to be at least four feet below the predicted storm eroded profile or the minimum historical profile elevation.

The principal causes of damage to ocean and gulf fishing piers are the effects of storm waves. A successful pier design requires both an understanding of the wave climate in the region and a projection of an extreme storm wave event that may reasonably be expected to occur at the pier site. With the projection of an extreme stormwave event that may reasonably be expected to occur at the pier site, wave forces may be calculated. The Wave forces act on a pier's structural members on both a horizontal and vertical plane; therefore, it is necessary to conduct separate computations for both the lateral waveforce as well as the vertical uplift forces.

Recently, there have been some breakaway deck sections dislodged from new fishing piers during tropical storm conditions that were substantially below the design storm tide elevation and wave conditions. These dislodged deck sections were located above and immediately seaward of the pile caps of those piers. It is believed that the best strategy to account for this upward wave reflection effect is to include breakaway deck sections in lieu of raising the pier deck any higher than the normal design would require. In doing so, the problem only becomes a periodic nuisance to reset the dislodged deck sections while maintaining the integrity of the structure.

Pile driving is employed in pile-supported structures to increase the density of the sediment. Piles are driven by a succession of blows either by a drop hammer or by a diesel, steam, or compressed-air-powered hammer. Diesel powered hammers and diesel vibratory hammers are most common. With vibratory hammers, a variable-speed oscillator is attached to the top of the pile, consisting of two counter-rotating eccentric weights that are in phase twice per cycle in the vertical direction. This introduces a pulsation or vibration through the pile that can be made to coincide with the resonance frequency of the pile, which creates a push-pull effect at the pile tip to disturb the soil structure, and thus improves the rate of pile driving.

Like other major structures, ocean and gulf fishing piers should be designed and constructed to safely support any anticipated normal loads without exceeding the appropriate specified allowable stresses for the materials used in the construction. The structural design of fishing piers requires the consideration of all appropriate design loads acting in combination, to include normal dead loads, live loads, construction loads, wind loads, hydrostatic loads, hydrodynamic loads, and wave loads. The depth-limited breaking wave loads for the selected design storm event are the greatest forces to be considered in the pier's design. However, the complete structural design also includes the other various loads that may reasonably be expected.

FEMA 55 Coastal Construction Manual (2011) Recommendations

In response to increased hazards and lessons learned from past storms, regulatory requirements for construction in coastal areas have increased over the past decade. Design of a successful coastal building must consider the effects of coastal hazards and coastal processes over a period of decades. Design loads and conditions are based on some probability of exceedance, and it is always possible that design loads and conditions can be exceeded. Designers can anticipate this and modify their initial design to better accommodate higher forces and more extreme conditions. The benefits of doing so often exceed the costs of building higher and stronger.

Although many aspects of coastal design and construction have improved over the years, the harsh coastal environment continues to highlight deficiencies in the design and construction process. The design and construction community should incorporate the lessons learned from past events in order to avoid repeating past mistakes, and to break the disaster-rebuild-disaster cycle.

Communicating risk to homeowners in a variety of ways, both technical and non-technical, is important so they understand the benefits and drawbacks of decisions they make. Designers should communicate how design decisions and material selections can reduce risk, and the mitigation of residual risk through insurance.

It is important for homeowners to understand how the choices they make in designing their home could potentially reduce its risk of being damaged or destroyed by natural hazards. Designers need to be familiar with the potential risks for the property and be prepared to suggest design measures that not only meet the needs and tastes of homeowners, but that also provide protection from hazard impacts. In addition, design choices that have implications for building performance during a hazard event and on insurance premiums should be discussed clearly with the homeowner.

Although the effects of natural hazards can be reduced through thoughtful design and construction, homeowners should understand that there will always be residual risk from coastal hazards as long as they choose to build in a coastal environment. Proper design elements can mitigate some of those risks, but there is no way to completely eliminate residual risk in coastal areas. As described in this chapter, mitigating natural hazard risk in a coastal environment entails implementing a series of risk reduction methods, such as physical risk reduction and risk management through insurance. While some level of residual risk will remain, owners can use these tools to protect themselves and their investments.

FEMA P-499 Home Builder's Guide to Coastal Construction (Technical Fact Sheet Series, December 2010)

FEMA has produced a series of 37 fact sheets that provide technical guidance and recommendations concerning the construction of coastal residential buildings (Appendix Z). The fact sheets present information aimed at improving the performance of buildings

subject to flood and wind forces in coastal environments and 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.

Although not directly related to the scope of this current study, marine debris that has been found following coastal storms and hurricanes includes a significant amount of residential construction materials, resulting from existing structures and sites under construction. These fact sheets provide useful guidance in reducing the loss and/or damages to land-based structures during these storms.

Literature and Additional Resources

- 0322.1.8 - Engineered Wood Products and and Connectors in Marine and Flood Zone Environments
- Guide to Docking Choices: Which Types of Docks are the Best?
- North Carolina CAMA Handbook for Coastal Development
- LDSI Waterway Debris Mapping Tool
- FEMA499

VII. Outreach and Education Recommendations and Materials

In order to disseminate the recommendations and best practices described above, it is necessary to plan and implement a robust outreach and marketing campaign. This campaign, targeted towards coastal property owners, as well as marine contractors, will communicate the above findings in an effort to promote more resilient docks and piers along the NC coast and ultimately reduce the presence of marine debris in our waterways.

Without a funded plan to engage the public and ignite action by coastal property owners, however; the data and findings from this project will have little impact on this pervasive issue. In order to gain traction on regulatory avenues, we must have an informed and engaged public, which is acutely aware of the issue, thus elevating it to local, state and eventually, federal levels. Below are preliminary recommendations that are achievable with current resources, but the need still exists to create and implement a multi-year multimedia campaign which can be replicated in other states.

Extension Materials/Distribution

- Develop and launch a web page (short url: nccoast.org/docks) to highlight the problem of dock/pier derived marine debris and how the public can help.
- Utilize this web page to house all extension materials, as well as photos, infographics and user testimonials. Potential materials include:

    - BMP's and technical recommendations (as described above, edited for contractor and public audiences, respectively)
    - Trifold brochure (professionally printed)
        - Audience - coastal property owners, marine-related businesses
        - Goal - educate coastal property owners on the importance of resilient dock/pier structures
            - Include introduction to problem
            - Questions to ask their contractor
            - Recommendations for more resilient structures
            - Environmental factors they should consider
        - Include QR code to webpage and photos of what a resilient structure may look like
    - Multimedia materials - photos, videos, testimonials
        - Video of a resilient dock being constructed (time lapse) then what it looks likes after a flooding event compared to non-resilient docks
        - Testimonials from property owners who have chosen to build a better structure
        - Videos of sound construction techniques, highlight construction BMPs
- Once all materials are finalized, launch webpage and send out press release
    - Media list/press contacts in Google Drive
    - Reach out to local media contacts for more in-depth stories/reporting
        - Coastal Review Online feature series on contractors and the importance of building better docks - come out prior to hurricane season, along with pre-hurricane marine debris prevention checklist
        - Include removal work (tonnage) in press release, tie to larger problem of marine debris

Target Groups/Audiences/Avenues for Distribution

- Mail materials to property owners of derelict structures (addresses derived from South Wings aerial imagery fly-overs of areas hardest hit by Hurricane Florence); include letter and trifold brochure
- HOA's with residential dock access
- Local governments
    - Get on agendas of local boards/commissions to extend materials and speak on the importance of resilient structures
    - Make sure local government staff have materials on hand to disseminate to residents/permit seekers (this includes local building inspection/zoning offices)
- Division of Coastal Management, U.S. Army Corps of Engineers
    - A DCM representative is part of the larger stakeholder group and the Director is aware of the work, but once materials are complete, federation staff will schedule a meeting with Director Davis to share findings and see how DCM could help disseminate the information
- Contractor outreach
    - Brochure/fact sheet/flyer for contractor supply stores, boat shows

        - Similar content to trifold, but audience is strictly contractors; market resiliency as selling point

Social Media

- Succinct posts with good graphics highlighting the issue and key takeaways
- Photo drive compiled with photos from removal crews, as well as images of structures that follow construction BMPs
- Develop graphics with primary messaging for sharing on Facebook and Instagram - match to brochure
- Develop posting calendar in conjunction with press release and public roll out
- Contact property owners who have followed these recommendations, create/distribute video testimonials (i.e., why they chose to do it, what it means, why they're glad we're doing this work - storytelling)
- Share with local governments to post on their social media pages

References

"5 Questions You Should Ask Your Contractor." *Farrell Marine*, 23 July 2020, farrellmarine.com/about-us/5-questions-you-should-ask-your-contractor/.

"5 REASONS TO CHOOSE A CONCRETE FLOATING DOCK FOR YOUR HOME OR MARINA." *NordiDock Concrete Floating Dock Systems*, nordidock.com/?p=24.

"7 Questions To Ask Before Hiring A Marine Contractor Company." *Thaler Contracting Inc.*, 15 July 2019, www.thalercontracting.com/7-questions-to-ask-before-hiring-a-marine-contractor/

"Aluminum and Corrosion." *UK Aluminum Industry Fact Sheet 2*, Aluminum Federation, www.alfed.org.uk/files/Fact%20sheets/2-aluminium-and-corrosion.pdf.

"Benefits of Driven Piles." *Pile Driving Contractors Association*, www.piledrivers.org/benefits-of-driven-piles/.

Burns, M. (1999). *The dock manual: Designing, building, maintaining*. Pownal, VT: Storey Books.

Comstock, Roxie. "Understanding Walers: What Is a Waler?" *Pile Buck*, Pile Buck International, Inc., www.pilebuck.com/marine/understanding-walers-what-is-a-waler/.

Concerning floatation devices on state-owned aquatic lands and in state waters., S. 5466, 63rd Cong., State of Washington (2013).

Conno, Joe. "Advantages of Owning a Fixed Boat Dock." *Waterfront Gurus*, 19 Jan. 2020, waterfrontgurus.com/advantages-of-owning-a-fixed-boat-dock/.

"Corrosion Protection Methods for Underwater Piles." Edited by Fasi Ur Rahman, *The Constructor*, 20 Oct. 2016, theconstructor.org/geotechnical/corrosion-protection-underwater-piles/13819/.

"Dock Pilings: Choosing Pilings for Docks." *Steel Pipe Distribution | Buy & Sell Steel Piping and Tubing | New & Used*, www.crestwoodtubulars.com/dock-pilings.html.

Editor. "The Ultimate Guide to Dock Piling Materials." *Decks & Docks Lumber Co.*, 5 Nov. 2018, www.decks-docks.com/the-ultimate-guide-to-dock-piling-materials.

Engineered Wood Products and Connectors in Marine and Flood Zone Environments Code: 2018 Residential Code Date: April 10, 2019 Section: R322.1.8 and R4605.5

Find a Clean Marina. (2020). Retrieved July 15, 2020, from https://www.boatus.org/clean-boating/clean-marinas/

Georgian Bay Forever. (2019). *Lots to Reflect on this World Environment Day* [Brochure].

Guidelines for Selecting a Marine Contractor. New York Sea Grant, Jan. 2015, www.seagrant.sunysb.edu/glcoastal/pdfs/selectingacontractor.pdf.

"Homepage EN." *Bellingham Marine*, www.bellingham-marine.com/.

Kimos, Andrew. "Driven Piles vs. Jetted Piles - A Comparison." *Buildipedia*, Buildipedia.com,LLC., 11 Sept. 2009, buildipedia.com/aec-pros/construction-materials-and-methods/driven-piles-vs-jetted-piles-a-comparison.

Maine Shore and Bank Protection Projects. (n.d.). Retrieved July 15, 2020, from https://www.nae.usace.army.mil/Missions/Civil-Works/Shore-Bank-Protection/Maine/

Marcy, J. B., & Johnson, J. (2009). *Flotation Analysis for Boat Docks on U.S. Army Corps of Engineers Projects* (pp. 1-21, Rep.). Washington, D.C.: U.S. Army Corps of Engineers.

Materials and Methods of Encapsulation, Oregon State Marine Board § 250-ORS 830.110 (Oregon Secretary of State 2019).

Mayle, Mary Carr. "Port Docks Playing Host to Marine Life." *Savannah Morning News*, Gannett Co., Inc., 31 Aug. 2012, www.savannahnow.com/exchange/2012-08-30/port-docks-playing-host-marine-life#.URML0Ohmct4.

Owens, – Claude E. "Custom Modular Residential and Commercial Floating Docks." *EZ Dock*, 14 May 2021, www.ez-dock.com/.

"Pressure-Treated Southern Pine." *Southern Pine*, www.southernpine.com/pressure-treated/.

Rittmaster, R. (2018, May 11). Camden's Unencapsulated Polystyrene Ordinance: What Does it Mean for Homeowners? Retrieved July 14, 2020, from https://www.penbaypilot.com/article/camden-s-unencapsulated-polystyrene-ordinancewhat- does-it-mean-homeowners/101788

Staff, WOOD Magazine. "Greenheart." *WOOD Magazine*, 3 May 2017, www.woodmagazine.com/materials-guide/lumber/wood-species-2/greenheart.

Townshend, Anna. "Bigger and Stronger: Dock Builders Talk Trends in Design and Infrastructure." *Marina Dock Age*, The Waterways Journal Inc., 22 Mar. 2019, www.marinadockage.com/dock-builders-talk-design-infrastructure/.

Unencapsulated Polystyrene Ordinance for Blue Hill Maine. (2019, November 23). Blue Hill, ME.

United States, National Parks Service, Commercial Services. (2012). *Clean Marina Guidebook*. Retrieved July 15, 2020, from https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/NPSCS%20 Clean%20Marina%20Final%202012.pdf

United States, NOAA, Coastal Smart Growth. (n.d.). *Glossary*. Retrieved July 15, 2020, from https://coastalsmartgrowth.noaa.gov/pdf/glossary.pdf

United States, Town Council, Town of Camden. (2017). *Unencapsulated Polystyrene Ordinance* (pp. 47-48). Camden, ME: Town of Camden.

Appendices


CONTRACTOR'S CHOICE

DATE: August 27, 2019

MEMORANDUM FOR: The Record

FROM: David Westerholm, Director,
Office of Response and Restoration, National Ocean Service

SUBJECT: Environmental Compliance Review for "North Carolina Hurricane Florence Marine Debris Clean-up", implemented by North Carolina Coastal Federation.
Grant Award #: NA19NOS9990033

ENCL: (1) Environmental Compliance Worksheet

The National Oceanic and Atmospheric Administration's (NOAA) Policy and Procedures for Compliance with the National Environmental Policy Act and Related Authorities (NOAA Administrative Order 216-6A and Companion Manual for NAO 216-6A) establishes NOAA's policy and procedures for compliance with the National Environmental Policy Act (NEPA), the CEQ regulations, Executive Order (EO) 12114 (Environment Effects Abroad of Major Federal Actions), EO 11988 and 13690 (Floodplain Management), and EO 11990 (Protection of Wetlands). It was used by NOAA to examine the *North Carolina Hurricane Florence Marine Debris Clean-up* grant, implemented by North Carolina Coastal Federation for its potential to impact the quality of the human environment. The accompanying evaluation documents describe the proposed action, its effects, and any required consultation and permit requirements under other applicable environmental laws and regulations.

NOAA has determined the techniques to be implemented in this grant and their anticipated effects are adequately addressed by the analysis in the Marine Debris Program (MDP) Programmatic Environmental Assessment (PEA; NOS 2013). The accompanying evaluation documents also summarize the review of this grant for compliance with consultations and permits under other applicable environmental laws and regulations.

In view of the information presented in this document and the analysis contained in the PEA prepared for the MDP, the decision to approve this grant does not represent a change in the proposed action and analysis described in the MDP PEA. There are no new circumstances or information relevant to environmental concerns and the conclusions in the Finding of No Significant Impact signed on April 1, 2013 remain applicable. There is no need for additional NEPA analysis for this action.

Environmental Compliance Worksheet

NOAA Marine Debris Program, Office of Response and Restoration

PROPOSED FEDERAL ACTION

Descriptive Title of Proposed Action			*Award Number*
North Carolina Hurricane Florence Marine Debris Clean-up			**NA19NOS9990033**
Who is conducting the Proposed Action? North Carolina Coastal Federation	*Location of Proposed Action (City)* Southeast Coast	*State* NC	*Funding Mechanism* Grant - Removal
Description of Proposed Action Site Location(s) Project site locations are located across the marine and coastal zone of the state. Specific removal locations are identified in the accompanying grant proposal documentation.	*Start Date* 09/01/2019		*Federal Funding* $249,657
	End Date 08/31/2021		*Non-federal Funding* $276,325

Description of Proposed Action

During this two year project (09/01/2019 – 08/31/2021), the North Carolina Coastal Federation will focus on cleaning up disaster debris left in the wake of Hurricane Florence in Pender, New Hanover, and Brunswick counties. They will partner with the North Carolina Division of Coastal Management and local governments to remove debris fields consisting of dock debris, wood, metal, Styrofoam, and plastic that still remain in the estuary, on remote shorelines, in tidal marshes, and publicly owned conservations areas.

The primary goals of this project are to:

- Remove 70,833 tons of Hurricane Florence marine debris on over 3,092 acres of oyster reef, submerged aquatic vegetation, shallow subtidal, coastal wetlands and islands
- Develop and disseminate a set of best management practices for prevention, removal, and disposal of hurricane marine debris
- Promote more resilient building codes for docks
- Create a replicable case study on how to clean up storm debris scattered throughout the estuaries
- Provide robust public outreach by conduction four community volunteer clean ups

The North Carolina Coastal Federation will focus on the Southeastern part of the state (see area map Figure 1). Broadly, crews will remove marine debris on estuarine waters off the Intracoastal Waterway (ICCW) and the Cape Fear River within Pender, New Hanover, and Brunswick counties. First priority will be given to areas readily accessible from the ICWW, including the extensive uninhabited marsh spoil islands, tidal creek mouths and wetlands, and areas within the National Estuarine Research Reserve or other public lands and/or sanctuaries (i.e. Permuda Island, Morris Landing, Masonboro Island, Zeke's Island, and Carolina Beach State Park).

The North Carolina Coastal Federation will hire third party contractors, including commercial fishermen and marine contractors, to collect large and medium marine debris. Contractors will use barges and skiffs to access debris fields via waterways and will tow floating material to various pick-up locations at or near public boat ramps. Brief periods of noise will likely result from on-water preparatory and actual removal activities; however, these would be consistent with regular boating activities already occurring in the area. Minor turbidity will likely result from actual removal activities for those larger marine debris items like treated wood and/or vessels in contact with the substrate; however these similarly will be short-term in duration and have no lasting impact on surrounding living marine resources or habitat.

Personnel will also access sites from the upland and pick up debris using best management practices to minimize further damage to marsh platforms. The material collected will be transported to the appropriate disposal facility. Efforts will be made to have separate dumpsters for treated wood, recyclable, and non-recyclable items. In addition, discussions are underway with New Hanover County's landfill authorities to accommodate usable construction materials within the landfill's existing dedicated area for the re-use of these materials by area contractors, builders and residents.

Volunteers will be recruited to remove smaller items that can be removed by hand (i.e., plastic bottles, aluminum cans, and other assorted household debris).

Best management practices will include practices such as field marking seagrass, oyster reefs, and shell bottom to keep construction equipment and activities from encroaching into these areas. Environmental windows or seasonal restrictions for debris removal will be observed as conditions of permitting. The Regularity Requirements and Best Management Practices (BMPs) – Hurricane Florence USCG ESF-10 Response North Carolina document (Appendix I) will be tailored to the project and provided to the contract staff conducting removals.

Environmental Compliance Worksheet

NOAA Marine Debris Program, Office of Response and Restoration

TYPE of ANALYSIS

Indicate the type of analysis being used for this action. *Link to MDP PEA:* http://marinedebris.noaa.gov/sites/default/files/mdp_pea.pdf

Type of NEPA Analysis Being Used

MDP Programmatic Environmental Assessment (PEA)

REVIEW for PEA CONSISTENCY

1. Check the categories from Section 3.2 of the MDP PEA under which the proposed project fits (check all that apply).

☒ *3.2.1 Research and Assessments* ☒ *3.2.2 Prevention, Reduction and Removal* ☐ *3.2.3 Collaboration and Tools* ☒ *3.2.4 Outreach and Education*

2. Are the individual ***activities or techniques*** *to be carried out under this project fully described in the MDP PEA? If not, are they similar enough to support a conclusion that their impacts will be no different from those described in the PEA? Please reference Table 1 in Section 3.2 of the MDP PEA (pg. 18) and describe below.* ☒ *Yes* ☐ *No*

The activities and techniques are fully described by the MDP PEA (beginning in Section 3, Table 1, pg 20). Activities specifically to be conducted fall under the following MDP PEA categories: "Underwater cleanups and debris removal," "Underwater debris removal mechanical means of Derelict fishing gear (crab pots, ghost nets, etc.)," "Derelict vessel removal or impact mitigation" and "Disposal/Recycling". More detailed description of removal techniques and site specific locations are provided in accompanying proposal documentation.

3. Are the ***impacts and affected resources*** *that are likely to result from this project fully described in the MDP PEA? Please reference Sections 4 and 5, respectively, of the MDP PEA (pg. 46).* ☒ *Yes* ☐ *No*

Impacts to species from this project will be minimal, and are fully described in the PEA (beginning pg. 66). The removals undertaken in this award are consistent with the types of removals MDP conducts regularly, and despite the volume of removals to be conducted across the state, there are no anticipated activities in these projects that would lead to any significant adverse impact on the affected environment. When impacts are not beneficial, they will be minor and short-term in nature, as would be expected from in-situ heavy machinery, vehicle, vessel and personnel activities, and as described in the MDP PEA (pg. 69).

4. Are the ***best management practices*** *and any* ***mitigation measures*** *to be used during this project adequate to ensure any environmental impacts are not significant? Describe below. See Table 2 in Section 3.3 of the MDP PEA (pg. 42), which lists some programmatic BMPs.* ☒ *Yes* ☐ *No*

To rule out impacts to marine and coastal species, the project will follow MDP PEA guidelines (beginning pg. 42), as well as any other conservation or avoidance measures required or proposed by consulting resource agencies. Standard BMPs include minimum approach and work distances and operational protocols passed along to contractors to eliminate the potential for disturbance and incidental take. MDP will further define BMPs for avoidance and communicate those to grantees and contractors, and will document these during consultations with resource agencies.

COMPLIANCE with APPLICABLE LAWS

NOAA is responsible for ensuring that the program complies with all environmental laws relevant to the natural resources affected by NOAA and NOAA-funded actions. Use this section to describe any consultations, authorizations and permitting processes that NOAA has completed. For each statute below, check the type of consultation and explain the process for consulting with the relevant agency. Also, as appropriate list the relevant resources in the action area (ESA species, critical habitat, EFH, cultural resources, etc...) and how you determined their presence / absence; summarize effects to any relevant resources (including any BMPs, modifications to the project or mitigation measures); dates of any communications with resource agencies; and a brief conclusion of how NOAA MDP has fully complied with the statute. Include relevant documentation (e.g. communications, concurrences, analyses, etc.) as separate attachments.

1. ***Endangered Species Act (ESA) - Section 7***

NMFS Species

☒ *No Effect* ☐ *Technical Assistance (No Effect)* ☐ *Informal Consultation* ☐ *Formal Consultation*

NOAA MDP has determined that due to the timing, magnitude, duration, location, and implementation of BMPs, the project will have not effect on listed species and Critical Habitat. See attached memo on this determination.

USFWS Species

☐ *No Effect* ☐ *Technical Assistance (No Effect)* ☒ *Informal Consultation* ☐ *Formal Consultation* *Agency Concurrence Date:* June 27, 2019

USFWS finds that the proposed project is not likely to adversely affect any federally-listed endangered or threatened species, their formally designated critical habitat, or species currently proposed for listing under the Act at these sites (attached).

2. ***Magnuson–Stevens Fishery Conservation and Management Act (MSFCMA) - Section 305(b)*** *Essential Fish Habitat (EFH)*

☐ *No Adverse Effect* ☐ *MDP-OHC Programmatic Consultation* ☒ *Consultation* *Agency Concurrence Date:* August 14, 2019

NOAA Fisheries Service concurred that this project would not have substantial individual or cumulative adverse impacts on essential fish habitat or federally managed fishery species (attached).

3. ***National Historic Preservation Act (NHPA)* - Section 106**

☐ *No potential to cause effects* ☒ *No historic properties affected* ☐ *No adverse effects* ☐ *Adverse effects resolved*

Date of SHPO/THPO Concurrence: June 14, 2019

North Carolina Department of Natural and Cultural Resources State Historic Preservation Office finds there are no historic resources which would be affected by the project as proposed (attached).

4. ***Coastal Zone Management Act (CZMA) - Section 307*** *(Federal Consistency)*

☒ *No Effect* ☐ *No Effect (Negative Determination)* ☐ *Consistency Determination* ☐ *No federal responsibility*

North Carolina Department of Environmental Quality Division of Coastal Management determined that the proposed project is consistent with North Carolina's approved coastal management program (attached).

5. ***National Marine Sanctuaries Act (NMSA) - Section 304(d)***

☒ *No Effect* ☐ *Technical Assistance (No Effect)* ☐ *Consultation*

No effects to Sanctuary resources are expected, as project activities do no occur in a National Marine Sanctuary.

	Yes	No
6. ***Clean Water Act (CWA) / Rivers and Harbors Act of 1899*** *Will the proposed action discharge dredged or fill material or other pollutants into waters of the United States (eg. tidal, non-tidal, wetlands, lakes, streams, rivers, channels, other water conveyances), or involve structures or work in navigable waters of the United States? Indicate the type and status of any required permits in the comments field below.*	☐	☒
7. ***Marine Mammal Protection Act (MMPA)*** *Will the proposed action directly or indirectly take marine mammals?*	☐	☒
8. ***Migratory Bird Treaty Act (MBTA)*** *Will the proposed action take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such a bird?*	☐	☒
9. ***EO 11988*** *Will the proposed action support construction or permanent improvements to an area in or near a floodplain?*	☐	☒
10. ***EO 11990*** *Will the proposed action support construction or permanent improvements to an area in or near a wetland?*	☐	☒
11. ***EO 13175*** *Will the proposed action implement or develop policies that have direct effects on one or more Indian or Alaska Native tribes?*	☐	☒
12. *Does the applicant have all necessary permits? Include any relevant documentation as separate attachments. If 'No', indicate the expected timeline for completing all permit requirements in the comments field below.*	☐	☒

Enter any comments / explanation for questions #6 - 12:

MDP will work with grantees to ensure compliance with all permitting requirements are met. Grant activities and funding expenditures will be limited by Special Award Condition to planning and assessment activities prior to the permit being issued.

NEPA EXTRAORDINARY CIRCUMSTANCES

The questions in this section verify whether the impacts from the proposed action would be considered "significant" as defined by NEPA (40 CFR 1508) and Section 4.A. of NOAA NAO 216-6A. These questions are also used to determine whether further NEPA analysis is needed for Categorically Excluded actions.

Will the proposed action:

a. have adverse effects on human health or safety that are not negligible or discountable? ☐ Yes ☒ No

This proposed action will have no adverse effects on human health or safety. Section 4.4 of the MDP PEA describes program impacts on the human environment, and this effort's impacts are consistent with the description in that section.

b. have adverse effects on an area with unique environmental characteristics (e.g., wetlands and floodplains, national marine sanctuaries, or marine national monuments) that are not negligible or discountable? ☐ Yes ☒ No

This proposed action will have no adverse effects on areas with unique characteristics that are not negligible or discountable. Active personnel or equipment in the field may lead to direct, yet temporary and insignificant, disturbance of the physical environment. However, any such effects are negligible and discountable, and in the long run will result in beneficial impacts to the project area. Sections 5.2.1 and 5.2.2 of the MDP PEA describe such effects, and are consistent with the effects of this action.

c. have adverse effects on species or habitats protected by the ESA, the MMPA, the MSA, NMSA, or the MBTA that are not negligible or discountable? ☐ Yes ☒ No

See previous Section - Compliance with Applicable Laws.

d. have the potential to generate, use, store, transport, or dispose of hazardous or toxic substances, in a manner that may have a significant effect on the environment? ☐ Yes ☒ No

The proposed action will not generate, store or transport toxic or hazardous materials or discharges. In some cases generally, marine debris may be contaminated with hazardous substances, however NOAA does not expect to encounter such debris during this action. If encountered, all disposal will be conducted in compliance with applicable laws.

e. have adverse effects on properties listed or eligible for listing on the National Register of Historic Places authorized by the National Historic Preservation Act of 1966, National Historic Landmarks designated by the Secretary of the Interior, or National Monuments designated through the Antiquities Act of 1906; Federally recognized Tribal and Native Alaskan lands, cultural or natural resources, or religious or cultural sites that cannot be resolved through applicable regulatory processes? ☐ Yes ☒ No

See previous Section - Compliance with Applicable Laws.

f. have a disproportionately high and adverse effect on the health or the environment of minority or low-income communities, compared to the impacts on other communities (EO 12898)? ☐ Yes ☒ No

Consistent with Executive Order 12898, the proposed action would not have disproportionately high and adverse human health or environmental effects on minority or low income populations. MDP projects tend to benefit all populations in the project area equally, and all communities would typically benefit as a result of removal, prevention or research outcomes.

g. contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area or actions that may promote the introduction, growth, or expansion of the range of the species? ☐ Yes ☒ No

Consistent with the stewardship principles and objectives set forth in Executive Order 13112, the proposed action will follow best practices in preventing the spread of invasive species, similar to those described in Sections 3.3 and 6.15 in the MDP PEA.

h. potentially violate Federal, State, or local law or requirements imposed for protection of the environment? ☐ Yes ☒ No

The proposed action will comply with all relevant environmental laws.

i. have highly controversial environmental effects? ☐ Yes ☒ No

The proposed action does not employ any techniques that are controversial or result in highly controversial effects.

j. have the potential to establish a precedent for future action or an action that represents a decision in principle about future actions with potentially significant environmental effects? ☐ Yes ☒ No

The proposed action is a stand-alone effort and does not establish a precedent that would require any future action.

k. environmental effects that are uncertain, unique, or unknown? ☐ Yes ☒ No

The proposed action does not have any uncertain, unique or unknown environmental effects.

l. have the potential for significant cumulative impacts when the proposed action is combined with other past, present and reasonably foreseeable future actions, even though the impacts of the proposed action may not be significant by themselves? ☐ Yes ☒ No

The proposed action, when combined with other past, present and reasonably forseeable future actions would not result in any significant cumulative impacts.

FINAL DETERMINATION

☐ The proposed action is categorically excluded from the need to prepare an EA or EIS. It does not individually or cumulatively have significant effects on the quality of the human environment and is consistent with activities identified in NOAA Categorical Exclusion records. In addition, there are no extraordinary circumstances that would preclude this proposed action from being categorically excluded. The proposed action has not been segmented from a larger, interdependent, connected or cumulative action with the potential for significant impacts. Any individual or cumulative effects are negligible.

☒ The action is consistent with the MDP Programmatic Environmental Assessment (PEA, 2013) and Finding of No Significant Impact (FONSI). The project and its potential impacts may be limited through terms or conditions placed on the recipient of NOAA funds. It requires no further environmental review.

☐ The action or its impacts are not covered by the analysis within the PEA or applicable CE. It requires preparation of a separate environmental assessment (EA), environmental impact statement (EIS), or adoption of another agency's EA or EIS.

☐ Other

Form Preparer Signature:

LATSHAW.SARAH.A.1031868994 Digitally signed by LATSHAW.SARAH.A.1031868994 Date: 2019.06.13 10:08:55 -04'00'

MDD NEPA Official Signature:

BARRY.THOMAS.FRANCIS.1390971490 Digitally signed by BARRY.THOMAS.FRANCIS.1390971490 Date: 2019.08.27 14:42:36 -04'00'


SALT LIFE

Residential Docks and Piers:

Inventory of Laws, Regulations, and Policies for the Southeastern United States

NOAA Coastal Services Center
LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

Tips for Reviewing This Document

Legend for Residential Docks and Piers Tables	
Text in Italics	Indicates proposed (or recent) regulation changes.
Regular Type	Existing laws, regulations, etc.
-------------------	Dotted line separates information presented within a table cell so that the information is easier to read.

Acronyms and Abbreviations Used in Residential Docks and Piers Tables	
ADA	Americans with Disabilities Act
AEC	Area of Environmental Concern
CAMA	Coastal Area Management Act
DCM	Division of Coastal Management
dept	department
DEP	Department of Environmental Protection
ERP	Environmental Resource Permitting program—used in FL
FAC	Florida Administrative Code
ft	foot or feet
FS	Florida Statute
GP	General Permit—a type of permit issued through FL's Wetland Resource Permitting program (only used in FL panhandle); For NC, this is an expedited form of major permit
MP	Major Permit—a type of permit issued in NC
max	maximum
min	minimum
n/a	not applicable
OCRM	Office of Ocean and Coastal Resource Management
NGP	Noticed General Permit—a type of permit issued through FL's Environmental Resource Permitting program
POC	point of contact
SGP	Standard General Permit—a type of permit issued through FL's Environmental Resource Permitting program
sq ft	square foot or square footage
SSL	Used to refer to "sovereign submerged lands" in Florida's responses. Sovereign submerged lands are state-owned lands lying under water resources. A submerged sovereign lands authorization, in addition to a regulatory permit, is required to use sovereign submerged lands.
USACE	U.S. Army Corps of Engineers
WMD	Water Management District
WRP	Wetland Resource Permitting program—used in FL panhandle
#	number(s)
$<, \leq$	less than, less than or equal to
$>, \geq$	greater than, greater than or equal to

Document Layout

This document has been arranged in table format, so that one can easily compare each state's information by topic. Although each table provides different information, all tables follow a similar format.

For each table (See Sample Table Setup),

- any relevant information that did not lend itself to presentation in table format is found in written form above each table,
- table number and title are listed across the top of the table,
- states are listed in the left-hand column in alphabetical order, and
- topics or areas in question are listed across the top row.

Sample Table Setup:
Additional relevant information or background

Table #: Table Title

	General Heading for Table	
State	Topic/ Question	Topic/ Question
GA		
FL		
NC		
SC		

RESIDENTIAL DOCKS AND PIERS: INVENTORY OF LAWS, REGULATIONS, AND POLICIES FOR THE SOUTHEASTERN UNITED STATES

INTRODUCTION

While the homes threatened by erosion and the developer illegally filling in marshlands are the projects that make the headlines, for many state regulatory programs, it's the residential docks and piers that take up the most time. When is a dock too long? What about crossing extended property lines? And at what point does a creek have too many docks?

There are no easy answers to any of the dock and pier related questions. Each state has to craft the laws and policies that are best for its natural resources and its political and legal environment. At the same time, mistakes in judgment can be costly for the organization, the homeowner, and the natural resources.

At the request of the Georgia Coastal Management Program, the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center compiled an inventory of dock information for four states—Georgia, Florida, North Carolina, and South Carolina. Federal laws, state laws and regulations, permitting policies, and contact information are included in a tabular format that is easy to use.

DISCLAIMER

This inventory briefly summarizes residential dock and pier permitting in the southeastern United States. The inventory was designed to aid coastal managers and staff in comparing permitting regulations across four states: Georgia, Florida, North Carolina, and South Carolina. Only information related to residential dock and pier permitting was included. This inventory summarizes permitting information in general terms and should not be construed to cover every permutation possible under state law. For a comprehensive look at an area in question or for more details about a particular requirement, consult the original material listed in the associated reference and/or contact the state permitting office.

Special Thanks to
- Georgia Coastal Management Program, Georgia Department of Natural Resources
- Bureau of Beaches and Wetland Resources, Florida Department of Environmental Protection
- Critical Area Permitting Section, Ocean and Coastal Resource Management, South Carolina Department of Health and Environmental Control
- Division of Coastal Management, North Carolina Department of Environment and Natural Resources

Prepared by
Melissa M. Patterson, Coastal Coordinator
NOAA Coastal Services Center

APRIL 2003

Publication Number: NOAA/CSC/20319-PUB

TABLE OF CONTENTS

Table 1: Executive Summary by State

State	Date of Federal Approval of Coastal Zone Management Program	State's Coastal Population[2]	State's Miles of Coast	Acres of Tidal/ Coastal Marshes	Main Permitting Authority and General Jurisdiction for Docks and Piers within the State[5]	State's Position on Docks and Piers[8]	Total # of Dock/ Pier Permit Applications Received[9]	Total # of Docks and Piers Permitted[9]
	EXECUTIVE SUMMARY							
	SCOPE OF STATE COASTAL PROGRAM[1]					**FAST FACTS ON RESIDENTIAL DOCKS AND PIERS PERMITTING PROGRAM**		
GEORGIA	Jan. 1998	In 2000, 538,717 In 1990, 397,737	2,344	378,000	Coastal Resources Division 11 Coastal Counties	• Dock permit grants permission to use state-owned tidal waters and marshlands. • 3 permits are required: GA, USACE, and local government building permit • Has a Fast Track Permit that is issued jointly.	Fiscal Year 2000 n/a Fiscal Year 2001 n/a	Fiscal Year 2000 321 Fiscal Year 2001 195
FLORIDA	Sept. 1981	In 2000, 15,982,378 In 1990, 12,937,926	8,436	• 337,448 coastal marshes[3] • 534,960 mangrove swamp[3]	Department of Environmental Protection[6] Entire State is considered to be within the coastal zone; however, coastal zone consistency requirements are generally reviewed within Florida's 37 coastal counties.	• Florida has a comprehensive system of laws regulating environmental resource permitting, including residential docks and piers. • Docks on sovereign or state-owned lands require an additional authorization for use of such lands. Authorization is most often issued concurrently with dock permit. • Regular dock maintenance does not require a permit, but may require a sovereign submerged land authorization. • In accordance with state law, permits are administered by the Department of Environmental Protection in conjunction with Florida's Water Management Districts.	July 1999-June 2000[10] [11]NGP & GP-492 [12]ERP SGP-89 July 2000-June 2001 [11]NGP & GP-566 [12]ERP SGP-150	July 1999-June 2000[10] [11]NGP & GP-450 [12]ERP SGP-81 [13]Exempt Docks-2649 July 2000-June 2001 [11]NGP & GP-514 [12]ERP SGP-135 [13]Exempt Docks-2595
NORTH CAROLINA	Sept. 1978	In 2000, 826,019 In 1990, 710,903	3,375[3]	2,200,000 acres of estuarine waters[4]	Division of Coastal Management 20 Coastal Counties	• One joint (NC and USACE) permit process. • Regular maintenance of dock does not require a permit. In some cases, a local building permit may also be needed. • Only major permits require public notice; general permits have a blanket public notice built in.	Calendar Year 2000 [14]n/a Calendar Year 2001 [14]n/a	Calendar Year 2000 [15]GP-927; MP-31 Calendar Year 2001 [15]GP- 1050; MP-35
SOUTH CAROLINA	Sept. 1979	In 2000, 981,338 In 1990, 833,519	2,876	504,000	Office of Ocean and Coastal Resource Management—Regulations Department 8 Coastal Counties	• A dock permit allows a dock to be built on state lands: i.e., building permit. • 2 permits may be required: SC, USACE. In some cases, a local building permit may also be needed. • Dock permits expire 5 years after issuance. • Before construction begins; the applicant must get a construction placard from OCRM. This placard indicates the applicant's intention to build the permitted dock within the next 90 days. • All docks—including single residence, community docks, dock master plans—require public notice. • No dock may impede navigation or restrict reasonable use of state lands and waters. • A permit is not needed for regular maintenance.	Calendar Year 2000 725 Calendar Year 2001 815	Calendar Year 2000 717 Calendar Year 2001 808

REFERENCE

[1] Unless otherwise noted, information provided for "scope of state coastal program" comes from National OCRM Web site: *www.ocrm.nos.noaa.gov/czm/national.html*.
[2] For 1990 and 2000, population data came from the census bureau and was calculated by summing the population figures for each state's coastal counties as defined for CZMA.
[3] FL's figures are approximate and are derived from FL DEP modified FLUCCS (Florida Land Use Classification and Code System) coverage on GIS
[4] NC number comes from its publication found at *http://dcm2.enr.state.nc.us/news/facts.htm*.
[5] Source: Ocean Planning and Information System, *www.csc.noaa.gov/opis/html/policy.htm*.
[6] Florida's permitting authority is shared among DEP, water management districts (WMD), and 1 delegated local government, Broward County. See "State Agency's Jurisdiction and Limitations" (pg.4) for more information.

[8] Individual references for "Fast Facts" are available from the tables that follow.
[9] State POC provided # of docks information. State POC is provided in Table 3.
[10] Numbers reflect **only** docks permitted by DEP. Docks requiring individual ERP or WRP permits are not represented by these numbers.
[11] Refers to Noticed General Permits (NGP) and General Permits (GP). Numbers don't include NGP issued for boat ramps with an associated dock.
[12] These numbers represent Standard General Permits (SGP) for docks that included two or less boat slips.
[13] This is the number of exempt docks verified by DEP. This number includes some boat ramps and does not represent all exempt docks built within the state.
[14] NC currently has no good way to track the # of permit applications received. If a general permit is not appropriate, a residential dock/pier may be permitted through the major permit process. See "State and Local Permitting of Docks and Piers" in Table 3 (pg.5). For further information on NC permitting process, see Table 4 (pgs. 9, 11, 13).
[15] The Major Permit (MP) authorizes many kinds of structures: docks, piers, marinas, etc. MP # here estimates the # of major permits issued for residential docks.

U.S. ARMY CORPS OF ENGINEERS INTERACTIONS WITH STATE GOVERNMENTS

The U.S Army Corps of Engineers (USACE) is the federal agency charged with oversight of the nation's navigable waters. Residential docks and piers are permitted pursuant to Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C 403) and Section 404 of the Clean Water Act (33 U.S.C. 1344). Section 404 permits are required only for projects placing fill material in U.S. waters. In order to implement these laws in each state, USACE has divided the nation into divisions based on regional watersheds. The states included in this review are part of the USACE South Atlantic Division, which consists of NC, SC, GA, FL, and AL. In each state, various district offices are set up. Despite the similar organization, the way USACE district offices and state governments work together seems to differ from state to state. For more information on USACE, visit: *www.usace.army.mil/inet/functions/cw/cecwo/reg/index.htm.*
Generally, the Corps issues 3 types of permits:

- Individual permits—Requires full public review.
- Regional permits—A regional permit is a form of general permit with varying scope (i.e., can be issued for a state, region, county, etc.). Regional (general) permits are issued by the district engineer when permitted activities are similar in nature and cause minimal individual and cumulative environmental impact. A programmatic general permit, another type of regional permit, can be issued when it reduces duplication of regulator efforts among local, state, or federal agencies. This programmatic general permit grants permitting authority to a state, local, or federal government agency to act for USACE in certain circumstances.
- Nationwide permits—Another form of general permit, which must meet certain criteria, and is issued by the chief engineer through the federal rulemaking process.

Federal permit fees vary based on activity type; some activities require no permit fee. The district engineer makes final determination on fee amount.

- Noncommercial activity -$10-
- Commercial or industrial activity -$100-
- No fee is charged for transferring a permit from one owner to another.

Table 2: U.S. Army Corps of Engineers Interactions with State Governments Regarding Permitting of Residential Docks and Piers

STATE	USACE District Office by State	State and USACE District Office Interactions When Permitting Docks and Piers
GEORGIA	Savannah District *http://144.3.144.48/permit.htm*	Has a Fast Track Permit issued cooperatively by GA Coastal Resources Division and USACE Savannah District Office. The permit, issued through a regional agreement,[1] is a programmatic general permit submitted to GA Coastal Resources Division by applicant. A dock/pier must meet certain criteria to get a Fast Track Permit. No public notice is required. The USACE permit and GA Revocable License may be received the same day a completed application is submitted.
FLORIDA	Jacksonville District *www.saj.usace.army.mil/permit/index.html*	FL and USACE have a joint permit application that is submitted to either FL DEP or a state Water Management District (WMD), in accordance with an activity-based division of responsibilities.[2] When a permit application arrives, a copy of it is sent to USACE. Permit applications are processed independently. In parts of Florida, DEP and USACE have a signed agreement authorizing the state to issue a state programmatic general permit, which allows the state to issue a federal permit along with the state permit. This agreement is not effective in the Florida panhandle or Monroe County, where the Florida Keys are located. (POC Interview)
NORTH CAROLINA	Wilmington District *www.saw.usace.army.mil/wetlands/index.htm*	NC Division of Coastal Management (DCM) and USACE Wilmington District have a Memorandum of Agreement allowing DCM to issue both general permits for projects in U.S. navigable waters. If the dock/pier meets certain criteria, a general permit (a form of nationwide permit) may be issued on-site by DCM. If the proposed project does not fit into the category above, DCM requires the application to go through a joint DCM/Corps of Engineers 291 permit process for full agency review. The 291 process is required for larger projects because of potentially increased impacts to Areas of Environmental Concern (ACE). Because the process is more involved, a permit cannot be issued on-site. This process is sometimes used for residential docks and piers if, for example, an applicant would like four slips on his or her pier. If approved through the joint 291 process, a state permit is issued by DCM and a federal permit is issued by USACE. (POC Interview)
SOUTH CAROLINA	Charleston District *www.sac.usace.army.mil/permits/index.html*	A USACE permit is required only when the proposed residential dock project is on a federal navigation channel; otherwise, a general permit from the SC Office of Coastal Resource Management (OCRM) is sufficient. OCRM provides a coastal zone consistency determination for USACE permits. OCRM and USACE Charleston District have no cooperative permit agreement in SC. However, these agencies do issue joint public notices for permits. A permit application must be submitted to both USACE and OCRM separately. A joint form may be submitted to both agencies. Although, OCRM will accept the USACE permit application form, the Corps does not accept OCRM's permit application form. A (POC Interview)
REFERENCE		[1] This regional agreement was began July 2001 and expires July 2006. [2] See Table 3, column heading "State and Local Permitting of Docks and Piers," for a more in-depth explanation of "activity-based division of responsibilities."

Table 3: State Organization and Implementation for Permitting Residential Docks and Piers

State	State Organization & Implementation				
	State Point of Contact	Statutory Authority: Law, Regulation, and Policies and Procedures	Implementing State Agency and Division	State Agency's Jurisdiction and Limitations	State and Local Permitting of Docks and Piers
GEORGIA	Coastal Resources Division Phone: (912) 264-7218 This states information was last updated: April 17, 2003.	Coastal Marshlands Protection Act of 1970	GA Department of Natural Resources (DNR)—Coastal Resources Division (CRD)	Permit all tidally influenced water bodies and all areas economically tied to coastal resources, 11 coastal counties. The Coastal Resources Division serves as a clearing house for permits outside the coastal zone by passing the information on to the appropriate permitting body.	In GA, two ways to get a private, single-family, residential dock permit: 1. Fast Track Permit issued jointly with USACE through an agreement called a Programmatic General Permit. Applications are submitted to Coastal Resources Division. 2. Individual Permit-one must submit an application to the USACE for permit and GA for revocable license[2] 3. Larger structures, commercial, and community docks/piers require an authorization from the Coastal Marshlands Protection Committee. Local building permit may be required.
FLORIDA	Jim Stoutamire, Administrator, Office of Submerged Lands and Environmental Resources, Bureau of Beaches and Wetland Resources Phone: (850) 245-8490 E-mail: *Jim.Stoutamire@dep.state.fl.us* Doug Fry, Administrator, Program Development and Support Section, Bureau of Beaches and Wetland Resources Phone: (850) 245-8480 E-mail: *Doug.Fry@dep.state.fl.us* This states information was last updated: Feb. 6, 2003.	Florida has a comprehensive system of laws that govern permitting in the state[1]: • Ch. 253—State Lands Law • Ch. 258—State Parks and Preserves • Ch. 373—Water Resources • Ch. 403—Environmental Control Each law's function, in relation to residential dock and pier permitting, is explained in background section on the right.	Florida's permitting authority is shared among • Dept of Environmental Protection (DEP) • Water management districts (WMD) • One delegated local government, Broward County	Regulates all activities within state involving water resources and environmental control unless the activity is statutorily exempt. The entire state is considered to be in the coastal zone. The Environmental Resource Permitting (ERP) Program has an activity-based division of responsibility among the state, water management districts, and one delegated local government. For instance, • DEP handles all permit requests for docking facilities, unless these facilities are part of a "larger development." • WMD handles permits not falling into the above category, like permits for a new subdivision with associated docks. The ERP is not in effect in the Northwest Florida Water Management District (in FL Panhandle). DEP issues permits in this area through the Wetland Resource Permitting (WRP) Program. For more information, see Florida Administrative Code (FAC) chapter 62-312 and Florida Statute (FS) 373.414.	BACKGROUND: FL's system of regulation requires the use of one or more of the following laws when issuing a residential dock permit. • State Lands law—Unlike the other states reviewed, permission to use sovereign submerged lands is not granted by issuance of the regulatory permit. The Board of Trustees of the Internal Improvement Trust Fund provides a separate authorization allowing use of state-owned lands for private purposes. In most permitting cases, this authority is delegated to DEP and WMD. • Water Resources law —Part IV provides for a division of permitting authority and responsibilities for docks and piers between DEP and WMD; establishes authority for the wetland resource (NW FL) and the environmental resource (in rest of state) permit programs. This includes regulation of any dredging and filling in wetlands or other surface waters. • Environmental Control law—Provides certain exemptions from permitting; protects water quality. • State Parks and Preserves law—Further restricts permissible structures inside aquatic preserves and state parks, including docks and piers. Restrictions depend on location of preserve/park and nature of resources.[3] The ERP provides five ways to get a private, single or multi-family, residential dock: exemption, noticed general permit, standard general permit, individual permit, or conceptual permit. The type of permit needed is dependent on the location, size, and planned use of the proposed dock. (POC Interview) For NW FL, WRP provides three ways to get a private, single, or multi-family dock: exemption, general permit, or individual permit. Again, type of permit needed is dependent on location, size, and planned use. (POC Interview)
REFERENCE			[1] See Table 6 (pg.15)for Web site addresses and guidance to references mentioned in these sections. [2] GA's dock permit is a revocable license that grants permission to use state-owned tidal waters and marshlands. [3] See Table 5b (pg.14) for an explanation of how management agreements may amend use standards to fit the preserve's nature and resources.		

Table 3: State Organization and Implementation for Permitting Residential Docks and Piers (continued)

	State Organization and Implementation				
State	**State Point of Contact**	**Statutory Authority: Law, Regulation, and Policies and Procedures**	**Implementing State Agency and Division**	**State Agency's Jurisdiction and Limitations**	**State and Local Permitting of Docks and Piers**
North Carolina	David Moye, Coastal Management Representative Phone: (252) 946-6481 E-mail: *David.Moye@ncmail.net* --- For general information, contact Brian Long, Public Information Officer. Phone: (919) 733-2293 --- This state's information was last updated Dec. 27, 2002.	Coastal Area Management Act of 1974, as amended	NC Department of Environment and Natural Resources (DENR)—Division of Coastal Management (DCM)	Permit all activities in areas of environmental concern (AEC), which cover almost all coastal waters and less than 3% of land in the 20 coastal counties. Four categories of AEC exist: estuarine and ocean system, ocean hazard system, public water supplies, and natural and cultural resources.[1] --- Permits outside this zone are handled by NC Dept of Environment and Natural Resources. (POC Interview)	In NC, three ways to get a private, residential dock permit: 1. Major permit is issued for development in the coastal zone and requires 30-day public notice. In addition, a copy of the permit application must be delivered to adjacent property owners by certified mail. Permit expires on Dec. 31 three years after issuance. 2. General permit is an expedited form of major permit and has a blanket public notice. However, signed statements of no objection are required from adjacent property owners. This permit can only be issued for private, noncommercial development. Construction permit expires after 90 days. 3. Permit by exemption was allowed if the dock/pier met certain criteria. *Since very few of the docks permitted met this exemption, as of Aug 1, 2002, this exemption was repealed.*[2] (POC Interview)
South Carolina	Richard Chinnis, Director of Regulatory Programs Phone: (843) 747-4323 X 129 E-mail: *chinnira@dhec.sc.gov* --- This state's information was last updated March 24, 2003.	Coastal Tidelands and Wetlands Act—formerly known as Coastal Zone Management Act (Ch 39 Title 48 of the 1976 code as amended) --- Rules and Regulations for Permitting in the Critical Areas of the Coastal Zone—publication date June 1999 --- Policies and Procedures of the SC Coastal Management Program—updated July 1995	SC Department of Health and Environmental Control (DHEC)—Ocean and Coastal Resource Management (OCRM) Division	Permit all activities in the critical areas, which are the coastal waters, tidelands, beaches, and primary ocean front sand dunes of eight coastal counties. --- Permits outside the critical area, but within the coastal zone, are handled by Office of Environmental Quality Control within the Bureau of Water. This permit, the State Navigable Waters Permit, is issued with a coastal zone consistency statement. (POC Interview)	In SC, to get a private, single-family, residential dock permit: 1. If on a federally maintained waterway, submit an application to both USACE and OCRM. 2. For all other waterways in critical areas, only submit an application to OCRM. --- Some local governments, like Beaufort County, have used Special Area Management Plans to further limit the scope of docks within their region. For instance, Beaufort's dock max length is 300 ft. However, OCRM cannot enforce local requirements when they are more restrictive than state requirements. Locals must enforce any additional dock restrictions. (POC Interview)
Reference				[1] Specific definitions are available for the 4 categories of AEC. These are listed in the CAMA handbook available on-line at *http://dcm2.enr.state.nc.us/Handbook/handbook.htm*. [2] For more information about permits by exemption, see dock eligibility in Table 5 (pg.9).	

Table 3: State Organization and Implementation for Permitting Residential Docks and Piers (Continued)

<table>
<tr><th rowspan="2">STATE</th><th colspan="2">STATE ORGANIZATION AND IMPLEMENTATION</th></tr>
<tr><th>Environmental Impacts of Concern to State</th><th>State Enforcement of Permitting Regulations</th></tr>
<tr><td>GEORGIA</td><td>Georgia is concerned with adverse impacts development may have on the marsh. Although GA has no submerged aquatic vegetation, DNR is concerned with other environmental impacts of docks.</td><td>GA's dock permit is a revocable license that grants permission to use state-owned tidal waters and marshlands.</td></tr>
<tr><td>FLORIDA</td><td>Florida, like many other coastal states, is concerned with the environmental impacts of docks. Some of these concerns are listed below:
• Adverse impacts to biological communities that provide functions to fish and wildlife—like seagrass and other aquatic vegetation (such as marshes and mangroves)—due to shading and dredge/fill activities.
• Loss of endangered species—such as the manatee, which is affected by both increased boater activity and loss of seagrass (e.g., Johnson's seagrass)
• Adverse effects of docks on other wetland-dependent species—for instance, those that nest and breed in the uplands and in adjacent shellfish beds.
• Degradation of water quality—turbidity from installation of related pilings and leaching of chromium, arsenic, and copper from such pilings.
• Prop dredging and other dredging of access channels sometimes associated with dock use
• Archaeological and historical resources

When reviewing permits for approval, DEP uses a permitting test that requires consideration of the direct, secondary, and cumulative impacts of docks and piers. While Florida is concerned about environmental impacts, the state is also concerned about protecting the rights of riparian property owners. (POC Interview)</td><td>The general process for obtaining a permit in Florida:
1. Pre-application meetings with state representatives are encouraged.
2. Upon receipt of the application, the state has 30 days to request any additional information it deems necessary.
3. Once a complete permit application is received, the state has 90 days to issue/deny the permit application. During this time, staff conduct a site investigation. Most permits allow a five-year construction period.
4. After a permit is issued, the applicant is required to give the state a written notice before beginning construction. Once construction is complete an applicant must provide a signed document certifying that the dock was built as specified in the permit. Depending on the inspector's workload, a dock may be inspected at this point. DEP regional offices and WMD have a targeted number of compliance inspections per year.
5. Docks on sovereign submerged lands require a lease or consent of use.[1] This authorization is generally linked (timewise and sequence-wise) to issuance of the regulatory permit. Most private residential single-family docks qualify for a consent of use if they:
• preempt less than 10 square feet per linear ft of shoreline, OR
• otherwise use the min size necessary to provide reasonable access.
Generally, the only residential docks that require leases are large single-family docks, large multi-family docks, and all multi-family docks in aquatic preserves. Docks requiring a lease are inspected prior to any renewal of the lease. (POC Interview)

The permit processor is typically responsible for future compliance and enforcement. In some offices, though, staff permitting and enforcement responsibilities are kept separate. WMDs have field technicians, whose primary responsibility is to perform compliance inspections. Approximately 62 DEP staff, 86 WMD staff, and 15 delegated local government staff have compliance and enforcement responsibilities under the State ERP and WRP programs.[2] (POC Interview)

Permit violations are often discovered when someone reports nearby construction or when docks requiring leases are inspected. Once a violation is discovered, FL has a three step enforcement procedure.
1. A non-compliance letter is sent to the property owner stating DEP's concerns.
2. The property owner is given a chance to respond. Usually, this means that a staff member, manager, and the property owner (party at fault) meet informally in the DEP district office. If an agreement can be reached, a consent order is issued detailing the modification to be made to the structure, any mitigation required, permit fee, and any fines levied. The consent order's specifications vary with severity of the violation.
3. If no agreement can be reached between DEP and the owner, DEP can institute a proceeding in circuit court. DEP may fine offenders up to $10,000 per day per violation. However, instituting proceedings in circuit court is considered only as a last resort. A new law, ELRA (Environmental Legislation Reform Act) allows DEP to assess up to $10,000 in administrative penalties without going through courts. (POC Interview)</td></tr>
<tr><td>REFERENCE</td><td></td><td>[1] See "State Permitting of Docks and Piers" (pg.4), specifically the State Lands Law, for an explanation of why this is required. This reference explains how each Florida law contributes to residential dock and pier permitting process. See "Permitting Fees" (pg.12) for fee information.
[2] See "State Agency's Jurisdictions and Limitations" (pg.4) for a description of the ERP and WRP programs.</td></tr>
</table>

Table 3: State Organization and Implementation for Permitting Residential Docks and Piers (Continued)

STATE	STATE ORGANIZATION AND IMPLEMENTATION: Environmental Impacts of Concern to State	STATE ORGANIZATION AND IMPLEMENTATION: State Enforcement of Permitting Regulations
NORTH CAROLINA	NC is concerned about the cumulative impacts of docks and, like other coastal states, has a hard time quantifying these impacts. Specific concerns include submerged aquatic vegetation for some areas, as well as shellfishing resources. Because of development activity, the number of docks/piers is steadily increasing. However, it is difficult for DCM to determine when there are too many of these structures. (POC Interview) The following regulations illustrate this concern: • "'T's, finger piers, decks, & platforms shall have no more than 6 ft of any dimension extending over coastal wetlands." [15A NCAC 07H .0208] See special requirements for permitted structures (Table 4) for definitions. • Development in AEC is prohibited that "would have a substantial likelihood of causing pollution" of state waters where shellfish resources are "an existing use to the extent that such waters would be officially closed to the taking of shellfish." This also applies to development near or within closed shellfish waters. See regulation for more information. [15A NCAC 07H .0602] • NC general regulations stipulate that structures are permissible that have no significant adverse impacts on fishery resources, water quality, or adjacent wetlands. "Significant adverse impacts shall include but not be limited to development that would directly or indirectly impair water quality standards, increase shoreline erosion, alter coastal wetlands or Submerged Aquatic Vegetation (SAV), deposit spoils waterward of normal water level or normal high water level, or cause degradation of shellfish beds."[15A NCAC 07H .0209]	NC uses three basic methods to ensure compliance with permit regulations: site visits before and during construction, quarterly aerial surveillance to look for unpermitted activity and monitor ongoing projects, and civil penalties for noncompliant construction. The number of site visits conducted varies depending on the project's complexity and time required to complete construction. When a violation is found, fines are levied depending on the severity of the violation and mitigation/restoration is required. Max fine per day is $2,500. DCM staff may issue a notice of violation, halt development, require restoration, and assess a penalty for the violation. Small violations, like building a compliant structure without a permit, may be assessed a $100 fine plus cost of permit. Other violations are not so easily resolved. As required by law, fines collected are deposited into the state's general fund and then turned over to local school boards. For more information, look at subchapter J of the North Carolina Administrative Code [15 NCAC 07J .0101-.0502] (POC Interview). NC has a compliance coordinator for the enforcement program. In the field, all 14 field representatives are responsible for permits and enforcement in their work areas. The enforcement program covers 20 counties. Each field representative is assigned an area of coverage based on estimated travel times and population. (POC Interview) DCM has found quarterly aerial surveillance very effective in spotting new or noncompliant construction. This method allows DCM to cover a large area in a relatively short time. In addition, DCM has the same crew fly the same area quarterly, so the crew has a good knowledge of the area. Any inconsistencies are noted, photographed, and then compared to previous aerial photography and permit applications. DCM has complete aerial coverage of 20 coastal counties since 1978. (DCM has shoreline coverage and USACE has complete county coverage.) Photography is updated approximately every 5 years. (POC Interview)
SOUTH CAROLINA	Although SC has no submerged aquatic vegetation, OCRM is concerned with other environmental impacts of docks. OCRM's regulations are designed to minimize impacts to surrounding habitat from shading, leachate, and erosion/turbidity caused by increased propeller action. The main difficulties in assessing the environmental impacts of docks and piers: • Lack of conclusive research on cumulative impacts of docks • Finding and accessing the research that has been done (POC Interview)	SC's dock permit is a revocable license. OCRM can revoke or suspend permits for those who violate the conditions of the permit, and/or add to the permitted structure, etc. For those who build without a permit, an after-the-fact permit may be obtained if the structure complies with dept guidelines. Any noncompliant parts of the structure must be removed and fines paid before an after-the-fact permit can be obtained. OCRM has the authority to require a dock be torn down and the area restored; however, they have not yet had to use this authority. (POC Interview) Docks are checked by OCRM twice: • Plans are reviewed and changed during permit application, and • Structures are checked for compliance during construction after permittee has requested a construction placard. Although OCRM does not typically do random dock checks, it has found that the public is a good watchdog. In addition, when inspectors are checking a permitted dock, they may spot other permit violations or unpermitted docks. Fines collected by OCRM are deposited in the state's general fund. (POC Interview)

Table 4: State Requirements for Permissible Residential Docks and Piers

State	State Requirements for Permissible Residential Docks and Piers					
	Special Requirement(s) for Permitted Structures	**Dock Eligibility and Lot Restrictions**	**Maximum Length**	**Maximum Walkway Width**	**Minimum Height Above Water**	**Total Square Footage Requirements**
Georgia	The dock structure must be built of uniform materials and be structurally adequate and not out of character with other existing docks within visual proximity of the proposed docks. Docks that do not fit these conditions will be reviewed by the Savannah District USACE under an additional more comprehensive permit process.	N/A	The channelward face of the structure(s), or any portion of the structure(s), may be located channelward from the low tide line a maximum distance of 40 feet or 1/3 the channel width, whichever is less.	6 ft	N/A	• Max fixed deck area is 864 sq ft • Max floating deck area is 576 sq ft
Florida	No across-the-board restrictions on dock/pier construction. However, specific standards are applied to construction based on the proposed dock's location and size/scope. <u>Residential Dock Location:</u> • Is it in FL panhandle? Use WRP. • Is it on state lands? State lands law applies. • Is it in an aquatic preserve? State parks and preserve law applies.[1, 2] <u>Size/Scope of Residential Dock:</u> • Type of permit required depends on the size/scope of the proposed dock and dock's impact on surrounding resources[3] • ERP permit types: exemption, noticed general permit, standard general permit, individual permit, or conceptual permit • WRP permit types: exemption, general permit, or individual permit (POC Interview) --- • Alterations to rule [FAC 18-20.004 (5)] are allowed to accommodate Americans with Disabilities Act. • Monroe County contains the Florida Keys - additional criteria must be met for docks in this area. [FAC 62-312.410 & 18-21.0041]	N/A overall --- For docks built on state lands, the following setbacks from adjoining riparian property owners apply: • 10 ft for marginal docks • 25 ft for all other docks • If lot is < 65 ft wide, no setback is required, as long as there is no infringement on neighbor's riparian rights. --- To build a dock authorized by permit exemption: • One dock per 65 ft of shoreline OR for lots with < 65 ft shoreline, one dock is allowed per lot • Recreational, noncommercial use • < 500 sq ft in Outstanding FL Waters [includes aquatic preserves, class I and II waters [FAC 62-302]; < 1,000 sq ft in all other waters [FS 403]	25% of water body for multi-family docks; none for others --- For docks in aquatic preserves: • 500 ft waterward of mean high water line OR up to 20% of water body's width at dock site, whichever is less • single-family docks cannot extend farther than a max depth of -4 ft mean low water • If building a dock from an existing bulkhead at max depth, dock may extend 25 ft from bulkhead [FAC 18-20.004 (5)]	N/A --- To obtain WRP general permit: walkways may not be > 6 ft --- For docks in aquatic preserves: • single-family – 4 ft • multi-slip – 6 ft	N/A for ERP or WRP --- For docks in aquatic preserves over resource protection areas: • walkway $\geq$ 5 ft above mean high water • terminal platforms $\geq$ 5 ft above water; up to 25% of platform may be lowered to provide easier water access	Generally N/A for ERP or WRP --- To obtain ERP noticed general permit: 2,000 sq ft max, including pier, terminal platform, and other structures --- • Multi-family docks cannot exceed 40 sq ft per 1 linear ft of shoreline owned by applicant • Multi-family docks must meet these unit-to-slip[4] ratios: 1 to 6 units = 1 to1 unit:slip for units 7 to 14 = 2 to 1 unit:slip for units 15 to 28 = 3 to 1 for units 29 or > = 4 to 1 [FAC 18-21.004 (4)(a)1] --- For docks in aquatic preserves: • For single-family dock, terminal platform max size is 160 sq ft • Multi-family cannot be > 10 sq ft of preempted area per linear ft of shoreline (unless a lease is obtained) • Unit-to-slip ratio above applies to some multi-family • For multi-slip dock, max 8 ft terminal platform width, max 3 ft finger pier width, and 25 ft length (POC Interview)
Reference	[1] "Florida Aquatic Preserves," FAC Ch.18-20.004(5), is a supplemental requirement that applies to all sovereign submerged lands in aquatic preserves. The requirements for residential docks built on sovereign submerged lands (state lands) in aquatic preserves are listed under the heading, "For docks in aquatic preserves." [2] The FL Aquatic Preserves regulation defines the terms used within the regulation. See Table 5a, Fast Facts on Florida's Aquatic Preserves, for statutory definitions. Some exceptions to the standards/criteria for Florida's Aquatic Preserves exist. See Table 5b for an explanation. [3] See "Environmental Impacts of Concern to the State" for more information resource impacts. [4] A unit refers to one dwelling unit in a condominium complex or other multi-unit dwelling.					

Table 4: State Requirements for Permissible Residential Docks and Piers (continued)

	State Requirements for Permissible Residential Docks and Piers					
State	**Special Requirement(s) for Permitted Structures**	**Dock Eligibility and Lot Restrictions**	**Maximum Length**	**Maximum Walkway Width**	**Minimum Height Above Water**	**Total Square Footage Requirements**
North Carolina[1]	Generally, exceptions to the rule will be allowed only if the exception is necessary for safer use, will improve public access, or supports a water-dependent use that could not otherwise occur. For pier length, ¼ water body limit can be overridden if • USACE and/or local government established an official pier-head line • OR if pier is located between longer adjacent piers within 200 ft of applicant's property. Still, the applicant's pier cannot exceed his neighbor's nor be > 1/3 width of water body.	No restrictions on dock eligibility by lot size. However, you are required to have 15 ft between the adjacent property and your dock. Lots less than 30 ft wide would be ineligible unless a waiver is obtained in writing from adjacent property owners. For small lots, applicant may also choose to build a joint dock with adjacent property owner. *To build a pier by authorized exemption: applicant's lot ≥ 75 ft wide, have no enclosures, no commercial use, and cannot stretch over shellfish franchises or leases (unless applicant provides written proof lessee does not object). Exemption was revoked Aug. 1, 2002.* (POC Interview) Docking space for more than two boats is permissible by major permit.	Pier length is limited by: • Established pier length along same shoreline for similar use, (not applicable to piers < 100 ft unless piers interfere with navigation or public uses) • Not extending into channel of the water body • Not extending > ¼ width of natural water body, human-made canal, or basin measured from waterward edge of any coastal wetland vegetation[2] • Piers > 400 ft only allowed if additional length provides access to deeper water at rate of at least 1 ft per 100 ft of pier or to span navigation obstruction	6 ft - A major permit is required to exceed 6 ft width	Elevated at least 3 ft above coastal wetland substrate as measured from the bottom of the decking (includes all docks, piers, "T"s, and associated structures)	No total max sq ft covered area requirement is used to limit size of docks/piers; NC instead applies a combination of pier length + sq ft coverage by boathouses + a limit of 4 sq ft per linear ft of shoreline for "T"s, finger piers, decks, and platforms.
South Carolina[3]	Yes; For those who need handicap access, OCRM may require permittee to follow ADA guidelines for public dock facilities. Guidelines: 5 ft by 5 ft turnaround every 200 ft of dock length	Have one dock per lot built with least environmentally damaging alignment For lots platted and recorded after 5/23/93: • Need at least 75 ft water frontage with 75 ft between extended waterfront property lines • OR lots that are buildable with at least 50 ft frontage can get a common dock with the adjacent property • Lots with < 50 ft frontage are not eligible for a dock	1,000 ft including all associated structures	4 ft, unless applicant can justify a need for wider structure[4]	Elevated at least 3 ft above mean high water	Total max covered area is limited by the total dock walkway length restriction + creek size sq ft restrictions.[5]
Reference	[1] Unless otherwise noted, this information came from NC Administrative Code [15A NCAC 07H .0208], additional explanations can be found in CAMA Handbook for Development in Coastal North Carolina, and on NC Web site *http://dcm2.enr.state.nc.us/Permits/permits.htm*. [2] See "special requirements for permitted structures" for NC above. [3] Unless otherwise noted, this information came from SC Regulations [30-12.A-E]; OCRM Policies and Procedures [III-37 through III-38], and proposed regulation change documents. [4] See "special requirements for permitted structures" for SC above. [5] SC total sq ft requirement (walkway length restrictions + creek size restrictions) is explained in "Floating Docks/ Floats." (pg.11)					

Table 4: State Requirements for Permissible Residential Docks and Piers (Continued)

State	Floating Docks / Floats	Boat Houses / Roofs / Covered Areas	Handrails	Storage / Containers / Enclosures	Maximum Boat Hoists or Lifts/ Slips / Vessel Draft
	STATE REQUIREMENTS FOR PERMISSIBLE RESIDENTIAL DOCKS AND PIERS				
GEORGIA	• Max floating deck area is 576 sq ft • No fixed or floating docks shall be constructed over marsh vegetation.	• All covered areas over fixed docks are limited to a maximum height of 12 ft above the decking at the lowest deck height. • The fixed deck house may be open-side, partially or totally covered and enclosed with screen. The covered portion may be constructed either with wall of a single layer or woven screen wire or wainscot (lower 3 feet of the wall finished with wood, upper section finished in woven screen). • The dock house shall not be fully enclosed with wood, glass, fiberglass, metal, or any other solid type materials.	N/A	N/A	Boat hoists (covered or open) are limited to a maximum of 16 feet by 30 feet.
FLORIDA	For ERP or WRP general permit: • Terminal platforms may not be built over submerged grass beds, coral communities, and wetlands. [FAC 62-341.427] --- Floating docks are treated like fixed docks. When building a dock by exemption, a floating dock may be exempt if it is: • ≤ 500 sq ft in an Outstanding Florida Water or • ≤ 1,000 sq ft in all other waters A new exemption was created for floating vessel platforms (platforms must float at all times and support a boat out of the water at all times): • < 200 sq ft in outstanding FL waters • < 500 sq ft for other waters	• Boathouses, boat lifts, and gazebos, may not be built over submerged grassbeds, coral communities, and wetlands. For ERP [FAC 62-341.427] and for WRP [FS 372.808] • Any dock built on submerged sovereign lands, boathouses, roofs, and gazebos may not be fully enclosed. This excludes docks built in man-made canals which are not on state-owned property. (POC Interview) --- When building a dock by exemption, boathouses, covered slips, and gazebos are allowed if total area for these structures does not exceed • 500 sq ft in Outstanding FL Waters or • 1,000 sq ft in all other waters Structures may not have walls or doors, act as living quarters, or be used commercially.	Handrails are sometimes required to prevent mooring over shallow areas with resources.	• No wet bars or living quarters are allowed over sovereign submerged lands. • Structures cannot be enclosed by walls and doors on all sides. • Storage containers are sometimes allowed for boat and safety equipment. (POC Interview)	To obtain ERP noticed general permit: • Boats cannot be moored over submerged grassbeds, coral communities, and wetlands. [FAC 62-341.427] --- To obtain WRP general permit: • Construction cannot take place over submerged grass beds, coral communities, and wetlands. [FAC 62-312.808] --- For docks in aquatic preserves: • Private residential single-family dock allows 2 slips, or 4 slips for a shared dock[1] • Private residential multi-slip dock allows > 3 slips for multi-unit residential dwellings • For any single-family dock ending in resource protection areas 1 or 2, must have a min 1 ft clearance between vessel's deepest draft and top of submerged resources at mean low water • Multi-slip dock cannot terminate in resource protection areas 1 or 2, but may pass over these areas if there are no negative environmental impacts • Multi-slip dock must provide for a clearance of 1 ft clearance between vessel's deepest draft and the bottom of the water body at mean low water (POC Interview)
REFERENCE	[1]Neighboring property owners are allowed to share a dock between the two properties, if the owners agree to this. (POC Interview)				

Table 4: State Requirements for Permissible Residential Docks and Piers (Continued)

State	Floating Docks /Floats	Boat Houses/ Roofs / Covered Areas	Handrails	Storage / Containers / Enclosures	Maximum Boat Hoists or Lifts/ Slips / Vessel Draft
	State Requirements for Permissible Residential Docks and Piers				
North Carolina[1]	Any portion of a dock or pier (either fixed or floating) extending from the main structure that is 6 ft or less in width is a "T" or finger pier. Any portion of a dock or pier (either fixed or floating) > 6 ft wide is a deck or platform. [15A NCAC 07H .0208] Size is dependent on the type of permit issued. • By exemption, max 200 sq ft • By general permit, max 400 sq ft • By major permit, combined area of 'T's, finger piers, decks, and platforms must not exceed a combined total area of 4 times linear ft of shoreline.	Boathouses only on lots with 75 ft of linear shoreline. Total sq ft cannot be > 400[2], as measured from greatest exterior dimensions. Top half of boathouses can be enclosed with sides extending down ½ height of walls. Piers, docks, decks, platforms, and boathouses can only be a single story and can be roofed. Roofs cannot have second story use.	N/A	• No enclosed structures over the water • Any storage containers must be portable	Boathouse size is dependent on type of permit issued. • By general permit, total area enclosed by boatlifts shall not exceed 400 sq ft. A boatlift may be covered by a boathouse or left uncovered. Owners can have up to two boatlifts that fit within 400 sq ft. A jet ski is classified as a vessel, so a jet ski lift counts as one of two allowable lifts. • By major permit, total area enclosed by a boathouse can exceed 400 sq ft. More lifts are permissible if a major CAMA permit is applied for. ≥ 10 slips qualifies the proposed dock as a marina. Due to increased potential impacts, more requirements must be met before a permit is issued.
Reference					
South Carolina[3]	Floats cannot rest on bottom at low tide. For creeks _(of this size)_, fixed pier heads and floating docks are limited to a combined sq ft and walkway length: • < 20 ft wide, docks are prohibited[4] • 20-50 ft wide, limited to 120 sq ft • 51-150 wide, limited to 160 sq ft • > 150 ft wide, limit size to 600 sq ft (size requirements do not include walkway)	• No enclosed boathouses • Roofs are permitted on a case-by-case basis, on merits • Roofs must be clearly shown on public notice application • If dock has roof, it cannot have attic or enclosed ceiling storage • No rails, ladders, or steps to roof • Max roof height is 12 ft from floor decking to roof's highest point, including ornaments	Limited to what is minimally needed for safety as in Southern Building Code (1994, section 1015.1)	• Storage: a bench-like locker of 3 ft high by 3 ft deep by 8 ft long • No walls or screens	• Smallest hoist for purpose • Single-family 1 hoist allowed • Hoist is open-sided with no enclosures • Catwalks limited to 3 ft • Roofs subject to creek size and sq ft requirements • Boat storage docks will be considered on a case-by-case basis in lieu of elevated boatlifts. Square footage, including boat storage dock, is restricted to overall limit for floating docks.
Reference	[1] Unless otherwise noted, this information came from NC Administrative Code [15A NCAC 07H .0208] and unofficial explanations can be found in "CAMA Handbook for Development in Coastal North Carolina." [2] A larger boathouse may be permitted through the major permit process. [3] Unless otherwise noted, this information came from SC Regulations [30-12.A-E]; OCRM Policies and Procedures [III-37 through III-38], and proposed regulation change documents. [4] < 20 ft wide, docks are prohibited on newly platted lots. Existing lots are grandfathered in for 5 years from July 2002.				

Table 4: State Requirements for Permissible Residential Docks and Piers (Continued)

State	State Requirements for Permissible Residential Docks and Piers: Dock Placement	Community Planning Requirement	Conditions For Rebuilding Destroyed Docks	Permitting Fees (Type of dock—Fee in dollars)
Georgia	Walkways crossing tidal tributaries navigable by watercraft must be bridged so that navigation is not impeded. The bridge must have a minimum clearance of 6 ft from the mean high water line and the bottom of the bridge and pilings must provide for safe navigation in the channel.	CRD encourages developers to meet with permitting staff and local governments to develop a riparian coordination plan for subdivisions.	If a dock is considered unserviceable, a permit is required to replace or repair it.	No permitting fees are currently charged.
Florida	Generally, no dock may impede navigation, water flow, flood control, or degrade water quality. Structures over or on submerged sovereign lands: • limited to water-dependent uses. [FAC 18-14.003] • must not adversely affect riparian rights • meet other applicable rule criteria [found in FAC 18-20 & 18-21] For docks in aquatic preserves: • Riparian owners may have docks to allow reasonable access to water.[FS 258.42] [FAC 18-20.004(2)(e)] • Design (configuration of dock) and location (placement on-site) modification may be required to minimize adverse impacts to resources [FAC 18-20.004(5)(a)2] • Docking facilities should be designed to prevent vessels from damaging resources (i.e., limitation of #, length, drafts, and types of vessels allowed) [FAC 18-20.004(5)(a)3]	None. However, to build a dock by permit exemption, multi-family complexes and other complexes/facilities are considered one parcel of land. This means only one dock is permissible per 65 ft of shoreline regardless of actual breakdown of ownership in the complex. This is the first tool that permit processors use when permitting docks. • WMDs permit residential docks that are part of a subdivision development. Most subdivision dock applications come in as part of a larger subdivision development plan. • Neighboring property owners are allowed to share a dock between the two properties if the owners agree to this. The FL aquatic preserve system identifies resource protection areas in which certain uses/activities are restricted. As a result, multi-family docks cannot end in resource protection areas 1 or 2 because of increased possible impacts. However, single-family docks are allowed to terminate in resource protection areas 1 or 2 with applicable modifications to the dock design. The unintended consequence of this rule is that while one multi-family dock is not allowed, many single-family docks are allowed. So, although multi-family docks reduce the overall number of docks, their use is penalized under current rules. (Rule amendments are planned to correct this.) (POC interview)	Generally, no permit is required to replace or repair a functional dock, if these conditions are met: • repair is part of continual maintenance • dock is usable and provides access to moored boats or was destroyed by 1 event (e.g., storm, fire, flood, or accident), • is in the original location • has the same or original configuration/dimensions • requires no fill/dredging except to install pilings [FS 403.813(2)(d)] When a dock on state lands is destroyed by a sudden natural event, replacement is generally allowed within 1-year through • exemption FS 403.813(2)(d), or • the terms of an emergency order. Process for rebuilding after a natural disaster: 1. Governor issues a state executive order. 2. Florida DEP issues an emergency order, outlining applicable deadlines and conditions for rebuilding destroyed structures. In the past, Florida has specified a 1 year period for rebuilding of destroyed docks. For docks destroyed by other means, conditions for replacement may apply: • Docks and piers may be repaired or replaced to the original configuration so long as the structural damage only constitutes up to 50% of the original structure. • If more than 50% of the original structure is damaged or destroyed by a man-made or natural disaster, the entire structure shall be brought into full compliance with the current regulations. (POC Interview)	Under the ERP,[2] private residential docks may be authorized by • exemption – no fee • noticed general permit – $100 • standard general, individual, or conceptual permits – fee varies with the type and scale of proposed dock – generally $300. Under the WRP,[2] private residential docks may be authorized by • Exemption – no fee • General permit – $100 fee • Individual permit – $300-600 WRP permits are construction permits lasting for 5 years. Docks constructed on state lands require an authorization for use: • If the dock qualifies for a consent of use – no fee • If the dock or use requires a lease, as determined by DEP, a $200 application fee + annual lease fee payment is required.
Reference	[1] The amount of damage to the original structure is based on the over-water surface area or the cost to rebuild. [2] See Table 3 for explanation of each permitting system and its applicability.			

Table 4: State Requirements for Permissible Residential Docks and Piers (Continued)

State	State Requirements for Permissible Residential Docks and Piers: Dock Placement	Community Planning Requirement	Conditions For Rebuilding Destroyed Docks	Permitting Fees Type of dock—Fee in dollars
NORTH CAROLINA[1]	• Piers cannot interfere with access to riparian property. • Min setback of 15 ft between the pier and adjacent property owner's areas of riparian access. Can be waived if adjacent property owners are co-applicants.[2] • Also note, 15 ft setback cannot be waived when requesting dock under the exemption. • Applicants must notify owner of any part of a shellfish franchise or lease that a proposed dock would cover. Lessee can mark a navigation route from the pier to the lease edge. [15A NCAC 07H .0208]	• None. However, marinas can be used in lieu of single-family docks. • Marinas developed in public trust waters to provide docking space for residential developments cannot have > 27 sq ft of public trust areas for every 1 linear ft of shoreline adjacent to these public trust areas for construction of docks and mooring facilities. The 27 sq ft restriction does not apply to fairway areas between parallel piers or any portion of pier used solely to access slips from land. • Other restrictions apply to marinas including regulations to protect water quality in shellfishing areas. See Use Standards Section 5 [15A NCAC 07H .0208] [15A NCAC 07H .0208] and (POC Interview)	NC has two regulations that pertain to rebuilding destroyed docks: replacement of existing structures and nonconforming development [15A NCAC 07J .0210 & .0211]. Replacement of structures damaged or destroyed by natural elements, fire, or normal deterioration is development and requires a CAMA permit. Structure is considered destroyed if cost of proposed work exceeds 50% of structure's physical value at time of damage, as determined by local building inspection office. Replacement is allowed if structure complies with current rules. No permit is required for any repair or maintenance that totals less than 50% of the structure's value. Replacement of nonconforming development within an AEC built before effective date(s) of rule(s) with which development is inconsistent is allowed if these criteria are met regarding the structure: • Will not be enlarged beyond original dimensions • Serve same or similar use • No practical alternatives for replacement that provide same/similar benefits in compliance with current rules • Rebuilt to comply with current rules to max extent possible After a natural disaster, DCM generally authorizes a temporary rule that allows owners to replace their docks/piers without paying another permit fee for one year. After that time, owners may still rebuild their docks but they must pay a permit fee. In either case, the owner must comply with current rules. (POC Interview)	*Private, residential dock (authorized by permit exemption) – no fee. Since very few of the docks permitted met this exemption, this was repealed as of Aug. 1, 2002.* Private, residential dock (general permit) – $100 Private, residential dock meeting specific criteria (major permit) – $250 Public or commercial development involving little land disturbance (major permit) – $400
SOUTH CAROLINA[3]	• Bridging of small creeks is not allowed. • Pier must be put in first navigable creek with a defined channel or creek with a history of navigational access/use.	Subdivision developers are encouraged to develop joint use or community docks through submission of a dock master plan.	Docks destroyed beyond repair must conform to existing regulations in effect at the time of rebuilding. However, a dock may be rebuilt to its previous configuration if reconstruction is completed within three years. Before rebuilding, OCRM recommends getting a construction placard. OCRM passed the above regulation in July 2002 because experience with Hurricane Hugo revealed that a 1 year period was too short for docks to be rebuilt to original specifications.	Private, single-family noncommercial activity: < 100 ft dock – $150 ≥ 100 ft dock – $250 Commercial and Industrial Activities – $1,000 Marinas – $1,000 State Agencies – $0 Local Governments – $50
REFERENCE	[1] Unless otherwise noted, this information came from NC Administrative Code [15A NCAC 07H .0208] and unofficial explanations can be found in "CAMA Handbook for Development in Coastal North Carolina." [2] Setback, the division line between areas of riparian access, is established by drawing a line along channel/deep water and drawing perpendicular line to upland property line's intersection with shore. [3] Unless otherwise noted, this information came from SC Regulations [30-12.A-E]; OCRM Policies and Procedures [III-37 through III-38], and proposed regulation change documents.			

Table 5a: Fast Facts on Florida Aquatic Preserves

FAST FACTS ON FLORIDA'S AQUATIC PRESERVES	
Term Used in Regulation	**Statutory Definition**
Aquatic Preserve	"Any and all of those areas which are exceptional areas of sovereignty lands and the associated water body so designated in Part II of Chapter 258, F.S., including all sovereignty lands, title to which is vested in the Board, and such other lands as the Board may acquire or approve for inclusion by the Legislature. These areas also include the water column over such lands, which have been set aside to be maintained in an essentially natural or existing condition of indigenous flora and fauna and their supporting habitat and the natural scenic qualities and amenities thereof."
Board	"The Governor and Cabinet sitting as the Board of Trustees of the Internal Improvement Trust Fund."
Dock	"A fixed or floating structure, including moorings, used for the purpose of berthing buoyant vessels either temporarily or indefinitely."
Pier	"A structure in, on, or over sovereignty lands, which is used by the public primarily for fishing or swimming. A pier shall not include a dock."
Private residential Multi-Slip Dock	"A docking facility which is used for private recreational or leisure purposes for multi-unit residential dwellings which shall include but is not limited to condominiums, townhouses, subdivisions and other such dwellings or residential areas and which is designed to moor three or more boats. Yacht clubs associated with residential developments, whose memberships or utilization of the docking facility requires some real property interest in the residential area, shall also be included."
Private Residential Single-Family Dock	"A dock which is used for private, recreational or leisure purposes for a single-family residence, cottage, or other such dwelling unit and which is designated to moor no more than two boats. This also includes docks, with mooring of no more than a total of four boats, located on property lines between two upland single-family residences."
REFERENCE	Definitions taken directly from FAC Chapter 18-20 Florida Aquatic Preserves, *www.dep.state.fl.us/water/rules/18-20.pdf.*

Table 5b: Fast Facts on Florida Aquatic Preserves

As noted in the inventory above, there are some exceptions to the standards and criteria applied to residential docks built within aquatic preserves. This table clarifies where those exceptions may be found.

FAST FACTS ON FLORIDA'S AQUATIC PRESERVES	
Title of Regulation—Citation	**Exceptions to dock standards/criteria for Florida's Aquatic Preserves.**
"Sovereignty Submerged Lands Management": Chapter 18-21 Florida Administrative Code	All specific aquatic preserve standards and criteria are **in addition to** applicable requirements found in FAC chapter 18-21, which implements the state lands law. [FS 253]
"Biscayne Bay Aquatic Preserve": Chapter 18-18 Florida Administrative Code	Biscayne Bay Aquatic Preserve is primarily implemented through chapter 18-18 of the Florida Administrative Code; while, the rest of the aquatic preserves are implemented through chapter 18-20 entitled Florida Aquatic Preserves. [FAC 18-18 & 18-21] The rules governing Biscayne Bay are different from those governing other aquatic preserves due to the management agreement governing the preserve and the trustee's delegation to Dade County. Biscayne Bay use standards can be found in FAC chapter 18-18.005
"Florida Aquatic Preserves": Chapter 18-20 Florida Administrative Code	Lake Jackson and Boca Ciega Bay / Pinellas County aquatic preserves, regulated by FAC 18-20.017, .019, respectively, are held to specific standards/criteria formulated based on each aquatic preserve's unique nature.

Table 6: Works Cited By State

STATE	WORKS CITED BY STATE	
	Title of Resource Used	**Reference to Information Source (links provided where available[1])**
FOR ALL STATES	Ocean Planning Information System (OPIS)	Used as background reference to get an overview of each state's coastal management program. OPIS provides easy access to comprehensive ocean-related data and information that will enhance regional, integrated approaches to coastal and ocean resource management. *www.csc.noaa.gov/opis/*
	OCRM's state and coastal management program summaries	Used to describe scope of state coastal programs in Executive Summary (Table 1), unless otherwise indicated. *www.ocrm.nos.noaa.gov/czm/czmsitelist.html*
GEORGIA	The information provided herein comes from Georgia Web site.	*www.dnr.state.ga.us/dnr/coastal/habitat/docks.html*
	Phone Interview[2]	Charles B. Bennett, Habitat Program Manager, Georgia Coastal Resources Division. Phone Interview and e-mail correspondence. April 17, 2003.
FLORIDA	State Lands law (Title XVIII, Chapter 253, F.S.) Water Resources law (Title XXVIII, Chapter 373, F.S.) State Parks and Preserves law (Title XVIII, Chapter 258, Part II, F.S.) Environmental Control law (Title XXIX, Chapter 403, Part I and PartV, F.S.)	Link to Florida's statutes, which are searchable by title, chapter, and part: *www.flsenate.gov/Statutes/index.cfm?Mode=Search%20Statutes&Submenu=2&Tab=statutes*
	1998 Coastal Management Program Guide provides detailed statutory summaries.	*www.dep.state.fl.us/secretary/legislative/coastal/publications/programguide98/index.htm*
	Florida Dept of Environmental Protection Web site contains many sections related to permitting residential docks and piers. The Web sites listed here were used as a starting point; however, the duplication of information among the sites makes specific citations difficult.	• Main information on environmental resource permitting program is indexed here by topic: *www.dep.state.fl.us/water/wetlands/erp/index.htm* • Jurisdictional and organizational information *www.dep.state.fl.us/beaches/* and *www.dep.state.fl.us/water/wetlands/erp/wmd.htm* • Florida's statutes and permitting rules are indexed here: *www.dep.state.fl.us/water/wetlands/erp/rules/guide.htm* • Overview and history of environmental resource permitting program: *www.dep.state.fl.us/water/wetlands/erp/overview.htm*
	Phone Interviews with Bureau of Beaches and Wetland Resources, Florida Department of Environmental Protection[2]	Doug Fry, Alice Heathcock, and Daniel Lawson, Bureau of Beaches and Wetland Resources, Florida Department of Environmental Protection. Initial Phone Interview – November 7, 2002. Follow-up Phone Interview – February 4, 2003.
NORTH CAROLINA	North Carolina Administrative Code	*http://dcm2.enr.state.nc.us/Rules/current.htm*. Subchapters 7H, 7J, and 7K contain pertinent information on residential docks and piers.
	"CAMA Handbook for Development in Coastal North Carolina"	Unofficial explanations can be found in CAMA Handbook: *http://dcm2.enr.state.nc.us/Handbook/contents.htm*
	North Carolina Dept of Environment and Natural Resources Division of Coastal Management's Web site provides a wealth of information on its CAMA and policies.	*http://dcm2.enr.state.nc.us/Rules/rules.htm*
	Phone Interviews[2]	David Moye, Coastal Management Representative, North Carolina Division of Coastal Management. Initial Phone Interview – May 2, 2002. Follow-up Phone Interview – June 6, 2002.
SOUTH CAROLINA	South Carolina Regulations [30-12.A-E]	*www.lpitr.state.sc.us/coderegs/c030.htm*
	OCRM Policies and Procedures [III-37 through III-38]	*Policies and Procedures of the South Carolina Coastal Management Program: An excerpt of the South Carolina Coastal Management Program Document,* Updated July 1995.
	Proposed regulation change documents	Interim copy of current regulations governing the critical area, *www.scdhec.net/eqc/ocrm/HTML/regs2002.html*
	South Carolina OCRM's regulatory Web site contains useful information.	*www.scdhec.net/eqc/ocrm/HTML/regulate.html*
	Personal Interview	Richard Chinnis, Director of Regulatory Programs, Ocean and Coastal Resource Management Division. Intial Interview – September 20, 2001. Follow-up Interview – March 25, 2003.
REFERENCE	[1] All World Wide Web addresses listed in this section were accessible on April 2, 2003, and accurately reflected information referenced here and in the text. Site content at these links may change, or the links may become inactive at any time. [2] Besides the interviews listed here, numerous e-mails and short phone calls were exchanged as each state's information was verified and final consultations made. See Table 3 point of contact column (pg.3) for the last date each state's information was updated.	

About the NOAA Coastal Services Center

Guiding the conservation and management of the nation's coastal resources is a primary function of the federal government's National Oceanic and Atmospheric Administration (NOAA). This goal is accomplished through a variety of mechanisms, including collaboration with state coastal management programs.

The Coastal Services Center is a division of NOAA located in Charleston, South Carolina. The Center supports coastal resource managers by facilitating access to and utilization of the most up-to-date technology, information, and management strategies available in the field of coastal resource management.

NOAA Coastal Services Center
2234 South Hobson Avenue
Charleston, SC 29405-2413
www.csc.noaa.gov

Contact information:
Melissa Patterson, Coastal Coordinator
(843) 740-1200
Melissa.Patterson@noaa.gov

National Oceanic and Atmospheric Administration. NOAA Coastal Services Center. 2003. Residential Docks and Piers: Inventory of Laws, Regulations, and Policies for the Southeastern United States. NOAA/CSC/20319-PUB. Publication. Charleston, SC: NOAA Coastal Services Center.

R325.4 Means of egress. The means of egress for mezzanines shall comply with the applicable provisions of Section R311.

R325.5 Openness. Mezzanines shall be open and unobstructed to the room in which they are located except for walls not more than 36 inches (914 mm) in height, columns and posts.

Exceptions:

1. Mezzanines or portions thereof are not required to be open to the room in which they are located, provided that the aggregate floor area of the enclosed space is not greater than 10 percent of the mezzanine area.
2. In buildings that are not more than two stories above *grade plane* and equipped throughout with an automatic sprinkler system in accordance with Section R313, a mezzanine shall not be required to be open to the room in which the mezzanine is located.

SECTION R326 SWIMMING POOLS, SPAS AND HOT TUBS

R326.1 General. The design and construction of pools and spas shall comply with Appendix V.

SECTION R327 DOCKS, PIERS, BULKHEADS AND WATERWAY STRUCTURES

R327.1 General. *Docks, piers, bulkheads* and waterway structures shall be constructed in accordance with Chapter 36 of the *North Carolina Building Code.*

Exception: Structures complying with the following are not required to meet the provisions of Chapter 36 of the *North Carolina Building Code* or this code.

1. Fixed piers associated with a one- or two-family dwelling meeting all of the following:
   - 1.1. A maximum of four boat slips for a single owner of a one- or two-family dwelling or two adjacent, riparian owners.
   - 1.2. A maximum height of 15 feet (4572 mm) measured from deck to mud line at any location along the pier.
   - 1.3. A maximum normal pool depth of 13 feet (3962 mm) on lakes and ponds and a maximum mean low water depth of 7 feet (2134 mm) in other locations.
   - 1.4. A maximum walkway width of 6 feet (1829 mm).
   - 1.5. A maximum pile spacing of 8 feet (2438 mm), in both directions.
   - 1.6. A maximum of 576 square feet (53.5 m^2) for non-walkways areas.
   - 1.7. A maximum boat slip length of 40 feet (12.2 m).
   - 1.8. A maximum roofed area of 576 square feet. (53.5 m^2) with an additional maximum 2 foot (610 mm) overhang.
   - 1.9. Constructed with no enclosed or multilevel structures.
   - 1.10. Supporting a boatlift with a maximum design capacity no greater than 16,000 pounds (71.2 kN).
2. Floating docks associated with a one- or two-family dwelling meeting all of the following:
   - 2.1. A maximum of four boat slips for a single owner of a one- or two-family dwelling or two adjacent, riparian owners.
   - 2.2. A maximum normal pool depth of 20 feet (6096 mm) for docks with guide piles on lakes and ponds and a maximum mean low water depth of 10 feet (3048 mm) for docks with guide piles in other locations.
   - 2.3. A maximum boat slip length of 40 feet (12.2 m).
   - 2.4. Finger piers, crosswalks or other floating surfaces having a minimum width of 3 feet (914 mm) wide to a maximum of 6 feet (1829 mm) wide, except for a single 8-foot by 16-foot (2438-mm by 4877-mm) section.
   - 2.5. When constructed with a roof and the following conditions exist:
     - i. Ultimate design wind speed is 115 mph (51 m/s) or less;
     - ii. Roof load is 20 psf (0.96 kPa) or less;
     - iii. A maximum eave height of 10 feet (3048 mm);
     - iv. A maximum roof slope of 4:12;
     - v. A maximum roofed area of 576 square feet. (53.5 m^2) with an additional maximum 2 foot (610 mm) overhang;
     - vi. A minimum boat slip width of 12 feet (3658 mm);
     - vii. A minimum floating dock width of 4 feet (1219 mm) along both sides of the boat slip;
     - viii. A maximum dead load of 12 psf (0.57 kPa);
     - ix. Floating structures supporting roof structures are balanced or anchored to reduce the possibility of tipping.
   - 2.6. Constructed with no enclosed or multilevel structures.
   - 2.7. Supports a boat lift with a maximum design capacity no greater than 16,000 pounds (71.2 kN).

NOAA 1105 - Promote more resilient building codes for docks

I. Interviews with relevant professionals

- ➔ Kathryn Thurston, Zoning Administrator - City of Wilmington (Kathryn.Thurston@wilmingtonnc.gov / 910.341.3249)
- ➔ Edward McCaleb, Chief Code Compliance Official - New Hanover County (emccaleb@nhcgov.com / (910) 798-7472)
- ➔ Spencer Rogers, NC Sea Grant (rogerssp@uncw.edu / 910-962-2491)
- ➔ Tara MacPherson, Wilmington Regional District Manager - DCM (tara.macpherson@ncdenr.gov / 910-796-7425)
- ➔ Samantha Burdick, Coastal Resiliency Coordinator - DCM (samantha.burdick@ncdenr.gov / (252) 808-2808 ext. 230)
- ➔ Buck Bennett, Compliance and Enforcement Manager - Georgia DNR (buck.bennett@dnr.ga.gov / 912-262-3132)
- ➔ Eryn Futral, Risk Management - NC Department of Public Safety (eryn.futral@ncdps.gov)
- ➔ Derek, Bobby Cahoon Construction (bobbycahoonconstruction@yahoo.com)
- ➔ Tony Garrett, Bellingham Marine (tgarrett@bellingham-marine.com / 910.210.4865)
- ➔ John Plisich, FEMA (404-354-5283)
- ➔ Gene Foxworth, Assistant County Manager - Carteret County (Eugene.Foxworth@carteretcountync.gov / (252) 728-8545)
- ➔ Jonathan Howell, Major Permits Coordinator - DCM (jonathan.howell@ncdenr.gov / (252) 229-9257)
- ➔ Gary Greene, Gary Greene Engineers (ggreene@garygreene-engineers.com / 9198558488)
- ➔ Tony Wilson, Planning Director - Town of Wrightsville Beach (twilson@towb.org)
- ➔ Jimmy North, Coastal Marine Construction (jimmymnorth@gmail.com)

II. Key takeaways from interviews

Kathryn Thurston - the City of Wilmington conducted an informal field survey of docks and piers within the city that were easily accessible from public waters. Measured platform size, number of decks with roof structure, floating dock numbers and sizes, etc. Table with averages is in Google Drive. At the local level (City of Wilmington) size limitations are 50% of CAMA allowable, the state building code and CAMA regs are only controls on construction.

If there was an ordinance change, they would prefer to see it done through CAMA. The City has no building code inspectors, all inspections are conducted through New Hanover County. The City doubts the County would want to enforce standards they do not also adopt.

Kathryn was not aware of any strong ordinance language, but recommended we speak with Eryn Futral, who has had the opportunity to review a lot of ordinances in her new position, as well as Edward McCaleb at the County in regards to code inspections. In addition to Daniel Shirley, she recommended Jimmy North as another marine contractor who does solid work.

Edward McCaleb - up until 2017, residential docks and piers located in VE flood hazard zones had to be engineered by a registered design professional (same as current commercial docks and piers requirements). Once the residential building code was amended in 2017, this was no longer required. Building code has recently been weakened, McCaleb does not think a strengthening of the code is likely at this point in time.

In New Hanover County, if a homeowner wants to construct a dock/pier, they must submit drawings which are reviewed by the county. Once constructed, the County completes a final inspection to make sure the structure meets the drawings. Once this occurs, a certificate of occupancy is issued and no more inspections occur. County requirements mostly address structure size, pile depth and pile spacing; does not address building materials. In addition to County zoning requirements, must meet CAMA requirements of course. City has a number of zoning ordinances that aren't enforced in County.

Some jurisdictions may have more restrictive standards; in general, law and administrative code prevents local jurisdictions from developing standards that exceed state level BUT local zoning departments can impose additional zoning restrictions (building departments cannot). McCaleb recommended I reach out to Linda Painter in County zoning. She reported that New Hanover County doesn't have any standards for docks and piers other than those required by the state building code and CAMA. From our conversation, I gathered McCaleb thought a change at the zoning level would be the best path forward.

In the Google Drive is a scan of Section R327 that McCaleb sent from the North Carolina Residential Code. It exempts residential docks from Chapter 36 of the state building code requirements and specifies size requirements, heights, number of boat slips, roof area, etc. McCaleb also sent this link to a discussion regarding materials regulated by the NC Residential Code: 0322.1.8 - Engineered Wood Products and and Connectors in Marine and Flood Zone Environments, which outlines pressure treatment options as well as connector options for optimization in sea water. Something to take into consideration when looking at specific construction specs.

Spencer Rogers - member of the state building code committee that recommended the last couple revisions in the marine structures chapters (which loosened current regulations). Spencer reiterated that this is not a new question, but we are taking a different perspective, coming from the clean-up side, not damage/life-safety side. In general, building codes have been drifting away from damage reduction approaches and moving more toward life-safety issues; Spencer doesn't think it's likely building code would take up these issues. Flood codes, which are generally more interested in structure, might be something to consider.

Building standards cannot be adopted by local governance; it is pretty clearly understood that the same building design goals that build houses work well for marinas. Problem is not how to design, but how to have functional water-dependent use. Engineers required for commercial uses - in the best design conditions, facilities may be designed as empty, without boats. With boats, loadings are drastically increased. In practical terms, most marinas cannot be empty before storm events.

Previous versions of code attempted to set design limits where they thought professional design might be an advantage, but ended up overdesigning residential marinas that didn't really need it. Requirements were not significantly improving residential docks/piers, last round of amendments removed requirement for residential docks and piers to be designed by a licensed PE. Building code council isn't beyond looking at some damage reduction reductions, but so much is local site-selection driven, standard design change is not really feasible.

Spencer suggests we go at it from the property owner's view (i.e., saving money, not necessarily marine debris reduction). Insurance doesn't typically cover the cost of rebuilding, it may be covered by one storm, but not the next.

In storm events, small waves cause immense damage - you can see failure with a 1.5 ft breaking wave. Lateral waves/wave uplift will break something regardless - the goal is to minimize what breaks, and design *where* you want it to break. It's more cost-effective to keep dock pilings in place, even if you lose the decking. Hog farm grates reduce uplift loads because they are porous, but still have issues with lateral waves because they are heavy. An advantage is that they sink and stay nearby so you can often recover them after a storm. Adjusting the deck level for a specific storm frequency is also a good idea, especially if you build higher than expected breaking waves. Severe damage starts when waves start to clip the bottom of floor joists. Floating dock in a wave field - all bets are off.

Materials - SeaGrant funded research 30 years ago (Judith Weiss, RI) looking at treated lumber - creosote vs CCA (Chromated copper arsenate) lumber because of marine bores (CCA is chemically bonded to wood cells, takes far less to treat; is pesticide; CCA stays loose until bonded, can take month or more in winter. Surface residue is toxic, which led to banning CCA lumber in most residential uses, other than in salt water). Later, they learned that performance of other materials is nowhere near as good as CCA because it is not bonded, so they leach into the environment later on. Most docks are built with CCA materials in the water, but not above the surface.

Permits/inspections - most municipalities require local building permits, in addition to CAMA permits, but these permits only evaluate whether or not a dock/pier can be built, location in waterway/AEC, length/width, etc. Once constructed, the structure can be inspected, but since exempt from the building code, there is nothing for local staff to inspect other than whether it exists or not. This one time inspection is not always conducted, and is primarily for tax/property records.

<u>Tara MacPherson</u> - could not reach via telephone, only email. DCM does not address building code issues at all; they permit the structures and local governments have building code guidelines and are addressed in the building permits.

I followed up asking about any CAMA rules that may prevent 'cut-off' debris and if there was a DCM staffer who may be interested in participating in the stakeholder group to lend agency perspective and insight on the permitting process. Have not yet heard back.

<u>Samantha Burdick</u> - definitely interested in the issue from a resiliency perspective, but not something they have looked at. Suggested looking at recommendations for hurricane resistant housing and general building, may be able to pull relevant information from new design standards. Discussed presentations from the 2019 resilience summit; work funded by the insurance industry. Not directly applicable to piers/docks since they're not typically covered by insurance, but lessons learned may be applicable.

<u>Buck Bennett</u> - could not reach via telephone, only email. Georgia does not have any "state" requirements for building docks, only have the standard requirements for PRDs on length, width, placement, etc. Some local communities have established guidelines since Hurricanes Michael and Irma, some are requiring hurricane construction standards and building permits now. When asked about

which governments, he checked with a colleague and they don't have any in Georgia, but certain counties in Florida, including Wakulla County do. They have building codes for docks that are far tighter than the state of Georgia and the Corps, and have to be designed by a Florida Licensed PE.

I have reached out to Wakulla County to see what I can learn about their requirements (I found nothing of use on their website).

Eryn Futral - has not found any additional construction standards beyond what is recommended in the NC NFIP Model ordinance, FEMA Technical Bulletins, NC Building Code, or ASCE 24. All of which require construction which remains in place or breaks apart during the occurrence of the base flood and demonstrates no harmful diversion of flood waters or wave runup and wave reflection that would increase damage to adjacent buildings and structures.

When she was employed with the City of Wilmington, she did research for an ordinance amendment proposal in regards to pier construction. It was more focused on light penetration, but she found a variety of products that could be worth a look for length of life. The aluminum products were used quite a bit in Florida which is no stranger to hurricanes. Eryn also sent this "Guide to Docking Choices" which doesn't go into weather related conditions or resilience directly, but does a good job of outlining and comparing different dock construction options.

Eryn also put me in touch with Dan Brubaker (NC NFIP Coordinator) who discussed how the NC Residential Code makes exceptions for smaller docks associated with single-family homes. Only larger docks have to comply with any code requirements. We may want to ask the OSFM (office of the state fire marshal??) whether code changes would be warranted.

Gene Foxworth - I spoke with Gene, as well as the Chief Building Inspector, Chris Jones. Since Florence, they've shifted their perspective a bit in regards to structures. When replacing their docks, they're now building back with concrete slabs, and FEMA is paying for them. He said FEMA is starting to see the writing on the wall, as well. Chris is working with the public quite a bit - seems like there's increased interest from property owners on how to build a lasting dock, he's offering input on more durable dock design. Hog slats and concrete are two of the biggest techniques they're seeing. They don't have any building requirements beyond the minimum standards in the state building code, and don't think an engineer is necessary. Same effect can be achieved by focusing on materials and techniques. Does not expect that a local ordinance would fly, would prefer for it to come from CAMA.

Jonathan Howell - permitting for residential structures is focused mostly on environmental factors (SAVs (submerged aquatic vegetation??), oysters, resources, water classification, PNA (primary nursery area), water depth requirements, etc.) and since structures are so site-dependent, DCM doesn't get into any specifics, they leave it up to local governments to determine any building requirements. Property owners often ask about structure recommendations, but since they are a public agency, are very weary to promote any kind of technique, method, etc. Instead, speak in general terms, listing pros and cons for different techniques. Do recommend property owners to only get what they need - just because they can have up to 2,000 square feet doesn't mean they should. Definitely strong interest from property owners. Doesn't think it's likely DCM would incorporate any requirements into the GP, the extensive vetting and very high threshold required to prove they are in everyone's best interest would likely prohibit anything from being adopted coast-wide. Could see DCM providing our BMP's to property owners as a resource, without official endorsement. As for implementation, thinks focus on strong public outreach is important, as well as drafting of ordinances that local governments could adopt.

Knows a lot of communities who might adopt something like this. No standards/anything regarding 'cut-off' debris, but if agency staff saw it, they would ask the person to remove it.

Bobby Cahoon Construction - most important thing from their perspective is vibrating the pilings in sufficiently. This makes a huge difference; when they're washed in, the hole is blown out and it takes a long time to build back up and doesn't fill in as strong. By vibrating them, the seal is tight; he recommends a 10 foot minimum - all revolves around solid foundation. Also important is good hardware (especially for saltwater) and good quality lumber. Most newer docks are built fairly well, the problem is really with the old docks that are band-aided/pieced together year after year, storm after storm. Sees a lot of big family homes that are passed down generation to generation and the younger folks can't afford to keep up with the expense and choose the bare minimum with repair. He thinks an area to focus on is follow-up in dock repair, especially after storms. So many emergency permits are issued and there's no one to quality check the work; some contractors purposely built something they know won't last to keep themselves in business. Certainly does not favor more 'government regulations/requirements,' though.

John Plisich - Coming from mitigation perspective; since docks are not covered in flood insurance, FEMA isn't involved in the residential side, but has information from the commercial side that may be of interest. Suggested the following resources: FEMA 55 - includes engineering examples, calculations, takes into account scour, erosion, hydrostatic loads, etc. FEMA 499 - homebuilders guide to coastal construction (not directly related to docks, but includes good fact sheets on coastal building). FDEP fishing pier design guidance - looks at historical pier damage in Florida as well as methodologies in construction. Surprisingly enough, Mecklenburg County has fairly stringent dock permit requirements, they set forth boundary conditions to prevent property owners from having to hire an engineer, but leave it open so that they can build above the standards should their site require more design. In his perspective, it really all comes down to how much money do you want to put into it - do you want a frame with strong pilings that stay in place, but the boards will wash out? Do you just want to rebuild each time? Do you want a structure that will be partially damaged, totally damaged, with a specific storm height? Recommended careful consideration into how we characterize the narrative, suggested focusing on cost of rebuilding $$$ Do we want to enact code, or provide guidance?

Tony Garrett/Lee Ishee - Tony and Lee work for Bellingham Marine, which is the largest dock manufacturer and marine contractor in the world; they build 90% of commercial structures in the US and work in 28 countries. Their number one recommendation is site-specific engineering - many builders have no idea what goes into wave and wind criteria and that is site-specific. They develop wave and wind criteria based on historical data for each build, especially on large marinas. Creek engineered dock systems, too for smaller residential structures. Also emphasized the importance of follow-up to make sure it's adhered to. They recommend property owners look for builders with at least 10 years of experience, avoid pop up contractors (especially after storm events); do your homework and vet the builder. They wish property owners knew more about all of the different kinds of docks, there are so many. Their website has lots of good info on dock systems. In addition to expense and lack of knowledge, they think the biggest thing preventing people from building more durable docks is timeframe - property owners want it built, and want it built now - they don't want to wait. They say that if a company doesn't have a backlog, then they're doing something wrong. They build to NC building code and local permit requirements, all about confidence and how much risk the property owner is willing to take. Other important factors- calculations of loads, live loads, anchoring system (area may be too rough for the dock and it gets thrown around). Also, fixed piers versus floating docks. Fixed - either rip the top structure off completely or (if it's a sturdy structure) pull the whole thing out of ground.

Floating dock stays on water at all times (as long as pilings are higher than water level). Floating docks always stay the same height as the vessel (prevent safety hazard). Floating docks - encapsulate on concrete often. They say it's a federal requirement (FERC) that all new foam docks must be encapsulated.

Gary Greene - When writing Chapter 36 of NC Building code, he tried to get residential docks banned in FEMA VE zones. He's also on a national committee developing a national code for piers and wharves (there is not one available in the U.S.). Same committee is also providing input / review of the New York waterfront code that is being developed. One item of interest in the New York code will be required inspections/ maintenance of waterfront structures. He hopes to include required maintenance/ inspections of waterfront structures in the NC code.

There are so many restrictions and requirements on houses, but nothing on docks. Important focus is on connectors (screws/steel) and maintenance. Code is decent, but often not enforced; local building inspectors don't know/care. Height of guide piles is important. Difficult to draft prescriptive code, differing soils, water levels. Very site-specific.

Local Government	County	NC Coastal Region
Beaufort County	BEAUFORT	North
Town of Bath	BEAUFORT	North
Town of Washington Park	BEAUFORT	North
City of Washington	BEAUFORT	North
Town of Aurora	BEAUFORT	North
Town of Chocowinity	BEAUFORT	North
Town of Belhaven	BEAUFORT	North
Town of Pantego	BEAUFORT	North
Bertie County	BERTIE	North
Town of Windsor	BERTIE	North
Town of Colerain	BERTIE	North
Brunswick County	BRUNSWICK	South
Bald Head Island	BRUNSWICK	South
City of Southport	BRUNSWICK	South
Navassa	BRUNSWICK	South
Ocean Isle Beach	BRUNSWICK	South
Town of Belville	BRUNSWICK	South
Town of Boiling Spring Lakes	BRUNSWICK	South
Town of Bolivia	BRUNSWICK	South
Town of Calabash	BRUNSWICK	South
Town of Carolina Shores	BRUNSWICK	South
Town of Caswell Beach	BRUNSWICK	South
Town of Holden Beach	BRUNSWICK	South
Town of Leland	BRUNSWICK	South
Town of Northwest	BRUNSWICK	South
Town of Oak Island	BRUNSWICK	South
Town of Saint James	BRUNSWICK	South
Town of Sandy Creek	BRUNSWICK	South
Town of Shallotte	BRUNSWICK	South
Town of Sunset Beach	BRUNSWICK	South
Town of Varnamtown	BRUNSWICK	South
Camden County	CAMDEN	North
Carteret County	CARTERET	South
Indian Beach	CARTERET	South
Morehead City	CARTERET	South
Cedar Point	CARTERET	South
Cape Carteret	CARTERET	South
Bogue	CARTERET	South
Peletier	CARTERET	South
Newport	CARTERET	South
Beaufort	CARTERET	South
Emerald Isle	CARTERET	South
Pine Knoll Shores	CARTERET	South

Atlantic Beach	CARTERET	South
Chowan County	CHOWAN	North
Edenton	CHOWAN	North
Craven County	CRAVEN	South
New Bern	CRAVEN	South
Havelock	CRAVEN	South
River Bend	CRAVEN	South
Trent Woods	CRAVEN	South
Cove City	CRAVEN	South
Dover	CRAVEN	South
Vanceboro	CRAVEN	South
Currituck County	CURRITUCK	North
Dare County	DARE	North
Kitty Hawk	DARE	North
Southern Shores	DARE	North
Duck	DARE	North
Nags Head	DARE	North
Kill Devil Hills	DARE	North
Manteo	DARE	North
Gates County	GATES	North
Gatesville	GATES	North

Hertford County	HERTFORD	North
Murfreesboro	HERTFORD	North
Ahoskie	HERTFORD	North
Winton	HERTFORD	North
Hyde County	HYDE	North
Carolina Beach	NEW HANOVER	South
Kure Beach	NEW HANOVER	South
Wilmington	NEW HANOVER	South
Wrightsville Beach	NEW HANOVER	South
New Hanover County	NEW HANOVER	South
Onslow County	ONSLOW	South
Holly Ridge	ONSLOW	South
Jacksonville	ONSLOW	South
Richlands	ONSLOW	South
Swansboro	ONSLOW	South
Town of North Topsail Beach	ONSLOW	South
Onslow County	ONSLOW	South
Pamlico County	PAMLICO	South
Oriental	PAMLICO	South
Bayboro	PAMLICO	South
Vandemere	PAMLICO	South
Mesic	PAMLICO	South
Minnesott Beach	PAMLICO	South
Pasquotank County	PASQUOTANK	North
Elizabeth City	PASQUOTANK	North
Pender County	PENDER	South
Atkinson	PENDER	South
Burgaw	PENDER	South
Saint Helena	PENDER	South
Surf City	PENDER	South
Topsail Beach	PENDER	South

Watha	PENDER	South
Pender County	PENDER	South
Perquimans County	PERQUIMANS	North
Hertford	PERQUIMANS	North
Winfall	PERQUIMANS	North
Tyrrell County	TYRRELL	North
Columbia	TYRRELL	North
Washington County	WASHINGTON	North
Plymouth	WASHINGTON	North
Roper	WASHINGTON	North

Contact info not provided by DCM, and found online

Original - Replies to DCM

Region	# Cities	Responses
North	39	18
South	66	25

New - Replies to DCM/NCCF

Region	# Cities	Responses
North	39	20
South	66	38

Contact Name	Contact Title
Brandon Hayes	Lead Inspector
James Latham	Mayor
Washington Park Town Office	Office
Bobby Roberson	City Manager
Judy Lannon	Clerk
James Mobley	Mayor
Woody Jarvis	Town Manager
Bobbie Ricks	Town Manager
Chris Surgeon	Building Inspector
Allen Castelloe	Town Administrator
Colerain Town Office	Office
Kirstie Dixon	Planning Director
Chris McCall	Village Administrator
Bruce Oakley	City Manager
Navassa Town Office	Office
Justin Whiteside	Assistant Town Manager
Athina Williams	Town Clerk
Boiling Spring Lakes Town Hall	Inspections and Zoning Office
Bolivia Town Hall	Office
Chuck Nance	Town Administrator
Carolina Shores Town Hall	Office
Chad Hicks	Town Administrator
David Hewitt	Town Manager
Niel Brooks	Assistant Town Manager
Northwest Town Hall	Office
Rebecca Squires	Parks and Recreation Director
Gary Brown	Town Manager/Town Clerk
Sandy Creek Town Hall	Office
Robert Waring	Planning Director
Carey White	Chief Building Inspector
Varnamtown Town Hall	Office
Barbara Rhoads, P. E.	Building Inspector
Tracy Barnes	LPO (Limited Practice Officer?)
Linda Brickhouse	Deputy Town Clerk
Sandi Watkins	Planning and Inspections Director
Chris Seaberg	Town Administrator
Zach Steffey	Town Manager
Bogue Town Hall	Office
Peletier Town Hall	Office
Robert Will	Planning
Kyle Garner	Planning Director
Josh Edmondson	Town Planner
Jim Taylor	Building Inspector

Michelle Shreve	Planning Director
Holly Colombo	Chief Building Inspector, CAMA Officer LPO
Elizabeth Bryant	Director of Planning & Community Development
Chad Strawn	Planning and Inspections Assistant Director
Matt Boswell	Chief Building Inspector
Katrina Marshall	Planning Director
Allison McCollum	Zoning
Holly Willis	Town Clerk
Dred Mitchell, Jr	Mayor
John Percy Wetherington, Sr.	Mayor
Chad Braxton	Mayor
Laurie LoCicero	Planning Director
Donna Creef	Planning Director
Rob Testerman	Planning Director
Wes Haskett	Deputy Town Manager/Planning Director
Joe Heard	Director of Community Development
Andy Garman	Assistant Town Manager
Meredith Guns	Planning Director
Melissa Dickerson	Planner
Edgar Mitchell	Building Inspector
Elton Winslow	Mayor

Corrie Harrison	Permit Technician
Carolyn Brown	Town Administrator/Clerk
Ahoskie Town Hall	Office
Amanda Henderson	Town Clerk
Kris Noble	County Manager
Ed Parvin	Assistant Town Manager
Nancy Avery	Town Clerk
Adrienne Harrington	Permits
Tim Owens	Town Manager
Ken Vafier	Planning Manager
Angie Manning	Planning Manager
Carin Faulkner	Town Manager
Ryan King	Planning Director
Richlands Town Hall	Office
Andrea Correll	Planning Director
Deb Hill	Planning Director
Onslow Planning and Development	Planning and Development
Pamlico Building Inspections	Building Inspections
Diane Miller	Town Manager
Keith Cowell	Mayor
Tom Woodruff	Town Manager
Booker Jones	Mayor
Carolyn Braly	Town Manager
Shelley Cox	Planning Director
Stanley Ward	Director/Chief Building Inspector
Kyle Breuer	Planning Director
Margie Craver	Town Clerk
Burgaw Town Hall	Office
Mary Bakan	Village Clerk
Stephanie Hobbs	Assistant Town Manager
William Rivenbark	Inspections

Watha Town Hall	Office
Kyle Breuer	Planning Director
Rhonda Money	Planner
Hertford Town Hall	Town Manager
Fred Yates	Mayor
Joseph (Joie) Spencer	Chief Inspector
Rhett White	Manager
Ann Keyes	Planning Director
Plymouth Town Hall	Public Works Director
Roper Town Hall	Office

Percentage
46.2
37.9

Percentage
51.3
57.6

Contact Info	Response to DCM?	Followed Up?	Response?
brandon.hayes@co.beaufort.nc.us	Yes	N/A	N/A
townofbath@embarqmail.com	No	TRUE	FALSE
(252) 946-3157	No	FALSE	FALSE
broberson@washingtonnc.gov	No	TRUE	FALSE
aurora@embarqmail.com	No	TRUE	FALSE
townofchoco@suddenlinkmail.com	No	TRUE	FALSE
townmanager@belhavennc.us	No	TRUE	FALSE
(252) 943-2832	No	FALSE	FALSE
chris.surgeon@bertie.nc.gov	Yes	N/A	N/A
windsor.admin@mchsi.com	No	TRUE	FALSE
townofcolerain@mediacombb.net	No	TRUE	FALSE
kirstie.dixon@brunswickcountync.gov	No	TRUE	FALSE
cmccall@villagebhi.org	No	TRUE	TRUE
boakley@cityofsouthport.com		TRUE	TRUE
(910) 371-2432		FALSE	FALSE
justin@oibgov.com	Yes	N/A	N/A
townadministrator@townofbelville.com		TRUE	TRUE
rbek@cityofbsl.org		TRUE	FALSE
(910) 253-5303		FALSE	FALSE
tacalabash@atmc.net	No	TRUE	TRUE
910-575-4877		FALSE	FALSE
chicks@caswellbeach.org	No	TRUE	TRUE
david.hewitt@hbtownhall.com	Yes	N/A	N/A
nbrooks@townofleland.com	Yes	N/A	N/A
(910) 655-3110		FALSE	FALSE
rsquires@ci.oak-island.nc.us	Yes	N/A	N/A
gbrown@stjames.town		TRUE	FALSE
townofsandycreek1988@outlook.com		TRUE	FALSE
rwaring@townofshallotte.org	No	TRUE	TRUE
cwhite@sunsetbeachnc.gov	No	TRUE	TRUE
(910) 842-3095		FALSE	FALSE
brhoads@camdencountync.gov	Yes	N/A	N/A
tracyb@carteretcountync.gov	No	TRUE	FALSE
deputyclerk@indianbeach.org	No	TRUE	TRUE
Sandi.Watkins@moreheadcitync.org>	Yes	N/A	N/A
cdseaberg@cedarpointnc.org	No	TRUE	FALSE
zsteffey@capecarteret.org	Yes	N/A	N/A
(252) 393-3055	No	FALSE	FALSE
(252) 393-8666	No	FALSE	FALSE
rwill@townofnewport.com	No	TRUE	TRUE
k.garner@beaufortnc.org	Yes	N/A	N/A
jedmondson@emeraldisle-nc.org	Yes	N/A	N/A
biceo@townofpks.com	No	TRUE	FALSE

planner2@atlanticbeach-nc.com	Yes	N/A	N/A
holly.colombo@chowan.nc.gov	Yes	N/A	N/A
elizabeth.bryant@edenton.nc.gov	Yes	N/A	N/A
cstrawn@cravencountync.gov	Yes	N/A	N/A
boswellm@newbernnc.gov	Yes	N/A	N/A
kmarshall@havelocknc.us	Yes	N/A	N/A
zoning@riverbendnc.org	No	TRUE	FALSE
townclerk@trentwoodsnc.org	Yes	N/A	N/A
dcmitchelljr@gmail.com		TRUE	FALSE
mayorofdover@embarqmail.com	No	TRUE	FALSE
chadb@vanceboronc.com	No	TRUE	FALSE
laurie.loCicero@currituckcountync.gov	No	TRUE	FALSE
donnac@darenc.com	Yes	N/A	N/A
rob.testerman@kittyhawktown.net	No	TRUE	FALSE
whaskett@southernshores-nc.gov	Yes	N/A	N/A
jheard@townofduck.com	Yes	N/A	N/A
andy.garman@nagsheadnc.gov	No	TRUE	FALSE
meredith@kdhnc.com	Yes	N/A	N/A
dickerson@townofmanteo.com	Yes	N/A	N/A
emitchell@gatescountync.gov	Yes	N/A	N/A
mayorwinslow@hotmail.com	No	TRUE	FALSE

corrie.harrison@hertfordcountync.gov	Yes	N/A	N/A
cbrown@murfreesboronc.net	Yes	N/A	N/A
(252) 332-5146	No	FALSE	FALSE
townofwinton@gmail.com		TRUE	FALSE
knoble@hydecountync.gov	Yes	N/A	N/A
ed.parvin@carolinabeach.org	Yes	N/A	N/A
n.avery@townofkurebeach.org	No	TRUE	TRUE
adrienne.harrington@wilmingtonnc.gov	Yes	N/A	N/A
towens@towb.org	Yes	N/A	N/A
kvafier@nhcgov.com	Yes	N/A	N/A
Angie_Manning@onslowcountync.gov	No	TRUE	FALSE
(910) 329-7081		FALSE	FALSE
rking@jacksonvillenc.gov	No	TRUE	FALSE
(910) 324-3301		FALSE	FALSE
acorrell@ci.swansboro.nc.us	Yes	N/A	N/A
dhill@north-topsail-beach.org	Yes	N/A	N/A
(910) 455-3661		FALSE	FALSE
pcbi@pamlicocounty.org	Yes	N/A	N/A
Manager@TownOfOriental.com	Yes	N/A	N/A
townofbayboro@gmail.com	Yes	N/A	N/A
townofvandemere@gmail.com	No	TRUE	FALSE
bj739@embarqmail.com	No	TRUE	FALSE
missesottbeach.gov@gmail.com	Yes	N/A	N/A
coxs@co.pasquotank.nc.us	Yes	N/A	N/A
sward@cityofec.com	Yes	N/A	N/A
kbreuer@pendercountync.gov	Yes	N/A	N/A
atkinsontownclerk@yahoo.com		TRUE	TRUE
(910) 259-2151		FALSE	FALSE
sthelena@bizec.rr.com		TRUE	FALSE
shobbs@townofsurfcity.com	No	TRUE	TRUE
inspections@topsailbeach.org	No	TRUE	TRUE

(910) 552-6013		FALSE	FALSE
kbreuer@pendercountync.gov	Yes	N/A	N/A
rhondamoney@perquimanscountync.gov	No	TRUE	FALSE
manager@townofhertfordnc.com	No	TRUE	TRUE
fred@inteliport.com	No	TRUE	FALSE
joies@tyrrellcounty.net	Yes	N/A	N/A
rhett_townofcolumbia@yahoo.com	Yes	N/A	N/A
akeyes@washconc.org	No	TRUE	FALSE
publicworksdirector@visitplymouthnc.com	No	TRUE	TRUE
t.roper@mchsi.com	No	TRUE	FALSE

Building permit required for docks/piers/(and bulkheads)?	Ordinance
Yes	
Situationally Dependent	
Yes	
Yes	
No	
Yes	
Yes	
Yes	
Yes	
Yes	
Yes	
Yes	
Yes	
Yes	14-31 Accessory Uses or Buildings
Yes	
Yes	
Yes	
Yes	

Yes	
Yes	
Yes	Permits handled by Chowan County
Yes	
Yes	See Comments
Yes	
Yes	Permits handled by Craven County
Yes	
Yes	
Yes	
Yes	
Yes	
Yes	

Yes	
Yes	
Yes	
Yes	
Yes	
Yes	
Yes	
Yes	
Yes	
Yes	
Yes	
Yes	
No	
No	§ 151.217 CONSERVATION LAND CLASSIFICATION
Yes	
Yes	
Yes	
No	
Yes	

Yes	
Yes	
Yes	
Yes	
No	

Construction Standards?	Notes/Responses
No	they enforce Chapter 36 of the North Carolinas code. Beaufort County does not have
	the building code and would not require a permit. Once you reach the sizes that are
	the local district field representative in obtaining the required permit for the
	go by DCM's policies.
	Residential", "Boating Facility, Community", and "Pier, Residential, Private", but
	docks and piers would be zoning setbacks. We do not have any other "local" codes
No	regulations and require a CAMA permit.
	would be required by the floodplain regulations.
	Language on repairing an old dock/pier, but no information on building a new one
No	
No	NC Building Code requirements
	office.
No	Docks shall be built in accordance with the North Carolina State Building Code
Yes	have a 15 ft. setback requirement for piers and docks from the extended property lines
	govern the building or repair of residential docks and piers.
No	Street. Nothing covered.
No	NC Building Code requirements

Yes	Local requirements are that roofs are not permitted on docks/piers. Their inspections are done by Carteret County.
	Require a permit IF it does not meet the Exceptions listed in Section R327 of The NC Residential Building Code 2018 edition.
	Require a permit IF it does not meet the Exceptions listed in Section R327 of The NC Residential Building Code 2018 edition.
No	NC State Building Code requirements
	They follow guidance from the NC Dept. of Insurance. See memo from the Dept. Permit required if the structure exceeds the limitations in the exception of Section R327.1. The structure is required to be permitted and constructed in accordance with Chapter 36 of the NC Building Code. https://www.ncdoi.com/OSFM/Engineering_and_Codes/Documents/Interpretations5/2018%20Residential/R324%202018%20NCRC%20v1.pdf
No	
No	
No	Need to be sealed by an engineer
No	Building permits are required for bulkheads and may be required for docks and piers (according to new Building Code).
No	No additional construction standards beyond the NC Building Code and CAMA standards
No	Commercial building code covers pier construction in Chapter 36. Section 3602 covers the requirements of permits from various agencies. Residential piers and docks are required to meet the commercial codes of chapter 36 however, residential code R237 includes information for residential piers and docks that creates exceptions for not having to meet the requirements of chapter 36 of the commercial code...If a building can demonstrate that their project meets the requirements of the exception, a building permit is not required. If it does not meet ALL of the items on the checklist, a permit and inspections are required as well as drawings from a registered design professional. Exemption form from DOI covers both fixed piers as well as floating docks. This exception is for residential piers/docks only. Commercial piers/docks require permits and inspections.
	Require engineered plans and CAMA permit to consider the building permit application complete. Fee schedule provided in email.
No	See Chapter 36 pertaining to pier & docks.

	Hertford County issues a Flood Plain Development Permit along with any Building/Trades permit required for the work. Hertford County uses the NCBC Chapter 36 Docks, Piers, Bulkheads and Waterway Structures.
	The Town gives the zoning permit, but the county gives the building permit.
	The Town does not issue building permits. The Hertford County Building Inspector enforces the Town zoning ordinances and would issue the permit. You may reach their office at 252-358-7814
No	Utilize state building code for construction
	Considering a bulkhead ordinance
	We are an Ocean Hazard community only. No rivers, estuaries, or canals. Only pier we have is Kure Pier with no additional regulations except for building code and CAMA.
	Special Use Permit may be required
No	NC Building Code, Chapter 36
No	Defer to CAMA and County (State) building code and do not impose any other additional requirements when building at the water's edge
No	They do not require an additional permit for piers, docks or bulkheads. The Town's Code of Ordinances § 151.217 CONSERVATION LAND CLASSIFICATION governs this type of work.
No	
No	
No	As far as the Town of Atkinson goes, there are none. I am pretty sure all of those regulations would be with the county or State.
	The Town of Surf City has a flood damage prevention ordinance locally. All construction and/or permitting is regulated by the state building code.
	Yes, we have a beach access ordinance and also require permits for piers and docks per local ordinance.

No	I just send landowners to the local CAMA office in Elizabeth City to get one of their permits.
	When building a deck or pier, we follow CAMA guidelines. Applicant has to submit a permit to build.
No	Requires building permits for docks and piers but not bulkheads. Enforces NC State Building Code for docks and piers.
No	Defer to DCM
	We adhere to the County's building code and permitting that pertains to docks & piers. I believe that they follow NC State building codes for this.

Zoning Ordinance

Memo

Chapter 36 DOCKS, PIERS, BULKHEADS AND WATERWAY STRUCTURES

STATE AMENDMENT

Section 3601 GENERAL AND SCOPE

STATE AMENDMENT

3601.1 General

STATE AMENDMENT

The intent of this chapter is to provide minimum standards for the design, construction and maintenance of *docks, piers, bulkheads*, and waterway structures. The guidelines in this chapter address minimum standards for foundations, design forces, structural integrity, material selection and utilization and construction techniques.

3601.2 Scope

STATE AMENDMENT

The following structures shall be designed in accordance with the requirements of this chapter:

1. *Docks, piers, gangways*, and *catwalks*, other than residential and farm docks and piers exempted from this chapter in the exceptions below, shall be designed by a registered design professional.
2. All *bulkheads* having an exposed height greater than 5 feet or with a superimposed load shall be designed by a registered design professional and require special inspection. Special inspection shall be waived for bulkheads of any height constructed from property line to property line of one- or two-family dwellings and including attachment to neighboring *bulkheads*.
3. Oceanfront retaining walls, *bulkheads* and other types of retaining walls used by the public on the coastline of the ocean or adjacent inlets shall be designed by a registered design professional.
4. Marine terminal or port facilities for berthing, mooring, docking and servicing ships, barges, or tug boats that handle cargo of all types, including bulks, containers, liquids, fuels, and people, which shall be designed by a registered design professional in accordance with accepted industry standards.
5. Groins not exempted below, jetties, breakwaters, oceanfront seawalls, and oceanfront revetments shall be designed by a registered design professional in

accordance with accepted industry standards.

Exceptions: The following structures are exempt from the requirements of this chapter:

1. Sill structures combined with marsh plantings and certain groins in accordance with the Department of Environmental and Natural Resources general permit requirements.

2. Oceanfront and inlet sandbag revetments in accordance with the Department of Environmental and Natural Resources general permit requirements.

3. Revetments constructed on single family residential property having a height no greater than 10 feet and slope greater than 1.5 horizontal: 1.0 vertical and in accordance with the Department of Environmental and Natural Resources general permit requirements.

4. Farm structures not on public waters.

5. *Piers* and *docks* associated with one- or two- family dwellings meeting the exceptions of the *North Carolina Residential Code*.

Section 3602 DEFINITIONS

STATE AMENDMENT

ADDITIVES. Substances added to a polymer resin or vinyl chloride material to aid in processing the material.

BOAT SLIP. A berthing place for one or two watercraft where the watercraft can be securely moored to cleats, piling, or other devices while the boats are in the water. Boat slips are commonly configured as “side-ties” or as single- or double-loaded “U” shaped berths.

BULKHEAD. A vertical wall structure designed to retain shoreline material and prevent erosion due to wave activity. CATWALK. A narrow footway platform extending alongside a structure.

DESIGN WAVE. A design wave that is potentially most damaging to an economically feasible structure, or wave for which a structure is designed.

DOCK. A structure extending alongshore or out from the shore into a body of water, usually accommodating multiple boat slips, to which boats may be moored in order to load or unload people or cargo.

EXTRUSION. Manufacturing process whereby a material is pushed through a die to form a shape of constant cross section. Vinyl Chloride sheet piling is generally manufactured using an extrusion process.

FETCH. Open water exposure over which waves are generated.

FIBER. One or more glass, carbon, or aramid filaments in the form of a continuous strand or roving in an *FRP* material.

FIBER ARCHITECTURE. Construction of a composite material from layers with different types and orientations of fibrous material.

FIBER ORIENTATION. Fiber orientation is the alignment of the longitudinal axis of a fiber in an *FRP* material with respect to the stated reference axis.

FIBER REINFORCED POLYMER (*FRP*). A composite material which consists of a polymer resin based matrix reinforced with fibers of glass, carbon, aramid, or hybrid combinations of these fiber types.

FIBER VOLUME FRACTION. The volume of reinforcement fiber in a cured composite divided by the volume of the composite section.

FILLER. Substance added to the matrix of a *FRP* material intended to alter its engineering properties, performance, or cost.

GANGWAY. A footway bridge extending from the *dock, pier, bulkhead*, or shore, usually to a floating structure.

GLASS TRANSITION TEMPERATURE (Tg). Temperature at which the polymer matrix of an *FRP* material changes from a glassy state to a rubbery state.

KING PILE. The primary structural member that supports horizontal panels to form a vertical wall sometimes used in *bulkhead* or groin construction.

LAMINA. A layer of fibers and resin in an *FRP* material.

MATERIAL LONGITUDINAL DIRECTION. Direction in an *FRP* material parallel to the direction of pultrusion (pulling) during the manufacture of a plate or structural shape.

MATERIAL TRANSVERSE DIRECTION. Direction in an *FRP* material orthogonal to the longitudinal direction.

MATRIX. Continuous constituent of an *FRP* material surrounding the reinforcing fibers and consisting of a polymer resin with any fillers and additives.

PIER. An elevated deck structure, usually pile supported, extending out into the water from the shore.

PILE. A timber, concrete, metal, or composite member embedded into the ground to support or brace a structure. "Piles" or "piling" are plural forms of "pile."

PRIVATE WATERFRONT STRUCTURES. A *dock, pier, bulkhead*, or associated structure not open to the general public and with no more than ten total boat slips and no more than ten owners.

PUBLIC WATERFRONT STRUCTURES. A *dock, pier, bulkhead*, or associated structure located on *multifamily* residential property (greater than ten *dwelling units*), public property or commercial property.

PULTRUSION. Manufacturing process whereby a material is pulled through a die to form a shape of constant cross section. *FRP* plates and structural shapes are generally manufactured using a pultrusion process.

RESIN. An organic polymer possessing indefinite and often high molecular weight and a softening or melting range that exhibits a tendency to flow when subjected to stress.

REVETMENT. A sloping structure usually constructed of stone or concrete and placed on a shoreline to protect it against erosion by wave and current action.

ROVING. In an *FRP* material, a roving is a large number of continuous parallel filaments or a group of untwisted parallel strands.

SHEET PILE. A pile with a generally slender flat cross section to be embedded into the ground or seabed and meshed or interlocked with like members to form a diaphragm, wall, or *bulkhead*.

SYMMETRIC COMPOSITE. A symmetric composite is a composite material in which the sequence of lamina below the laminate mid-plane is a mirror image to those above the laminate mid-plane.

Section 3603 PERMITS AND APPROVALS

STATE AMENDMENT

3603.1 General

STATE AMENDMENT

In addition to a building permit, permits may be required from federal, state, or county agencies such as the United States Army Corps of Engineers or the North Carolina Department of Environmental and Natural Resources. In cases of structures to be built on lakes operated by an electric utility for the generation of power, a permit from the operating utility may also be required.

Section 3604 MINIMUM DESIGN LOADS

STATE AMENDMENT

3604.1 General

STATE AMENDMENT

Every structure shall be of sufficient strength to support the imposed dead, live, snow, wind, impact, and seismic loads without exceeding the prescribed stresses for the various materials described elsewhere in this code. Adequate consideration shall be made for forces imposed by earth, water, docking, and mooring.

3604.2 Dead loads

STATE AMENDMENT

The weight of the component parts of a structure shall be used in the design when it will influence the strength of the structural elements. All utilities, permanent furniture, dock boxes, and mooring hardware should be considered as dead load.

3604.3 Live loads

STATE AMENDMENT

Design live loads shall be the greatest load that will likely be imposed on the structure, including superimposed loads on retained material that exert horizontal loads on the structure. Where vehicles are allowed, actual weight of vehicles and wheel loads as specified in the latest edition of Standard Specifications for Highway Bridges of the American Association of State Highway and Transportation Officials or obtained from the vehicle manufacturer shall be used. The design load shall be posted at the *dock* or *pier* approach where vehicles are allowed. Minimum live loads are:

1. Fixed *piers, docks, catwalks* - Private waterfront piers: 40 psf or 300 pounds concentrated load on any area 2 foot square. Public waterfront piers: Design loads shall be the greatest combinations of loads exerted on the structure but not less than 60 psf.

2. Floating *docks* - Private waterfront *docks*: 20 psf, public waterfront *docks*: 30 psf, or 300 pounds concentrated load on any area 2 feet square. Under dead and live load, all floating docks shall have a minimum of 3 inches freeboard from the top of the flotation device, other than low freeboard watercraft (e.g. kayak) launching facilities. All floating *docks* subject to this chapter shall have not more than 5 degrees tilt from the horizontal under uniform live loading on one-half of the dock width or under concentrated load of 400 pounds applied within 12 inches of any side.

3. *Gangways - Gangways* shall be designed for a live load of 100 psf. Flotation for gangway landing shall be designed for 50 psf, live load.

4. *Bulkheads, revetments* - Design loads shall be the greatest combinations of loads exerted on the structure. Consideration shall be given to horizontal loads exerted by superimposed loads on the retained earth and by inclined surface slopes. Superimposed loads shall be considered when exceeding 50 psf and located within a horizontal distance of three times the height of the *bulkhead* from the face of the *bulkhead*.

3604.4 Snow loads

STATE AMENDMENT

Design snow loads shall be as prescribed in Chapter 16.

3604.5 Wind loads

STATE AMENDMENT

Design wind loads shall be as prescribed in Chapter 16 without moored vessels. In wind regions with a design wind speed greater than 90 mph, the design wind speed shall be no less than 90 mph (3 second gust). This gust wind speed shall be adjusted for duration and height (not restricted to 15 feet minimum) for wind pressures applied to vessels moored at the facility in accordance with Chapter 16.

3604.6 Impact loads

STATE AMENDMENT

Design impact loads shall be as prescribed in Chapter 16 but not less than 1.25 times the kinetic energy exerted by a striking vessel or vehicle.

3604.7 Seismic loads

STATE AMENDMENT

Design seismic loads shall be as prescribed in Chapter 16. Seismic loads are not applicable for any structure exempted from design by a registered design professional.

3604.8 Water loads

STATE AMENDMENT

Hydrostatic and hydrodynamic loadings shall be considered as follows:

3604.8.1 Hydrostatic pressures

STATE AMENDMENT

Hydrostatic pressures shall be considered in conjunction with the equivalent fluid pressure of soil and any surcharge acting on the structure. For *bulkheads*, hydrostatic pressures shall be estimated based on maximum difference between retained and offshore water surface elevations.

3604.8.2 Current loads

STATE AMENDMENT

Current loads for structures and vessels shall be determined from records on current velocity using accepted engineering practice.

3604.8.3 Anchorage for uplift

STATE AMENDMENT

Sufficient anchorage against uplift between all components, except elements specifically designed to break away, shall be provided. Resisting forces shall be not less than 1.5 times the applied uplift force.

3604.8.4 Wave forces

STATE AMENDMENT

Wave forces shall be determined from wave records where available. Where no wave records are available, the design wave shall be determined from probable wind speed, direction, fetch, and water depth that will yield a critical wave. Forces shall then be calculated using accepted engineering practice.

3604.8.5 Forces due to passing vessels

STATE AMENDMENT

All *piers* and floating *docks* shall be designed for water loading generated by wind and passing vessels. Adjacent to federal designated channels, water loading shall be based on commercial and recreational vessels with minimum passing speeds of 10 and 20 knots, respectively.

3604.9 Earth loads

STATE AMENDMENT

Lateral earth pressures shall be determined by considering the specific soil properties and applying earth pressure theories generally accepted for soil mechanics in engineering practice. A geotechnical investigation or other adequate consideration shall be given by the registered design professional for the effect of probable varying levels of retained water, tide, and flood water. Pressures exerted by the earth shall be checked for dry, moist, and saturated conditions as applicable.

3604.10 Erosion

STATE AMENDMENT

The effects of reasonably predictable erosion, propeller wash-induced scour, and wave-induced scour shall be given ample consideration.

3604.11 Water levels

STATE AMENDMENT

The ability to accommodate dead, live, wind, current, and wave loadings for the range of water levels (from low water to base flood level) anticipated at the site shall be given consideration. For public and private floating *docks*, guide piling systems shall be capable of accommodating water levels extending a minimum of 2 feet above base flood elevation plus the freeboard of the dock structure.

Section 3605 MATERIALS

STATE AMENDMENT

3605.1 General

STATE AMENDMENT

The quality of materials and fasteners used for load-supporting purposes shall conform to *acceptable engineering practice*.

3605.2 Piling and foundations

STATE AMENDMENT

Materials used for piling and repairing piling shall comply with applicable provisions of Chapter 18 and the material requirements of Sections 3605.3 through 3605.7.

3605.2.1 Helical anchors

STATE AMENDMENT

Helical anchors shall be hot-dip galvanized. A representative number of helical anchors subjected to tensile loading shall be load tested in accordance with ASTM D 3689 to two times their design load capacity. Load testing of anchors in tension shall include creep testing of a representative number of the anchors. Helical anchors shall be designed and installed as determined by a registered design professional.

3605.3 Wood

Wood shall be pressure treated with a preservative recommended by the American Wood Preserver
application. Wood species, preservative treatment, minimum lumber size, and lumber grade shall be
Handrails, guardrails, wallcaps, and decking may be constructed of naturally durable species where
water mark.

TABLE 3605.3
SPECIFICATONS FOR SOUTHERN PINE[2] LUMBER IN FRESH AND SALT WATER SERVI

SPECIFICATONS FOR SOUTHERN PINE LUMBER IN FRESH AND SALT WATER SERVI

LOCATION	COMPONENT	AWPA USE CATEGORY[1, 4]		DIMENSIONS	LUMBER G
		Saltwater	Freshwater		Saltwater
Above normal high water	Decking[3]	3B	3B	5/4″ 2″ Nominal Min.	Premium No. 2
	Guardrails	3B	3B	2″ Nominal Min.	No. 2
	Wallcaps	3B	3B	2″ Nominal Min	No. 2
	Walers	3B	3B	4 x 6 Nominal	No. 2
	Cross bracing	3B	3B	2″ to 4″ Nominal	No. 2
Splash zone	Split pile caps	4B	4B	2″ to 4″ Nominal	No. 2
	Stringers	4B	4B	2″ Nominal	No. 2
Below normal high water	Sheet piles	5B	4C	2″ to 4″ Nominal	Marine No. 1[7]
	Walers	5B	4C	4 x 6 Nominal	Marine No. 1[7]
	Cross bracing	5B	4C	2″ to 4″ Nominal	Marine No. 1[7]
	Rectangular timber piles	Not Allowed[6]	4C	6 x 6 Nominal	Not allowed[6]
	Round timber piles	5B[6]	4C	ASTM D 25	ASTM D 25
Engineered lumber	Glulam timber	5B	4B	4″ Nominal Min.	Note 5
	Parallel strand lumber	5B	4B	3½″ Nominal	1.8E or better

	strand lumber				

1. Lumber shall be pressure treated with preservative treatment in accordance with AWPA U1.
2. At the discretion of the building official, lumber species other than Southern Pine may be approve conditions are submitted, and the lumber is treated for comparable service life to the treatment s 3605.1.
3. Wood composite decking, treated or untreated, shall provide equivalent service life to the treated
4. All notches, holes, and field cuts shall be field treated in accordance with AWPA M4.
5. Glulam grade shall be specified as a layup combination or stress class in accordance with the Natic manufacturer's published data. Layup combinations shall consist of species and grades capable of equivalent to the AWPA use categories specified in Table 3605.1.
6. Commercial pile wraps may be used to extend the life expectancy of timber piles exposed to marir
7. AWPA requirements for Marine No. 1 specify that no heartwood be exposed on any face prior to p

3605.3.1 Wood connections

STATE AMENDMENT

All steel bolts, rods, and other hardware shall be hot-dip galvanized or protected with an equivalent system. All bolts, rods and other metal materials shall be no smaller than ⅝ inch in diameter. Beams, girders, or pile caps shall be attached to the piling with a minimum of two ⅝-inch hot-dip galvanized steel bolts per beam member through bolted at each piling connection. Piling shall not be notched so that the cross-section is reduced below 50 percent. Threaded fasteners shall not be tightened directly against wood surfaces but used only in conjunction with standard ogee or flat washers. Cold formed metal connectors shall not be used in wet applications or applications subject to wetting and drying cycles. Mooring hardware, including cleats, and pile guides shall be through bolted using sizes recommended by the manufacturer.

3605.4 Concrete

STATE AMENDMENT

Concrete components shall comply with applicable provisions of Chapter 19 and ACI 318. Minimum concrete strength, air entrainment, maximum chloride content, and maximum water cement ratio shall be determined from ACI 318 on the basis of required structural strength, required resistance to freeze-thaw exposure, required abrasion resistance, and required resistance to water penetration and salt water intrusion. Minimum concrete cover shall be increased and reinforcing steel spacing shall be decreased in accordance with ACI 350, to reduce crack size. All steel embedments, other than reinforcing steel, shall be stainless, hot-dip galvanized, or coated for corrosion protection. Field welds and abrasions of coatings on embeds shall be touch coated in the field.

3605.5 Structural steel

STATE AMENDMENT

Steel components shall comply with applicable provisions of Chapter 22 and AISC 360. All structural steel members, fasteners, and fittings shall be protected from corrosion by coating or cathodic protection for the specific exposure. Steel bulkhead components and dock components shall be hot-dip galvanized or coated to achieve the corrosion protection required for the degree of exposure of corrosive elements. Field welds and abrasions to coatings shall be touch coated after erection or installation is completed. Cold formed metal joists, girders, columns, and studs shall not be used in applications where the members are constantly wet or subject to wetting and drying cycles.

3605.6 Aluminum

STATE AMENDMENT

Aluminum *bulkhead* sheets or aluminum *bulkhead* or *dock* components shall be of proper alloy to resist corrosive elements in the adjacent water and soil. Bulkhead components and hardware shall be aluminum or stainless steel. Aluminum shall be galvanically and physically isolated from concrete and galvanically isolated from steel. Connection hardware and fasteners for aluminum components may be stainless steel or galvanized steel if isolated from aluminum structural elements.

3605.7 Plastics and composites

STATE AMENDMENT

Bulkheads, structural shapes, plates, and guardrail systems manufactured from vinyl chloride based materials or fiber reinforced polymer (FRP) materials shall be designed to comply with manufacturer's published load tables or manufacturer's published mechanical properties subject to the requirements for specific materials in Sections 3605.7.1, 3605.7.2, and 3605.7.3. Plastic and composite members shall contain additives to inhibit ultraviolet radiation degradation or shall be protected from ultraviolet radiation by an *approved* coating.

3605.7.1 Sheet piling manufactured from vinyl chloride based materials

STATE AMENDMENT

Vinyl chloride materials for sheet piling shall be specified and tested for conformance in accordance with ASTM D4216, including weathering tests in accordance with ASTM D1435. Mechanical properties shall be established in accordance with the tests specified in Table 3605.7.1. Design values of the tabulated properties shall conform to the limiting values specified in the table. The manufacturer of the sheet piling shall produce a certificate of analysis from a third party testing agency certifying the vinyl chloride material from which the sheet piling is manufactured conforms to the physical properties specified. The third party testing agency shall be accredited in accordance with ISO 17025 to conduct the specified tests. Testing programs shall address changes in material sources and composition over time, and test data shall accurately represent the properties of the product produced at any given time.

TABLE 3605.7.1
LIMITATIONS ON MECHANICAL PROPERTIES FOR VINYL CHLORIDE BASED SHEET PILING

MECHANICAL PROPERTY	TEST PROTOCOL	LIMITATIONS ON PROPERTY
Notch impact resistance	ASTM D 256	2.0 ft-lb./in minimum
Drop dart impact resistance, Procedure A	ASTM D 4226	1.0 in-lb./mil minimum
Drop dart impact resistance, Procedure B	ASTM D 4226	2.0 in-lb./mil minimum
Tensile strength	ASTM D 638	6,500 psi minimum
Modulus of elasticity in tension	ASTM D 638	377,000 psi minimum
Deflection temperature under 264 psi	ASTM D 648	158 psi minimum
Linear coefficient of expansion	ASTM D 696	4.4 x 10^{-3} in/in/°F maximum

3605.7.1.1 Deflection of vinyl chloride based sheet piling

STATE AMENDMENT

Deflection of vinyl sheet pile bulkheads shall not exceed the lesser of $^1/_{60}$ times the height from the mud line to the top of the wall or 2 inches. Effects of in-service temperatures exceeding 80°F on modulus of elasticity shall be considered in deflection calculations and selection of materials.

3605.7.1.2 Service stresses for vinyl chloride based sheet piling

STATE AMENDMENT

Service load stresses in the vinyl sheet piling shall not exceed 3,200 psi.

3605.7.1.3 Ultraviolet light stabilization

STATE AMENDMENT

Vinyl chloride based materials shall be compounded with stabilizing agents. Addition of stabilizers during the extrusion process is prohibited.

3605.7.1.4 Impact resistance of vinyl materials

STATE AMENDMENT

Vinyl sheet pile bulkheads shall have sufficient impact resistance, determined in accordance with ASTM D 256 and ASTM D 4226, to resist impact from vessels traveling at mooring speeds, resist wave impact when installed in high velocity flood zones (V-Zones on Flood Insurance Rate Maps), and to resist impact from debris likely to collide with the *bulkhead* at flood stage or in areas subject to storm surge.

3605.7.1.5 Fire, smoke, and toxicity

STATE AMENDMENT

Vinyl materials shall be tested for the in-service thickness in accordance with ASTM D 635 with a resulting burning rate of 2½ inches per minute or less.

3605.7.2 Pultruded fiber reinforced polymer (*frp*) sheet piling, shapes and plates

STATE AMENDMENT

Mechanical properties for FRP structural components shall be established in accordance with the tests specified in Table 3605.7.2. Each manufacturer shall publish the characteristic values for the product in accordance with ASTM D 7290. The manufacturer of the *FRP* shall produce a certificate of analysis certifying the *FRP* material and constituent materials from which the *FRP* components are manufactured conform to the physical properties specified. Testing programs shall address changes in material sources and composition over time, and test data shall accurately represent the properties of the product produced at any given time. Manufactured components shall be inspected in the plant in accordance with ASTM D 3917 for dimensional tolerances and according to ASTM D 4385 for visual defects. Inspection reports shall be provided.

TABLE 3605.7.2
LIMITATIONS ON PHYSICAL AND MECHANICAL PROPERTIES FOR FIBER REINFORCED POLYMER COMPONENTS[1]

PROPERTY	ASTM TEST METHOD	MINIMUM NUMBER OF TESTS
Barcol hardness	D 2583	5
Glass transition temperature T_g	D 4065	5
Coefficient of thermal expansion	D 696	5
Moisture equilibrium content	D 570	5
Longitudinal tensile strength	D 638	10
Transverse tensile strength	D 638	10
Longitudinal tensile modulus	D 638	10
Transverse tensile modulus	D 638	10
Longitudinal compressive strength	D 6641	10
Transverse compressive strength	D 6641	10
Longitudinal compressive modulus	D 6641	10

modulus		
Transverse compressive modulus	D 6641	10
Longitudinal flexural strength	D 790	10
Transverse flexural strength	D 790	10
Longitudinal flexural modulus	D 790	10
Transverse flexural modulus	D 790	10
In-plane shear strength	D 5379	10
In-plane shear modulus	D 5379	10
Inter-laminar shear strength	D 2344	10
Longitudinal pin bearingstrength	D 953[2]	10
Transverse pin beariang strength	D 953[2]	10
Pull through strength per fastner *t* = ⅜″ *t* = ½″ *t* = ¾″	D 7332, Proc. B	10

1. Property requirements for shapes apply to sheet piles.
2. Tests shall be conducted for material thicknesses, *t*, tabulated and bolt sizes from ⅜ inch to 1 inch in diameter. No more than one third of the bolt shank within the thickness of the connection material may be threaded. Bolts shall be installed snug tight.

3605.7.2.1 Maximum service temperature

STATE AMENDMENT

Service temperature of FRP structural components shall not exceed T_g-40°F, where T_g is the glass transition temperature determined in accordance with ASTM D 4065.

3605.7.2.2 *FRP* constituent materials

STATE AMENDMENT

Fibers and matrix constituents shall comply with the following requirements:

3605.7.2.2.1 Fiber type

STATE AMENDMENT

Fibers shall be glass, carbon, aramid, or hybrid combinations of these fiber types. Glass fibers shall conform to ASTM D 578.

3605.7.2.2.2 Fiber architecture and content

STATE AMENDMENT

The fiber architecture of any pultruded element comprising the cross section of a pultruded *FRP* structural member shall be symmetrical and balanced. Each pultruded *FRP* structural element shall contain a minimum total fiber volume fraction of 30 percent.

3605.7.2.2.3 Fiber orientations

STATE AMENDMENT

Each element of a pultruded *FRP* structural member shall have fibers oriented in a minimum of two directions separated by a minimum of 30 degrees. In the direction of the longitudinal axis of the member, the percentage of continuous fiber in each pultruded element shall be a minimum of 30 percent of the total fiber reinforcement by volume for shapes and a minimum of 25 percent of the total fiber reinforcement by volume for plates. When multiple elements share a common edge in the direction of pultrusion, at least 50 percent of the nonroving reinforcement in the element having the largest percentage of nonroving reinforcement shall extend through the junction connecting the elements.

3605.7.2.2.4 Minimum fiber tensile strength

STATE AMENDMENT

Determined in accordance with ASTM D 7290, the characteristic value of the tensile strength of the fiber strands, yarns, and rovings shall be at least 290,000 psi. Tensile tests shall be conducted in accordance with ASTM D 2343.

3605.7.2.2.5 Resin

STATE AMENDMENT

A commercial grade thermoset resin shall be used for fabricating pultruded *FRP* structural members.

3605.7.2.2.6 Other constituent materials

STATE AMENDMENT

Additives to the resin system that influence processing or curing, such as fillers, promoter, accelerators, inhibitors, UV-resistant agent, and pigments shall be compatible with the fiber and resin system.

3605.7.2.3 Durability and environmental effects

STATE AMENDMENT

Materials for *FRP* structural components shall be selected, designed, and manufactured to tolerate long-term environmental effects anticipated during the service life of the structure.

3605.7.2.3.1 Factors considered in material selection

STATE AMENDMENT

The following factors shall be considered in selecting *FRP* materials for marine structures:

a. Performance criteria for the structure;

b. Intended service life of the structure;

c. Expected environmental conditions, including likelihood of exposure to alkalis or organic solvents;

d. Protective measures; and

e. Feasibility of maintenance and repair during service.

3605.7.2.3.2 Adjustment of material properties to account for environmental effects

STATE AMENDMENT

Unless the glass transition temperature determined in accordance with ASTM D 4065 and the tensile strength of the composite in the longitudinal and transverse directions determined in accordance with ASTM D 638 can be shown to retain at least 85 percent of their characteristic values after conditioning in the environments listed below, the nominal strength and stiffness shall be reduced for design purposes in accordance with test data produced from testing simulating the anticipated environment. Materials that cannot retain at least 15 percent of their characteristic values after conditioning the listed environments are prohibited in structural applications. Design tensile strength shall be reduced in accordance with material specific tests when in-service temperatures exceed of 90°F. Condition test samples as follows:

a. Water: Samples shall be immersed in distilled water having a temperature of 100 ± 30°F and tested after 1,000 hours of exposure.

b. Alternating ultraviolet light and condensing humidity: samples shall be exposed according to Cycle No. 1 (0.89 W/m^2/mm, 8 hours UV at 60°C, 4 hours condensation at 50°C) using UVA-340 lamps in an apparatus meeting the requirements of ASTM G 154. Samples shall be tested within two hours after removal from the apparatus.

3605.7.2.4 Impact resistance of FRP materials

STATE AMENDMENT

FRP sheet pile *bulkheads* shall have sufficient impact resistance, determined in accordance with ASTM D7136, for the intended application.

3605.7.2.5 Deflection of FRP sheet piling

STATE AMENDMENT

Deflection of vinyl sheet pile *bulkheads* shall not exceed the lesser of $^1/_{60}$ times the height from the mud line to the top of the wall or 2 inches. Effects of in-service temperatures in excess of 90°F on modulus of elasticity shall be considered in deflection calculations.

3605.7.2.6 Fire, smoke, and toxicity

STATE AMENDMENT

FRP materials shall be tested for the in-service thickness in accordance with ASTM D 635 with a resulting burning rate of 2½ inches per minute or less.

3605.7.3 Carbon fiber reinforced polymer repair products

STATE AMENDMENT

Carbon fiber reinforced plate and wrap used for flexural and shear reinforcement of existing concrete structures shall be designed in accordance with the design procedures specified in ACI 440.2R. Mechanical properties of carbon fiber reinforced plate and wrap shall be established in accordance with the tests specified in ACI 440.3R.

3605.8 Masonry

STATE AMENDMENT

Masonry used in *bulkheads* and *dock* work shall comply with Chapter 21.

Section 3606 CONSTRUCTION OF PIERS, DOCKS, CATWALKS, GANGWAYS, AND FLOATING DOCKS

STATE AMENDMENT

3606.1 Fixed piers

STATE AMENDMENT

Fixed *piers* shall be constructed in accordance with Sections 3606.1.1 through 3606.1.4.

3606.1.1 Required depth of piles

STATE AMENDMENT

Fixed *piers* shall be supported by pilings with tip penetrations dependent on the soil conditions and the total applied load. *Piers* support by shallow piling, legs or columns with point bearing on rock shall have provisions to resist horizontal forces and overturning, as well as flotation uplift. *Piles* shall be installed in accordance with the requirements of Chapter 18 and inspected in accordance with the requirements of Chapter 17.

3606.1.2 Structural steel and concrete members

STATE AMENDMENT

Structural steel members shall be designed in accordance with AISC 360, Chapter 22 of this code, and the material requirements of this chapter. Concrete members shall be designed in accordance with ACI 318, Chapter 19 of this code, and the materials requirements of this chapter.

3606.1.3 Size of wood piles

STATE AMENDMENT

Piles shall be sized in accordance with the American Wood Council National Design Specification. In no case shall round timber piles be less than 7 inches in diameter at the butt and have a minimum tip diameter of less than 5½ inches. Rectangular timber piles shall not be less than nominal 6 inches by 6 inches.

3606.1.4 Bracing of wood piles

STATE AMENDMENT

Where required by design, bracing shall be sized to limit stresses in the piles from lateral loads in accordance with the American Wood Council National Design Specification to prevent buckling.

3606.1.5 Wood girder and joist spans

STATE AMENDMENT

Maximum spans for *pier pile* caps or girders and joists or stringers shall be determined in accordance with the American Wood Council National Design Specification considering the member to be subject to wet use.

3606.1.6 Connections

STATE AMENDMENT

Connections between *piling* or legs to *pile* caps, stringers, beams, bracing and deck shall have sufficient capacity to safely support all applied loads and provide transfer of load to adjoining members.

3606.1.7 Gangways

STATE AMENDMENT

On coastal waterways, the maximum slope permitted shall be 3:1 at 0.0 mean low water or above and 2½:1 below 0.0 mean low water. On lakes and other inland waters, the maximum slope shall be 3:1 not less than 90 percent of the time and 2½:1 not more than 10 percent of the time.

3606.2 Flotation units

STATE AMENDMENT

Flotation units shall be foam-filled encapsulated floats or polystyrene billets securely wrapped with Class I woven geotextile fabric in accordance with AASHTO M288. The use of metal barrels not specifically designed for use as flotation devices and unwrapped polystyrene billets are prohibited.

3606.3 Electrical service

STATE AMENDMENT

All electrical service to marine structures shall be in accordance with the *North Carolina Electrical Code*.

3606.4 Fire protection

STATE AMENDMENT

All fire protection for marine structures shall be in accordance with applicable provisions of the *North Carolina Fire Prevention Code*.

3606.5 Fuel docks

STATE AMENDMENT

Fuel *docks* and other marine facilities handling flammable liquids shall comply with the *Flammable* and *Combustible Liquids Code*, NFPA 30 and the *North Carolina Fire Prevention Code*. All fuel installations shall be designed to prevent fuel spillage from entering the water. The fuel *docks* or floats shall be isolated to the extent that fire or explosion would have minimal opportunity to spread to or from the fuel *dock* to the berths. Storage tanks for public facilities shall be located a minimum distance of 50 feet from the dispenser with a shutoff valve at the tank.

3606.6 Guardrails

STATE AMENDMENT

For walkways, access piers, steps, or ramps, guardrails or other safety provisions shall be provided along the edges where the vertical drop to the lesser of the mean low water level, normal low water level (sounds), normal pool (lakes and rivers), or mud line exceeds 6 feet. Edges having a primary function other than walks or access ways, such as docking frontage and swimming access shall not require guardrails. Guardrails shall be designed in accordance with Chapter 16 for balconies. Guardrails shall be a minimum of 42 inches high and shall prevent the passage of a 21-inch sphere except where required otherwise by Chapter 11. Edge protection shall be provided as required by other rules.

> **Exception**: For private waterfront *piers* and *docks*, guardrails or other safety provisions shall be provided along the edges where the vertical drop to the lesser of the mean low water level, normal low water level (sounds), normal pool (lakes and rivers), or mud line exceeds 8 feet. Guardrails shall be a minimum of 36 inches high and shall prevent the passage of a 21-inch sphere. Edge protection shall be provided as required by other rules.

3606.7 Accessibility

STATE AMENDMENT

Piers, docks, catwalks, gangways, and floating docks shall comply with Chapter 11 and ANSI/ICC A117.1 for accessibility.

3606.8 Egress

STATE AMENDMENT

Piers and *docks* shall be provided with means of egress in accordance with Sections 3606.8.1 through 3606.8.4.

3606.8.1 Occupant load

STATE AMENDMENT

Occupant load for *piers* and *docks* shall be calculated as follows:

3606.8.1.1 Piers and boardwalks

STATE AMENDMENT

Occupant load for piers and boardwalks intended for recreational fishing shall be calculated based on 3 linear feet of rail per person on the perimeter plus 50 square feet per person on a net area with a perimeter 3 feet inside the rail. Occupant load for *piers* and boardwalks intended for other uses shall be in accordance with Chapter 10.

3606.8.1.2 Public waterfront docks

STATE AMENDMENT

Occupant load for *docks* constructed at public marinas intended for mooring of private pleasure craft shall be calculated based on 30 square feet of net dock area per person.

3606.8.1.3 Private waterfront docks

STATE AMENDMENT

Occupant load for private waterfront *docks* shall be calculated based on 20 square feet per person.

3606.8.2 Piers

STATE AMENDMENT

Piers intended for recreational fishing, assembly, or educational purposes with travel distance to exit discharge exceeding 600 feet and greater than 15 feet above mean low water shall have emergency access ladders at 300 feet intervals and at the end of the *pier*. The *pier* shall be constructed of noncombustible material with the exception that the floor decking may be heavy timber.

3606.8.3 Public waterfront docks

STATE AMENDMENT

Public waterfront *docks* intended for mooring of private pleasure craft with travel distance to exit discharge in excess of 600 feet shall have a second means of egress or a means of rescue from the water. Construction for these docks shall be noncombustible, with the exception that wood walers may be embedded in the *dock* edges for attachment of mooring hardware.

3606.8.4 Buildings constructed on piers and docks

STATE AMENDMENT

Buildings constructed on public waterfront *piers* and *docks* shall comply with the requirements of all applicable provisions of the North Carolina State Building Code.

Section 3607 CONSTRUCTION: BULKHEADS AND REVETMENTS

STATE AMENDMENT

3607.1 Bulkheads

STATE AMENDMENT

Bulkheads shall be constructed in accordance with Sections 3607.1.1 through 3607.1.5.

3607.1.1 General

STATE AMENDMENT

Bulkheads shall be constructed in a manner to be effective against erosion and provide for bank stabilization. The *bulkhead* system may consist of any of the following or combinations thereof: braced sheet pile walls with tie backs, king piles, and horizontal panels, gravity walls, cantilever and counterfort retaining walls. *Bulkhead* walls shall be constructed to prevent passage of fine material (See ASTM D 2487) through joints or cracks from the fill side to the stream side.

3607.1.2 Systems

STATE AMENDMENT

Local site conditions and performance of *bulkheads* in service shall govern in selection of a system. The potential for erosion and scour at the mud line shall also be investigated, and compensating features shall be reflected in the construction. *Bulkheads* shall be terminated by either tying into adjoining structures or by extending the *bulkhead* line a minimum of 10 feet in a landward direction at an angle of not less than 45 degrees to the shoreline in order to protect against end erosion or flanking by wave action. No structure shall be terminated without regard for end anchorage and stabilization.

3607.1.3 Guardrails

STATE AMENDMENT

Where designated public walkways, steps, or ramps run adjacent to *bulkheads* within 6 feet, guardrails or other safety provisions shall be provided along the top of the wall where the vertical drop to the lesser of the mean low water level, normal low water level (sounds), normal pool (lakes and rivers), or mud line exceeds 6 feet. Guardrails shall be designed in accordance with Chapter 16 for balcony guardrails. Guardrails shall be 42 inches high and shall prevent the passage of a 21-inch sphere except where required otherwise by Chapter 11. Edge protection shall be provided as required by other rules.

> **Exception**: For private waterfront *bulkheads* with designated walkways within 6 feet, guardrails or other safety provisions shall be provided along the edges where the vertical drop to the lesser of the mean low water level, normal low water level (sounds), normal pool (lakes and rivers), or mud line exceeds 8 feet. Guardrails shall be a minimum of 36 inches high and shall prevent the passage of a 21-inch sphere. A wall cap 30 inches or less in width shall not be considered a designated walkway unless it is connected to a walkway. Edge protection shall be provided as required by other rules.

3607.1.4 Wood construction

STATE AMENDMENT

For wood grades, member sizes, preservative treatment, and protection of metal fasteners and fittings, see Section 3605.3.

3607.1.5 Bulkheads of materials other than wood

STATE AMENDMENT

Vinyl, fiber reinforced polymer, aluminum, concrete, and steel *bulkheads* shall be constructed in a manner to ensure performance. Connections shall be designed to resist the full applied load. For materials and corrosion protection reference Sections 3605.4 through 3605.7.

3607.2 Revetments

STATE AMENDMENT

Revetments shall be constructed in accordance with Sections 3607.2.1 through 3607.2.2

3607.2.1 Rigid revetments

STATE AMENDMENT

Rigid revetments shall be founded on a firm foundation to prevent undermining and progressive instability. Provisions shall be made to provide for toe protection to compensate for known or anticipated scour. Additional protection may be needed in active areas and may consist of sheet piling along the toe or stone rip rap. A pattern of weep holes shall be provided in the face to relieve hydrostatic pressure behind the wall. Joints shall be sealed or provided with a properly designed filter to prevent loss of fines from the protected slope.

3607.2.2 Flexible revetments

STATE AMENDMENT

Adequate provisions shall be made to prevent migration of fine materials through the structure. The face shall not be steeper than one unit horizontal to one unit vertical. Flatter slopes may be needed for stability depending on the construction materials and site conditions. The face may consist of armor stone, rip rap, or individual interlocking concrete units or poured concrete. Toe protection provisions shall be provided as discussed for the rigid type and the top of slope shall be detailed to prevent erosions under the revetment from surface water runoff. Flexible revetments shall be provided with a filter layer designed to prevent loss of fines from the protected slope and to relieve hydrostatic pressure behind the face.

CHAPTER 36

PIERS, BULKHEADS AND WATERWAY STRUCTURES

SECTION 3601 GENERAL

The intent of this chapter is to provide minimum standards for the design construction and maintenance of piers bulkheads and waterway structures that are not covered by other existing codes or design standards This chapter exempts farm structures not on public waters marine terminal or port facilities for berthing mooring docking and servicing ships barges or tug boats which handle cargo of all types including bulks liquids fuels and passengers.

The design of piers bulkheads and waterway structures is essential for the protection of life and property without causing adverse effects to the shoreline These structures by their very nature result in some modification of physical environment and therefore require minimum design standards The guidelines in this chapter address minimum standards for foundations design forces structural integrity material selection and utilization and construction techniques.

SECTION 3602 PERMITS AND APPROVALS

The construction of any pier bulkhead or waterway structure in public waters or the placement of dredged materials in waters or wetlands generally requires the owner to obtain permits prior to construction A permit from the United States Army Corps of Engineers is generally required for all marine construction In addition to the permit issued by the Corps of Engineers additional permits may be required from municipal county or state governments and/or local marine commissions In cases of structures to be built on lakes operated by an electric utility for the generation of power a permit from the operating utility may also be required.

SECTION 3603 MINIMUM DESIGN LOADS

3603.1 General. Every structure shall be of sufficient strength to support the imposed dead live wind and impact loads without exceeding the allowable stresses prescribed for the various materials elsewhere in this code. Adequate consideration shall be made for forces imposed by earth water docking and mooring.

3603.2 Dead loads. The weight of the component parts of a structure shall be used in the design when it will influence the strength of the structural elements

3603.3 Live loads. Design live loads shall be the greatest load that will probably be imposed on the structure including superimposed loads on retained material which exert horizontal loads on the structure Where vehicles are allowed use actual weight of vehicles and wheel loads as specified in the latest edition of *Standard Specifications for Highway Bridges* of the American Association of State Highway Bridges; of the American Association of State Highway and Transportation Officials The design load shall be posed at the dock or pier approach where vehicles are allowed Minimum live loads are'

1. FIXED PIERS DOCKS CATWALKS-40 pounds per square foot (psf) (1915 Pa) or 300 pounds (1335 N) concentrated load on any area 2 foot (610 mm) square
2. FLOATING PIERS DOCKS FINGERS-20 psf or 300 pounds (1335 N) concentrated load on any area 2 feet (610 mm) square Under dead load floating piers shall have a minimum of 15 inches (381 mm) freeboard. The pier shall have not more than 6 degrees (0.11 rad) tilt from the horizontal under uniform live loading on one-half of ~~the pier~~ width or under concentrated load of 600 pounds (2669 N) applied on any side
3. BULKHEADS SEAWALLS REVETMENTS-Design loads shall be the greatest combinations of loads exerted on the structure Consideration shall be given to horizontal loads exerted by superimposed loads on the retained earth and by inclined surface slopes.
4. PUBLIC FISHING PIERS

   4.1. Mean low water line to land-100 psf (4788 Pa).

   4.2. Mean low water line to end of pier-50 psf (2304 Pa).

3603.4 Wind loads. As prescribed in Chapter 16.

3603.5 Impact loads. As prescribed in Chapter 16 but not less than 1 25 times the kinetic energy exerted by a striking vessel or vehicle

3603.6 Water loads. Hydrostatic horizontal pressures along with the equivalent fluid pressure of soil and any surcharge thereon shall be considered Provide sufficient anchorage against uplift between all components and between the structure and its support of not less than 1 5 times the uplift force Wave forces shall be determined from wave records where available Where no wave records are available the design wave shall be determined from probable wind speed direction fetch and water depth which will yield a critical wave. Forces shall then be calculated using current coastal engineering practice.

3603.7 Earth loads. Lateral earth pressures shall be determined by considering the specific soil properties and applying earth pressure theories generally accepted for soil mechanics in engineering practice. Except for simple and inexpensive structures this normally requires the services of specialists in soil mechanics and/or foundations design Adequate consideration shall be given for the effect of probable varying levels of ground water tide and flood water Pressures exerted by the earth shall be checked for dry saturated and submerged conditions as applicable

3603.8 Erosion. The effects of reasonably predictable erosion and wave-induced scour shall be given ample consideration.

SECTION 3604 ENGINEERED DESIGNS

3604.1 Docks, piers and catwalks. Docks, piers and catwalks used by the public or are intended for use by vehicles shall be designed by a professional engineer or architect.

3604.2 Bulkheads and other type retaining walls. Bulkheads and other types of retaining walls used by the public having an exposed face above the ground or above mean low water of 5 feet (1524 mm) or greater shall be designed by a professional engineer or architect.

3604.3 Ocean-front retaining walls, bulkheads and retaining walls. Ocean-front retaining walls, bulkheads and other types of retaining walls used by the public on the coastline of the ocean or adjacent inlets shall be designed by a professional engineer or architect.

SECTION 3605 MATERIALS

3605.1 General. The quality of materials and fastenings used for load-supporting purposes shall conform to good engineering practices. In areas subject to attack from wood borers such as termites, teredoes or limnoria, the wood used shall be approved wood having natural resistance or shall be pressure treated with a preservative recommended by the American Wood Preservers Association for the specific application. Piling shall comply with applicable provisions of Chapter 18. Wood components shall comply with applicable provisions of Chapter 23. Concrete components shall comply with applicable provisions of Chapter 19. Steel components shall comply with applicable provisions of Chapter 22. In areas of severe corrosion such as salty or brackish waters, all metal components shall be protected by coating, cathodic protection or be oversized accordingly to allow for the specific exposure. Aluminum bulkhead sheets or aluminum bulkhead or dock components shall be of proper alloy to resist corrosive elements in the adjacent water and soil. Galvanized bulkhead components and dock components shall be coated by the "hot dip" process to sufficient cover to provide corrosion protection equal to the degree of exposure of corrosive elements. Masonry used in bulkheads and dock work shall comply with Chapter 21.

SECTION 3605 CONSTRUCTION OF PIERS, DOCKS, CATWALKS AND FLOATING DOCKS

3606.1 Fixed piers. Fixed piers for coastal areas shall be supported by pilings with tip penetrations of not less than 8 feet (2438 mm) dependent on the total applied load. Less penetration is approved only if other means of resisting flotation uplift is provided. Pier support by shallow piling, legs or columns with point bearing on rock shall have provisions for horizontal forces and overturn as well as flotation uplift. Connection between piling or legs to cap beams, stringers, beams and deck shall have sufficient capacity to safely support all applied loads and provide transfer of load to adjoining members. Maximum spans for pier joists shall be in accordance with the *Span Table for Joists and Rafters* as published by the National Forest Products Association or may be designed in accordance with accepted engineering practice.

3606.2 Metal barrel flotation units. The use of metal barrels not specifically designed for use as flotation devices is prohibited.

3606.3 Decomposable flotation units. Floating docks or piers using exposed polystyrene billets (or other foam material) shall be designed for 125 percent of tabulated loads to allow for deterioration from environmental effects.

3606.4 Electrical service. All electrical service to marine structures shall be in accordance with the *North Carolina State Electrical Code*.

3606.5 Fuel docks. Fuel docks and other marine facilities handling flammable liquids shall comply with the *Flammable and Combustible Liquids Code*, NFPA 30 and the *North Carolina Fire Code*. All fuel installations shall be designed to prevent fuel spillage from entering the water. The fuel docks or floats shall be a separate structure form berths and shall be isolated to the extent that fire or explosion would have minimal opportunity to spread to or from the fuel dock to the berths. Storage tanks for public facilities shall be located a minimum distance of 50 feet (15240 mm) from the dispenser with a shutoff valve at the tank.

3606.6 Handrails. For walkways, access piers, steps or ranges, personnel handrails or other safety provisions shall be provided along the edges where the vertical drop to the mean low water level or mud line exceeds 6 feet (1829 mm). Edges which have a primary function other than walks or access ways, such as docking frontage and swimming access shall not require railings. Railings shall be designed in accordance with Chapter 16 for balcony railings.

3606.7 Maintenance of public structures. The building official shall have the authority to condemn and close to the public any structure which is considered unsafe, and it shall not be used by the public until the deficiencies are corrected. Before the structure is reopened to the public, a certification by a professional engineer or architect shall be required. Each owner shall be responsible for the proper and satisfactory maintenance of any public structure covered by this section. All such structures shall be subject to inspection at any time by the building official.

SECTION 3607 CONSTRUCTION: BULKHEADS, SEAWALLS AND REVETMENTS

3607.1 Bulkheads.

3607.1.1 Bulkheads shall be constructed in a manner to be effective against erosion and provide for adequate bank stabilization. The bulkhead system may consist of either of the following combinations thereof: braced sheet pile walls with tie backs, king piles and horizontal panels, gravity walls, cantilever and counterfort retaining walls. Bulkhead walls shall be constructed to prevent passage of fine material through joints or cracks from the fill side to the stream side.

3607.1.2 Local site conditions and performance of bulkheads in service should govern in selection of a system. The potential for erosion and scour at the mud line shall also be investigated and appropriate compensating features shall be reflected in the construction. Bulkheads shall be terminated by either tying into adjoining structures or by extending the bulkhead line a minimum of 10 feet (3048 mm) in a landward direction at an angle of not less than 45 degrees (0.79 rad) to the shoreline in order to protect against end erosion or flanking by wave action. No structure shall be terminated without regard for end anchorage and stabilization. Sheet pile bulkheads with an exposed vertical height of 4 feet (1219 mm) or greater shall be stabilized at the top by providing adequate anchorage such as the use of batter piles or tie backs. Anchor blocks for tie backs shall be located landward of the soil wedge formed by the wall and a line projected on an angle of the material being retained. The tie back anchor shall be located no closer than twice the height of the exposed vertical surface of the wall. Sheet pile embedment shall be determined by analysis and design but shall not be less than the length of the pile exposed above ground. Cantilever and gravity wall bulkheads shall be founded on a firm foundation with special construction given to undermining and progressive instability.

3607.1.3 Where public walkways, steps or ramps run adjacent to bulkheads, personnel handrails or other safety provisions shall be provided along the top of the wall where the vertical drop to the mean low water line or mud line exceeds 6 feet (1829 mm). Handrails shall be designed in accordance with Chapter 16 for balcony railings.

3607.1.4 Wood members used for permanent features shall be not less than 2 inches (51 mm) in nominal thickness. All steel bolts, rods and other hardware shall be hot dipped galvanized or protected with an equivalent system. Bolts, rods and other metal materials shall be no smaller than ½ inch (12.7 mm) in diameter or thickness. Threaded fasteners shall not be tightened directly against wood surfaces but used only in conjunction with standard ogee or flat washers.

3607.1.5 Concrete, steel and cement asbestos bulkheads shall be constructed in a manner to assure adequate performance. Connections shall be designed to resist the full applied load. Adequate attention shall be given to material protection against corrosion and concrete cover for reinforcing steel. Concrete shall have a 28-day minimum compressive strength of 3,000 pounds per square inch (20 685 kPa) and shall be "air-entrained" type concrete.

3607.2 Seawalls. Seawalls may be constructed of concrete or stone rubble mound or other suitable materials. They shall be founded on a firm foundation and may require the use of piling or other suitable support. The face shall be shaped and supported to withstand the full force of the design wave. A provision shall ~~be provided~~ to prevent undermining and progressive instability by installing a sheet pile wall along the toe and/or by placing adequate stone rip rap protection.

3607.3 Revetments.

3607.3.1 Rigid revetments shall be founded on a firm foundation to prevent undermining and progressive instability. Provisions should be made to provide for adequate toe protection by extending the face a minimum of 2 feet (610 mm) below the mud line plus a depth to compensate for known or anticipated scour. Additional protection may be needed in active areas and may consist of sheet piling along the toe and/or stone rip rap. An adequate pattern of weep holes shall be provided in the face to relieve hydrostatic pressure behind the wall. Joints shall be sealed to prevent loss of fines from the protected slope.

3607.3.2 Flexible revetments may be utilized where foundations will produce minor consolidation and settlement. Adequate provisions shall be made to prevent migration of fine materials through the wall. The face shall not be steeper than one unit horizontal to one unit vertical. Flatter slopes may be needed for stability depending on the construction materials and site conditions. The face may consist of stone rip rap or individual interlocking concrete units or poured concrete. Toe protection provisions shall be provided as discussed for the rigid type. Flexible revetments must be porous enough to allow for water passage and thereby relieve hydrostatic pressure behind the face.

SECTION 3608
CONSTRUCTION OF GROINS AND JETTIES

3608.1 Groins.

3608.1.1 Groins are designed and constructed for the purpose of building or maintaining a protection beach by trapping littoral drift (beach materials) or to retard the recession of an eroding shoreline. The planning and design of a groin/groin system shall be based on wave height, period and direction, characteristics of beach material and beach slope.

3608.1.2 Location. Groins shall extend landward a sufficient distance to prevent flanking.

3608.1.3 Types. Groins shall be either (1) very low, impermeable and nonadjustable or (2) impermeable and adjustable.

3608.1.4 General specifications. Adjustable groins shall be maintained at elevations in accord with actual beach needs and development of desirable changes of the beach profile, and so as to avoid damage to adjacent beaches. In no case shall the top of such groins be set higher than 2 feet (610 mm) above the beach profile. Impermeable nonadjustable groins shall not extend seaward beyond the mean low water line, and their top elevation shall not be higher than 6 inches (152 mm) above the beach profile. Considerations of the degree of beach protection to be provided by proposed groins, and the acceptability of such installations, will be based primarily on the following factors: direction and volume of littoral drift; wave force and direction; wind force and direction; land usage; type of bulkhead; type of groin; and spacing and lengths of groins.

A complete coastal engineering study may be required before approval is given to the number type and length of groins The design should account for the wave and current forces focused on the beach The groin/groin system should not adversely modify the littoral drift to the extent to cause severe erosion on the lee side of the structure

3608.2 Groins and jetties. There is no universal type of groin/groin system or jetty because of the wide variations in conditions at each location It is incumbent on the owner of a groin or jetty type structure to recognize the legal implications of the coastal structure and to plan design construct and maintain the structure accordingly. It is thus prudent to seek the advice of a professional engineer or architect with coastal engineering experience.

SECTION 3609 DEFINITIONS

BASIN, BOAT. A naturally or artifically enclosed or nearly enclosed harbor area for docking and securing small craft

BULKHEAD. A vertical wall structure designed to retain ~~shoreline material~~ and prevent erosion due to wave activity

BULKHEAD LINE. The line formed along the shore by the most seaward elements of the bulkhead

CATWALK. A narrow footway platform extending alongside a structure

DATUM, PLANE. The horizontal plane to which soundings ground elevations water surface elevations are referenced.

DOCK. A pier wharf or platform for the unloading of materials or living beings

FETCH. The area in which waves are generated having a rather constant direction or speed

GANGWAY. A narrow footway bridge extending from the shore usually to a floating structure

GROIN. A shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore.

GROIN SYSTEM. A series of groins that function to protect a section of shoreline.

JETTY. A structure designed to protect and/or stabilize a navigation entrance

KING PILE. The primary structural member that supports horizontal panels to form a vertical wall sometimes used in ~~bulkhead or~~ groin construction

LITTORAL DRIFT. The sedimentary material transported along the shore by waves and currents

LONGSHORE TRANSPORT. The movement of littoral drift (material) running parallel to the shoreline.

PIER. An elevated deck structure usually pile supported extending out into the water from the shore.

PIERHEAD LINE. The limiting line to which any pier or ~~dock structure~~ can extend into the water

PILE. A cylindrical timber concrete or metal member embedded into the ground to support or brace a structure.

PILE, SHEET. A pile with a generally slender flat cross section to be embedded into the ground or seabed and meshed or interlocked with like members to form a diaphragm wall or bulkhead

REVETMENT. A flexible structure usually constructed of stone or concrete and placed on a bank slope to protect it against erosion by wave and current action

SEAWALL. A massive structure built along and parallel to a ~~shoreline for~~ the purpose of protecting and stabilizing the shore against erosion resulting from heavy wave activity

WAVE, DESIGN. A wave that is potentially most damaging to an economically feasible structure or wave for which a structure is designed.

The Rozalia Project has found that foam pollution stemming from unencapsulated polystyrene docks introduces significant environmental, social, and economic costs and is prevalent off the coast of Maine.

The Rozalia Project launched the Dock Foam Pollution Study to investigate the amount of dock foam pollution off the coast of Maine. This study aims to determine statistical and geographic trends in the amounts of dock foam pollution the Rozalia Project collected from 2013 to 2019. It will be the foundation of efforts to reduce pollution caused by unencapsulated foam docks by analyzing trends and communicating with subject matter experts. This study will help determine the actions, such as regulation, education and/or communication, that will have the most potential to ultimately reduce unencapsulated dock foam in Maine and across the nation. While this document focuses on the coastal waters of Maine, it is meant to act as a template for similar efforts in other locations.

THE PROBLEM

Figure 1. Cleanup Participants sort over 4,500 pieces of dock foam on Squirrel Island

Expanded polystyrene foam is a common material to use as dock flotation because it is light and inexpensive. However, the environmental and social costs of this un-biodegradable material far outweigh its trivial benefits. When exposed to the elements, unencapsulated polystyrene will become brittle and crack, potentially crumbling into thousands of foam beads/fragments that destroy the aesthetic and health of shorelines and threaten aquatic ecosystems. When consumed by marine creatures, these foam beads/fragments can block airways or digestive tracts, and even stop animals from absorbing nutrients (Rittmaster, 2018).

Furthermore, polystyrene contains chemicals such as benzene, styrene, and ethylene. In small quantities, these chemicals can leach into water (Georgian Bay Forever, 2019), and in larger ones, can pose significant health risks. Also, other toxins can easily bind with polystyrene's molecular structure. As a result, dock foam often poisons marine animals, as polystyrene concentrates and magnifies these toxins. This toxicity moves up the food chain, affecting entire ecosystems and eventually humans. (Marcy & Johnson, 2009).

It is important to note that downstream disposal of polystyrene foam docks is not a viable solution. Materials Recovery Facilities do not make money from collecting dock foam, and therefore do not accept this type of pollution. Thus, encapsulating foam docks is an attractive alternative: doing so prevents foam dock pollution and eliminates the need for downstream cleanups. Economically, paying for encapsulated dock foam is initially more expensive than purchasing unencapsulated foam, but the investment quickly pays off. Encapsulated docks last significantly longer, require far less maintenance, and eliminate the potential risks unencapsulated docks pose. They prevent toxin magnification, save the lives of marine animals, and ensure a healthy and aesthetic ecosystem.

Encapsulating polystyrene dock foam can no longer be an afterthought: doing so saves lives and ecosystems and must be a priority.

POLICY LANDSCAPE

Select states, cities, towns, and agencies across the United States have adopted policies, ordinances, or voluntary initiatives to regulate unencapsulated polystyrene docks. This regulatory framework can inform the process and content of future policy and initiatives both in Maine and across the United States. Below are examples of different approaches to regulations on unencapsulated docks:

Camden, Maine: In November 2017, the town of Camden voted in favor of eliminating unencapsulated polystyrene foam in both docks and buoys from all waters under Camden's jurisdiction. The ordinance cites unencapsulated polystyrene as a "nuisance and public health hazard," and mandates that citizens of Camden must not use unencapsulated polystyrene foam in new or replacement docks, or for dock repairs. The ordinance also incorporates a five-year phase out of existing materials: by 2022, all dock owners must have disposed of all unencapsulated foam (*Unencapsulated Polystyrene Ordinance* 2017). To help with the logistics, a local news source notes a nearby waste disposal site that disposes of old materials, as well as local companies that revitalize floating structures to comply with the new ordinance (Rittmaster, 2018). A nearly identical ordinance introduced in the adjacent town of Blue Hill, ME did not pass (*Unencapsulated Polystyrene Ordinance for Blue Hill Maine* 2019).

State of Oregon: Oregon prohibited the use of unencapsulated dock foam in 1992. The law states: "Any polystyrene foam flotation or part thereof installed, removed, replaced, or repaired during construction or maintenance activities shall be effectively contained. All unused or replaced polystyrene foam shall be removed from the waters of this state and disposed of in an approved manner at an upland disposal site or recycled." The statute also lists acceptable materials and methods of encapsulation. The Oregon State Marine Board provides further information and assistance (*Materials and Methods of Encapsulation* 2019). A similar policy was introduced in Washington, but did not pass (*Concerning floatation devices on state-owned aquatic lands and in state waters* 2013).

U.S. Army Corps of Engineers (USACE): The USACE is the largest provider of outdoor recreation in the United States, and is organized geographically into 45 Districts within regional divisions. In 1992, the USACE enacted a policy that aimed to ban the use of unencapsulated dock foam. In 2007, it conducted a follow-up survey to gauge compliance. 34 Districts responded to the survey: only 15 of those had adopted policies requiring encapsulated docks. Overall, respondents reported 181,272 slips, of which 91,780 had encapsulated flotation. While these numbers represent an increase in encapsulated docks, the USACE's 1992 attempt at policy was ambiguous and allowed for interpretation; as a result, only a third of the Districts adopted it (Marcy & Johnson, 2009). Further improvements could stem from a phase-out timeline or more clear, specific policy within the Corps.

National Parks Service (NPS): In 2007, the NPS enacted a voluntary program called the Clean Marina Initiative in an effort to promote healthier aquatic ecosystems within its parks. Individual marinas can opt-in to this program by conducting marina evaluations or taking a Clean Marina pledge. An item of the evaluation checklist as well as the program's Best Management Practice is that all forms of flotation should be encapsulated in plastic, wood, or steel. Thus, as the foam ages and deteriorates, it will be encased within a durable material. Because becoming a Clean Marina within the NPS is voluntary, not all parks have adopted this program, but various success stories exist (*Clean Marina Guidebook* 2012).

NOAA Clean Marina Program: NOAA also has a voluntary Clean Marina Program that aims to reduce pollution, and it recognizes participating marinas as environmental stewards. The most recent evaluation of the Clean Marina Program in 2008 recorded 701 certified clean marinas across the U.S. (Marcy & Johnson, 2009). The program aims to serve local governments, recreators, businesses, and individuals (NOAA, *Glossary*). Requirements to become a certified Clean Marina vary greatly throughout the U.S., but 32 states now have at least one certified clean marina: 13 of these require encapsulated dock foam for the marina to become certified (*Find a Clean Marina* 2020).

METHODS

Cleanups were conducted at 39 different islands, beaches, harbors, coves and marinas using a variety of different methods. The dock foam material collected appears similar to that of a polystyrene cooler. It washes up on shorelines and beaches in various sized microplastic foam beads/fragments. The materials collected at each cleanup were sorted, and the amounts of pieces collected were recorded.

Beach Cleanup: Cleanup participants gather trash into large bags, sort it, and dispose of it accordingly.

Dock Walk: Participants place a net in the water and walk along a shoreline, beach, or marina. Participants can then calculate the surface area of the cleanup and extrapolate the total amount of trash collected.

Figure 2. Cleanup participant packs up dock foam pieces on Great Gott Island

Neuston Tow: A neuston tow is a net attached to the Rozalia Project's research vessel, *American Promise.* The tow captures objects floating in the neuston layer (the area where the surface of the water meets the air).

Figure 3. The Rozalia Project's ROV: Hector the Collector.

ROV: The Rozalia Project's surface-controlled Videoray Pro 4 ROV (named Hector!) takes photos and videos and collects trash from below the surface. The ROV can travel up to 1000 feet underwater in any temperature, and is harmless to the underwater world.

Dipnet: A dipnet is a fishing net with pole extensions the crew uses aboard *American Promise*. When crew members encounter floating dock foam underway, they use a dipnet to retrieve it.

RESULTS

1. Overall, dock foam pollution accounted for 22% of the total amount of plastic the Rozalia Project collected from 2013-2019.

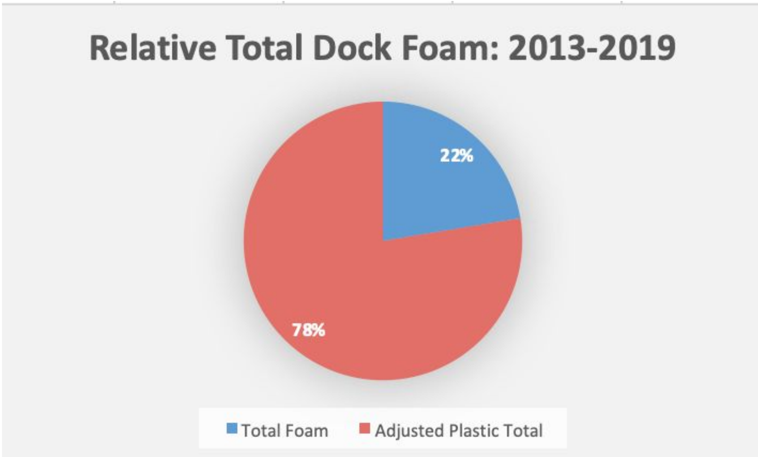


Figure 4. Percent of total plastic pollution that dock foam accounted for between 2013-2019, given that participants collected at least one piece of dock foam in each cleanup. Dock foam thus accounted for almost ¼ of the total amounts of plastic collected.

2. Out of 166 total trash cleanups the Rozalia Project led between 2013-2019, 74.7% (124 cleanups) yielded at least one piece of dock foam.

3. Of the 39 locations that the Rozalia Project cleaned up, the Project revisited nine locations three times or more: Saddleback Island, Matinicus Island, Heron's Neck, Greens Island/Sand Cove, Damariscove Island, Seapoint Beach, Hurricane Island, Ocean Point Marina, Frenchboro, Star Island, Malaga Island. The Rozalia Project collected multiple pieces of dock foam pollution each time it revisited a location, illustrating that polystyrene is persistent and cleaning up dock foam pollution needs to be an ongoing effort.

4. The Rozalia Project collected the largest amount of dock foam in 2015 and the least in 2017. The unadjusted total amounts of dock foam collected are displayed in Table 1. The number of cleanups occurring each year, however, could skew these totals. Thus, Table 2 shows the total dock foam pieces collected divided by the number of cleanups each year. The Project conducted the most cleanups in 2013 (44), followed by 2015 (27), and the least in 2016 (3).

	Year						
	2013	2014	2015	2016	2017	2018	2019
Micro foam 0-5mm	1,649	1,098	1,184	298	34	157	108
SMALL foam 5-30mm	631	344	1369	174	297	567	646
LARGE foam >30mm	1131	499	3835	635	551	372	527
Total	3,411	1,941	6,388	1,107	882	1,096	1,281

Table 1. Total amounts of dock foam pollution (micro, small, large, total) each year

	Year						
	2013	2014	2015	2016	2017	2018	2019
Micro foam 0-5mm	37	73	44	99	2	14	11
SMALL foam 5-30mm	14	23	51	58	21	52	65
LARGE foam >30mm	26	33	142	212	39	34	53
Total	78	129	237	369	63	100	128

Table 2. Total amounts of dock foam pollution (micro, small, large, total) each year divided by the number of cleanups that year

5. Of all plastic pollution the Rozalia Project collected each year, dock foam accounted for the largest portion in 2013 (40.59%), and the smallest portion in 2019 (15.13%).

	Year						
	2013	2014	2015	2016	2017	2018	2019
Adjusted Plastic Total	8404	5570	18048	5096	4643	5596	8467
Foam Index Micro	19.62	19.71	6.56	5.85	0.73	2.81	1.28
Foam Index Small	7.51	6.18	7.59	3.41	6.40	10.13	7.63
Foam Index Large	13.46	8.96	21.25	12.46	11.87	6.65	6.22
Foam Index Total	40.59	34.85	35.39	21.72	19.00	19.59	15.13

Table 3. Percent of total amount of plastic collected that dock foam pollution (micro, small, large, total) represents each year, given that participants collected at least one piece of dock foam

6. Large pieces of foam (>30mm) accounted for the largest percent of all pieces of foam pollution collected (47%) from 2013-2019.

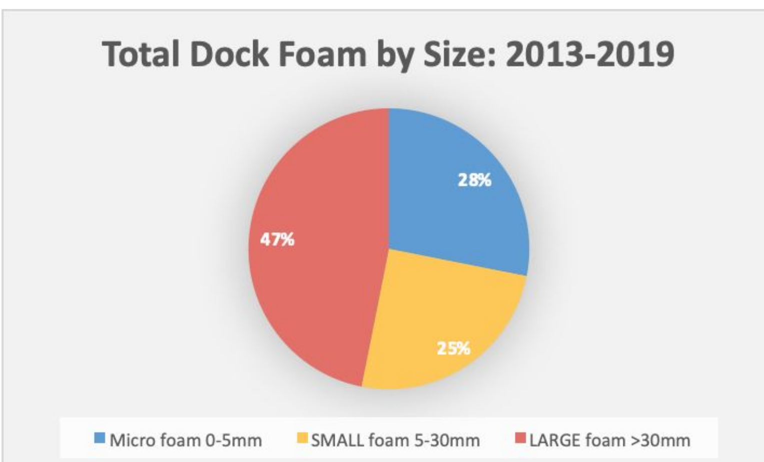


Figure 5. Percent of total dock foam collected that each size of foam represents. Large foam pieces make up the largest portion (47%) with small and micro accounting for roughly similarly lesser amounts (25% and 28% respectively).

7. Mapping the data and adjusting for effort revealed many small-yield cleanups and few "hotspots" between 2013 and 2019. Hotspots are cleanups that when adjusted for effort, yielded between 88 and 1,794 pieces.

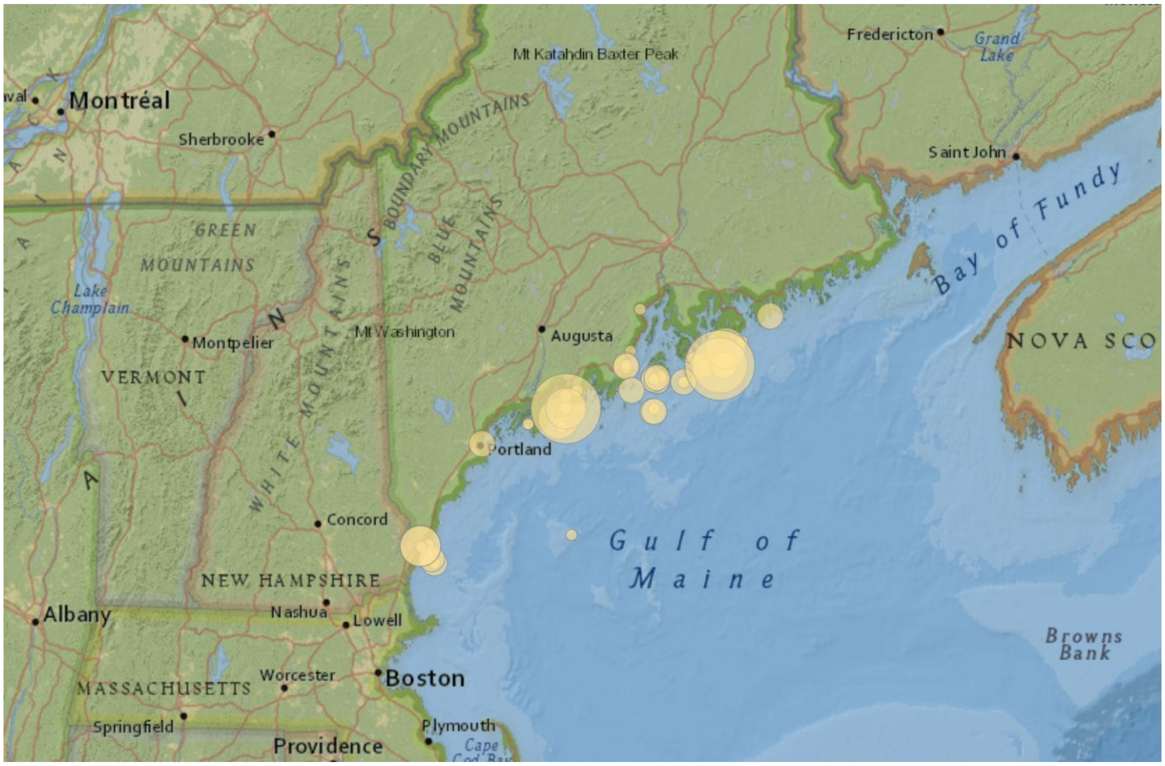


Figure 6. Total number of dock foam pieces collected at 124 cleanups from 2013-2019 divided by participants x hours to correct for effort. Different sizes were created by using five natural breaks in the data.

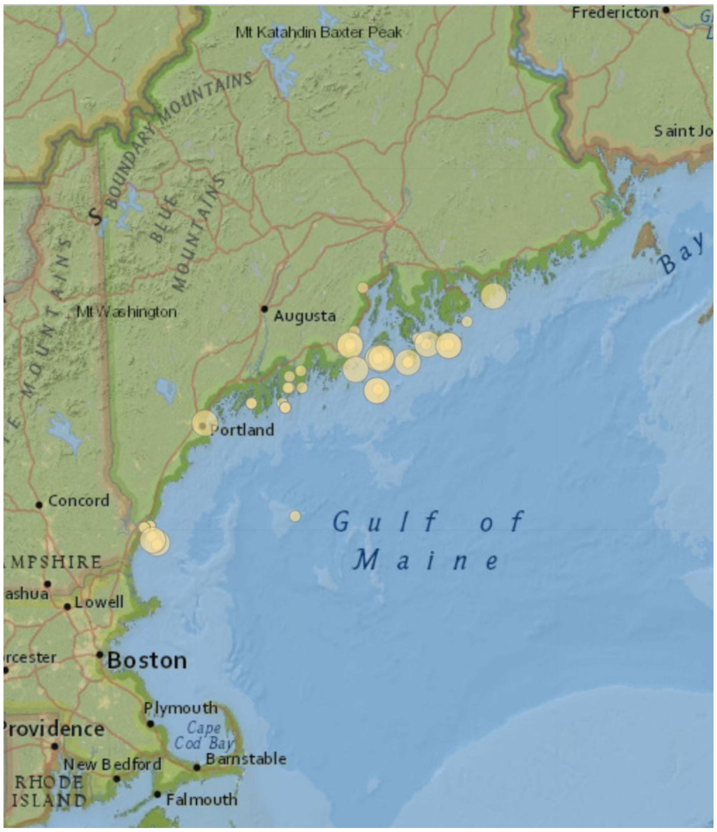
8. Only eight of 124 cleanups were dock foam pollution hotspots when adjusted for effort. Some cleanups yielded over 1000 pieces of foam, even when divided by participants x hours.

Date	Location	Micro	Small	Large	Total	ParticipantsxHours	Adjusted Total
6/28/13	East Boothbay - Ocean Point Marina	869	25	3	897	0.5	1794
7/11/13	KPYY Dock, Kittery	177	18	13	208	1.5	138.67
8/7/13	Shoreline Frenchboro - Big Beach	2	49	248	299	0.4	747.5
8/8/13	Shoreline Frenchboro- Big Beach, Middle Beach, Little Beach	39	19	146	204	0.67	306
7/11/14	Ocean Point Marina	1019	73	0	1092	7	156
7/13/15	KPYY off dock	411	27	8	446	4	111.5
7/26/15	Squirrel Island, Boothbay Harbor	0	0	1139	1139	6	189.83
8/10/15	Great Gott Island	0	0	1586	1586	18	88.11

Table 4. Data from the largest cleanups depicted in Figure 6; the 1st, 2nd and 3rd largest natural breaks in the data.

CONCLUSIONS

Dock foam pollution off the coast of Maine poses a major hazard to the health of humans, aquatic ecosystems, and marine creatures.



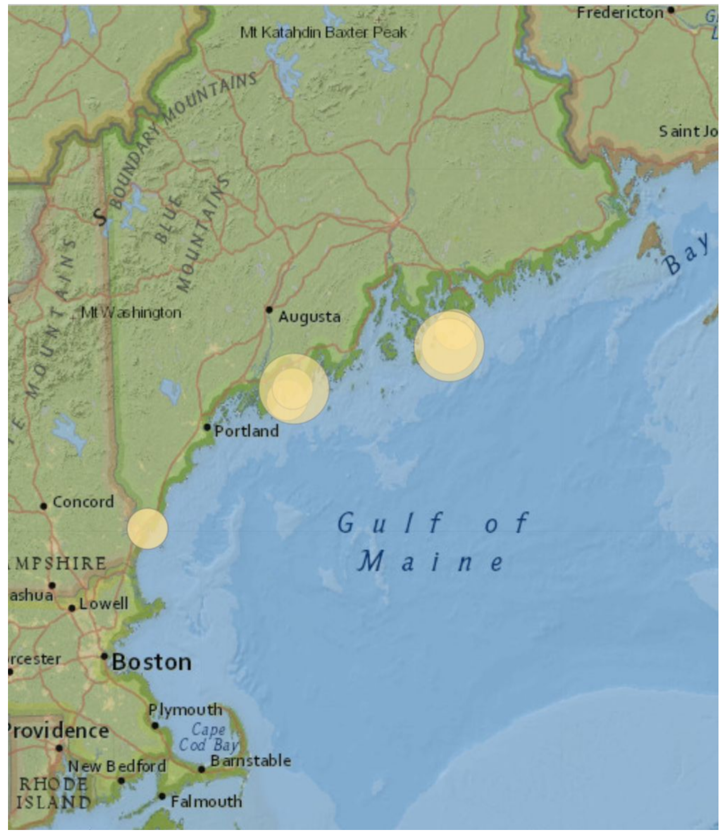


Figure 7 and Figure 8. Total number of dock foam pieces collected at 124 cleanups in which participants collected at least one piece of dock foam. Left: adjusted total <= 75 pieces. Right: adjusted total > 75 pieces

As Figures 7 and 8 depict, cleanups dispersed throughout the coast of Maine yielded small amounts of dock foam when adjusted for effort. In fact, of the 124 total cleanups that yielded at least one piece of dock foam, 116 of them produced less than 75 pieces of dock foam when adjusted for effort. Thus, only eight cleanups were hotspots. Of these hotspots, the Rozalia Project cleaned up two in response to a dock exploding and washing ashore, breaking into thousands of pieces. Under normal circumstances, unencapsulated dock foam is ubiquitous off the coast of Maine. But unencapsulated docks are volatile: at any time, polystyrene chunks could break loose, explode on shore, and create extreme amounts of neon, brittle, blue pollution.

Two of the eight dock foam cleanup hotspots hail from Boothbay. Ocean Point Marina in Boothbay uses unencapsulated foam docks, and cleanups of this marina consistently found dock foam, usually in high amounts. This is because these cleanups are highly localized; the foam collected originates from docks meters away. Thus, totals from Boothbay are not easily comparable to those from other hotspot locations, where foam may have washed up from marinas miles away. However, the high concentrations of foam found in Boothbay exemplify that commercial marinas using unencapsulated foam docks need immediate reform.

Unencapsulated dock foam is not an isolated issue.

Polystyrene dock foam found far from commercial hotspots has likely been carried there by currents, wind, and other external factors especially related to severe weather events such as the frequent nor'easters in the Gulf of Maine, thunderstorms and hurricanes. Foam can drift and affect aquatic environments miles away from where it originates. Hot spots such as Frenchboro, Squirrel Island, and Great Gott Island, for example, are not home to large commercial marinas or residential hubs. The foam found in large quantities at these locations invariably washed ashore from somewhere else.

Although dock foam pollution may not be the first thing that comes to mind when thinking about ocean trash, it made up almost one fourth of the total plastic pollution the Rozalia Project collected from 2013-2019. With the potential to explode into thousands of pieces ranging in size from a few millimeters to multiple square feet, polystyrene is an ugly and dangerous problem. Dock foam pollution is persistent, and cannot be solved by cleanups alone.

WAYS FORWARD

Maine needs concrete policy regulating unencapsulated dock foam.

Camden and Oregon’s policies are favorable models for a couple of reasons. Both policies create manageable ways to begin the process, mandating repairs to or replacements of unencapsulated docks use encapsulated materials. Camden’s five-year phase out gives both commercial docks and homeowners time to make improvements. The state of Maine can mirror these policies. New regulations should outline which materials are acceptable to use and describe where to dispose of old materials and how to install new, encapsulated docks.

On the other hand, voluntary initiatives such as those pioneered by USACE, NPS, and NOAA have proved to be partially effective at best, leaving vitally important choices at the discretion of those who may be insufficiently informed. Instead of voluntary initiatives, a mix of policy, education, and scientific communication would likely prove most effective in decreasing dock foam pollution.

CONTACTS

The Rozalia Project is more a subject matter expert than a lobbyist. In order to create legislative change, the Project plans to contact and collaborate with the following people and groups in Maine and Northern New England.

Conservation Law Foundation
Natural Resources Council of Maine
New England Aquarium
Surfrider Foundation Maine
Environment Maine

FURTHER QUESTIONS/INVESTIGATIONS

- *Private vs. Commercial:* How does a cleanup's proximity to private or commercial docks affect the amount of dock foam collected? 2,410 of Maine's 2,500 miles of shoreline are privately owned (U.S. Army Corps of Engineers, *Maine Shore and Bank Protection Projects*), but do homeowners contribute as much to the problem as commercial marinas?
- *Dock Owner Demographics:* What demographic do most dock owners fall into? Are dock owners with unencapsulated docks generally second homeowners or local, generational residents?
- *Other Factors:* How do variables such as ocean currents and population play into the amount of dock foam pieces collected?
- *Cleanup Methods and Data Collection:* How do different cleanup methods affect the total number of dock foam pieces collected? Generally, the standard deviation of total dock foam pieces collected over time is high. How large of a role does noise within the cleanup data play?

REFERENCES

Burns, M. (1999). *The dock manual: Designing, building, maintaining*. Pownal, VT: Storey Books.

Concerning floatation devices on state-owned aquatic lands and in state waters., S. 5466, 63rd Cong., State of Washington (2013).

Find a Clean Marina. (2020). Retrieved July 15, 2020, from https://www.boatus.org/clean-boating/clean-marinas/

Georgian Bay Forever. (2019). *Lots to Reflect on this World Environment Day* [Brochure]. Toronto, ON: Author.

Maine Shore and Bank Protection Projects. (n.d.). Retrieved July 15, 2020, from https://www.nae.usace.army.mil/Missions/Civil-Works/Shore-Bank-Protection/Maine/

Marcy, J. B., & Johnson, J. (2009). *Flotation Analysis for Boat Docks on U.S. Army Corps of Engineers Projects* (pp. 1-21, Rep.). Washington, D.C.: U.S. Army Corps of Engineers.

Materials and Methods of Encapsulation, Oregon State Marine Board § 250-ORS 830.110 (Oregon Secretary of State 2019).

Rittmaster, R. (2018, May 11). Camden's Unencapsulated Polystyrene Ordinance: What Does it Mean for Homeowners? Retrieved July 14, 2020, from https://www.penbaypilot.com/article/camden-s-unencapsulated-polystyrene-ordinance-what-does-it-mean-homeowners/101788

Unencapsulated Polystyrene Ordinance for Blue Hill Maine. (2019, November 23). Blue Hill, ME.

United States, National Parks Service, Commercial Services. (2012). *Clean Marina Guidebook*. Retrieved July 15, 2020, from https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/NPSCS%20Clean%20Marina%20Final%202012.pdf

United States, NOAA, Coastal Smart Growth. (n.d.). *Glossary*. Retrieved July 15, 2020, from https://coastalsmartgrowth.noaa.gov/pdf/glossary.pdf

United States, Town Council, Town of Camden. (2017). *Unencapsulated Polystyrene Ordinance* (pp. 47-48). Camden, ME: Town of Camden.

Appendix J

Existing programs regarding unencapsulated/encapsulated floating dock floats
Below are examples of different approaches to regulations on unencapsulated docks:

Camden, Maine
In November 2017, the town of Camden voted in favor of eliminating unencapsulated polystyrene foam in both docks and buoys from all waters under Camden's jurisdiction. The ordinance cites unencapsulated polystyrene as a "nuisance and public health hazard," and mandates that citizens of Camden must not use unencapsulated polystyrene foam in new or replacement docks, or for dock repairs. The ordinance also incorporates a five-year phase out of existing materials: by 2022, all dock owners must have disposed of all unencapsulated foam (*Unencapsulated Polystyrene Ordinance* 2017). To help with the logistics, a local news source notes a nearby waste disposal site that disposes of old materials, as well as local companies that revitalize floating structures to comply with the new ordinance (Rittmaster, 2018). A nearly identical ordinance introduced in the adjacent town of Blue Hill, ME did not pass (*Unencapsulated Polystyrene Ordinance for Blue Hill Maine* 2019).

Excerpt from the 2019 Blue Hill Ordinance
"Polystyrene is a petroleum product, commonly known as 'Styrofoam.' It is often used as flotation devices because of its buoyancy. It is neither readily recyclable nor biodegradable and takes hundreds of years to degrade in the environment. When exposed to the elements, it fragments into small, non- biodegradable pieces that may be ingested by marine life, wild and domestic water birds and other wildlife. Polystyrene is a known carcinogen. When ingested, the Polystyrene fragments may block the digestive system of birds, mammals, and aquatic species, killing them through starvation or toxicity. Birds, aquatic and land mammals, other organisms, and nesting rodents hasten the fragmentation of Polystyrene by forming nests in, under or on top of the material when seasonally stored on land. Mechanical trauma such as the dragging of floats over land may also cause the Polystyrene to break apart. The deterioration of larger Polystyrene floats into smaller pieces creates a pollution line along shorelines, intertidal land and other places where buoyant debris collects, which is a form of pollution and increases the chances of ingestion by water dependent mammals, birds, aquatic species and humans. Such pollution must be picked up and removed at the expense of the public and private citizens. To prevent such degradation, pollution and hazard to water dependent mammals, birds, aquatic species, and humans. Polystyrene floats may be encapsulated in a hard Polyethylene shell, which prevents the deterioration and spread of smaller sections of Polystyrene floats. The general health and welfare of all living beings requires that such use of Unencapsulated Polystyrene be banned from use in Blue Hill's Water Bodies"

State of Oregon:
Oregon prohibited the use of unencapsulated dock foam in 1992. The law states: "Any polystyrene foam flotation or part thereof installed, removed, replaced, or repaired during construction or maintenance activities shall be effectively contained. All unused or replaced

polystyrene foam shall be removed from the waters of this state and disposed of in an approved manner at an upland disposal site or recycled." The statute also lists acceptable materials and methods of encapsulation. The Oregon State Marine Board provides further information and assistance (*Materials and Methods of Encapsulation* 2019). A similar policy was introduced in Washington, but did not pass (*Concerning floatation devices on state-owned aquatic lands and in state waters* 2013).

U.S. Army Corps of Engineers (USACE):
The USACE is the largest provider of outdoor recreation in the United States, and is organized geographically into 45 Districts within regional divisions. In 1992, the USACE enacted a policy that aimed to ban the use of unencapsulated dock foam. In 2007, it conducted a follow-up survey to gauge compliance. 34 Districts responded to the survey: only 15 of those had adopted policies requiring encapsulated docks. Overall, respondents reported 181,272 slips, of which 91,780 had encapsulated flotation. While these numbers represent an increase in encapsulated docks, the USACE's 1992 attempt at policy was ambiguous and allowed for interpretation; as a result, only a third of the Districts adopted it (Marcy & Johnson, 2009). Further improvements could stem from a phase-out timeline or more clear, specific policy within the Corps.

National Parks Service (NPS):
In 2007, the NPS enacted a voluntary program called the Clean Marina Initiative in an effort to promote healthier aquatic ecosystems within its parks. Individual marinas can opt-in to this program by conducting marina evaluations or taking a Clean Marina pledge. An item of the evaluation checklist as well as the program's Best Management Practice is that all forms of flotation should be encapsulated in plastic, wood, or steel. Thus, as the foam ages and deteriorates, it will be encased within a durable material. Because becoming a Clean Marina within the NPS is voluntary, not all parks have adopted this program, but various success stories exist (*Clean Marina Guidebook* 2012).

NOAA Clean Marina Program:
NOAA also has a voluntary Clean Marina Program that aims to reduce pollution, and it recognizes participating marinas as environmental stewards. The most recent evaluation of the Clean Marina Program in 2008 recorded 701 certified clean marinas across the U.S. (Marcy & Johnson, 2009). The program aims to serve local governments, recreators, businesses, and individuals (NOAA, *Glossary*). Requirements to become a certified Clean Marina vary greatly throughout the U.S., but 32 states now have at least one certified clean marina: 13 of these require encapsulated dock foam for the marina to become certified (*Find a Clean Marina* 2020).

Camden and Oregon's policies are favorable models for a couple of reasons. Both policies create manageable ways to begin the process, mandating repairs to or replacements of unencapsulated docks use encapsulated materials. Camden's five-year phase out gives both commercial docks and homeowners time to make improvements. The state of Maine can mirror these policies. New regulations should outline which materials are acceptable to use and describe where to dispose of old materials and how to install new, encapsulated docks.

On the other hand, voluntary initiatives such as those pioneered by USACE, NPS, and NOAA have proved to be partially effective at best, leaving vitally important choices at the discretion of those who may be insufficiently informed. Instead of voluntary initiatives, a mix of policy, education, and scientific communication would likely prove most effective in decreasing dock foam pollution.

LDC AMENDMENT
MAP AMENDMENT

City Council July 17, 2018

LDC-3-718
Z-3-718

Kathryn H. Thurston, 910-341-3249, kathryn.thurston@wilmingtonnc.gov

Staff Recommendation	**APPROVAL**
Planning Commission Recommendation	**7/11/18 – Scheduled for public hearing**
City Council	**7/17/18 – Approved 7-0, Waived 2nd Reading, 7-0**

Request

Code Section(s)	Chapter 18, Article 13. Floodplain Management and Article 15. Definitions, to comply with FEMA requirements and to revise higher-standards for floodplain development
Request	A. Amend the Floodplain Management ordinance as required by the Federal Emergency Management Agency, and the North Carolina Division of Emergency Manangement (NCDEM), in order to maintain the City's compliance with the National Flood Insurance Program (NFIP) B. Adopt modifications to the Flood Insurance Study (FIS) report and Flood Insurance Rate Maps as directed by the Federal Emergency Management Agency (FEMA)
Applicant	City of Wilmington Kathryn Thurston, CFM, AICP Zoning Administrator/Floodplain Manager 305 Chestnut Street, 3rd Floor Wilmington, NC 28401

Case Overview

Article 13 of the City's Land Development Code (LDC) sets forth requirements for development within special flood hazard areas, as identified by the Federal Emergency Management Agency (FEMA) and decpicted on the Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs) for the City of Wilmington. As a participating community in the National Flood Insurance Program (NFIP), the city is required to adopt and enforce standards for development within identified flood hazard areas. This amendment will bring the city's floodplain regulations into compliance with state and federal requirements and reinstate the city's current higher standards designed to further protect against loss of life or property. The proposed rezoning is to formally adopt the revised preliminary flood maps released by FEMA in 2014. The maps and ordinance will be effective immediately upon adoption; however, insurance rates will not change for affected properties until the effective date of August 28, 2018.

ANALYSIS

1. History/Background

- The National Flood Insurance Program (NFIP) was established with the passage of the National Flood Insurance Act of 1968. The NFIP is a federal program that identifies floodplains and areas at risk of flooding and enables property owners in participating communities to purchase insurance as a protection against flood losses in exchange for state and community floodplain management regulations aimed at reducing future flood damages.
- To be eligible for participation in the program, a community must adopt and enforce floodplain management regulations in flood zones delineated on the Flood Insurance Rate Maps (FIRMs).
- The City of Wilmington has participated in this program since April 4, 1978 with April 17, 1978 as the effective date of the first FIRMs for the city.
- The FIRMs are updated periodically to reflect changes in the floodplain and improved precision of floodplain modeling technology.
- The most recent map changes were released on August 29, 2014, which began a four-year review process wherein city staff coordinated with New Hanover County staff, Brunswick County staff, and staff from affected jurisdictions within those counties.
- Pursuant to Section 18-465 of the LDC, the city has enforced the more restrictive of the preliminary maps versus the effective maps as regulatory for new development since the release of the preliminary maps.
- On October 29, 2015, FEMA published notice of the preliminary map release in the Lumina News and the Star-News, which began a 90-day appeals period during which community officials and citizens could appeal the new maps.
- No appeals were submitted; however, the city submitted two comments during the appeals period and, upon closer review by FEMA, those issues were addressed and the preliminary maps were updated to reflect the requested changes.
- The city, in conjunction with New Hanover and Brunswick Counties, participated in three public meetings during the appeals period to inform property owners of the changes to the FIRMs. (September 17, 2014, June 25, 2015, and July 15, 2015)
- On February 28, 2018, FEMA issued a Letter of Final Determination (LFD) to the City of Wilmington, outlining changes that resulted from updated flood risk modeling and the resultant maps.
- Communities that participate in the National Flood Insurance Program (NFIP), as the city does, are required to show evidence of adoption of the new maps and floodplain management regulations that meet or exceed the standards of Section 60.3(e) of the NFIP regulations within six (6) months of the date of the LFD.
- The city's deadline to amend the existing regulations and adopt the revised flood maps is August 28, 2018.
- To assist local jurisdictions with drafting floodplain management regulations that comply with NFIP standards, FEMA provided a template, referred to as the "model ordinance", that communities may use in whole or in part to satisfy the minimum standards as well as propose higher standards for development within special flood hazard areas.
- The changes proposed below are based on the model ordinance, with some changes in syntax and organization consistent with our existing code. Additionally, the city is proposing to retain the higher standards for development that are already in place and

incorporate clarifying language proposed by FEMA as pertains to technical guidance for swimming pools, gas tanks, elevators, concrete pads, and fill.

2. Summary of Proposed amendment

Following is the proposed amendment to the Land Development Code. A ~~strikethrough~~ underline version is included as attachment 7 to the case summary.

Amend Article 13. Flood Plain Management

Mandatory changes:

- Incorporation of suggested wording, grammatical changes and updated terminology used in the model ordinance provided by FEMA
- Inclusion of new definitions – retaining definitions that are currently in code
- Required Final Floodproofing Certificate
- Removal of automatic adoption of updated maps, including preliminary maps and Letters of Map Revision and the enforcement thereof as regulatory when more restrictive.
- Allowing flood openings in breakaway walls (mandatory to use in the Coastal A Zone, but not the VE zone. Allowing in VE zone, not requiring. May reduce damage if wave forces do not break away the walls. Wrightsville Beach and New Hanover County allow this).
- Including regulations for the new Coastal A zone for residential and nonresidential structures. (This change is mandatory based on NC Building Code, not NFIP standards).

Proposed higher standads:

- Requiring certification of a plot plan by a registered land surveyor or professional engineer (New Hanover County requirement)
- Requiring photographs with final Elevation Certificate (Required by New Hanover County and can safeguard the city and builder that construction was compliant at of construction).
- Requiring V-Zone Certification prior to certificate of occupancy (not currently required but can prevent future compliance issues and protect home-buyers).
- Adding a provision clarifying entry ways cannot be temperature controlled (already enforced; does not prevent air from “drifting” down below regulatory flood protection elevation).
- Adding plastic to list of lattice material allowed for enclosures below the regulatory flood protection elevation and specifying such enclosures must have a minimum opening ratio of 40 percent (this gives builders more flexibility in construction materials).
- Adding language that provides design parameters and certification requirements for concrete surfaces consistent with construction practices set forth by FEMA.
- Codifying current standards for fill in VE zones consistent with FEMA standards.
- Adding provisions for elevators, concrete slabs, swimming pools and spas consistent with FEMA standards.

In Model Ordinance but not proposing:

- Increasing the threshold to more than 5-years or less than 50% of the structure’s value to trigger substantial improvement requirements.
- Requiring an elevation certificate prior to start of construction.
- Prohibiting all fill in special flood hazard areas, which would mean no Conditional Letters of Map Revision or Letters of Map Revision based on fill.

- Annual inspections of enclosures below the regulatory flood protection elevation.
- Prohibition of any enclosures below base flood elevation (BFE)
- Requiring a deed-restricted agreement to be filed by property owners for enclosure areas below the BFE that states that those areas will not be converted to living space and will only be used for parking, storage and access.

3. Summary of revised maps:

FEMA requires communities that participate in the NFIP to adopt the maps as proposed for continued eligibility in the program. The table below briefly summarizes the changes from the effective maps to the preliminary maps. The revised maps are available on the Flood Risk Insurance Study website at www.fris.nc.gov and an overview of the areas experiencing the most change are included as attachments 3-6 to this report.

Table1. Comparison chart

	Effective	Preliminary	Difference
Acres in SFHA	4,554	5,216	+662
Residential Structures in SFHA	1,542	1,955	+453
Commercial Structures in SFHA	161	175	+14
Residential Parcels in SFHA	3,005	3,762	+757
Commercial parcels in SFHA	348	387	+39

- Areas of floodway and associated floodplain along the Clear Run Branch show higher flood elevations on the preliminary maps than the effective maps. City Stormwater is currently working on a capital project to reduce flood elevations in that area. The city's stormwater improvements are not reflected in this map update but will be part of a Letter of Map Amendment once the improvements are complete.
- Properties along Bradley Creek are experiencing increases to the area of the special flood hazard area, as well as increased flood elevations.
- Some properties along the Intracoastal Waterway, including Landfall and Summer Rest Road, are experiencing decreases in flood risk. Some are changing from coastal high hazard zones (VE) to less-restrictive AE flood zones, though the design flood elevations reflect increases in elevation in those areas.
- Properties along the river downtown, within Riverlights, and around Greenfield Lake will remain in an AE9 flood zone but the regulatory floodplain is widening in those areas.
- As a result of one of the comments submitted by the City based on topographical changes in the River's Edge subdivision, many properties have been removed from the regulatory floodplain in that neighborhood.
- Properties along Hewletts Creek, including the Pine Grove and Greenville Loop Road areas are increasing in both flood area and flood elevation.

4. Benchmark research

Staff reviewed the floodplain management regulations for City Council's eleven (11) identified benchmark cities. The results are summarized below and shown in Table 2 below.

- All of the city's benchmark cities participate in the National Flood Insurance Program.
- All of the city's benchmark cities have adopted standards for development in the floodplain that are higher than those mandated by FEMA.
- The most prevalent higher standard is the requirement of a "freeboard," or the elevation in feet above the BFE that structures must be built to for additional protection. The freeboard compensates for unknown factors such as wave action, bridge openings that may become blocked, and the hydrological effect of urbanization of the watershed that could contribute to flood heights greater than anticipated. Freeboard requirements result in reduced risk to life and property and significantly lowers flood insurance rates.

Table 2. Benchmark City Data

City	Participates in NFIP	Higher Standards?	Additional Information
Asheville, NC	Yes	Yes	Participates in CRS; freeboard requirement of BFE + 2'
Savannah, GA	Yes	Yes	Participates in CRS; freeboard requirement of BFE +1'
Charleston, SC	Yes	Yes	Participates in CRS; freeboard requirement of BFE +1'
St. Petersburg, FL	Yes	Yes	Participates in CRS; freeboard requirement of BFE +1', nonconversion agreement
Chattanooga, TN	Yes	Yes	Not CRS; freeboard requirement of BFE +1' for masonry construction and BFE +2' for wood frame construction
St. Augustine, FL	Yes	Yes	Participates in CRS; no fill in floodplain, freeboard requirement of BFE +1', elevate structures outside SFHA above road elevation
New Bern, NC	Yes	Yes	Participates in CRS; freeboard requirement of BFE +2'
Annapolis, MD	Yes	Yes	Not CRS; freeboard requirement of BFE +2'
Alexandria, VA	Yes	Yes	Participates in CRS; freeboard requirement of BFE +1'
Raleigh, NC	Yes	Yes	Participates in CRS; freeboard requirement of BFE +2'
Santa Fe, NM	Yes	Yes	Not CRS; freeboard requirement of BFE +1'
Wilmington, NC	Yes	Yes	Not CRS; freeboard requirement of BFE +2'

5. Consistency with Approved Plans

Create Wilmington Comprehensive Plan

The proposed amendment is consistent with the recommendations of the *Create Wilmington Comprehensive Plan* aimed at promoting public safety and preserving environmental resources.

Policies that pertain to the proposed amendment are provided below.

● **Strong Support** ◖ **Modest Support**

Policies	**3 Environment and Natural Resources**	
Sensitive Natural Areas		
6.2.1	Environmentally sensitive natural areas should be identified, mapped, protected, enhanced, and maintained.	●
6.2.2	Opportunities and incentives to mitigate the loss of sensitive areas that occur as part of the development process should be identified. Impact reduction and avoidance measures should be based on criteria that take environmentally sensitive natural areas and habitats into consideration.	●
6.2.3	Opportunities and incentives to mitigate the loss of sensitive areas that occur as part of the development process should be identified. Impact reduction and avoidance measures should be based on criteria that take environmentally sensitive natural areas and habitats into consideration.	◖
6.2.4	The design and construction of public facilities such as roads, sewers, or stormwater control, should utilize best management practices to minimize impacts on sensitive natural areas, open space, and conservation areas.	◖
Coastal Resilience		
6.5.1	The city should work to minimize impacts to developed and developable land from flooding, increased shoreline erosion, loss of wetlands, and contamination of ground water by saltwater under scenarios of sea level rise and increased flooding. Consideration should be given to long-term sea level rise scenarios in planning, design, and cost determination for infrastructure, such as roads, water and wastewater systems, and electric utilities.	●
6.5.3	Future planning should include strategic analysis under scenarios of vulnerability of the critical infrastructure, identifying vulnerable populations, evaluating the city's capacity and readiness to respond, and identifying measures to reduce vulnerabilities.	◖
6.5.4	More protective development standards, such as elevation requirements for buildings and prohibiting or compensating for filling in floodplains, should be encouraged where development occurs within the floodplain.	●

City of Wilmington Strategic Plan

The proposal is consistent with the recommendations of the *City of Wilmington Strategic Plan*. The focus area that most pertains to the proposed code amendment is *Provide Sustainability and Adaptability*. The city will protect and preserve our natural resources with quality design for the built environment. The City will make strategic decisions focused on the long-term financial, physical and social health of the entire City to enhance our ability to respond to changing economic and demographic conditions. Our actions will be based on a shared commitment to inclusiveness, equity and continuous improvement. Floodplains are hydrologically important, environmentally sensitive and ecologically productive areas that perform many natural functions, including mitigating flood waters, maintaining water quality and recharging groundwater reserves. Floodplains also often contain wetlands that support a diverse ecosystem and provide breeding and feeding ground for fish and other wildlife.The proposed amendment will exceed the federal minimum requirements for management of development activity in special flood hazard areas, thereby providing enhanced protection of this important resource.

The proposed amendment is also consistent with the focus area *Create a Safe Place.* The city will create a safe, inclusive community with neighborhood/area based public safety and support services. Requiring higher standards for development within special flood hazard areas helps offset the additional risk associated with those areas.

CONCLUSIONS

Adoption and enforcement of floodplain management regulations and Flood Insurance Rate Maps is required for the city's continued participation in the NFIP. As all statutory due-process requirements were met and the Letter of Final Determination was issued from FEMA, the city must adopt the updated maps prior to August 28, 2018 to ensure continued eligibility for participation in the NFIP. Additionally, the city must adopt provisions to regulate development within special flood hazard areas consistent with FEMA standards. Both the Comprehensive Plan and the Strategic Plan place significant emphasis on the protection of the city's natural and environmental resources, many of which are located within special flood hazard areas. Incorporation of many of the higher standards recommended by FEMA will help protect these sensitive areas as well as better safeguard the people who live proximate to them.

RECOMMENDATION

The proposed amendment will exceed the federal minimum requirements for management of development activity in special flood hazard areas, thereby providing enhanced protection of this important resource and protecting against the loss of life and property during flood events.

Based on consistency with the Comprehensive Plan, Strategic Plan and FEMA recommendations, staff recommends **approval** of the map amendment to adopt the updated Flood Insurance Rate Maps and Flood Insurance Studies and staff recommends **approval** of the proposed changes to the Land Development Code consistent with the Model Ordinance provided by FEMA.

NEIGHBORHOOD CONTACT

	Planning Commission	City Council
Advertisement Date(s)	6/29/18 & 7/6/18	7/6/18 & 7/13/18
Other – Contact(s)	Hunter Ford, Richard Joblonicky, Brandon Lisk, Justin Hoke, Bill Johnson, George Dunn, Ann Seymour, Mary Aldridge, Letty Ann Mudar, Don Oesterbo, Fran Summerlin, Anthony Johnson, Dennis Moore, Gerald and Marcia Borrelli, Mary Caroline Cole, Joyce Armstrong, James Jackson, Mary Kohunsky, Teri Butler, Matthew White, Kenneth McDaniel, Johanna Farabee, Steve Lewis, Gary Calabrese, Mark White, Dean Haas, Louis St. Peter, Stephen Lee, Glenn and Didi Taylor, Dixon Settle, Ed Jones, Pam Craig, Robert	

	Kurowski, Harry Parham, Mike Eason, Jack Jameson, Patrick Maines, Glenn Donovan, Daniel Boone, Jason Knoblauch, Lloyd Rothschild, Patrick Maines, Susan Agnoff, Pam Little, David Pollock, Deb Hooton, Loren Pessolano, John Mollozzi, Shirley Wade, Stephen Bloodworth, Katherine Haigh, William Field, Clarence and Jean Alford, Judy Roberson, Beth Ann Hillman, Frank Brown, Cynthia Murphey, Brandy Crawford, Leroy Dieffenbrock, Willie Dalrimple, Wilbur Holden, Paul Lawler, Jim Shaw, J.C. Lyle, Tina Roberts, Bryan White, Fred Butler, Laura Hines, Teresa McKaskel, Jim Weisen, Amy McGraw, Ian Sauer, Paul Brinkley, Jim Wiseman, Judy Robertson, Laurie Manning, Deb Hays

ACTIONS TO DATE

Planning Commission	**7/11/18 – Recommended approval, 6-0**
City Council	**7/17/18 – Approved, 7-0, waived 2nd reading, 7-0**

INFORMATION FROM THE 7/11/18 PLANNING COMMISSION MEETING
Following a presenation of the preliminary flood maps and an overview of the revised ordinance, several residents asked questions relative to stormwater management projects, mapping techniques and flood insurance rates. Following a brief discussion, the Planning Commission voted unanimously to approve the amendment and revised maps.

INFORMATION FROM THE 7/17/18 CITY COUNCIL MEETING
City staff gave a presenation of the preliminary flood maps and an overview of the revised ordinance and a representative of the National Flood Insurance Program gave a brief explanation of the insurance implications of the new maps. No one spoke in favor of or in opposition to the new maps. Following a brief question and answer period regarding the proposed higher standards and the newly regulated Coastal A zone, City Council voted unanimously to approve the amendment and revised maps.

ATTACHMENTS

1. FEMA Model Ordinance
2. Letter of Final Determination (dated 2/28/18)
3. Map of Structures in AE Zone under Effective Map (dated 6/15/18)
4. Map of Structures in AE Zone under Preliminary Map (dated 6/15/18)
5. Map of Structures in VE Zone under Effective Map (dated 6/15/18)
6. Map of Structures in VE Zone under Preliminary Map (dated 6/15/18)
7. Map Showing Changes in Special Flood Hazard Area (dated 7/3/18)
8. Map Showing Changes in Floodway (dated 7/3/18)
9. Land Development Code Article 13, Flood Plain Management and Article 15, Section 18-812. Definitions. (strikethrough and underline version)
10. Ordinance

REGULATORY REQUIREMENTS AND BEST MANAGEMENT PRACTICES (BMPs)
HURRICANE FLORENCE USCG ESF-10 RESPONSE NORTH CAROLINA

Sensitive Habitats, Wildlife, and Fisheries Resources

- Avoid and minimize response disturbance to sensitive benthic and shoreline habitats including:
  - Tidal marshes
  - Oysters reefs
  - Seagrasses
  - Tidal swamps
  - Other wetlands
  - Outer Coast Sand beaches
- Avoid and minimize response disturbance to all wildlife and fisheries species.
- Avoid and minimize response disturbance to the wild horse populations at five locations along the coast.

USACE Section 404 Clean Water Act and Section 10 Rivers and Harbors Act Permits

- Permit required if significant sediment disturbance is needed for vessel removal (contact the Environmental Unit [EU] for assistance).

State of North Carolina Permits/Authorizations

- Floating the vessel, protecting the wetland surface with mats, roller bags, etc., and pulling the vessel off the wetland during the highest of high tides are encouraged and do not require a permit from NC Division of Coastal Management.
- Restoration of the impacted wetland may be required if incidental scarring/excavation occurs while the vessel is removed.
- Permit required from NC Division of Coastal Management as well as other state and federal authorities for digging in wetlands or adjacent estuarine waters.

North Carolina SHPO Section 106 National Historic Preservation Act

- Cease all activities involving subsurface disturbance, and immediately contact the EU, if prehistoric/historic artifacts, such as pottery or ceramics, lithic artifacts, historic shipwrecks, dugout canoes, metal implements, historic building materials, or any other physical remains that could be associated with Pre-Columbian, early European, or American settlement are encountered at any time (and leave all artifacts in place). Response activities shall not resume without verbal and/or written authorization. In the event that unmarked human remains are encountered during response activities, stop all work immediately and contact the EU, who will notify the SHPO and the appropriate law enforcement authorities.
- Contact the EU prior to conducting any removal or recovery efforts that require substantial ground disturbance beyond the initial disturbance caused by the disaster event (additional SHPO coordination required).
- If removal activities take place near a vessel located on or adjoining to identified historical sites, further consultation will be required.

NOAA NMFS Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), and Essential Fish Habitat (EFH)

- All response vessel operators and crew must watch for and avoid collision with species protected under the ESA and MMPA.
- All response vessels shall operate at “Idle Speed/No Wake” at all times while in water depths where the draft of the vessel provides less than a 4-ft clearance from the bottom, and after a protected species has been observed in and has departed the area.
- All response vessels will follow marked channels and/or routes using the maximum water depth whenever possible.
- Stop operating mechanical construction equipment, including response vessels, immediately if a protected species is observed within a 50-ft radius of construction equipment and resume after the species has departed the area of its own volition.
- If the detection of species is not possible during certain weather conditions (e.g., fog, rain, wind), then in-water operations will cease until weather conditions improve and detection is again feasible.
- All response vessels:
  - 1. Maintain a minimum distance of 150 ft. from sea turtles.
  - 2. Maintain a minimum distance of 300 ft. from dolphins and whales.

NOAA NMFS ESA, MMPA, EFH - continued

- o 3. When sea turtles, dolphins, or whales are sighted while the vessel is underway (e.g., bow-riding), attempt to remain parallel to the animal's course. Avoid excessive speed or abrupt changes in direction until they have left the area.
- o 4. Reduce speed to 10 knots or less when mother/calf pairs or groups of marine mammals are observed, when safety permits.
- o 5. Maintain a minimum 1,500-ft. distance from North Atlantic right whales. Vessels 65 ft. in length or longer must comply with the Right Whale Ship Strike Reduction Rule (50 CFR 224.105) which includes reducing speeds to 10 knots of less in Seasonal Management Areas (https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-ship-strikes-north-atlantic-right-whales). Mariners shall check various communication media for general information regarding avoiding ship strikes and specific information regarding right whale sightings in the area. These include NOAA weather radio, USCG NAVTEX broadcasts, and Notices to Mariners.

- Turbidity must be monitored and controlled; prior to in-water work turbidity curtains should be installed as per below. Turbidity control measures may be waived if minimal turbidity will be generated during vessel removal or if the current is too strong for curtains to stay in place.
- Turbidity Control Measures:
  - o 1. Install floating turbidity barriers with weighted skirts that extend to within 1 ft. of the bottom around all work areas that are in, or adjacent to, surface waters.
  - o 2. Use these turbidity barriers throughout construction to control erosion and siltation and ensure that turbidity levels within the project area do not exceed background conditions (i.e., the normal water quality levels from natural turbidity).
  - o 3. Position turbidity barriers in a way that does not block species entry to or exit from designated critical habitat.
  - o 4. Monitor and maintain turbidity barriers in place until the authorized work has been completed and the water quality in the project area has returned to background conditions.
  - o 5. Turbidity barriers should avoid contact with tidal marsh, oyster reefs, and seagrasses, if feasible.
- Entanglement:
  - o 1. All turbidity curtains and other in-water equipment (including hard and sorbent booms) must be properly secured with materials that reduce the risk of entanglement of marine species (described below). Turbidity curtains and other equipment likewise must be made of materials that reduce the risk of entanglement of marine species.
  - o 2. In-water lines (rope, chain, and cable, including the lines to secure turbidity curtains, boom, buoys, etc.) must be stiff, taut, and non-looping. Examples of such lines are heavy metal chains or heavy cables that do not readily loop and tangle. Flexible in-water lines, such as nylon rope or any lines that could loop or tangle, must be enclosed in a plastic or rubber sleeve/tube to add rigidity and prevent the line from looping and tangling. In all instances, no excess line is allowed in the water.
  - o 3. Turbidity curtains and other in-water equipment (including hard and sorbent boom) must be placed in a manner that does not entrap species within the construction area or block access for them to navigate around the construction area.
- Measures to avoid:
  - o 1. Use of in-water explosives. NC NERR would like to be consulted if these need to be used in the boundaries of the NCNERR.
  - o 2. Trawling for debris removal.
  - o 3. Deployment of anchored items that do not employ stiff, taut, and non-looping anchor lines.
  - o 4. Dragging displaced vessels, debris, or other items across tidal marsh, oyster reef, and seagrass habitats - items should be hoisted or refloated if possible (see further guidance below).

NOAA NMFS ESA, MMPA, EFH - continued

- ☐ Any vessel collisions with and/or injury or impacts to any protected species (sea turtle, whale, sturgeon, etc.) shall be reported to the EU as soon as possible. Likewise, report any stranded, injured, trapped, entangled, or dead protected species to the EU as soon as possible. The EU will make further notifications to the appropriate agency contacts. Contact the EU through your chain of command.

Tidal Marsh, Oyster Reefs, Seagrasses:

- ☐ Avoid response vessel grounding, prop scarring, and prop washing in tidal marsh, oyster reef, and seagrass habitats.
- ☐ Avoid anchoring and spudding on tidal marsh, oyster reef, and seagrass habitats; anchor and spud on bare sand and mud bottoms only.
- ☐ If spudding on seagrasses cannot be avoided, fill spud holes to grade with sand, as feasible, to minimize impacts.
- ☐ Avoid/minimize shading of seagrasses with barges for more than a few days; move barges off of seagrasses onto bare sand or mud substrates when not undergoing active operations (such as in barge staging areas).
- ☐ Prior to hoisting or refloating displaced vessels, work crews should evaluate the intertidal and subtidal benthic resources in the immediate area and determine an ingress/egress and removal path that will have the least impact to any surrounding tidal marsh, oyster reef, and seagrass habitats (may or may not be the same as the existing grounding path). Habitat maps, charts and aerial/satellite photography can be used to facilitate this process.
- ☐ Temporary stakes/buoys should be used to mark the ingress/egress or extraction path and GPS navigation should be used, if applicable, to assist salvers in staying on course to avoid areas of greatest tidal marsh, oyster, and seagrass habitat extent and quality to the degree possible.
- ☐ Avoid dragging displaced vessels, debris, or other items across tidal marsh, oyster reef, and seagrass habitats - items should be hoisted or refloated if possible. Use of lift bags, rollers, equipment mats, and other methods should also be evaluated to minimize impacts, such as rutting and keel scarring.
- ☐ Where equipment or crews must access displaced vessels or debris across tidal marsh or shallow oyster or seagrass habitats, use specialized equipment with low pressure/flotation tires, equipment mats, walk boards, or other comparable methods to minimize disturbance.
- ☐ Avoid digging, jetting, excavation, and similar methods in tidal marsh, oyster reef, and seagrass habitats to remove displaced vessels.
- ☐ If the above suite of habitat-based BMPs cannot be applied, USACE and State permits may be required (see above).

USFWS Endangered Species Act (ESA), Migratory Bird Treaty Act (MBTA), Fish and Wildlife Coordination Act (FWCA) Manatees:

- ☐ Observe the following recommended USFWS Manatee Conservation Measures for In-Water Projects.
- ☐ Response personnel will be aware of the potential presence of manatees and the need to avoid vessel/equipment collisions and/or any harm with manatees.
- ☐ Response personnel should know the general appearance of the species and their habit of moving about completely or partially submerged in shallow water. Response personnel will be informed that they are responsible for observing water-related activities for the presence of manatees.
- ☐ Response personnel will be advised that there are civil and criminal penalties for harming, harassing, or killing manatees.
- ☐ All response vessels will operate at “no-wake/idle” speed at all times while in water where the draft of the vessel provides less than a four foot clearance from the bottom; vessels should follow routes of deep water whenever possible.
- ☐ If manatees are seen within 100 yards (300 ft.) of an in-water work area, all appropriate precautions shall be implemented to ensure protection of manatees. These precautions shall include operating all response vessels and equipment in such a manner that vessels/moving equipment do not come any closer than 50 to 100 ft. of any manatee. If a manatee is within 50 ft. of in-water work, all in-water activities must shut down, until the

USFWS ESA, MBTA, and FWCA - continued

manatee moves on its own volition at least 100 ft. away from the in-water work area. Manatees must not be herded or harassed into leaving the area.

- Siltation/turbidity barriers, hard/sorbent boom, anchor and tow lines, etc. will be made of materials in which manatees cannot become entangled; and will be properly secured and regularly monitored to avoid manatee entanglement/entrapment. Barriers must not block manatee entrance to or exit from essential habitat.
- Any collisions with or injury to a manatee shall be reported immediately. The report must be made to the U.S. Fish and Wildlife Service (ph. 919.856.4520 ext. 16), the National Marine Fisheries Service (ph. 252.728.8762), and the North Carolina Wildlife Resources Commission (ph. 252.448.1546). Likewise, report any stranded, injured, trapped, entangled, or dead manatee to the EU as soon as possible. The EU will make further notifications to the appropriate agency contacts.
- A sign should be posted in all vessels associated with the project where it is clearly visible to the vessel operator. The sign should state: CAUTION: The endangered manatee may occur in these waters during the warmer months, primarily from June through October. Idle speed is required if operating this vessel in shallow water during these months. All equipment must be shut down with and/or injury to the manatee must be reported immediately to the U.S. Fish and Wildlife Service (919.856.4520 ext. 16), the National Marine Fisheries Service (252.728.8762), and the North Carolina Wildlife Resources Commission (252.448.1546).
- The contractor should maintain a log detailing sightings, collisions, and/or injuries to manatees during project activities. Upon completion of the action, the contractor should prepare a report which summarizes all information on manatees encountered and submit the report to the Service's Raleigh Field Office.

Nesting Sea Turtles:

- Be aware of the potential for sea turtle nesting activity on outer coast (ocean-facing) sand beaches during nesting season. Adults nesting May-Sep; hatching/juveniles present Jun-Dec.
- Adult sea turtles, crawls, nests, eggs, and hatchlings should be protected during response activities on sea turtle nesting beaches, including hatchling turtles as they emerge from the nest and crawl to the sea.
- Sea turtle nesting surveys may be required prior to vessel removal or staging activities on outer coast beaches. Contact the EU to coordinate sea turtle nesting beach surveys through USFWS and/or NC WRC. Entry onto the beach will occur only after the Biological Monitor has completed the morning surveys, if required. Surveys are typically completed in the early morning; all operations on the beach should be conducted after nesting beach surveys are complete, in coordination with the Biological Monitor.
- After the beach has been surveyed, the Biological Monitor will mark/direct the response crew along the established travel corridor, as applicable.
- If an unmarked sea turtle crawl is encountered during or prior to response activities, the response crew will not disturb the integrity of the crawl or follow the crawl up the beach or into the dune/vegetation, and will contact the EU to inform them of the location of the crawl.
- Any marked nests within the areas where vessel removal or staging will occur (including access areas) shall be left in place. Marked nests shall be delineated by stake and survey tape or string around the nest. A circle with a 10-ft. radius centered at the nest is recommended for nest protection. Marked nests and areas with unmarked nests must be avoided during vessel removal and staging.
- If activity will occur near a marked nest or in the wrack line, a Biological Monitor or their authorized personnel shall be onsite during vessel removal.
- Equipment and work crews will only transit the beach seaward of the nesting area on the hard-packed sand (stay below the wrack line if present).
- If a sea turtle (either adult or hatchling) is observed, maintain at least 200 ft. between the turtle and response personnel and contact the EU.
- If sea turtle hatchlings are encountered, maintain at least 200 ft. between the hatchlings and response personnel, allow the hatchlings to crawl unobstructed to the water. Do not carry the hatchlings to the water. Contact the EU immediately.

USFWS ESA, MBTA, and FWCA - continued

- All response actions, equipment, and personnel shall observe a 10-ft. buffer from marked sea turtle nests. Care should be taken to avoid walking or driving equipment over a crawl so that a potential nest is not damaged.
- Any potential obstructions or entanglement hazards for sea turtles and hatchlings should be removed from the beach at the end of each day, this includes displaced vessels/marine debris (in staging areas), response vehicles, equipment, gear, lines, rigging, boom, etc.
- If altered, beach topography shall be re-established in all areas to the natural beach profile/grade at the end of operations each day. Re-establishing beach topography includes raking of tire, track, and keel ruts; filling pits or holes where debris were removed; etc.
- In the event a sea turtle nest is excavated during vessel/debris removal activities, immediately cease all work in that area and contact the EU.
- Minimize lighting at night that may disorient sea turtle hatchlings and nesting females. Consult with the EU regarding night operations near beaches.
- Upon locating a dead, injured, or sick sea turtle, or if eggs or nests are disturbed during response activity, contact the EU. The EU will make further notifications to the appropriate agency contacts.

Birds:

- Avoid known or observed seabird, shorebird, and wading bird nesting colonies and roosting aggregations to the extent possible. Many smaller islands, beaches, dunes, supratidal oyster deposits, and other shoreline areas may be nesting or roosting sites. Nesting season occurs from April 1 - August 31.
- Do not enter sites with active bird nesting colonies or roosts. If birds are flushed, move away from the area and observe a larger buffer distance to avoid and minimize disturbance. If vessel removals are likely to impact nesting colonies or roosting sites, contact the EU for further guidance.
- Avoid and minimize aircraft disturbance to bird nesting colonies and roosting aggregations. Limit overflights to a minimum 1,000 ft. altitude floor over colonies and roosts and limit excessive disturbance (e.g., repeated low passes, hovering, circling). If birds are flushed by aircraft move away from the area and maintain a higher floor over other observed colonies and aggregations.
- Contact the USFWS Raleigh Field Office (919.856.4520) in the event that a bald eagle nest is proximate to the work area.

Additional Considerations:

- Recreational users may be in the area. Appropriate measures should be taken to ensure safety and as appropriate. Notify the users of any hazards associated with vessels and removal efforts.
- Equipment and material staging areas should be located outside of areas of native vegetation and known endangered species habitats. Contact the EU for assistance.
- Minimize the disturbance footprint when removing displaced vessels.
- Collect all floating debris during vessel removal.
- Where possible, equipment should be operated from existing hard top or impacted sites to remove displaced vessels from natural habitats.
- Vessel removal activities should be accomplished with the smallest equipment needed, including hand crews where possible, to minimize disturbance of habitat (especially when working within critical habitats).
- Ingress and egress corridors for vehicle and equipment operations and vessel removal should minimize impact to natural habitats. Care should be taken to restrict equipment/vehicles to roadways and roadbeds and away from vegetated areas or areas of buried vegetation.
- To the degree possible, the removal of forested vegetation should be limited to fallen trees only, and only if required to remove displaced vessels; otherwise, leave fallen trees in place (applies to tidal swamps and other forested wetlands as well).
- Trimming of standing native trees during vessel removal should be minimized (applies to tidal swamps and other forested wetlands as well).
- The removal of healthy trees to remove embedded vessels should be avoided or minimized (applies to tidal swamps and other forested wetlands also).

USFWS ESA, MBTA, and FWCA - continued

- ☐ All trash resulting from the response should be removed from the area as appropriate or disposed of properly in covered trash receptacles.

For further guidance and assistance with BMPs, please work with the on-site BMP Coordinator or contact the EU through your chain of command. Checked boxes indicate BMPs that apply to specific operations or locations; if no boxes are checked, observe all BMPs as applicable and feasible given the type of operations and safety considerations. Document BMP compliance on daily 214 logs.

APPLICATION FOR WAIVER OF TIPPING FEES

This form should be completed and submitted to the Director of Environmental Management for consideration of a waiver of established tipping fees. The Director will review the application and make a recommendation to the Board of County Commissioners.

Submit the completed form to:

Joe Suleyman
Director, Environmental Management
3002 US Highway 421 North
Wilmington, NC 28401

SECTION ONE (To be completed by Applicant)

Name of Organization: North Carolina Coastal Federation, Inc.

Address: 309 W. Salisbury St.
Wrightsville Beach, NC 28480

Primary Contact: Ted Wilgis, Senior Coastal Specialist

Phone: (910) 509 - 2838 ext 202

Email Address: tedw@nccoast.org

1.) What is the mission of your organization?

The North Carolina Coastal Federation empowers coastal residents and visitors from all walks of life to protect and restore the water quality and critically important natural habitats of the North Carolina coast.

2.) What type of service(s) do/does your organization provide to the residents of New Hanover County?

The North Carolina Coastal Federation focuses its work in 5 areas that benefit local residents: 1) Clean coastal waters that support fishing and swimming. 2) Living Shorelines that prevent sound-side erosion and provide habitat. 3) Thriving oysters that support the coastal environment and economy. 4) Effective coastal management that protects our coast. 5) A coast that is free of marine debris.

3.) Outline the necessity of this request and its impact on your organization:

The Coastal Federation received funding from the NOAA Marine Debris Program, and we will receive additional grant and/or state funding to collect and dispose of marine debris found in coastal waters generated by recent storms. The grant funding pays local fishers and contractors to collect the debris, and private/municipal haulers and facilities to dispose of the debris. Any funds saved by waiving tipping fees will go towards additional collection and hauling of debris.

4.) Have tipping fees been waived in the past for this organization (circle one)?

YES NO

5.) Please attach a copy of any documentation of your organization's IRS status

6.) What waste removal/hauling company will be transporting your waste?

Coastal Waste and Hauling

7.) What is the estimated amount (in tons or cubic yards) of expected waste generation?

20 Tons ***OR*** ______ Cubic Yards

8.) Check type(s) of waste: ___Garbage or refuse x Construction waste

___Bulky waste (mattresses, furniture, etc.)

I hereby certify that the information above is true and accurate, and that I am authorized by my organization to submit this request on its behalf. I also understand that it is my organization's responsibility to ensure that no hazardous or prohibited wastes will be disposed of.

Signature: ________________________________ Date: ____________

SECTION TWO (To be completed by NHC DEM)

I have reviewed the tipping fee waiver request and
RECOMMEND / DO NOT RECOMMEND *approval (circle one).*

Signature: ________________________________ Date: ____________

Cc:
NHC Landfill Mgr.
Clerk to the Board

Cultural Resources Protection Plan for Debris Removal

Sponsor: Division of Coastal Management
Funding source: Emergency Watershed Program
Project number: 37-03-18-5038-005
Point of Contact: Paula Gillikin, N.C. Division of Coastal Management, Coastal Reserve Program

The goal of this project as related to cultural resources that fall under National or State Historic Preservation laws, is to comply with and avoid any impacts to these resources resulting from debris removal, including the removal of displaced vessels due to Hurricane Florence. These resources include all vessels and underwater archaeological artifacts that have been abandoned for more than 10 years in compliance with G.S. 121, Article 3, below. While the identified vessels are not cultural resources themselves, removal of such vessels could possibly expose cultural resources that are on top of or buried in the sediment. If cultural resources are encountered during debris removal, the Sponsor is committed to ensuring that the resource is properly documented and/or handled per SHPO's instructions and/or on-site inspection. None of the vessels that are identified in the proposal are historic in nature as they were documented as owned and/or abandoned or derelict vessels that were displaced due to Hurricane Florence.

The plan for removal of debris involves manual and mechanical means with debris items loaded onto boats and/or barges. A marine salvage company will be utilized to lift, float, and then tow displaced vessels when possible. Vessels found on land will be pulled from the shoreline and then floated and towed. To protect sensitive coastal habitats, mats, roller bags, or similar will be used to protect the substrate if the vessel will cause significant soil disturbance such as ruts. If needed, some vessels may be disassembled and then disposed of in pieces.

The project Sponsor acknowledges that excavation for debris removal could also expose cultural resources. While the use of excavation techniques is not anticipated, any debris site requiring excavation will be evaluated to determine if a Coastal Area Management Act permit will be required and both federal and state SHPO compliance staff will be contacted to notify them of the need to excavate sediment. A Coastal Area Management Act permit will be coordinated through the standard permit application review process The Sponsor will ensure that debris removal contractors are informed about debris removal best practices, permit triggers, and the requirement to consult the Sponsor when a cultural resource or suspected cultural resource is encountered. Unless otherwise advised by project SHPO reviewers, all work will cease and will not resume until after SHPO, through DCM, has given their approval to resume work.

The State agencies that manage sites A (Rachel Carson Reserve), B (Hammocks Beach State Park), C (Permuda Island), and D (Masonboro Island) have active relationships with SHPO personnel and are familiar with areas likely to contain cultural resources. Additionally, the Division of Coastal Management (Sponsor) regularly works with SHPO contacts in the administration of permits under the Coastal Area Management Act. These relationships and required consultations will further ensure protection of the resources. Accommodations will be made for SHPO personnel to observe debris removal operations in arreas where cultural resources are known to exist.

A list of SHPO contacts is found, below:

Chris Southerly
Deputy State Archaeologist
chris.southerly@ncdcr.gov
910 251 7323 office
910 251 7320 Front Desk

or

Nathan Henry
Assistant State Archaeologist
910 251 7327 office
nathan.henry@ncdcr.gov

North Carolina G.S. 121, Article 3, Subsections 121-122 *establishes title for the State to all shipwrecks, vessels, cargoes, tackle and underwater archaeological artifacts abandoned for more than ten (10) years and lying on the bottoms of navigable waters and ocean waters from within one marine league seaward from the Atlantic seashore extreme low watermark.*

The debris removal will not include any watercraft or parts of watercraft that have been submerged over ten years. If questionable the NC Dept. of Cultural Resource's Underwater Archaeology Branch will be consulted for clarification.

RE: Debris removal and SHPO

Henry, Nathan

Tue 5/21/2019 1:40 PM

To: Gillikin, Paula <paula.gillikin@ncdenr.gov>;

Hi Paula, If you can send your removal plan to SHPO for review it will come to us: environmental.review@ncdcr.gov

As far as the protection of cultural resources I would just add a paragraph like:

North Carolina G.S. 121, Article 3, Subsections 121-122 establishes title for the State to all shipwrecks, vessels, cargoes, tackle and underwater archaeological artifacts abandoned for more than ten (10) years and lying on the bottoms of navigable waters and ocean waters from within one marine league seaward from the Atlantic seashore extreme low watermark.

The debris removal will not include any watercraft or parts of watercraft that have been submerged over ten years. If questionable the NC Dept. of Cultural Resource's Underwater Archaeology Branch will be consulted for clarification.

Contacts:
Chris Southerly
Deputy State Archaeologist
chris.southerly@ncdcr.gov
910 251 7323 office
910 251 7320 Front Desk
or
Nathan Henry
Assistant State Archaeologist
910 251 7327 office
nathan.henry@ncdcr.gov

I think that should do it.

NC DEPARTMENT OF NATURAL AND CULTURAL RESOURCES

Email correspondence to and from this address is subject to the North Carolina Public Records Law and may be disclosed to third parties.

From: Gillikin, Paula
Sent: Monday, May 20, 2019 4:36 PM
To: Henry, Nathan <nathan.henry@ncdcr.gov>
Subject: Debris removal and SHPO

Hi Nathan,

We have been approved for funding to remo 'e debris at Rachel Carson Reserve, Hamocks Beach SP, Permuda, and Masonboro. Additional sites wı l likely follow - Eastern Carteret, Craven County, Pamlico County, Brunswick County, South New Hanov ɜr County.

The EWP folks are asking me to write-up our plan as it pertains to the removal of debris (main concern vessels) and protection of cultural resources. T ney would like me to include points of SHPO contact for the areas I listed, above. Can you please assist me?

Best,

Paula

Paula Gillikin
Central Sites Manager (Rachel Carson & Permuda Island Reserves)
N.C. Coastal Reserve and National Estuarine Research Reserve
N.C. Department of Environmental Quality

252 838 0886 office
paula.gillikin@ncdenr.gov

101 Pivers Island Road
Beaufort, NC 28516

DEQ
Department of Environmental Quality

Email correspondence to and from this address is subject to the North Carolina Public Records Law and may be disclosed to third parties.

North Carolina Coastal Federation
Working Together for a Healthy Coast

Agreement to Perform Contracted Services for the North Carolina Coastal Federation: NRCS Emergency Watershed Protection program for Hurricane Florence Marine Debris Cleanup Award #16-8191WA

Boat Owner/Operator Contract

Date: June 25, 2021

Services Performed By:

Services Performed for: North Carolina Coastal Federation, Inc.
3609 Hwy 24 (Ocean)
Newport, NC 28570

This Agreement, between ______________________________ (Contractor) and the North Carolina Coastal Federation (Client), is subject to the terms and conditions outlined below. This Agreement is the sole document outlining the scope of work. Any changes must be made in writing according to the procedure outlined in this document and signed by both parties. This Agreement is effective from June 28, 2021 and shall end on August 31, 2021.

Period of Performance
The services to be provided will begin on June 28, 2021 and continue until August 31, 2021, or until the contract services amount has been reached, whichever is first.

Background
The North Carolina Coastal Federation, Inc. received funding from the North Carolina Department of Environmental Quality: Division of Coastal Management (NCDEQ DCM) to survey, collect, remove, record and properly dispose of marine debris from North Carolina's coastal waters and public trust properties. The debris will be collected from public trust areas of the coast, and it may include household trash, plastic, bottles, cans, foam pieces, fishing gear, tires, building supplies, construction materials, and pressure-treated wood. The project will focus on public islands and marshes, including state parks, reserves, dredge spoil islands, and public waterways.

Contractor Responsibilities
Scope of Work – Boat Operator and Owner– The contractor will:
- Provide a boat/vessel and captain services for the duration of the contract.
- Ensure that all necessary and required safety and operating equipment are on the boat and in good operating condition during the project.

- Work with the Field Crew Supervisor and other Field Crew Members to collect pieces of marine debris in and along public waters and lands, including dredge spoil islands in an area extending throughout Onslow, Pender, New Hanover and Brunswick Counties.
- Follow safety protocols outlined in the federation's "Contractor Safety Protocols" (Attachment A) during transportation to and from clean-up sites, and while on site at cleanup areas and collection drop off areas.
- Ensure that the boat/vessel is operated safely within its design capacity for weight and passenger capacity and according to all pertinent regulations during the project.
- Ensure that the boat/vessel is maintained in good operating condition.
- Transport field crew to and from cleanup sites during workdays.
- Assure safety of field crew during transportation and keep an open line of communication with crew members in case of emergency.
- If needed, safely transport volunteer groups to and from cleanup sites during federation-led volunteer cleanups.
- Work with Field Crew Supervisor to make a timely determination on when to cancel a cleanup (day or partial day) based upon weather conditions or other factors, and to communicate that information to Field Crew Members hired as part of this project.
- Assist the Client in identifying cleanup sites.
- Ensure minimum disturbance to estuarine habitats during debris pick-up and transport through adhering to and implementing recommended BMPs from:
    a. (Sept 30 2014) Best Management Practices for the Removal of Debris from Wetland and Intertidal Areas: NOAA Marine Debris Program (Attachment B)
- Transport and properly dispose of marine debris collected when and where requested by the Client.
- Participate in project team calls and meetings as necessary.
- Work with the Client to address any questions or requests for information the funder may have.

Deliverables

The Contractor will operate and provide boat/vessel(s) to transport Field Crew Members to clean up small-scale marine debris from public trust properties along coastal waterways from Onslow, Pender, New Hanover and Brunswick Counties. Transport and properly dispose of collected marine debris.

Limits

The services provided are intended to provide the Client with the assistance necessary to complete the marine debris cleanup as required by the NCDEQ DCM funds.

The Contractor is not responsible for:

- Collecting marine debris outside of the scope of work
- Payment of contracted work force
- Oversight of volunteers

Client Responsibilities:

- Communicate grant-related requirements to the Contractor.
- Provide project area boundaries.
- Provide data collection tools and requirements.
- Contract directly with Field Crew Members.

- Respond promptly and thoroughly to any requests for information or questions from the Contractor.
- Keep the Contractor apprised of project developments in a timely manner.
- Review and complete any and all reports and documentation request by the funder.

Fee Schedule

- The Boat Owner/Operator will be considered an independent contractor and will be sent Form 1099-MISC at the end of the year.
- The total cost for services outlined in the scope of work is **$550 per day not to exceed 50 working days or $27,500** unless otherwise agreed to by both parties in writing as an amendment to this contract.

Invoice Procedures

Contractor will work with the Field Crew Supervisor to invoice Client for the above services rendered by submitting work logs and timesheets. Standard contractor invoicing is assumed to be acceptable. Contractor may submit invoices to Client no more frequently than every **10** working days. Payment of invoices by the Client should be received by the Contractor within **7** business days of the date of invoice.

Contract Agreement

IN WITNESS WHEREOF, the parties below have caused this Agreement to be effective as of June 28, 2021.

Client	**Contractor**
North Carolina Coastal Federation, Inc.	
______________________________	______________________________
Signature	Signature
______________________________	______________________________
Printed Name	Printed Name
______________________________	______________________________
Title	Title
______________________________	______________________________
Date	Date

Attachment B

Best Management Practices for the Removal of Debris from Wetland and Intertidal Areas: NOAA Marine Debris Program

- Avoid collisions and contact with all wildlife. Report sightings of stranded turtles and marine mammals, and distressed or dead birds, sharks, rays, and marine mammals to the appropriate State or Federal agency.
- All removal operations should take place during daylight hours. Night operations may require establishment of additional location specific BMPs in consultation with resource agencies and landowners.
- Avoid all bird and turtle nesting or aggregation areas or marine mammal haul-out locations.
- Ensure no nesting birds are adjacent to debris, in the footprint of vehicle traffic, or in the path of debris to be removed by dragging. On sites with nesting bird sensitivity, resource agency and/or landowner representatives should be present to identify any birds nesting in the area and determine the current status of the nesting birds and fledglings. If any of the birds in the area are still nesting (with eggs or young birds at the nest), it is preferable to delay the recovery until such time that no birds are nesting and the young birds have left the area.
- To limit disturbance to birds and other sensitive wetland and intertidal-associated species, work crews should be limited in size and number to the minimum number of personnel and equipment required to complete removal in an efficient time frame. Equipment and personnel should work as closely together as is feasible during recovery operations to minimize disturbance, rather than spread across the entire site.
- Avoid all unnecessary contact with wetland vegetation or soils on foot or by vehicle in transit to and from debris removal site.
- Use established pre-existing access/egress routes where feasible such as pre-existing roads, paths, trails, or waterways. If pre-existing access/egress routes do not exist, it may be necessary to establish temporary access/egress corridors to provide guidance and minimize traffic in wetlands and other sensitive habitats during clean-up operations.
- When conducting operations on water with vessels, avoid blocking major egress points in channels, river, passes, and bays.
- Minimize unnecessary disturbance or removal of natural sediment, organic, matter, and vegetation not required to access man-made debris items. If moving organic debris is required, replace or deposit in the nearest tidally influenced area. Organic debris plays vital ecological function in many intertidal areas and should remain in place to the extent possible.
  Historic and pre-contact-era artifacts of any type (e.g., pot sherds, arrowheads, ship timbers, and bottles) should not be collected and should be reported to the appropriate agency.
- Staging areas for sorting or storing recovered debris should not be located in wetlands or intertidal areas if possible.
- Remove all equipment and materials deployed to facilitate debris removal operations at conclusion of operations.

North Carolina Coastal Federation
Working Together for a Healthy Coast

Application and Payment Form
Contracted Services for the North Carolina Coastal Federation:
NRCS Emergency Watershed Protection program for Hurricane Florence Marine Debris Cleanup
Award #16-8191WA

June 17, 2021

Project Information

- The North Carolina Coastal Federation, Inc. received funding from the North Carolina Department of Environmental Quality: Division of Coastal Management to survey, collect, remove, record and properly dispose of marine debris from North Carolina's coastal waters and public trust properties.
- The debris will be collected from public trust areas of the coast in an area extending throughout Onslow, Pender, New Hanover and Brunswick Counties.
- The debris may include household trash, plastic, bottles, cans, foam pieces, fishing gear, tires, building supplies, construction materials, and pressure-treated wood.
- The debris will be collected and transported to stockpile and collection areas, loaded into containers and hauled to appropriate disposal sites.
- The project will focus on public islands and marshes, including state parks, reserves, dredge spoil islands, and public waterways.

Project Participants

- Workers will be considered independent contractors and will be sent Form 1099-MISC at the end of the year.
- Workers must have their own worker's compensation policy, OR sign a liability waiver (attached).
- Project requires workers to adhere to project contract provisions, contract clauses, and the following conditions:
  - Agree to guarantee availability for work from July 1, 2021 to August 31, 2021 (excluding holidays).
  - Work an average 8-hour day.
  - Complete a minimum of 15 working days.
  - Must be 18 years of age or older.
- By participating in this marine debris collection project:
  - Workers are agreeing to the conditions stated in the project information section above.
  - Workers will be acting solely as an independent contractor and not as an employee of the federal or state government or the North Carolina Coastal Federation.
  - The aforementioned groups are not liable for any incidents or accidents that occur as a result of this work.
- Federation staff will be on-site to ensure the work is being completed as outlined.

Participant Review Process

- All workers will be reviewed with the state and federal government's vendor list and will be ineligible if debarred or suspended from doing business with the state or federal government.
- Please fill the form out completely before faxing, hand carrying, scanning and emailing, or mailing it to:
  - North Carolina Coastal Federation - Southeast Office
    Attn: Ted Wilgis
    309 W. Salisbury St.
    Wrightsville Beach, NC 28480
    (910) 509-2838 Ext. 202
    (910) 231-6605 mobile
    (910) 509-2840 fax
    tedw@nccoast.org
- Applicants may be asked to submit additional information, upon request.

Please read the form carefully and fill it out completely before submitting

<table>
<tr><td colspan="2">NAME (FIRST AND LAST)</td><td colspan="3">DATE OF BIRTH</td></tr>
<tr><td colspan="2">SOCIAL SECURITY NUMBER or BUSINESS EIN</td><td colspan="3">RESIDENT COUNTY</td></tr>
<tr><td colspan="2">MAILING ADDRESS</td><td>CITY</td><td>STATE</td><td>ZIP CODE</td></tr>
<tr><td>HOME PHONE NUMBER</td><td>CELL PHONE NUMBER</td><td colspan="3">EMAIL ADDRESS (IF APPLICABLE)</td></tr>
<tr><td colspan="5">PLEASE INDICATE WHAT DATES YOU ARE UNAVAILABLE FOR WORK BETWEEN 07/01/21 – 08/31/21:</td></tr>
</table>

Can you send and receive text messages on your cell phone? YES_____ NO_____

I will adhere to all program rules outlined in the project orientation. I also acknowledge that the North Carolina Coastal Federation is not liable for any accidents, injuries or property damage incurred in the performance of this work.

____ ____________________

Signature **Date**

*****DO NOT FILL OUT BELOW THIS LINE*****

Number of working days: _______________

Amount to be paid: ____________________

Grant number: ________________________

Signature: ____

North Carolina Coastal Federation
Working Together for a Healthy Coast

Liability Waiver Form

Perform Contracted Services for the North Carolina Coastal Federation, Inc.:
NRCS Emergency Watershed Protection program for Hurricane Florence Marine Debris Cleanup
Award #16-8191WA

On this _____day of__________, 20___, intending to be legally bound hereby, the undersigned agrees and does hereby release from liability and indemnify and hold harmless the North Carolina Coastal Federation, Inc., and any of its employees in regards to the Maine Debris Cleanup Project. This release is for any and all liability for personal injuries (including death) and property losses or damage occasioned by, or in connection with any activity or accommodations for this event. The undersigned further agrees to abide by all the rules and regulation promulgated by the North Carolina Coastal Federation, Inc. and/or its vendors throughout the Marine Debris cleanup Project.

_______________________________ ___________________
Participant Name (please print) **Date signed**

____
Participant signature

Agreement to Perform Contracted Services for the North Carolina Coastal Federation:
NRCS Emergency Watershed Protection program for Hurricane Florence Marine Debris Cleanup
Award #16-8191WA

Field Crew Member Contract

Date: June 25, 2021

Services Performed By:

Services Performed for: North Carolina Coastal Federation, Inc.
3609 Hwy 24 (Ocean)
Newport, NC 28570

This Agreement, between ____(Contractor) and the North Carolina Coastal Federation, Inc. (Client), is subject to the terms and conditions outlined below. This Agreement is the sole document outlining the scope of work. Any changes must be made in writing according to the procedure outlined in this document and signed by both parties. This Agreement is effective from June 28, 2021 and shall end on August 31, 2021.

Period of Performance
The services to be provided will begin on June 28,2021 and continue until August 31, 2021, or until the contract services amount has been reached, whichever is first.

Background
The North Carolina Coastal Federation, Inc. received funding from the North Carolina Department of Environmental Quality: Division of Coastal Management (NCDEQ DCM) to survey, collect, remove, record and properly disposes of marine debris from North Carolina's coastal waters and public trust properties. The debris will be collected from public trust areas of the coast, and it may include household trash, plastic, bottles, cans, foam pieces, fishing gear, tires, building supplies, construction materials, and pressure-treated wood. The project will focus on public islands and marshes, including state parks, dredge spoil islands, and public waterways.

Contractor Responsibilities
Scope of Work – Field Crew Member – The contractor will:

- Work with the Field Crew Supervisor, Boat Owner/Operator and other Field Crew Members to collect pieces of marine debris in and along public waters and lands, including dredge spoil islands in an area extending throughout Onslow, Pender, New Hanover and Brunswick Counties.
- Follow safety protocols outlined in the federation's "Contractor Safety Protocols" (Attachment A) during transportation to and from cleanup sites, and while on site at cleanup areas and collection drop-off areas.
- Keep an open line of communication with the Field Crew Supervisor and Boat Owner/Operator in case of emergency.

- Assist the Client in identifying, locating, documenting and surveying cleanup sites.
- Ensure minimum disturbance to estuarine habitats during debris pickup and transport through adhering to and implementing recommended BMPs from:
    a. (Sept 30 2014) Best Management Practices for the Removal of Debris from Wetland and Intertidal Areas: NOAA Marine Debris Program (Attachment B)
- Properly dispose of marine debris collected when and where requested by the Client.
- Work with the Client to address any questions or requests for information the funder may have.

Deliverables
The Contractor will work as part of a field crew to clean up small-scale marine debris from public trust waters and lands along coastal waterways from Onslow, Pender, New Hanover and Brunswick Counties.

Limits
The services provided are intended to provide the Client with the assistance necessary to complete the marine debris cleanup as required by the NCDEQ DCM funds.
The Contractor is not responsible for:

- Collecting marine debris outside of the scope of work
- Payment of contracted work force
- Oversight of volunteers

Client Responsibilities:

- Communicate grant-related requirements to the Contractor.
- Provide project area boundaries.
- Respond promptly and thoroughly to any requests for information or questions from the Contractor.
- Keep the Contractor apprised of project developments in a timely manner.
- Review and complete any and all reports and documentation.

Fee Schedule

- The Field Crew Member will be considered an independent contractor and will be sent Form 1099-MISC at the end of the year.
- The total cost for services outlined in the scope of work is **$250 per day, not to exceed a total of $12,500 for 50 working days,** unless otherwise agreed to by both parties in writing as an amendment to this contract.

Invoice Procedures
Contractor will work with the Field Crew Supervisor to invoice Client for the above services rendered by submitting timesheets. Standard contractor invoicing is assumed to be acceptable. Contractor may submit invoices to Client no more frequently than every **10** working days. Payment of invoices by the Client should be received by the Contractor within **7** business days of the date of invoice.

Contract Agreement

IN WITNESS WHEREOF, the parties below have caused this Agreement to be effective as of June 28, 2021.

<u>Client</u>
North Carolina Coastal Federation, Inc.

____
Signature

____
Printed Name

____
Title

____
Date

<u>Contractor</u>

____
Signature

____
Printed Name

____
Title

____
Date

Attachment B

Best Management Practices for the Removal of Debris from Wetland and Intertidal Areas: NOAA Marine Debris Program

- Avoid collisions and contact with all wildlife. Report sightings of stranded turtles and marine mammals, and distressed or dead birds, sharks, rays, and marine mammals to the appropriate State or Federal agency.
- All removal operations should take place during daylight hours. Night operations may require establishment of additional location specific BMPs in consultation with resource agencies and landowners.
- Avoid all bird and turtle nesting or aggregation areas or marine mammal haul-out locations.
- Ensure no nesting birds are adjacent to debris, in the footprint of vehicle traffic, or in the path of debris to be removed by dragging. On sites with nesting bird sensitivity, resource agency and/or landowner representatives should be present to identify any birds nesting in the area and determine the current status of the nesting birds and fledglings. If any of the birds in the area are still nesting (with eggs or young birds at the nest), it is preferable to delay the recovery until such time that no birds are nesting and the young birds have left the area.
- To limit disturbance to birds and other sensitive wetland and intertidal-associated species, work crews should be limited in size and number to the minimum number of personnel and equipment required to complete removal in an efficient time frame. Equipment and personnel should work as closely together as is feasible during recovery operations to minimize disturbance, rather than spread across the entire site.
- Avoid all unnecessary contact with wetland vegetation or soils on foot or by vehicle in transit to and from debris removal site.
- Use established pre-existing access/egress routes where feasible such as pre-existing roads, paths, trails, or waterways. If pre-existing access/egress routes do not exist, it may be necessary to establish temporary access/egress corridors to provide guidance and minimize traffic in wetlands and other sensitive habitats during clean-up operations.
- When conducting operations on water with vessels, avoid blocking major egress points in channels, river, passes, and bays.
- Minimize unnecessary disturbance or removal of natural sediment, organic, matter, and vegetation not required to access man-made debris items. If moving organic debris is required, replace or deposit in the nearest tidally influenced area. Organic debris plays vital ecological function in many intertidal areas and should remain in place to the extent possible.
- Historic and pre-contact-era artifacts of any type (e.g., pot sherds, arrowheads, ship timbers, and bottles) should not be collected and should be reported to the appropriate agency.
- Staging areas for sorting or storing recovered debris should not be located in wetlands or intertidal areas if possible.
- Remove all equipment and materials deployed to facilitate debris removal operations at conclusion of operations.

North Carolina Coastal Federation
Working Together for a Healthy Coast

Agreement to Perform Contracted Services for the North Carolina Coastal Federation:
NRCS Emergency Watershed Protection program for Hurricane Florence Marine Debris Cleanup
Award #16-8191WA

Field Crew Supervisor Contract

Date: June 25, 2021

Services Performed By: ______________________________

Services Performed for: North Carolina Coastal Federation, Inc.
3609 Hwy 24 (Ocean)
Newport, NC 28570

This Agreement, between ______________________________(Contractor) and the North Carolina Coastal Federation, Inc. (Client), is subject to the terms and conditions outlined below. This Agreement is the sole document outlining the scope of work. Any changes must be made in writing according to the procedure outlined in this document and signed by both parties. This Agreement is effective from June 28, 2021 and shall end on August 31, 2021.

Period of Performance

The services to be provided will begin on June 28, 2021 and continue until August 31, 2021, or until the contract services amount has been reached, whichever is first.

Background

The North Carolina Coastal Federation, Inc. received funding from the North Carolina Department of Environmental Quality: Division of Coastal Management (NCDEQ DCM) to survey, collect, remove, record and properly disposes of marine debris from North Carolina's coastal waters and public trust properties. The debris will be collected from public trust areas of the coast, and it may include household trash, plastic, bottles, cans, foam pieces, fishing gear, tires, building supplies, construction materials, and pressure-treated wood. The project will focus on public islands and marshes, including state parks, dredge spoil islands, and public waterways.

Contractor Responsibilities

Scope of Work – Field Crew Supervisor – The contractor will:

- Manage a field crew of watermen/women to collect pieces of marine debris in and along public waters and lands, including dredge spoil islands in an area extending throughout Onslow, Pender, New Hanover and Brunswick Counties.

- Follow safety protocols outlined in the federation's "Contractor Safety Protocols" (Attachment A) during transportation to and from cleanup sites, and while on site at cleanup areas and collection drop-off areas.
- Keep an open line of communication with the Field Crew Members and Boat Owner/Operator in case of emergency.
- Document numbers of field crew and volunteer participants and hours worked on each trip.
- Provide completed timesheets and work log every 10 working days to the federation.
- Make a timely determination on when to cancel a cleanup (day or partial day) based upon weather conditions or other factors, and to communicate that information to Field Crew Members hired as part of this project.
- Take G.P.S. coordinates for sites of large debris or stockpiled debris for later pick up.
- Take G.P.S. coordinates, pictures, notes of condition for lost or derelict fishing gear and alert Coastal Federation supervisor for proper disposal procedure.
- Assist the Client in identifying, locating, documenting and surveying cleanup sites.
- Ensure minimum disturbance to estuarine habitats during debris pickup and transport through adhering to and implementing recommended BMPs from:
    a. (Sept 30 2014) Best Management Practices for the Removal of Debris from Wetland and Intertidal Areas: NOAA Marine Debris Program (Attachment B)
- Take photos and keep logs on the amount and types of debris collected and contractor trash bags that are filled each day.
- Properly dispose of marine debris collected when and where requested by the Client.
- Report all data collected to the Client monthly.
- Participate in project team calls and meetings as necessary.
- Work with the Client to address any questions or requests for information the funder may have.

Deliverables
The contractor will manage a field crew to clean up small-scale marine debris from public trust waters and lands along coastal waterways from waterways from Onslow, Pender, New Hanover and Brunswick Counties.

Limits
The services provided are intended to provide the Client with the assistance necessary to complete the marine debris cleanup as required by the NCDEQ DCM funds.
The Contractor is not responsible for:

- Collecting marine debris outside of the scope of work
- Payment of contracted work force
- Oversight of volunteers

Client Responsibilities:

- Communicate grant-related requirements to the Contractor.
- Provide project area boundaries.
- Provide data collection tools and requirements.
- Contract directly with Field Crew Members.
- Respond promptly and thoroughly to any requests for information or questions from the Contractor.
- Keep the Contractor apprised of project developments in a timely manner.

- Review and complete any and all reports and documentation.

Fee Schedule

- The Field Crew Supervisor will be considered as an independent contractor and will be sent Form 1099-MISC at the end of the year.
- The total cost for services outlined in the scope of work is **<u>$350 per day, not to exceed a total of $17,500 for 50 working days,</u>** unless otherwise agreed to by both parties in writing as an amendment to this contract.

Invoice Procedures

Contractor will work with the Field Crew Supervisor to invoice Client for the above services rendered by submitting timesheets. Standard contractor invoicing is assumed to be acceptable. Contractor may submit invoices to Client no more frequently than every **<u>10</u>** working days. Payment of invoices by the Client should be received by the Contractor within **<u>7</u>** business days of the date of invoice.

Contract Agreement

IN WITNESS WHEREOF, the parties below have caused this Agreement to be effective as of June 28, 2021.

<u>Client</u>	**<u>Contractor</u>**
North Carolina Coastal Federation, Inc.	
______________________________	______________________________
Signature	Signature
______________________________	______________________________
Printed Name	Printed Name
______________________________	______________________________
Title	Title
______________________________	______________________________
Date	Date

Attachment B

Best Management Practices for the Removal of Debris from Wetland and Intertidal Areas: NOAA Marine Debris Program

- Avoid collisions and contact with all wildlife. Report sightings of stranded turtles and marine mammals, and distressed or dead birds, sharks, rays, and marine mammals to the appropriate State or Federal agency.
- All removal operations should take place during daylight hours. Night operations may require establishment of additional location specific BMPs in consultation with resource agencies and landowners.
- Avoid all bird and turtle nesting or aggregation areas or marine mammal haul-out locations.
- Ensure no nesting birds are adjacent to debris, in the footprint of vehicle traffic, or in the path of debris to be removed by dragging. On sites with nesting bird sensitivity, resource agency and/or landowner representatives should be present to identify any birds nesting in the area and determine the current status of the nesting birds and fledglings. If any of the birds in the area are still nesting (with eggs or young birds at the nest), it is preferable to delay the recovery until such time that no birds are nesting and the young birds have left the area.
- To limit disturbance to birds and other sensitive wetland and intertidal-associated species, work crews should be limited in size and number to the minimum number of personnel and equipment required to complete removal in an efficient time frame. Equipment and personnel should work as closely together as is feasible during recovery operations to minimize disturbance, rather than spread across the entire site.
- Avoid all unnecessary contact with wetland vegetation or soils on foot or by vehicle in transit to and from debris removal site.
- Use established pre-existing access/egress routes where feasible such as pre-existing roads, paths, trails, or waterways. If pre-existing access/egress routes do not exist, it may be necessary to establish temporary access/egress corridors to provide guidance and minimize traffic in wetlands and other sensitive habitats during clean-up operations.
- When conducting operations on water with vessels, avoid blocking major egress points in channels, river, passes, and bays.
- Minimize unnecessary disturbance or removal of natural sediment, organic, matter, and vegetation not required to access man-made debris items. If moving organic debris is required, replace or deposit in the nearest tidally influenced area. Organic debris plays vital ecological function in many intertidal areas and should remain in place to the extent possible.
- Historic and pre-contact-era artifacts of any type (e.g., pot sherds, arrowheads, ship timbers, and bottles) should not be collected and should be reported to the appropriate agency.
- Staging areas for sorting or storing recovered debris should not be located in wetlands or intertidal areas if possible.
- Remove all equipment and materials deployed to facilitate debris removal operations at conclusion of operations.

Debris Crew Gear Lis

Equipment	Source	Link	Quantity	Replacement Schedule
Gloves	New River Nets		12	4
Sleds	Amazon.com	https://www.ama	4	8
Baskets	New River Nets		4	24
Board Puller	Guy C Lee Building		1	48
Trash Grabbers	Amazon.com	https://www.ama	4	8
Knife	Lowes	https://www.lowe	4	48
Spill Kit	Amazon.com	https://www.ama	1	48
Trash Cart	Lowes	https://www.lowe	2	48
Heavy Duty Tote	Lowes	https://www.lowe	1	48
5 Gallon Buckets	Lowes	https://www.lowe	2	24
5 Gallon Bucket Lids	Lowes	https://www.low	2	24
Cones	Lowes	https://www.lowe	2	48
First Aid Kit	Amazon.com	https://www.ama	1	48
Sharps Kit	Amazon.com	https://www.ama	1	48
Trash Bags	Lowes	https://www.lowe	10	6

Contract Length (months):

Cost Estimate for Contract:

t

Cost Per Unit	Total Cost	Operating Cost (Per Week)
$ 2.50	$ 30.00	$ 7.50
$ 59.99	$ 239.96	$ 30.00
$ 20.00	$ 80.00	$ 3.33
$ 122.86	$ 122.86	$ 2.56
$ 22.35	$ 89.40	$ 11.18
$ 14.98	$ 59.92	$ 1.25
$ 144.75	$ 144.75	$ 3.02
$ 149.00	$ 298.00	$ 6.21
$ 12.98	$ 12.98	$ 0.27
$ 3.78	$ 7.56	$ 0.32
$ 3.78	$ 7.56	$ 0.32
$ 14.98	$ 29.96	$ 0.62
$ 21.98	$ 21.98	$ 0.46
$ 13.67	$ 13.67	$ 0.28
$ 28.98	$ 289.80	$ 48.30
Total:	$ 1,448.40	

12.00

$ 5,548.92

HURRICANE FLORENCE MARINE DEBRIS CLEANUP PROJECT

FUNDING: NOAA MARINE DEBRIS PROGRAM

COORDINATION: NORTH CAROLINA COASTAL FEDERATION

CONTACT: TED WILGIS, NC COASTAL FEDERATION, (910) 509-2838

WWW.NCCOAST.ORG

PROHIBITED: ENTERING, TAMPERING OR REMOVING MATERIAL FROM DUMPSTER

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

North Carolina Coastal Federation
Working Together for a Healthy Coast

North Carolina Wildlife Resources Commission

Gordon S. Myers, Executive Director

SPECIAL USE PERMIT

May 20, 2019

Ted Wilgis
North Carolina Coastal Federation
Wrightsville Beach Historic Square
309 W Salisbury Street
Wrightsville, NC 28480
Permit #: 14753

The above named is authorized to:

X Use the following NC Wildlife access area(s) on SPECIFIED DATE(S) for This permit authorizes The North Carolina Coastal Federation to temporarily place two debris dumpster(s) (40 yd. container) NCWRC West Onslow Beach Boat Access Area in the area identified by the yellow rectangle in the attached map. The contracted field crew will bring bagged trash, debris and wood collected from the marsh and islands to the boat access area and load it into the dumpster. Once filled the dumpster will be hauled by Onslow County Solid Waste to their landfill, emptied and returned. The field crew will ensure that all trash and debris is contained and placed in the dumpster. The field crew may temporarily (no longer than 24 hours) neatly stockpile debris next to the dumpster if it is full, and then immediately place the debris in the dumpster. No material or debris will be left outside of the dumpster over the weekend

Dumpster removal and replacement should not occur on weekends to minimize impact during high use periods. If a boat is moored on site as requested it should be away from the launch ramp and not blocking access channel

Access Area	Body of Water	Effective Date	Expiration Date	No of Boats
WEST ONSLOW BEACH	INTRACOASTAL WATERWAY	05/21/2019 - 7:00AM	05/31/2019 - 3:00PM	1

THIS PERMIT IS SUBJECT TO THE FOLLOWING CONDITIONS:

- All litter or debris associated with this use will be picked up and removed from the area immediately following use of this site.
- Any damages to the site resulting from this activity shall be fully repaired within 45 days of the occurrence.
- This permit must be in possession and available during the special use listed above.
- The event organizer must possess a copy of this permit and make it available for inspection on request by Commission personnel.

FAILURE TO ABIDE BY THESE CONDITIONS WILL RESULT IN REVOCATION OF THIS PERMIT.

INDEMNIFICATION

The permit holder assumes all liability and agrees to defend, indemnify, and hold harmless the North Carolina

Mailing Address: Engineering and Lands Management • 1720 Mail Service Center • Raleigh, NC 27699-1720
Phone: (919) 707-0150 • Fax: (919) 707-0162

Wildlife Resources Commission except for the conduct of the North Carolina Wildlife Resources Commission or any of its employees in the performance of the permitted events.

By signing this permit, I certify that I have read, understand, and agree to adhere to the terms and conditions set forth herein.

TD Wilson, NC Coastal Federation

Special Use Applicant Name

Signature 5/20/19 *Date*

If you have any questions or comments regarding this permit, please do not hesitate to contact me.

Brian McRae
Section Chief-Land and Water Access
(919) 707-0269

cc: Colonel Arbie Evans Jr, Enforcement Division
Captain Brandon Joyner, Enforcement Division

North Carolina Coastal Federation
Working Together for a Healthy Coast

North Carolina Coastal Federation:
NRCS Emergency Watershed Protection program for Hurricane Florence Marine Debris Cleanup
Award #16-8191WA

Private Boat Ramp/Access Area Use Agreement

Date: July 24 2020

Project Info:
The North Carolina Coastal Federation, Inc. (federation), a 501C3 non-profit conservation organization, received funding from the Division of Coastal Management under the Natural Resources Conservation Service's Emergency Watershed Protection Program to remove marine debris generated by Hurricanes Florence and Dorian from North Carolina's coastal waters and public trust properties. The debris is being collected from areas of the coast that were impacted by both hurricanes, and is focusing on public islands and marshes, including state parks, dredge spoil islands, and public waterways.

This current effort builds on the previous marine debris collection project funded by the North Carolina General Assembly and the NOAA Marine Debris program. The previous project collected over 200 tons of debris from 42 miles along the Intracoastal Waterway (ICW) and adjacent areas during a six-month period by waterman hired by the federation.

Special Use Request:
The North Carolina Coastal Federation is requesting permission to temporarily place one debris dumpster (30-40 yd. container) at Atlantic Veneer Corporation 2457 Lennoxville Rd. Beaufort, NC 28516.

A three-person field crew of watermen from Carteret County are contracted by the federation to recover the marine debris from the Beaufort area, transport it by small boat to the mainland and load it into dumpsters. They also maintain the dumpster area for cleanliness and safety.

The federation greatly appreciates the support and willingness of the Atlantic Veneer Corporation to enable the project to use the private boat ramp.

Time Period of Use:
- July 20, 2020 – Dec 20, 2020
- Monday – Friday; 07:00 am – 6:00 pm

Agreement Conditions - Dumpster Use and Maintenance:
- The dumpster will be rented and transported by a private hauling company, Waste Removal NC.
- Federation staff and the field crew will maintain the dumpster area for cleanliness and safety.
- Federation staff and/or the field crew coordinator will communicate directly with the hauling company to ensure correct placement and timely emptying.
- The contracted field crew will bring bagged trash, debris and wood collected from the marsh and islands to the boat access area and load it into the dumpster.
- When the dumpster is full it will be hauled by the hauling company to the landfill, emptied and returned.
- The field crew will ensure that all trash and debris is contained and placed in the dumpster.

- The field crew may temporarily (no longer than 24 hours) neatly stockpile debris next to the dumpster if it is full, and then immediately place the debris in the dumpster when it is emptied. No material or debris will be left outside of the dumpster over the weekend.
- Federation staff will coordinate with the Town of Beaufort to ensure they are aware of the dumpster and its use for the project.
- When the use of the dumpster at the private boat ramp/ access area is complete, federation staff and the field crew will ensure that the dumpster is removed, no trash or debris is left on site, and if there is any damage to the site due to the project it is repaired.
- Landowner – Private Boat Ramp/Access Area Conditions:
    - Only debris resulting from the Hurricane Florence Marine Debris Cleanup is allowed to be placed into the dumpster. Debris or trash from the landowner is prohibited from being placed into the dumpster and will be removed.
    - Access to the dumpster for the field crew and waste hauling company will be maintained during operating hours.
    - Any damage to the dumpster resulting from the landowner's negligence will be the responsibility of the landowner.

Points of Contact:

North Carolina Coastal Federation
Sarah S. Bodin
3609 HWY 24 (Ocean)
Newport, NC 28570
(252) 393-8185 Ext. 118
(804) 316-7853 mobile
sarahb@nccoast.org

Field Crew Coordinator
James Tyler Chadwick
P.O Box 1362
Morehead, NC 28557
(252) 723-8736 mobile
tyler@carolinagoldoyster.com

Release of Liability

On this _____day of__________, 20___, intending to be legally bound hereby, the undersigned agrees and does hereby release from liability and indemnify and hold harmless the North Carolina Coastal Federation, and any of its employees in regards to the Maine Debris Cleanup Project. This release is for any and all liability for personal injuries (including death) and property losses or damage occasioned by, or in connection with any activity or accommodations for this event. The undersigned further agrees to abide by this agreement promulgated by the North Carolina Coastal Federation, Inc. and/or its vendors throughout the Marine Debris cleanup Project.

North Carolina Coastal Federation, Inc.

____
Todd Miller, Executive Director

____
Date

Atlantic Veneer Corporation

____
Mike Kraszeski

____
Date

North Carolina
Coastal Federation
Working Together for a Healthy Coast

NCDEQ/NCDCM/North Carolina Coastal Federation Florence Marine Debris Collection Project
Special Use Permit Request – NCWRC WEST ONSLOW BEACH Boat Access Area

Date: May 17, 2019

Background

The North Carolina General Assembly approved funding to remove marine debris from North Carolina's coastal waters and public trust properties. The debris will be collected from areas of the coast that were impacted by Hurricane Florence. The project will focus on public islands and marshes, including state parks, dredge spoil islands, and public waterways.

Special Use Permit Request

The North Carolina Coastal Federation is requesting permission to temporarily place one or two debris dumpster(s) (40 yd. container) along the edge of the parking area of the NCWRC West Onslow Beach Boat Access Area at 656 NC HWY 210, North Topsail Beach, NC 28460.

- Dumpster Use and Maintenance
  - The contracted field crew will bring bagged trash, debris and wood collected from the marsh and islands to the boat access area and load it into the dumpster.
  - Once filled the dumpster will be hauled by Onslow County Solid Waste to their landfill, emptied and returned.
  - The field crew will ensure that all trash and debris is contained and placed in the dumpster.
  - The field crew may temporarily (no longer than 24 hours) neatly stockpile debris next to the dumpster if it is full, and then immediately place the debris in the dumpster. No material or debris will be left outside of the dumpster over the weekend.
- Temporary Boat Mooring
  - If possible, it would be helpful if the field crew could moor their 24' Carolina Skiff at the boat access if needed. This is not a critical need, but would be a helpful option if needed and possible.

Time Period

- May 21, 2019 – May 31, 2019
- Monday – Friday; 07:00 am – 3:00 pm

Points of Contact:

Ted Wilgis - North Carolina Coastal Federation
309 W. Salisbury St.
Wrightsville Beach, NC 28480
(910) 509-2838 Ext. 202
(910) 231-6605 mobile
(910) 509-2840 fax
tedw@nccoast.org

Field Crew Coordinator
Joseph Huie
204 Fulcher Landing Rd.
Sneads Ferry, NC 28460
(910) 333-3406 mobile
jhuie@charter.net

REGULATORY REQUIREMENTS AND BEST MANAGEMENT PRACTICES (BMPs)
HURRICANE FLORENCE USCG ESF-10 RESPONSE NORTH CAROLINA

Sensitive Habitats, Wildlife, and Fisheries Resources

- Avoid and minimize response disturbance to sensitive benthic and shoreline habitats including:
  - Tidal marshes
  - Oysters reefs
  - Seagrasses
  - Tidal swamps
  - Other wetlands
  - Outer Coast Sand beaches
- Avoid and minimize response disturbance to all wildlife and fisheries species.
- Avoid and minimize response disturbance to the wild horse populations at five locations along the coast.

USACE Section 404 Clean Water Act and Section 10 Rivers and Harbors Act Permits

- Permit required if significant sediment disturbance is needed for vessel removal (contact the Environmental Unit [EU] for assistance).

State of North Carolina Permits/Authorizations

- Floating the vessel, protecting the wetland surface with mats, roller bags, etc., and pulling the vessel off the wetland during the highest of high tides are encouraged and do not require a permit from NC Division of Coastal Management.
- Restoration of the impacted wetland may be required if incidental scarring/excavation occurs while the vessel is removed.
- Permit required from NC Division of Coastal Management as well as other state and federal authorities for digging in wetlands or adjacent estuarine waters.

North Carolina SHPO Section 106 National Historic Preservation Act

- Cease all activities involving subsurface disturbance, and immediately contact the EU, if prehistoric/historic artifacts, such as pottery or ceramics, lithic artifacts, historic shipwrecks, dugout canoes, metal implements, historic building materials, or any other physical remains that could be associated with Pre-Columbian, early European, or American settlement are encountered at any time (and leave all artifacts in place). Response activities shall not resume without verbal and/or written authorization. In the event that unmarked human remains are encountered during response activities, stop all work immediately and contact the EU, who will notify the SHPO and the appropriate law enforcement authorities.
- Contact the EU prior to conducting any removal or recovery efforts that require substantial ground disturbance beyond the initial disturbance caused by the disaster event (additional SHPO coordination required).
- If removal activities take place near a vessel located on or adjoining to identified historical sites, further consultation will be required.

NOAA NMFS Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), and Essential Fish Habitat (EFH)

- All response vessel operators and crew must watch for and avoid collision with species protected under the ESA and MMPA.
- All response vessels shall operate at “Idle Speed/No Wake” at all times while in water depths where the draft of the vessel provides less than a 4-ft clearance from the bottom, and after a protected species has been observed in and has departed the area.
- All response vessels will follow marked channels and/or routes using the maximum water depth whenever possible.
- Stop operating mechanical construction equipment, including response vessels, immediately if a protected species is observed within a 50-ft radius of construction equipment and resume after the species has departed the area of its own volition.
- If the detection of species is not possible during certain weather conditions (e.g., fog, rain, wind), then in-water operations will cease until weather conditions improve and detection is again feasible.
- All response vessels:
  - 1. Maintain a minimum distance of 150 ft. from sea turtles.
  - 2. Maintain a minimum distance of 300 ft. from dolphins and whales.

NOAA NMFS ESA, MMPA, EFH - continued

- 3. When sea turtles, dolphins, or whales are sighted while the vessel is underway (e.g., bow-riding), attempt to remain parallel to the animal's course. Avoid excessive speed or abrupt changes in direction until they have left the area.
- 4. Reduce speed to 10 knots or less when mother/calf pairs or groups of marine mammals are observed, when safety permits.
- 5. Maintain a minimum 1,500-ft. distance from North Atlantic right whales. Vessels 65 ft. in length or longer must comply with the Right Whale Ship Strike Reduction Rule (50 CFR 224.105) which includes reducing speeds to 10 knots of less in Seasonal Management Areas (https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-ship-strikes-north-atlantic-right-whales). Mariners shall check various communication media for general information regarding avoiding ship strikes and specific information regarding right whale sightings in the area. These include NOAA weather radio, USCG NAVTEX broadcasts, and Notices to Mariners.

- Turbidity must be monitored and controlled; prior to in-water work turbidity curtains should be installed as per below. Turbidity control measures may be waived if minimal turbidity will be generated during vessel removal or if the current is too strong for curtains to stay in place.
- Turbidity Control Measures:
  - 1. Install floating turbidity barriers with weighted skirts that extend to within 1 ft. of the bottom around all work areas that are in, or adjacent to, surface waters.
  - 2. Use these turbidity barriers throughout construction to control erosion and siltation and ensure that turbidity levels within the project area do not exceed background conditions (i.e., the normal water quality levels from natural turbidity).
  - 3. Position turbidity barriers in a way that does not block species entry to or exit from designated critical habitat.
  - 4. Monitor and maintain turbidity barriers in place until the authorized work has been completed and the water quality in the project area has returned to background conditions.
  - 5. Turbidity barriers should avoid contact with tidal marsh, oyster reefs, and seagrasses, if feasible.
- Entanglement:
  - 1. All turbidity curtains and other in-water equipment (including hard and sorbent booms) must be properly secured with materials that reduce the risk of entanglement of marine species (described below). Turbidity curtains and other equipment likewise must be made of materials that reduce the risk of entanglement of marine species.
  - 2. In-water lines (rope, chain, and cable, including the lines to secure turbidity curtains, boom, buoys, etc.) must be stiff, taut, and non-looping. Examples of such lines are heavy metal chains or heavy cables that do not readily loop and tangle. Flexible in-water lines, such as nylon rope or any lines that could loop or tangle, must be enclosed in a plastic or rubber sleeve/tube to add rigidity and prevent the line from looping and tangling. In all instances, no excess line is allowed in the water.
  - 3. Turbidity curtains and other in-water equipment (including hard and sorbent boom) must be placed in a manner that does not entrap species within the construction area or block access for them to navigate around the construction area.
- Measures to avoid:
  - 1. Use of in-water explosives. NC NERR would like to be consulted if these need to be used in the boundaries of the NCNERR.
  - 2. Trawling for debris removal.
  - 3. Deployment of anchored items that do not employ stiff, taut, and non-looping anchor lines.
  - 4. Dragging displaced vessels, debris, or other items across tidal marsh, oyster reef, and seagrass habitats - items should be hoisted or refloated if possible (see further guidance below).

NOAA NMFS ESA, MMPA, EFH - continued

- ☐ Any vessel collisions with and/or injury or impacts to any protected species (sea turtle, whale, sturgeon, etc.) shall be reported to the EU as soon as possible. Likewise, report any stranded, injured, trapped, entangled, or dead protected species to the EU as soon as possible. The EU will make further notifications to the appropriate agency contacts. Contact the EU through your chain of command.

Tidal Marsh, Oyster Reefs, Seagrasses:

- ☐ Avoid response vessel grounding, prop scarring, and prop washing in tidal marsh, oyster reef, and seagrass habitats.
- ☐ Avoid anchoring and spudding on tidal marsh, oyster reef, and seagrass habitats; anchor and spud on bare sand and mud bottoms only.
- ☐ If spudding on seagrasses cannot be avoided, fill spud holes to grade with sand, as feasible, to minimize impacts.
- ☐ Avoid/minimize shading of seagrasses with barges for more than a few days; move barges off of seagrasses onto bare sand or mud substrates when not undergoing active operations (such as in barge staging areas).
- ☐ Prior to hoisting or refloating displaced vessels, work crews should evaluate the intertidal and subtidal benthic resources in the immediate area and determine an ingress/egress and removal path that will have the least impact to any surrounding tidal marsh, oyster reef, and seagrass habitats (may or may not be the same as the existing grounding path). Habitat maps, charts and aerial/satellite photography can be used to facilitate this process.
- ☐ Temporary stakes/buoys should be used to mark the ingress/egress or extraction path and GPS navigation should be used, if applicable, to assist salvers in staying on course to avoid areas of greatest tidal marsh, oyster, and seagrass habitat extent and quality to the degree possible.
- ☐ Avoid dragging displaced vessels, debris, or other items across tidal marsh, oyster reef, and seagrass habitats - items should be hoisted or refloated if possible. Use of lift bags, rollers, equipment mats, and other methods should also be evaluated to minimize impacts, such as rutting and keel scarring.
- ☐ Where equipment or crews must access displaced vessels or debris across tidal marsh or shallow oyster or seagrass habitats, use specialized equipment with low pressure/flotation tires, equipment mats, walk boards, or other comparable methods to minimize disturbance.
- ☐ Avoid digging, jetting, excavation, and similar methods in tidal marsh, oyster reef, and seagrass habitats to remove displaced vessels.
- ☐ If the above suite of habitat-based BMPs cannot be applied, USACE and State permits may be required (see above).

USFWS Endangered Species Act (ESA), Migratory Bird Treaty Act (MBTA), Fish and Wildlife Coordination Act (FWCA) Manatees:

- ☐ Observe the following recommended USFWS Manatee Conservation Measures for In-Water Projects.
- ☐ Response personnel will be aware of the potential presence of manatees and the need to avoid vessel/equipment collisions and/or any harm with manatees.
- ☐ Response personnel should know the general appearance of the species and their habit of moving about completely or partially submerged in shallow water. Response personnel will be informed that they are responsible for observing water-related activities for the presence of manatees.
- ☐ Response personnel will be advised that there are civil and criminal penalties for harming, harassing, or killing manatees.
- ☐ All response vessels will operate at “no-wake/idle” speed at all times while in water where the draft of the vessel provides less than a four foot clearance from the bottom; vessels should follow routes of deep water whenever possible.
- ☐ If manatees are seen within 100 yards (300 ft.) of an in-water work area, all appropriate precautions shall be implemented to ensure protection of manatees. These precautions shall include operating all response vessels and equipment in such a manner that vessels/moving equipment do not come any closer than 50 to 100 ft. of any manatee. If a manatee is within 50 ft. of in-water work, all in-water activities must shut down, until the

USFWS ESA, MBTA, and FWCA - continued

manatee moves on its own volition at least 100 ft. away from the in-water work area. Manatees must not be herded or harassed into leaving the area.

- Siltation/turbidity barriers, hard/sorbent boom, anchor and tow lines, etc. will be made of materials in which manatees cannot become entangled; and will be properly secured and regularly monitored to avoid manatee entanglement/entrapment. Barriers must not block manatee entrance to or exit from essential habitat.
- Any collisions with or injury to a manatee shall be reported immediately. The report must be made to the U.S. Fish and Wildlife Service (ph. 919.856.4520 ext. 16), the National Marine Fisheries Service (ph. 252.728.8762), and the North Carolina Wildlife Resources Commission (ph. 252.448.1546). Likewise, report any stranded, injured, trapped, entangled, or dead manatee to the EU as soon as possible. The EU will make further notifications to the appropriate agency contacts.
- A sign should be posted in all vessels associated with the project where it is clearly visible to the vessel operator. The sign should state: CAUTION: The endangered manatee may occur in these waters during the warmer months, primarily from June through October. Idle speed is required if operating this vessel in shallow water during these months. All equipment must be shut down with and/or injury to the manatee must be reported immediately to the U.S. Fish and Wildlife Service (919.856.4520 ext. 16), the National Marine Fisheries Service (252.728.8762), and the North Carolina Wildlife Resources Commission (252.448.1546).
- The contractor should maintain a log detailing sightings, collisions, and/or injuries to manatees during project activities. Upon completion of the action, the contractor should prepare a report which summarizes all information on manatees encountered and submit the report to the Service's Raleigh Field Office.

Nesting Sea Turtles:

- Be aware of the potential for sea turtle nesting activity on outer coast (ocean-facing) sand beaches during nesting season. Adults nesting May-Sep; hatching/juveniles present Jun-Dec.
- Adult sea turtles, crawls, nests, eggs, and hatchlings should be protected during response activities on sea turtle nesting beaches, including hatchling turtles as they emerge from the nest and crawl to the sea.
- Sea turtle nesting surveys may be required prior to vessel removal or staging activities on outer coast beaches. Contact the EU to coordinate sea turtle nesting beach surveys through USFWS and/or NC WRC. Entry onto the beach will occur only after the Biological Monitor has completed the morning surveys, if required. Surveys are typically completed in the early morning; all operations on the beach should be conducted after nesting beach surveys are complete, in coordination with the Biological Monitor.
- After the beach has been surveyed, the Biological Monitor will mark/direct the response crew along the established travel corridor, as applicable.
- If an unmarked sea turtle crawl is encountered during or prior to response activities, the response crew will not disturb the integrity of the crawl or follow the crawl up the beach or into the dune/vegetation, and will contact the EU to inform them of the location of the crawl.
- Any marked nests within the areas where vessel removal or staging will occur (including access areas) shall be left in place. Marked nests shall be delineated by stake and survey tape or string around the nest. A circle with a 10-ft. radius centered at the nest is recommended for nest protection. Marked nests and areas with unmarked nests must be avoided during vessel removal and staging.
- If activity will occur near a marked nest or in the wrack line, a Biological Monitor or their authorized personnel shall be onsite during vessel removal.
- Equipment and work crews will only transit the beach seaward of the nesting area on the hard-packed sand (stay below the wrack line if present).
- If a sea turtle (either adult or hatchling) is observed, maintain at least 200 ft. between the turtle and response personnel and contact the EU.
- If sea turtle hatchlings are encountered, maintain at least 200 ft. between the hatchlings and response personnel, allow the hatchlings to crawl unobstructed to the water. Do not carry the hatchlings to the water. Contact the EU immediately.

USFWS ESA, MBTA, and FWCA - continued

- ☐ All response actions, equipment, and personnel shall observe a 10-ft. buffer from marked sea turtle nests. Care should be taken to avoid walking or driving equipment over a crawl so that a potential nest is not damaged.
- ☐ Any potential obstructions or entanglement hazards for sea turtles and hatchlings should be removed from the beach at the end of each day, this includes displaced vessels/marine debris (in staging areas), response vehicles, equipment, gear, lines, rigging, boom, etc.
- ☐ If altered, beach topography shall be re-established in all areas to the natural beach profile/grade at the end of operations each day. Re-establishing beach topography includes raking of tire, track, and keel ruts; filling pits or holes where debris were removed; etc.
- ☐ In the event a sea turtle nest is excavated during vessel/debris removal activities, immediately cease all work in that area and contact the EU.
- ☐ Minimize lighting at night that may disorient sea turtle hatchlings and nesting females. Consult with the EU regarding night operations near beaches.
- ☐ Upon locating a dead, injured, or sick sea turtle, or if eggs or nests are disturbed during response activity, contact the EU. The EU will make further notifications to the appropriate agency contacts.

Birds:

- ☐ Avoid known or observed seabird, shorebird, and wading bird nesting colonies and roosting aggregations to the extent possible. Many smaller islands, beaches, dunes, supratidal oyster deposits, and other shoreline areas may be nesting or roosting sites. Nesting season occurs from April 1 - August 31.
- ☐ Do not enter sites with active bird nesting colonies or roosts. If birds are flushed, move away from the area and observe a larger buffer distance to avoid and minimize disturbance. If vessel removals are likely to impact nesting colonies or roosting sites, contact the EU for further guidance.
- ☐ Avoid and minimize aircraft disturbance to bird nesting colonies and roosting aggregations. Limit overflights to a minimum 1,000 ft. altitude floor over colonies and roosts and limit excessive disturbance (e.g., repeated low passes, hovering, circling). If birds are flushed by aircraft move away from the area and maintain a higher floor over other observed colonies and aggregations.
- ☐ Contact the USFWS Raleigh Field Office (919.856.4520) in the event that a bald eagle nest is proximate to the work area.

Additional Considerations:

- ☐ Recreational users may be in the area. Appropriate measures should be taken to ensure safety and as appropriate. Notify the users of any hazards associated with vessels and removal efforts.
- ☐ Equipment and material staging areas should be located outside of areas of native vegetation and known endangered species habitats. Contact the EU for assistance.
- ☐ Minimize the disturbance footprint when removing displaced vessels.
- ☐ Collect all floating debris during vessel removal.
- ☐ Where possible, equipment should be operated from existing hard top or impacted sites to remove displaced vessels from natural habitats.
- ☐ Vessel removal activities should be accomplished with the smallest equipment needed, including hand crews where possible, to minimize disturbance of habitat (especially when working within critical habitats).
- ☐ Ingress and egress corridors for vehicle and equipment operations and vessel removal should minimize impact to natural habitats. Care should be taken to restrict equipment/vehicles to roadways and roadbeds and away from vegetated areas or areas of buried vegetation.
- ☐ To the degree possible, the removal of forested vegetation should be limited to fallen trees only, and only if required to remove displaced vessels; otherwise, leave fallen trees in place (applies to tidal swamps and other forested wetlands as well).
- ☐ Trimming of standing native trees during vessel removal should be minimized (applies to tidal swamps and other forested wetlands as well).
- ☐ The removal of healthy trees to remove embedded vessels should be avoided or minimized (applies to tidal swamps and other forested wetlands also).

USFWS ESA, MBTA, and FWCA - continued

- ☐ All trash resulting from the response should be removed from the area as appropriate or disposed of properly in covered trash receptacles.

For further guidance and assistance with BMPs, please work with the on-site BMP Coordinator or contact the EU through your chain of command. Checked boxes indicate BMPs that apply to specific operations or locations; if no boxes are checked, observe all BMPs as applicable and feasible given the type of operations and safety considerations. Document BMP compliance on daily 214 logs.

Guidelines for Selecting a Marine Contractor

Most people who live or own a business on the water will, sooner or later, require the services of a marine contractor, either to construct or repair a dock, boathouse or ramp, or shoreline erosion control structure. Careful selection of a knowledgeable and reputable marine contractor to perform the work will often determine the quality and success of the project. It is critically important to choose an experienced contractor with expertise in the type of project that is proposed.

Differences Between Marine and Inland Construction

Marine construction is a specialized field dealing with the building, maintenance, and repair of structures in freshwater and marine coastal areas. These structures include erosion control projects such as bulkheads, seawalls, breakwaters, revetments, groins, jetties, artificial beach nourishment, coastal bluff reshaping and vegetative stabilization, as well as navigation projects such as docks, cribs, boat ramps and boathouses, marina basins and harbor projects, and dredging. This type of construction requires special, sophisticated equipment, such as barges, tugs, pumps and clamshell cranes, not used for general inland construction projects. Reputable marine contractors have this type of equipment, know how to operate it, and have experience putting it to use in diverse situations. Marine contractors can complete a shoreline construction project more efficiently and with greater assurance of quality control than could most inland contractors working in a coastal setting.

Construction in and along coastal waters is different from building in an inland location. The engineering and construction principles for land-based structures are not directly transferrable to coastal areas. The environment, physical forces, and often the soil types and morphology of coastal locations require specialized construction materials and techniques be used in marine construction compared with inland work. Knowledge of coastal processes such as waves, currents, and the transport of sediment particles is also important. It is possible that construction of an erosion control structure in one location could help alleviate the problem at that specific site, while causing a new problem in another, nearby location. For example, an improperly designed or placed bulkhead could solve an erosion problem by holding soil back and protecting it from wave attack while at the same time aggravating erosion along property adjacent to the structure by reflecting wave energy onto that unprotected site. To be successful in designing and building a coastal project, a marine contractor needs training and experience in coastal processes and marine construction techniques.

Figure 1. Marine contractors have specialized training and equipment not often uitilized in inland construction projects.

Sea Grant New York

New York Sea Grant
146 Suffolk Hall
Stony Brook University
Stony Brook, NY 11794-5000
631.632.8730 or
Great Lakes Coastal
Processes Specialist at
607.255.2832

www.nyseagrant.org

Selecting a Marine Contractor

Figure 2. A precast concrete bulkhead is assembled on the shore of a Lake Ontario embayment.

Marine contractors also need skill and experience at selecting the right building materials for coastal projects. For wooden docks and bulkheads, pressure-treated wood with certain minimum standards, is a necessity. A contractor should understand what type of preservative is needed and where to obtain suitably treated timbers. Different mixtures of concrete are required for coastal environments compared with dry-land settings. The use of an improper mixture could result in the structure deteriorating and failing long before it should, resulting in additional repair costs and, potentially creating a situation in which erosion may restart in the future. The selection of stone for a rock revetment is different than the selection of stone for an inland retaining wall. For example, although sandstone might work well for an inland wall, in a coastal environment it might prove to be too lightweight to withstand wave energies and will probably round out and move more easily than a denser, more angular dolomite. A marine contractor will know how to select the correct concrete or stone for a project.

Selecting a Marine Contractor

Most home or business owners would never hire a contractor to put a new roof on their home or build an addition to an existing place of business without first determining whether the contractor had ever performed such work before. Usually, the first contractor considered would not be hired unless the client was familiar with the contractor or knew a trusted someone who was. Generally, several contractors would be considered and the best would be selected. Similarly, some preliminary research into marine contractors will ultimately help to ensure the success of a coastal project.

First, one should obtain and read educational materials concerning the type of marine construction project to be performed. One or several alternatives which could apply to the situation should be identified and design techniques based on proven engineering principles and construction practices for such projects should be studied. Publications addressing a variety of marine construction projects are available from Sea Grant and the U.S. Army Corps of Engineers. Next, write down as much as possible about what is intended to be accomplished by the project. The present situation should be outlined, the problem to be solved should be stated, and preferences for type of construction and final appearance should be described.

Potential contractors should be given as clear a picture of the project as can be provided, but should not have preconceived solutions presented to them; at this stage, they should be free to propose a range of feasible designs from which the client can chose a final project. Important information would include the exact location of the project, a description of the problem to be solved, rough estimates of the height and angle of any bluff, the width of any fronting beach, the general composition of shoreline sediments (i.e., sand, clay, cobbles), any restrictions that would preclude heavy machinery or barges from easy access to the construction site, and a rough description of what the client wants to accomplish.

Since the number of potential marine contractors in working in any given area is usually small, one of the easiest ways to obtain their names is to walk the shoreline. Existing projects solving similar problems should be inspected and discussed with the owners regarding the company that did the construction. Questions to ask include: did the contractor have the proper equipment to successfully complete the project; were there any unusual problems during or subsequent to construction; how long has the project been in existence; and, is the owner satisfied with the way it has performed. Some, but not all, marine contractors are in your local listings; others have web sites on the Internet.

After several companies have been identified that perform the sort of work being proposed, each should be contacted and provided with all the information previously compiled. Each should be invited to personally inspect the project site at separate times, with ample time being allowed for them to adequately review the project and present their company's capabilities. Questions should be asked about price ranges for the various possible solutions, but the company representative's should not be told at this point how much is budgeted for the project. A list of similar marine construction projects completed by the company should be requested; these projects should be visited if time allows and their owners are willing. Reputable contractors will usually submit preliminary design specifications along with a price estimate for your consideration shortly after the initial site visit.

After carefully reviewing the plans, noting any questions or uncertainties, ask the contractor to explain the rationale for the proposed designs or the use of certain materials. Remember, an improperly designed structure can fail prematurely and create an additional expense in the future; it may even result in additional erosion at the site of the structure or at an adjacent site. Answers to these questions can provide useful insight into the contractor's training, experience, and knowledge of coastal construction. For example, if a design calls for the use of filter cloth, the contractor could be asked why. If a rock revetment is proposed, the contractor could be asked why a particular size and type of stone has been selected. If answers to questions such as these sound ambiguous or lack credibility, serious consideration ought to be given to selecting another company for the project. This is when the information learned from coastal erosion control publications studied beforehand can be most valuable a quick check will show whether there is something lacking or different between accepted design techniques and those proposed by the marine contractor. Be sure to discuss the entire scope and cost of the project and the anticipated time schedule.

With regard to the price estimate, the contractor should fully explain what the estimate is based upon. An alternative would be to have the project designed by a professional engineer and let several contractors submit bids based on those specifications. Although this would be more costly, it would assure that all estimates are figured on the same design.

Finally, the contractor that is determined to have the greatest capabilities for completing the project in an acceptable manner should be selected. The decision should take into account the contractor's experience, reputation, special qualifications, personnel available, time schedule, and grasp of the project and any related problems. Do not automatically hire the company that gives the lowest estimate. Instead, look at the materials proposed for use, the design specifications, and the quality of service being offered. A poorly designed/constructed structure could require repair sooner than a better, more expensive project, resulting in greater long term costs. The details should be in a written contract for signature by both the client and the contractor. Although this process requires extra time and effort, future rebuilding or repair costs may be reduced substantially.

Figure 3. A contractor could be asked why they chose concrete for a bulkhead instead of wood, like the older structure next door.

Permits for Coastal Construction Projects

Many projects involving the placement of fill or permanent structures along the shore, or disturbance of the shore or bed of a body of water, require permits from the New York State Department of Environmental Conservation (DEC), the U.S. Army Corps of Engineers, and possibly local jurisdictions, as well. Readers are advised to contact the nearest office of DEC or the Corps to determine what state and/or federal permits might be necessary; town or village codes enforcement offices should be able to identify local permit requirements.

General tips when shopping for a marine contractor:

- Don't shop on price alone. The cheapest contractors may not be the best contractors, and the least expensive project may not be the most effective project.
- Insist on good workmanship, including good on-site housekeeping.
- Know what you want ahead of time. Try to eliminate expensive midstream changes which can cause major problems.
- Make access and working conditions as easy as possible for the contractor.
- Understand the cost and scheduling impact of any additional work recommended by the contractor.
- Don't do business with a contractor who doesn't make safety a priority.

Selecting a Marine Contractor

Glossary of Coastal Structure Terms

Accretion The buildup of a beach by actions either of nature (such as deposition of sand by wind or waves) or of humans (mechanical deposition of beach fill or trapping of sand behind a groin or jetty).

Artificial beach nourishment The process of replenishing a beach (usually sand) from another location by mechanical means.

Breakwater A structure built either offshore from an eroding shoreline or connected to that shoreline, extending out into the water, to protect the shore from wave action, or to provide calm water for boat mooring or docking, when used to protect a harbor, basin or anchorage.

Bulkhead A structure or partition built to retain land and prevent it from sliding into a body of water. Bulkheads also protect the land behind them from direct attack by waves.

Coastal erosion The loss or displacement of land by the action of waves, currents, tides, waterborne ice, or impacts of storms; or the direct action of wind, runoff of surface water, or groundwater seepage on a coastal bluff or beach.

Filter cloth A special construction material, woven of modern synthetic fibers or compressed from synthetic or natural fibers, which is used extensively in marine construction behind and/or underneath erosion control structures. It is permeable enough to allow water to pass through, but impermeable enough that soil is prevented from being carried through the erosion control structure, causing the structure to become unstable and settle.

Flanking Erosion at and around the outward ends of land-connected shore-protection projects or other hardened portions of the shoreline. When not stopped or controlled, flanking can result in the failure of shore protection devices.

Groin A coastal erosion control structure usually built perpendicular to the shoreline to trap and hold littoral drift and slow the erosion of the shore. Groins can also be used to promote beach accretion.

Jetty A structure extending into a body of water for the purpose of directing and confining river or tidal flow into a channel and preventing or reducing shoaling of the channel by littoral material.

Littoral drift (a.k.a. longshore drift) The sediment (usually sand) moved along the shore in the nearshore zone by waves and currents.

Pile A long heavy timber or piece of metal, wood or concrete driven or jetted into the ground to serve as a support for or part of a coastal erosion control structure, dock, pier or jetty.

Recession The net landward movement or retreat of coastal bluffs and beaches over time due to erosion. Long- and short-term recession rates are usually expressed as feet or meters per year.

Revetment A facing of stone, concrete, and the like, built to protect a bluff, beach, embankment or structure from erosion by wave action or currents.

Riprap A facing of stones, randomly placed, to prevent erosion or scouring. May also refer to the stone used for such a layer.

Seawall A coastal erosion control structure built to separate the land from the water and to prevent damage from wave attack. A secondary purpose is to retain the land behind the structure.

Specifications A detailed description of construction project particulars, such as size of stone, quality and quantify of materials, contractor performance, terms and quality control.

Toe erosion The erosion that occurs at the lowest point of the front slope of bluffs at the water's edge, largely as a result of the continuous removal of earthen materials by waves, tides or currents.

Figure 4. A dolomite revetment construction to protect the Lake Ontario State Parkway from the ravages of stormwaves.

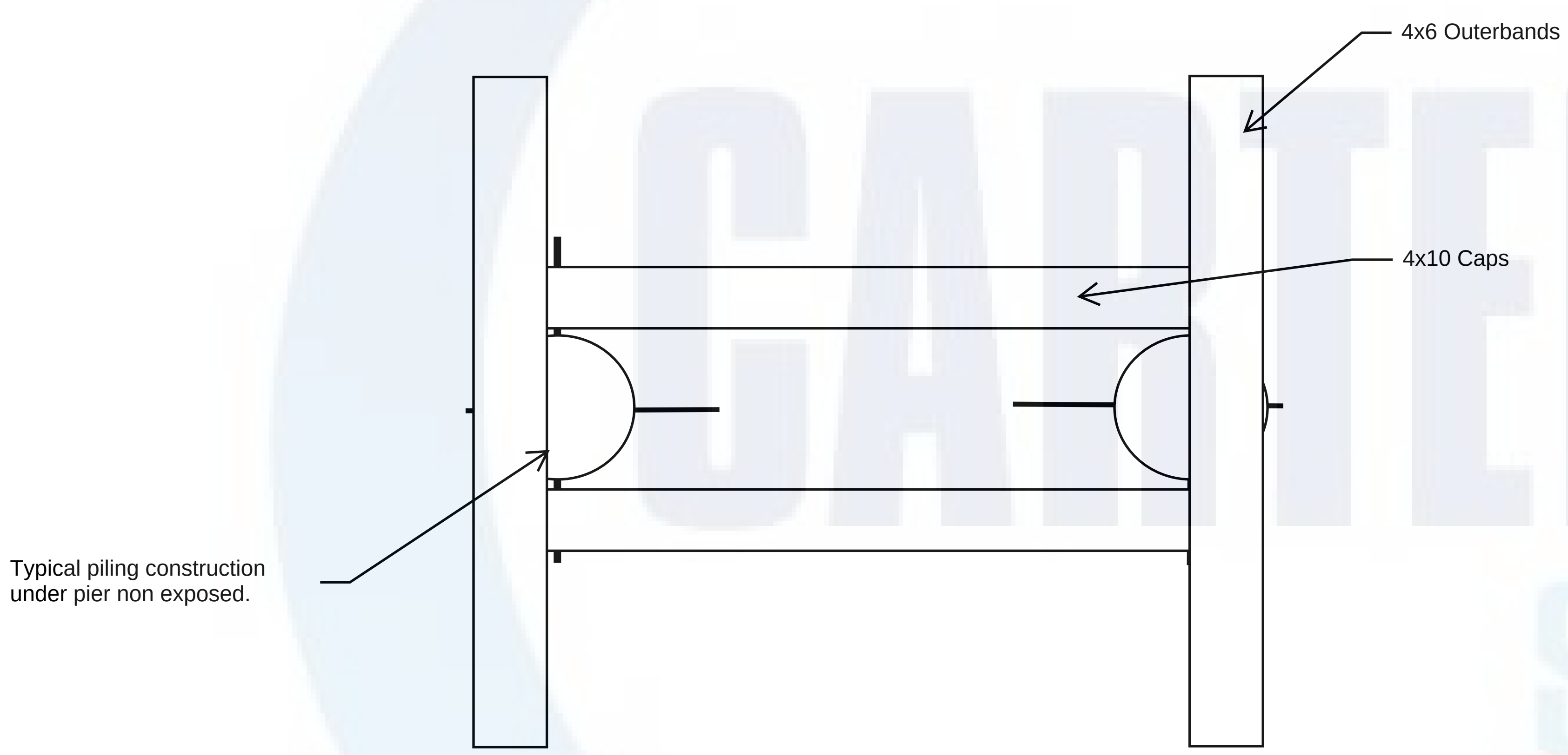
Coastal erosion processes and control information is available from:

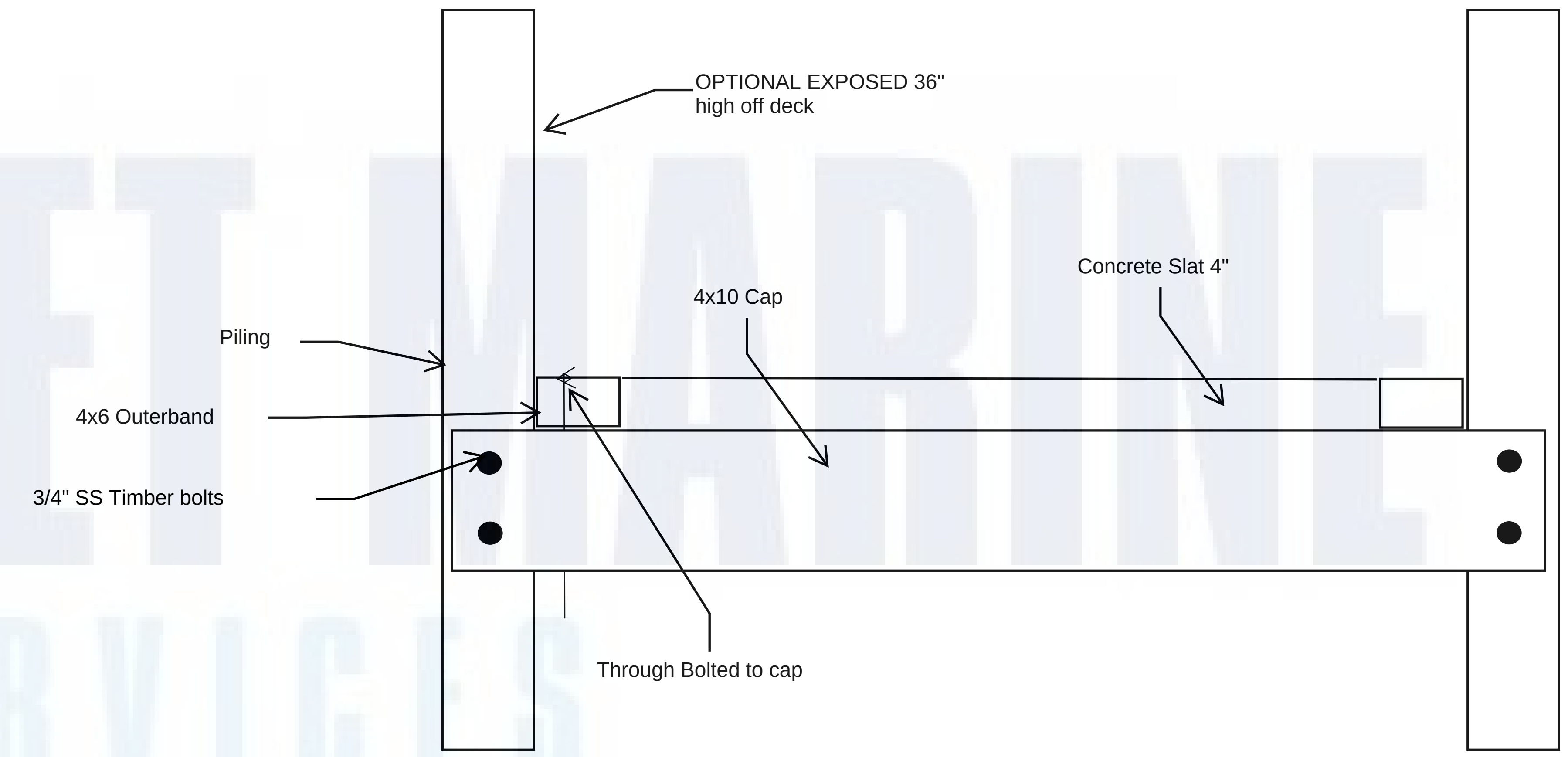
Sea Grant New York

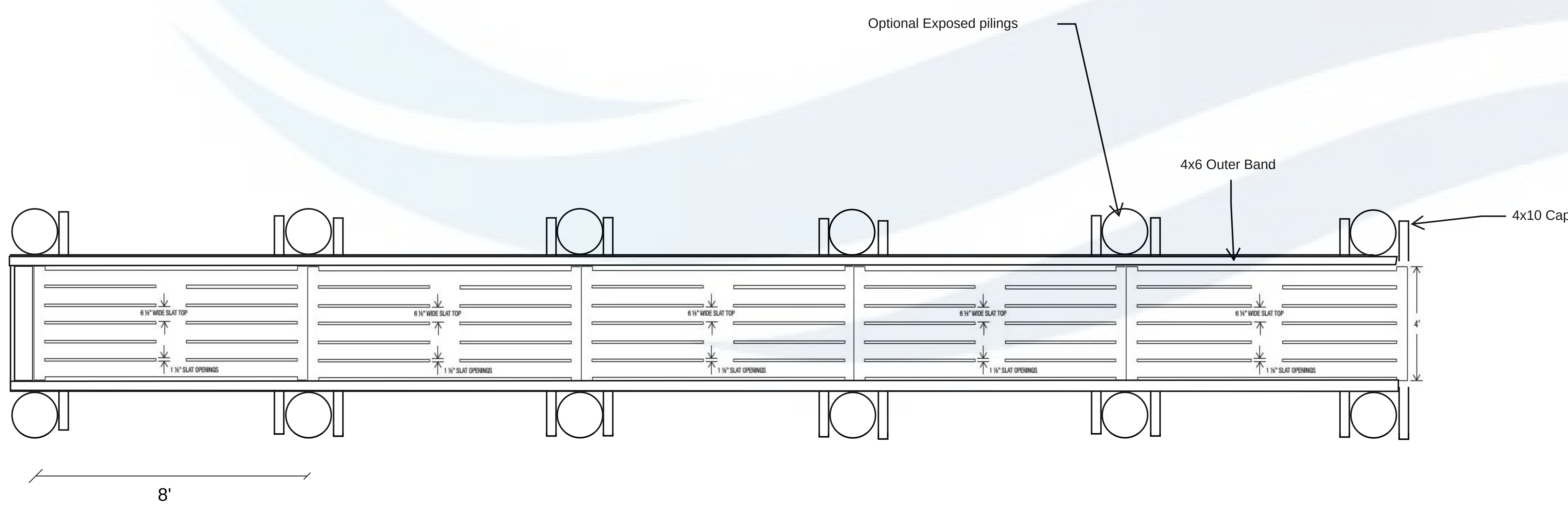
New York Sea Grant
146 Suffolk Hall
Stony Brook University
Stony Brook, NY 11794-5000
631.632.8730 or
Great Lakes Coastal
Processes Specialist at
607.255.2832

Revised January 2015

Standard Construction Methods - 4x8 Concrete Pier Slats
Galvanized 5/8" Timber Bolts
4x10 Caps(Girders)
4x6 Outerband
OPTIONS - Stainless Fasteners, 4x10 bands, handrails, lighting, electrical, plumbing, tables, benches, exposed pilings







NC Department of Insurance
Office of the State Fire Marshal - Engineering Division
1202 Mail Service Center, Raleigh, NC 27699-1202
919-647-0000

Engineered Wood Products and Connectors in Marine and Flood Zone Environments

Code: 2018 Residential Code **Date:** April 10, 2019 **Section:** R322.1.8 and R4605.5

Question 1:
What are the pressure treatment requirements for engineered wood products subject to intermittent wetting in marine and fresh water flood environments?

Answer 1:
Based on Weyerhaeuser (MicroLam) and Louisiana Pacific literature, all indications are that laminated veneer lumber (LVL) beams treated for exterior, marine or submerged applications (AWPA Use Categories 3, 4, and 5) are not readily available, and LVL is probably not appropriate for use in these applications. Likewise, wood I-joists are not available treated for exterior use and should not be used in environments subject to wetting. Weyerhaeuser Parallel Strand Lumber (PSL) is available treated for marine application with chromated copper arsenate (CCA) or creosote. Glu-Lam is also available treated for marine use. Any product subject to submersion in fresh water should be treated for American Wood Preservers Association (AWPA) UC4C, products located above mean high water and subject to frequent wetting should be treated for AWPA UC4B, and products subject to submersion in salt or brackish water should be treated for AWPA UC5B. The local code enforcement official may request weathering test data and treatment certificates on products in question.

Question 2:
How should connectors be protected from failure due to corrosion in marine and fresh water flood environments?

Answer 2:
Table 4605.5 lists coatings and stainless steel fasteners and connector requirements for coastal areas. Connectors subject to exterior or marine use should always be either hot dip galvanized after fabrication or stainless steel. Depending on bolts alone to transfer gravity loads to the piles is not a prudent practice. Over time, even hot dip galvanized or stainless steel bolts will corrode and require replacement. A better detail when the pile width is 2-inches or more than the girder would be to notch the girder into the side of pile to provide direct bearing on the pile. The girder may then be bolted to the vertical protrusion of the notch to provide uplift resistance, lateral load resistance and torsional stability. Figure 4603.6 in the Residential Code is another possible means of connecting the girder to the pile and providing direct bearing for the girder when the girder is too wide to notch into the pile. However, the disadvantage to this connection is the connection has little resistance to lateral loads perpendicular to the connection plates. In addition, the girder and the pile must be the same width or the connection shimmed in order to install connection plates on both sides of the girder. Connections for girders bearing on top of the pile with a plate on only one side of the girder do not provide adequate torsional restraint to

prevent the girder from rolling.

Keywords:
Pressure treated

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

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.

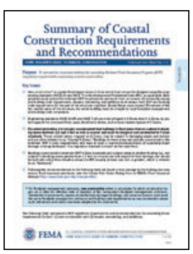
Available Fact Sheets

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.

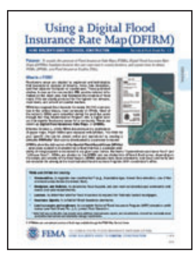
Category 1 – General


Coastal Building Successes and Failures

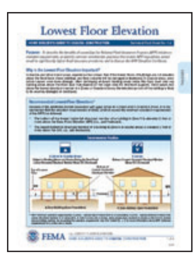
Fact Sheet No. 1.1, Coastal Building Successes and Failures – Explains how coastal construction requirements differ from those for inland construction, and discusses the characteristics that make for a successful coastal residential building. Includes design and construction recommendations for achieving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

V Zone Design and Construction Certification

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.

Designing for Flood Levels Above the BFE

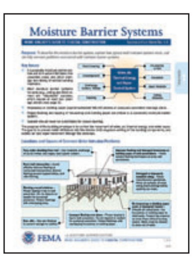
Fact Sheet No. 1.6, Designing for Flood Levels Above the BFE – Recommends design and construction practices that reduce the likelihood of flood damage in the event that flood levels exceed the BFE. It includes illustrations of appropriate construction practices and information on the insurance benefits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

Coastal Building Materials

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.

Non-Traditional Building Materials and Systems

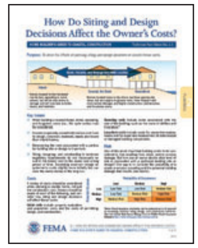
Fact Sheet No. 1.8, Non-Traditional Building Materials and Systems – Provides guidance on alternative building materials and techniques and their application in coastal environments. It includes discussions of Engineered Wood Products, Structural Insulated Panels, Insulating Concrete Forms, Prefabricated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



Moisture Barrier Systems

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



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

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.

Selecting a Lot and Siting the Building

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.

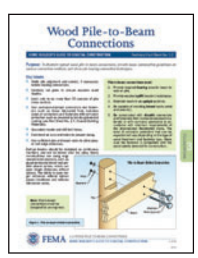
Category 3 – Foundations

Foundations in Coastal Areas

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).

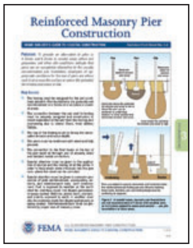
Pile Design and Installation

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.

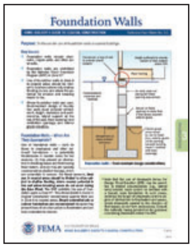


Wood Pile-to-Beam Connections

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.

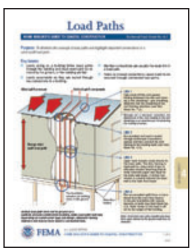

Reinforced Masonry Pier Construction

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.

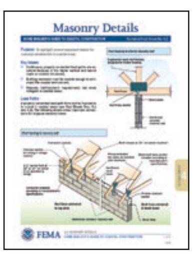

Foundation Walls

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.

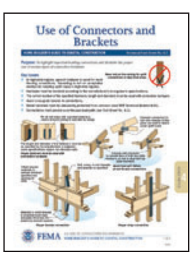
Category 4 – Load Paths


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.


Masonry Details

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.


Use of Connectors and Brackets

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


Housewrap

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.


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

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.


Siding Installation in High-Wind Regions

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.


Attachment of Brick Veneer in High-Wind Regions

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

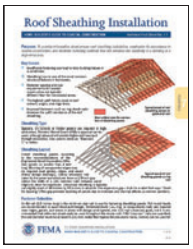

Window and Door Installation

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.

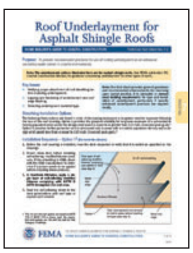

Protection of Openings– Shutters and Glazing

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.

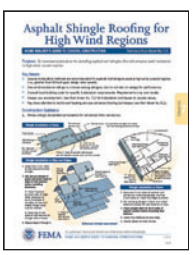
Category 7 - Roofing


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.

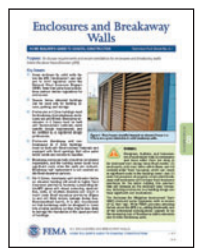

Minimizing Water Intrusion Through Roof Vents in High-Wind Regions

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.

FEMA P-499 Home Builder's Guide to Coastal Construction– 2005 to 2010 Crosswalk

Category	Category Code	Sheet	Title	2005 Edition Fact Sheet No.
Guide	G	1	Technical Fact Sheet Guide	
General	1	1	Coastal Building Success and Failures	1
General	1	2	Summary of Coastal Construction Requirements and Recommendations for Flood Effects	2
General	1	3	Using a Digital Flood Insurance Rate Map (DFIRM)	3
General	1	4	Lowest Floor Elevation	4
General	1	5	V Zone Design Certification	5
General	1	6	Designing for Flood Levels Above the BFE	New
General	1	7	Coastal Building Materials	8
General	1	8	Non-Traditional Building Materials and Systems	New
General	1	9	Moisture Barrier Systems	9
Planning	2	1	How Do Siting and Design Decisions Affect the Owner's Costs?	6
Planning	2	2	Selecting a Lot and Siting the Building	7
Foundations	3	1	Foundations in Coastal Areas	11
Foundations	3	2	Pile Design and Installation	12
Foundations	3	3	Wood Pile-to-Beam Connections	13
Foundations	3	4	Reinforced Masonry Pier Construction	14
Foundations	3	5	Foundation Walls	15

Category	Category Code	Sheet	Title	2005 Edition Fact Sheet No.
Load Paths	4	1	Load Paths	10
Load Paths	4	2	Masonry Details	16
Load Paths	4	3	Use of Connectors and Brackets	17
Wall Systems	5	1	Housewrap	23
Wall Systems	5	2	Roof-to-Wall and Deck-to-Wall Flashing	24
Wall Systems	5	3	Siding Installation in High-Wind Regions	25
Wall Systems	5	4	Attachment of Brick Veneer in High-Wind Regions	New
Openings	6	1	Window and Door Installation	22
Openings	6	2	Protection of Openings - Shutters and Glazing	26
Roofing	7	1	Roof Sheathing Installation	18
Roofing	7	2	Roof Underlayment for Asphalt Shingle Roofs	19
Roofing	7	3	Asphalt Shingle Roofing for High-Wind Regions	20
Roofing	7	4	Tile Roofing for High-Wind Areas	21
Roofing	7	5	Minimizing Water Intrusion through Roof Vents in High-Wind Regions	New
Roofing	7	6	Metal Roof Systems in High-Wind Regions	New
Attachments	8	1	Enclosures and Breakaway Walls	27
Attachments	8	2	Decks, Pools, and Accessory Structures	28
Attachments	8	3	Protecting Utilities	29
Repairs	9	1	Repairs, Remodeling, Additions and Retrofitting - Flood	30
Repairs	9	2	Repairs, Remodeling, Additions and Retrofitting - Wind	30
Guide	G	2	References and Resources	31

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

NAHB RESEARCH CENTER

Coastal Building Successes and Failures

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

GENERAL 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.

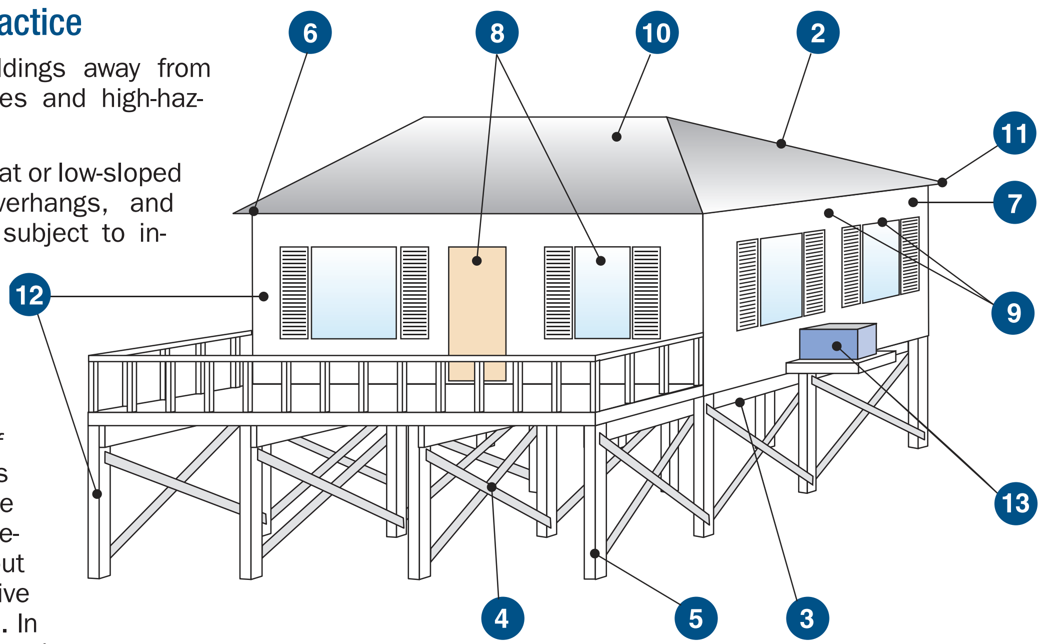
Figure 2. Well-sited building that still sustained damage.

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

NAHB RESEARCH CENTER

Summary of Coastal Construction Requirements and Recommendations

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 1.2

GENERAL 1

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 **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 **IRC:** R322.3.2 **ASCE:** ASCE 24 Sec. 2.4 **Other:** FEMA TB #5
Solid Foundation Walls [see Fact Sheet Nos. 3.1, 3.5] **NFIP 60.3(c)(3)**	**Prohibited**	**Requirement:** Flood vents must be installed to equalize pressures (see Fact Sheets Nos. 3.5 and 8.1). **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 **IRC:** R322.2.3 **ASCE:** ASCE 24 Sec. 2.5, ASCE 7 Sec. 5.4.4.2 **Other:** FEMA TB #5, FEMA 550
Open Foundation [see Fact Sheet No. 3.1] **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. **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 **IRC:** R322.3.3 **ASCE:** ASCE 7 Sec. 5.4.4.1, ASCE 24 Sec 4.5.5 **Other:** FEMA TB #5
Lowest Floor Elevation (not in a V Zone) [see Fact Sheet No. 1.5] **NFIP 60.3(c)**	**Not Applicable**	**Recommendation:** Elevate the bottom of the lowest horizontal structural member at, or above, BFE. **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 **IRC:** R105.3.1.1, R322.2.1, R322.1.5 **ASCE:** ASCE 24 Sec. 1.5.2, ASCE 24 Sec. 2.5, ASCE 24 Ch. 5, ASCE 24 Ch. 7 **Other:** FEMA TB #5
Bottom Lowest Horizontal Structural Member [see Fact Sheet No. 1.4] **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 **IRC:** R322.3.2 **ASCE:** ASCE 24 Sec. 4.4, ASCE 24 Sec. 2.5, ASCE 24 Ch. 5 **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 **IRC:** R322.3.2 **ASCE:** ASCE 24 Sec 4.4 **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. **Note:** Per ASCE 24-05 one foot of freeboard required for Risk Category II structures.	**Recommendation:** Freeboard is recommended in A Zones. **Note:** One foot above BFE is required per IRC R322.2.1 Item #2 for Coastal A Zones.	**IBC:** see ASCE 24 **IRC:** R322.2.1, R322.3.2 **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). **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). **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 **IRC:** R322.2.2, R408.7 **ASCE:** ASCE 24 Sec. 2.6, ASCE 24 Sec 4.6 **Other:** FEMA TB #1
Enclosures Below the BFE (not in V Zones) [see Fact Sheet No. 8.1] **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 **IRC:** R322.3.2, R322.3.4, R322.3.5 **ASCE:** ASCE 24 Sec. 4.6, ASCE 7 Sec. C5.3.3 **Other:** FEMA 55, FEMA TB #5, FEMA TB #9

GENERAL 1

	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 **IRC:** R322.14.2, R322.3.2 **ASCE:** ASCE 24 Sec 1.5.4, 45.4 **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 **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 **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 NFIP 60.3(a)(6)(i) and 60.3(a)(6)(ii)				**IBC:** 1403.6, App. G 401.3 **IRC:** R322.1.7, R P2602.2, R P3001.3, R P3101.5 **ASCE:** ASCE 24 Sec. 7.3.4 **Other:** FEMA 348, FEMA TB #4
Utilities [see Fact Sheet No. 8.3] 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. **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 **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 **ASCE:** ASCE 24 Ch. 7 **Other:** FEMA 348, FEMA TB #4
Certification				
Permits 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 **IRC:** R104.2, R105, App. E, App. J **ASCE:** ASCE 24 Sec. 4.6, ASCE 7 Sec. C5.3.3 **Other:** FEMA EMI IS-9

	Coastal Construction Requirements and Recommendations			
	V Zone	Coastal A Zone	A Zone	Additional Resources
Certification				
Elevation **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. **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. **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 **IRC:** R106.1.3, R322.1.2, R322.1.5, R322.2.1 **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 **IRC:** R301.1, R301.1.3,R301.2 **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) 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) **IRC:** R322.3.4 **ASCE:** ASCE 24 Sec. 4.6.1, 4.6.2, 2.6.1.1, ASCE 7 Sec. 5.3.3 **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) 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 **IRC:** R322.2.2 **ASCE:** ASCE 24 Sec. 2.6.1, 2.6.2.1, 2.6.2.2 **Other:** FEMA TB #1
Repairs, Remodeling, and Additions [See Fact Sheet No. 9.1]				
Substantial Improvements and Repairs of Substantial Damage 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. **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. **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 **IRC:** R322.1.6, R322.3.1 **ASCE:** ASCE 24 Sec. 4.3, ASCE 7 Sec. 1.6 **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 **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. **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). **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 **IRC:** R322.3.1 **ASCE:** ASCE 7 Sec. 1.6 **Other:** FEMA TB #1, FEMA TB #5, FEMA TB #9, FEMA 550
Lateral Additions That Do Not Constitute Substantial Improvement **NFIP 60.3(e)(5) and 60.3(c)(5)**	**Recommendation:** Make addition compliant with current NFIP requirements for V Zone construction. **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. **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) **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 **IRC:** R322.3.1 **ASCE:** ASCE 7 Sec. 1.6 **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 **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. **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). **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 **IRC:** N/A **ASCE:** N/A
Vertical Additions That Do Not Constitute Substantial Improvement **NFIP 60.3(e)(5) and 60.3(c)(5)**	**Recommendation:** Make the addition compliant with current NFIP requirements for V Zone construction. **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. **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). **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 **IRC:** N/A **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 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. **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. **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). **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 **IRC:** R401.1, R401.2, R401.3, R401.4, R401.4.1 **ASCE:** ASCE 24 Sec. 1.5.3, 1.5.3.1, 1.5.3.2, 1.5.3.3, ASCE 7 Sec. 1.6 **Other:** FEMA 550, FEMA TB #1, FEMA TB #5
Enclosures Below Buildings– When Enclosure Constitutes a Substantial Improvement 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. **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). **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 **IRC:** R322.1, R322.1.8, R322.3.5 **ASCE:** ASCE 24 Sec. 4.6, ASCE 7 Sec. 1.6 **Other:** FEMA TB #5, FEMA TB #9
Enclosures Below Buildings– When Enclosure Does Not Constitutes a Substantial Improvement NFIP 60.3(e)(5) and 60.3(c)(5)	**Recommendation:** Make the enclosure compliant with current NFIP requirements for new V Zone construction. **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. **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. **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 **IRC:** N/A **ASCE:** ASCE 24 Sec. 4.6 **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 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. **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 **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 **ASCE:** N/A **Other:** FEMA 550
Moving Existing Building 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. **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). **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 **IRC:** AE102.6 **ASCE:** ASCE 7 Sec. 1.6 **Other:** FEMA 550
Manufactured Housing				
General				**IRC:** R322.1.9, App. AE101 **ASCE:** Not Applicable **Other:** FEMA 85

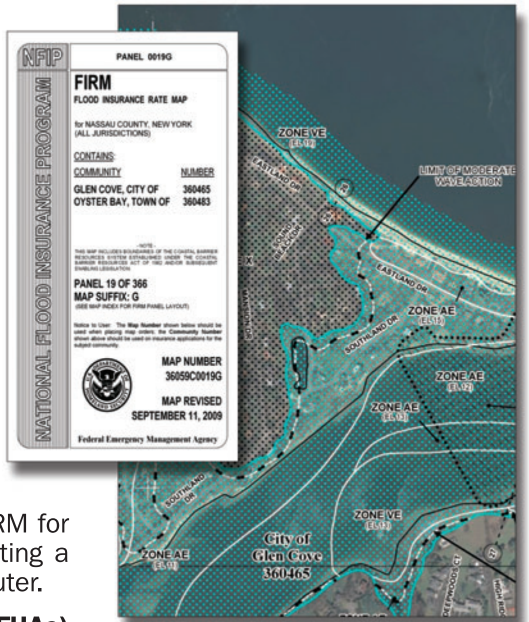
Developed in association with the National Association of Home Builders Research Center

Using a Digital Flood Insurance Rate Map (DFIRM)

HOME BUILDER’S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 1.3

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.

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.

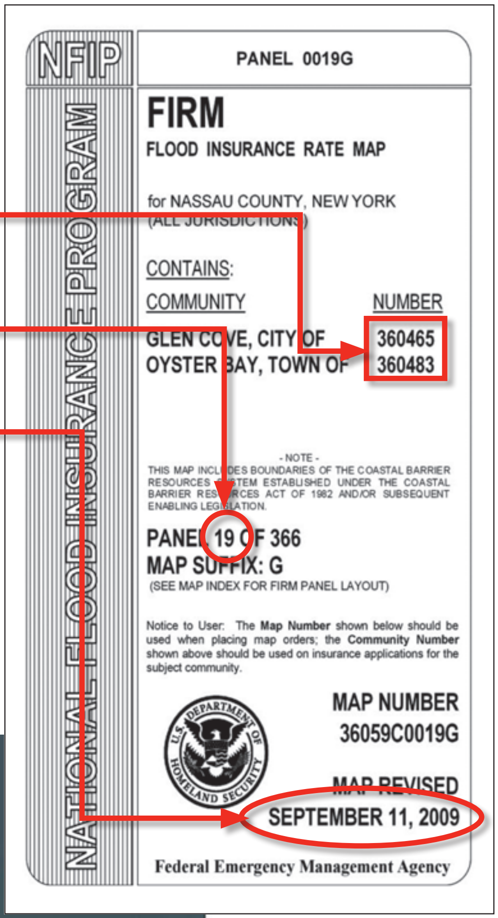
Sample DFIRM

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.

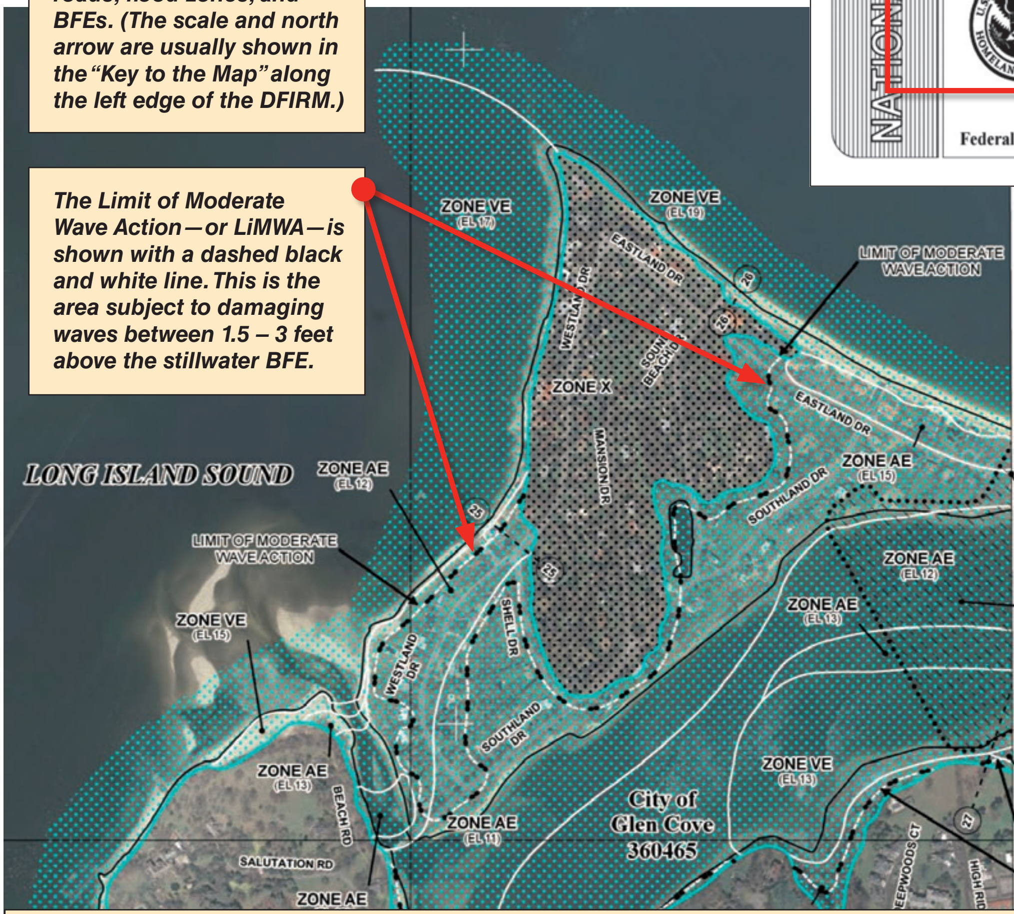
The panel number is 19. Note that an Index Map is available showing all DFIRM panels for all communities within Nassau County.

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?

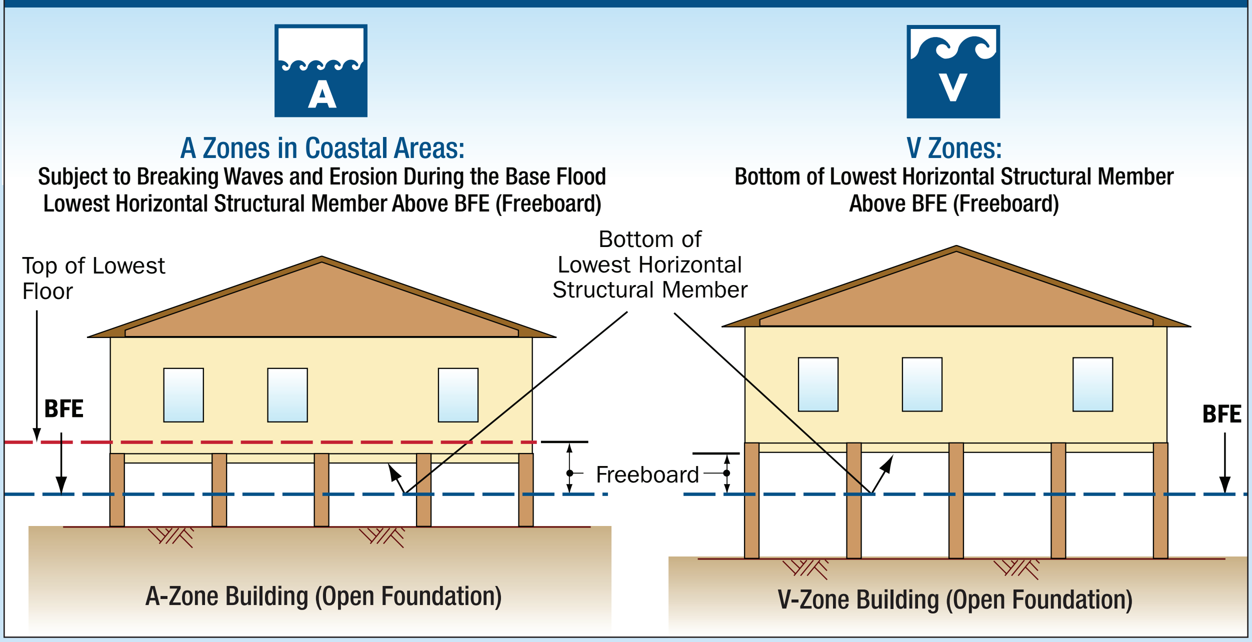
In riverine and other inland areas, experience has shown that if the lowest floors of buildings are not elevated above the flood level, these buildings and their contents will be damaged or destroyed. In coastal areas, wave action causes even more damage, often destroying enclosed building areas below 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).

Recommended Practice:



* 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

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION — Technical Fact Sheet No. 1.5

GENERAL 1

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:

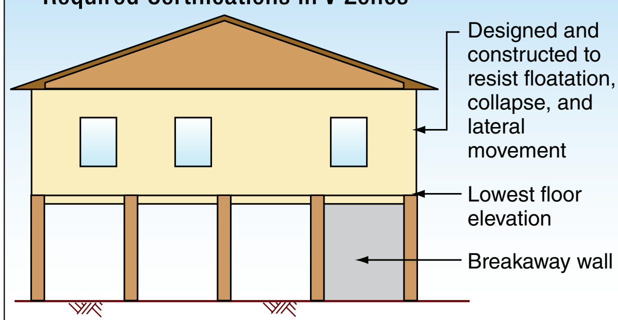
- The **bottom of the lowest horizontal structural member of the lowest floor** (excluding the pilings or columns) is elevated to, or above, the Base Flood Elevation (BFE).
- The pile or column foundation and structure attached thereto is **anchored to resist flotation, collapse, and lateral movement 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.

Required Certifications in V Zones



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.

1 GENERAL

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.

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.

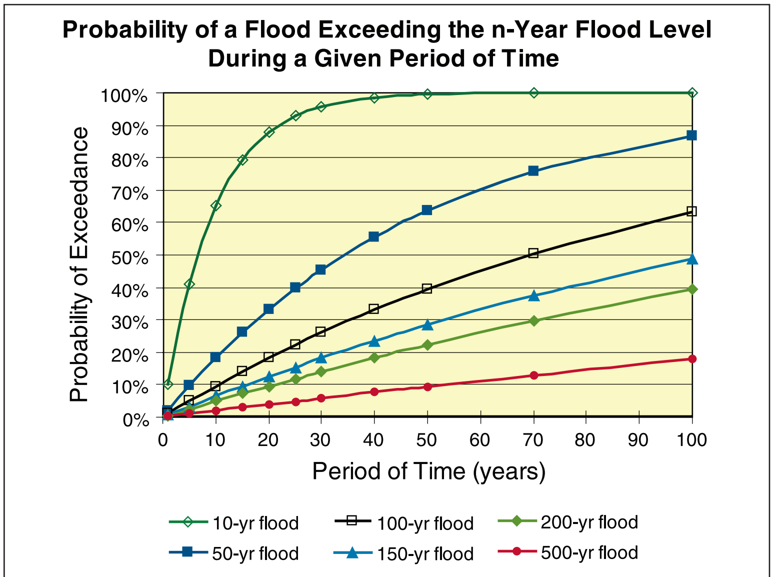


Figure 3. Probability that a flood will exceed the n-year flood level over a given period of time.

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

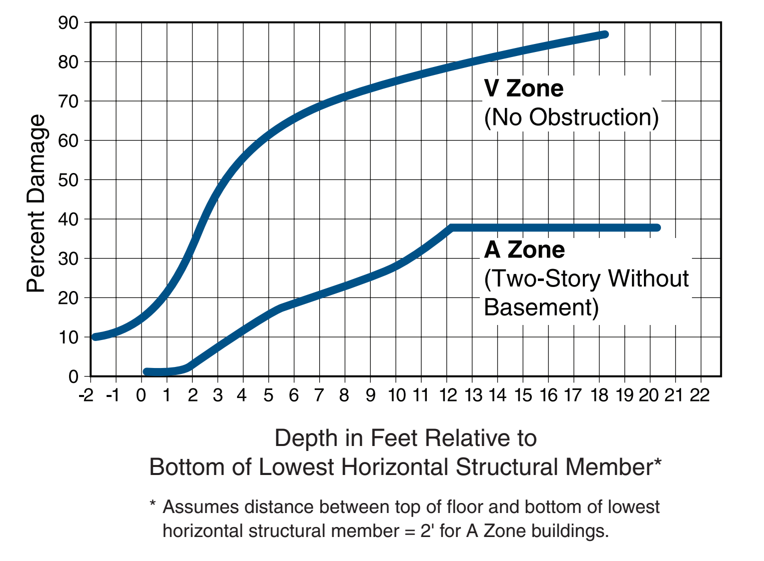


Figure 4. Flood depth versus building damage curves for V Zones and riverine A Zones.

(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.

- 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.

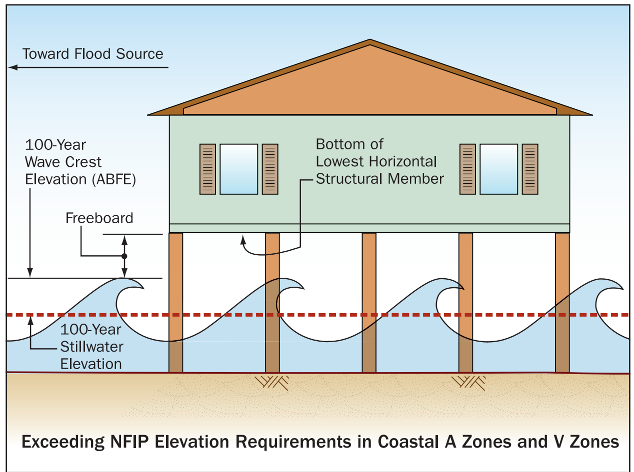


Figure 7. Recommended construction in Coastal A Zone and V Zone.

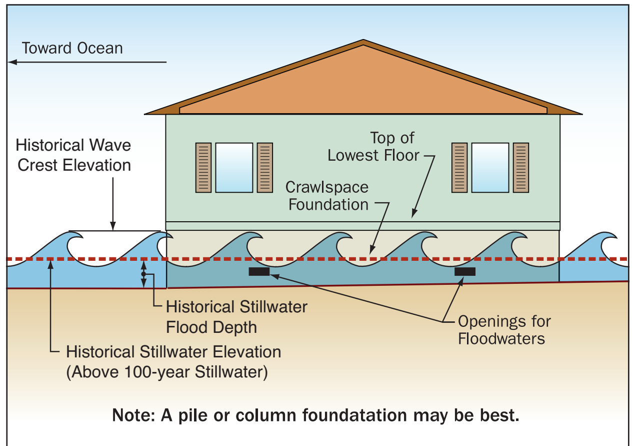


Figure 8. Recommended construction in Zone B, Zone C, and Zone X.

- 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;

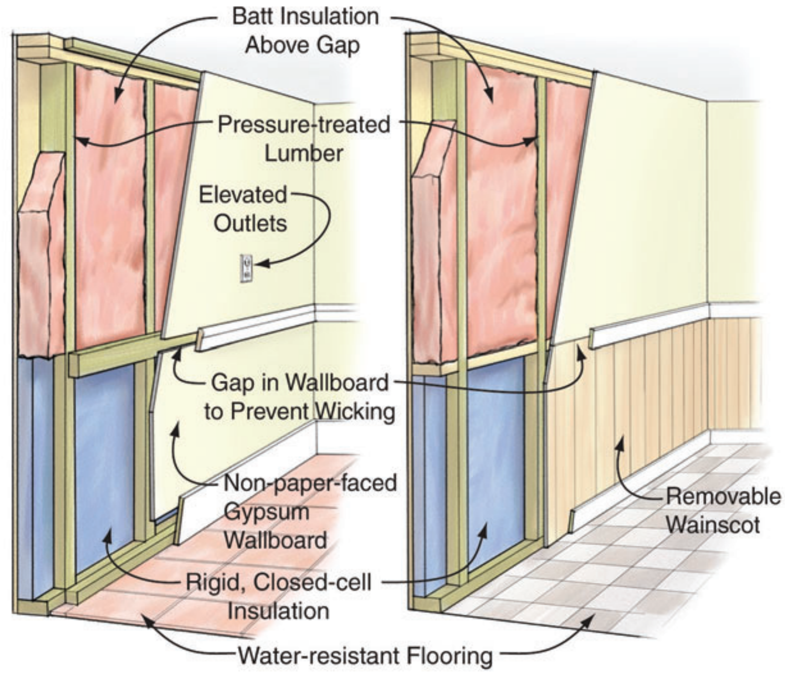
2) use non-paper-faced gypsum wallboard below gap, painted with latex paint;

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).



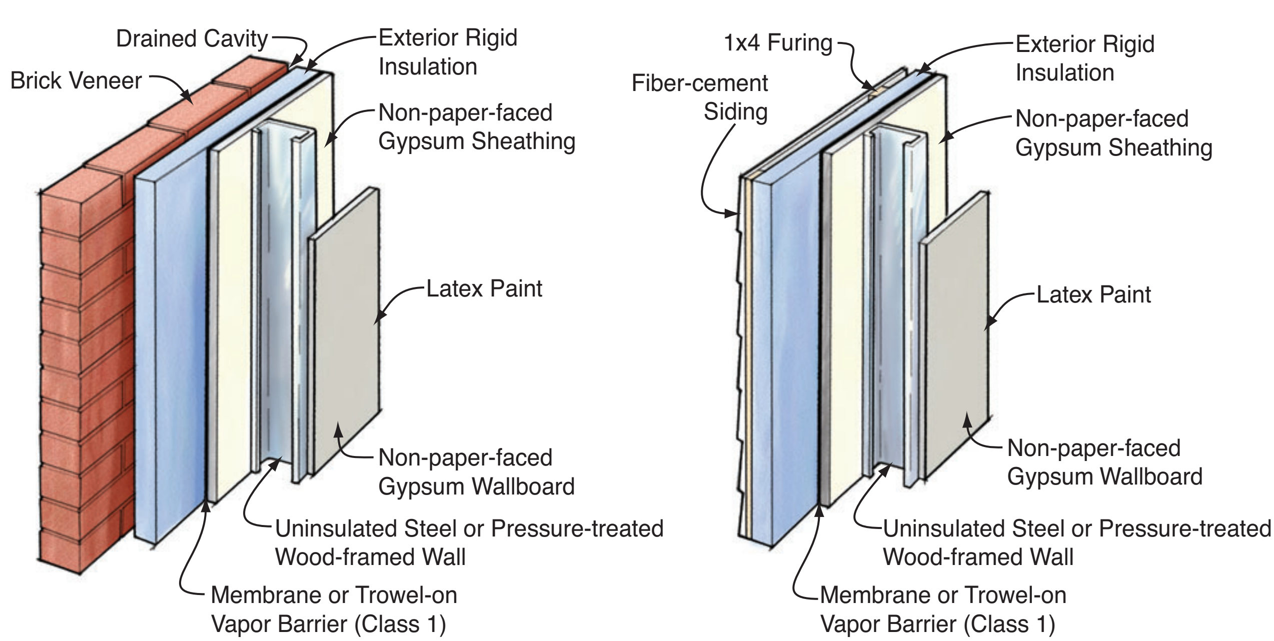


Figure 10. Recommended flood-resistant exterior cavity wall construction. The following materials and methods will limit flood damage to exterior cavity walls:

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).

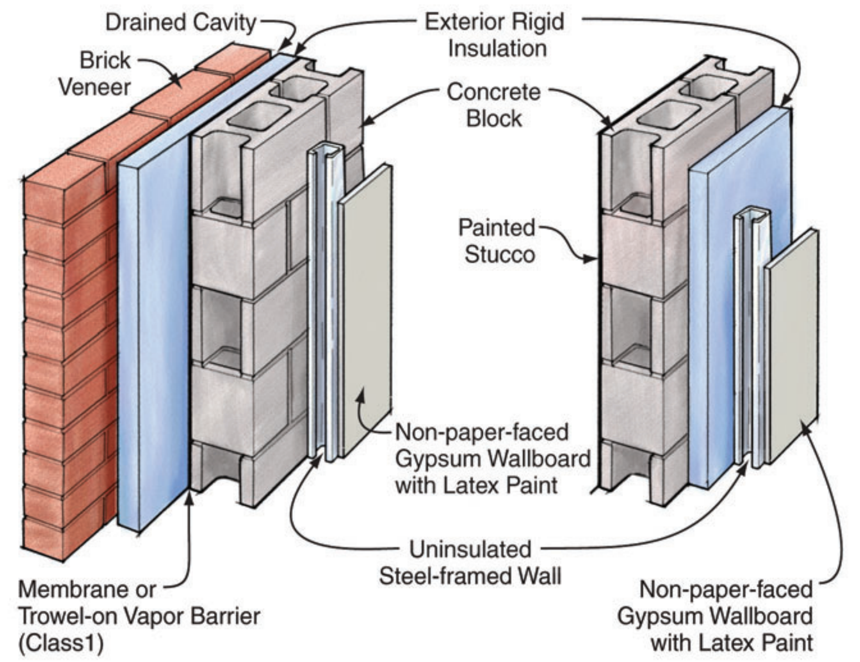


Figure 11. Recommended flood-resistant exterior mass wall construction. The following materials and methods will limit flood damage to exterior mass walls:

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).

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

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.

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.

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.

- 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.

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.

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 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

Moisture Barrier Systems

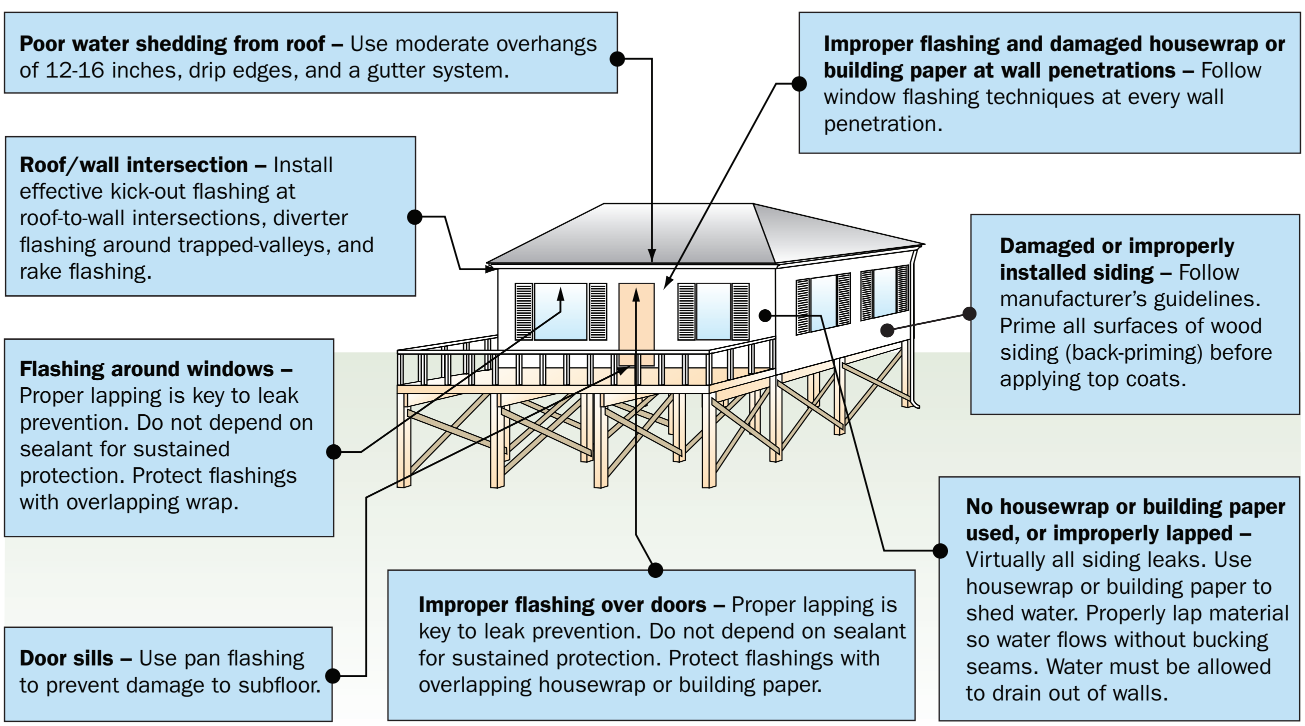
Purpose: *To describe the moisture barrier system, explain how typical wall moisture barriers work, and identify common problems associated with moisture barrier systems.*

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.

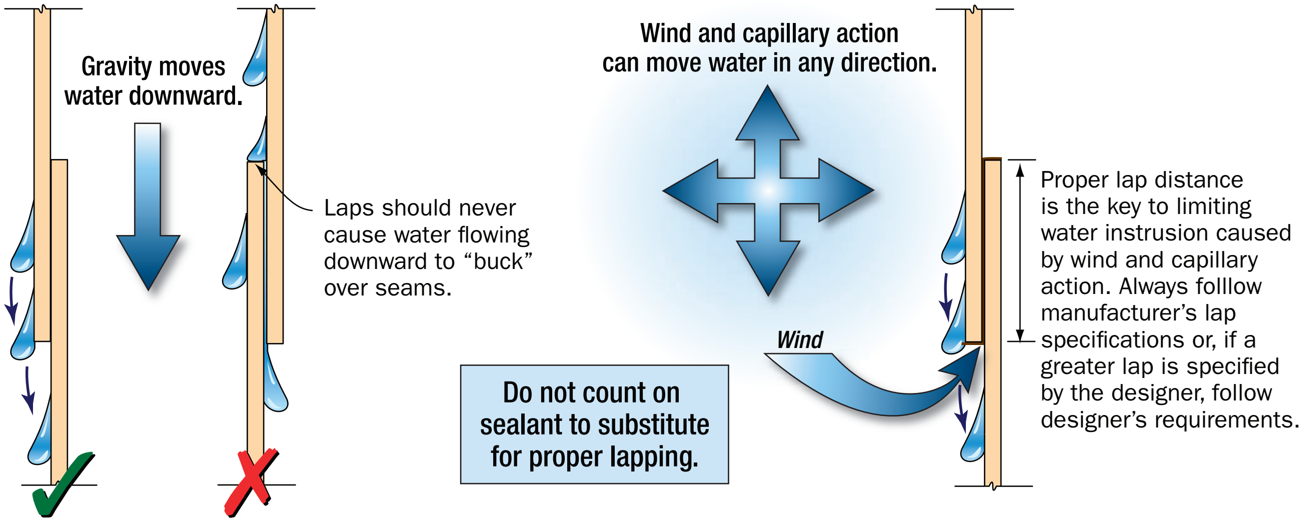
The purpose of the building envelope is to control the movement of water, air, thermal energy, and water vapor. The goal is to prevent water infiltration into the interior, limit long-term wetting of the building components, and control air and vapor movement through the envelope.

Locations and Causes of Common Water Intrusion Problems



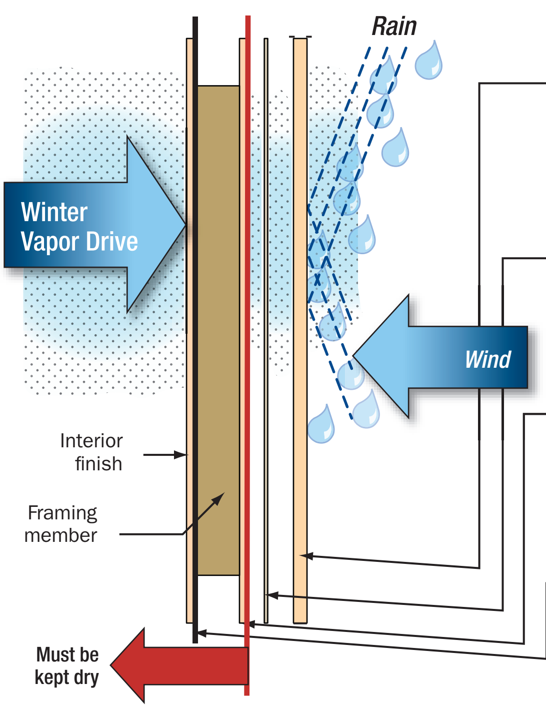
The location of water entry is often difficult to see, and the damage to substrate and structural members behind the exterior wall cladding frequently cannot be detected by visual inspection.

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).

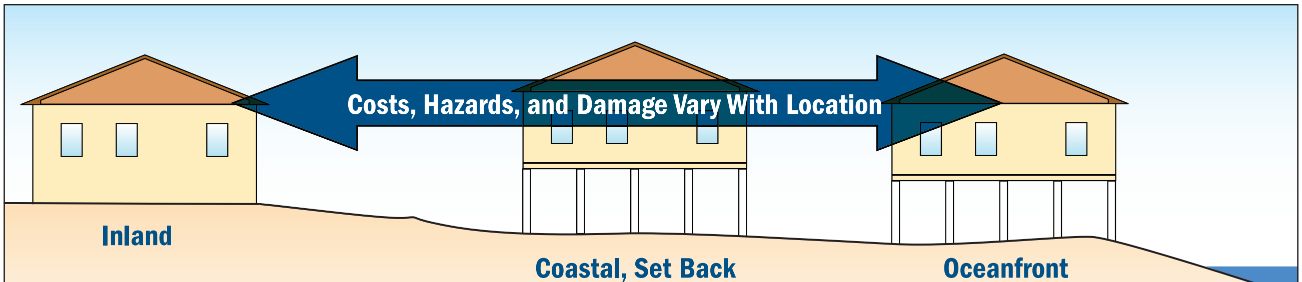
Developed in association with the National Association of Home Builders Research Center

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

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 2.1

PLANNING 2

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



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

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

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).

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

Siting

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

Design

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

Design Item (Items with asterisk "*" are required by the National Flood Insurance Program (NFIP) and/or local building code.)	Cross-Reference to Fact Sheets	Added Initial Costs[2] Required by Code or NFIP	Added Initial Costs[3] for Home Builder's Guide to Coastal Construction Recommended Practices	Effect of Design on Cost: Reduce wind/storm damage	Reduce flood damage	Longer material life	Reduce maintenance	Lower insurance	Lower utility bills
A Zone, pile/column foundation	1.1, 1.4, 3.1	High	High	✔	✔		✔		
V Zone, pile/column foundation*	1.1, 1.4, 1.5, 3.1	High			✔		✔		
Joists sheathed on underside		Low	Low		✔	✔			✔
Structurally sheathed walls*		Medium		✔					
Corrosion protection*	1.1, 1.7	Low		✔	✔	✔	✔		
Decay protection*	1.1, 1.7	Medium		✔	✔	✔	✔		
Hip roof shape	1.1	Low	Low	✔					
Enhanced roof sheathing connection*	1.1, 7.1	Low	Low	✔					
Enhanced roof underlayment*	7.2	Low	Low	✔					
Upgraded roofing materials*	1.1, 7.3	Medium		✔		✔	✔		
Enhanced flashing*	1.1, 6.1, 5.2	Low		✔		✔	✔		
Housewrap*	1.1, 6.1, 5.1	Low		✔					✔
Superior siding and connection*	5.3	Medium	Medium	✔			✔		
Protected or impact-resistant glazing*	1.1, 6.2	High	Medium	✔				✔	
Connection hardware*	1.1, 1.7, 4.3	Low		✔	✔				
Flood-resistant materials*	1.1, 1.7	Low			✔	✔		✔	
Protected utilities and mechanicals*	1.1, 8.3	Low		✔	✔	✔	✔		✔
Estimated Total Additional Cost ($ thousands)		15-30	±5	✔	✔	✔	✔	✔	✔

Low	<0.5% of base building cost	Estimates are based on a 3,000-square-foot home with a moderate number of windows and special features. Many of the upgraded design features are required by local codes, but the level of protection beyond the code minimum can vary, depending on the owner's preference.
Medium	0.5% - 2.0% of base building cost	
High	>2.0% of base building cost	

Notes:

2 Added costs when compared to typical inland construction

3 Added initial costs to exceed Code/NFIP minimum requirements

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

Selecting a Lot and Siting the Building

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION — Technical Fact Sheet No. 2.2

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

PLANNING 2

Key Issues

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

Siting, design, and construction should be considered together (see Fact Sheet No. 2.1), but know that poor lot selection and siting decisions can rarely be overcome by improved design and construction. Building failures (see Fact Sheet No. 1.1) are often the result of poor siting.

The Importance of Property Purchase and Siting Decisions

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

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

What Factors Constrain Siting Decisions?

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

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

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

Coastal Setback Lines – What Protection Do They Provide?

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

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

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

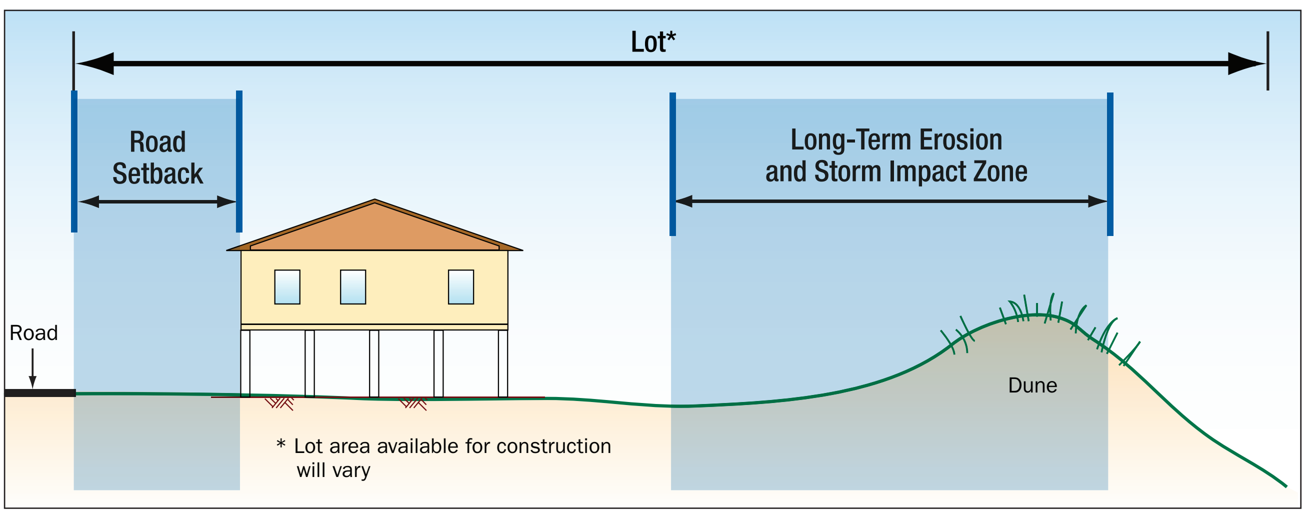
What Should Builders, Designers, and Owners Do?

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

Common Siting Problems

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

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



Recommended building location on a coastal lot.

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

Foundations in Coastal Areas

Purpose: *To describe foundation types suitable for coastal environments.*

Key Issues

- Foundations in coastal areas should elevate buildings above the Design Flood Elevation (DFE) in accordance with ASCE 24-05, while withstanding flood forces, high winds, scour and erosion, and floating debris in ASCE 7-10.
- Foundations used for inland construction are generally not suitable for coastal construction. Some examples of foundation systems that have a history of poor performance in erosion prone areas are slab-on-ground, spread footings, and mat (or raft) foundations.
- Deeply embedded pile or column foundations are required for V Zone construction. In A Zones they are recommended instead of solid wall, crawlspace, slab, or other shallow foundations, which are more susceptible to scour. (For the reference of this document, the term deeply embedded means "sufficient penetration into the ground to accommodate storm-induced scour and erosion and to resist all design vertical and lateral loads without structural damage.")
- Areas below elevated buildings in V Zones must be "free of obstructions" that can transfer flood loads to the foundation and building (see Fact Sheet No. 8.1, Enclosures and Breakaway Walls). Areas below elevated buildings in A Zones should follow the same recommended principles as those areas for buildings located in V Zones.

Figure 1. Near collapse due to insufficient pile embedment in Dauphin Island, Alabama.

(SOURCE: FEMA 549, HURRICANE KATRINA IN THE GULF COAST)

Foundation Design Criteria

All foundations for buildings in flood hazard areas must be constructed with flood-damage-resistant materials (see Fact Sheet No. 1.7, Coastal Building Materials). In addition to meeting the requirements for conventional construction, these foundations must: (1) elevate the building above the Base Flood Elevation (BFE), and (2) prevent flotation, collapse, and lateral movement of the building, resulting from loads and conditions during the design flood event (in coastal areas, these loads and conditions include inundation by fast-moving water, breaking waves, floating debris, erosion, and high winds).

Because the most hazardous coastal areas are subject to erosion, scour, and extreme flood loads, ***the only practical way to perform these two functions is to elevate a building on a deeply embedded and "open" (i.e., pile or column) foundation.*** This approach resists storm-induced erosion and scour, and it minimizes the foundation surface area subject to lateral flood loads.

ASCE 24-05 is recommended as a best practice for flood resistance design and construction, especially in V Zones and Coastal A Zones. This standard has specific information on foundation requirements for Coastal High Hazard Areas and Coastal A Zones and it has stricter requirements than the NFIP. Elevation on open foundations is required by the National Flood Insurance Program (NFIP) in V Zones (even when the ground elevation lies above the BFE) and is strongly recommended for Coastal A Zones. Some states and communities have formally adopted open foundation requirements for Coastal A Zone construction.

While using the approach of elevation of structures on pile foundations improves performance and minimizes some effects, even a deeply embedded open pile foundation will not prevent eventual undermining and loss due to long-term erosion (see Fact Sheet No. 2.2, *Selecting a Lot and Siting the Building*).

Performance of Various Foundation Types in Coastal Areas

There are many ways to elevate buildings above the BFE: fill, slab-on-grade, crawlspace, stemwall, solid wall, pier (column), and pile. Not all of these are suitable for coastal areas. In fact, several of them are prohibited in V Zones and are not recommended for A Zone construction in coastal areas (see Fact Sheet 1.2, *Summary of Coastal Construction Requirements and Recommendations for Flood Effects*).

Pile: Pile foundations are recommended for V Zones and Coastal A Zones. These open foundations are constructed with square or round, wood, concrete, or steel piles, driven or jetted into the ground, or set into augered holes. Critical aspects of a pile foundation include the pile size, installation method and embedment depth, bracing, and the connections to the elevated structure (see Fact Sheets Nos. 3.2, *Pile Installation* and 3.3, *Wood-Pile-to-Beam Connections*). Pile foundations with inadequate embedment will lead to building collapse. Inadequately sized piles are vulnerable to breakage by waves and debris.

Fill: Using fill as a means of providing structural support to buildings in V Zones is prohibited because it is susceptible to erosion. Also, fill must not be used as a means of elevating buildings in any other coastal area subject to erosion, waves, or fast-moving water. However, minor quantities of fill are permitted for landscaping, site grading (not related to structural support of the building), drainage around and under buildings, and for the support of parking slabs, pool decks, patios and walkways (2009 IRC Section R322.3.2). These guidelines are consistent with NFIP Technical Bulletin 5, *Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas (*08/08), which states: "Fill must not prevent the free passage of floodwaters and waves beneath elevated buildings. Fill must not divert floodwaters or deflect waves such that increased damage is sustained by adjacent or nearby buildings."

Slab-on-Grade: Slab-on-grade foundations are also susceptible to erosion and are prohibited in V Zones and are not recommended for A Zones in coastal areas. (Note that parking slabs are often permitted below elevated buildings, but are susceptible to undermining and collapse.) It is recommended that parking slabs be designed to be frangible (breakaway) or designed and constructed to be self-supporting structural slabs capable of remaining intact and functional under base flood conditions, including expected erosion. For more information, see NFIP Technical Bulletin 5, *Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas* (08/08).

Crawlspace: Crawlspace foundations are prohibited in V Zones and are not recommended for A Zone construction in coastal areas. They are susceptible to erosion when the footing depth is inadequate to prevent undermining. Crawlspace walls are also vulnerable to wave forces. Where used, crawlspace foundations must be equipped with flood openings; grade elevations should be such that water is not trapped in the crawlspace (see Fact Sheets Nos. 3.5, *Foundation Walls* and 8.1, *Enclosures and Breakaway Walls*).

Figure 2. Performance comparison of pier foundations. Piers on discrete footings (foreground) failed by rotating and overturning while piers on more substantial footings (in this case a concrete mat) survived (Pass Christian, Mississippi)

Stemwall: Stemwall foundations are similar to crawlspace foundations in construction, but the interior space that would otherwise form the crawlspace is often backfilled with structural fill or sand that supports a floor slab. Stemwall foundations have been observed to perform better during storms than many crawlspace and pier foundations. Although the IRC allows for heights of up to six feet, it is usually more economical and a better design choice to use another foundation system if stemwalls are over a few feet in height. During periods of high water backfill, soils may become flooded and cause damage to the slab. The designer should ensure that this does not cause consolidation of the backfill. In addition, in some soils such as sand, capillary action can cause water and moisture to affect the slab. Flood openings are not required in a backfilled stemwall foundation. Stemwall foundations are prohibited in V Zones but are recommended in A Zone areas subject to limited wave action, as long as embedment of the wall is sufficient to resist erosion and scour (see FEMA 549, *Hurricane Katrina in the Gulf Coast*).

Solid Foundation Walls: The NFIP prohibits solid foundation walls in V Zones and are not recommended for A Zone areas subject to breaking waves or other large flood forces—the walls act as an obstruction to flood flow. Like crawlspace walls, they are susceptible to erosion when the footing depth is inadequate to prevent undermining. Solid walls have been used in some regions to elevate buildings one story in height. Where used, the walls must allow floodwaters to pass between or through the walls (using flood openings). (See Fact Sheets Nos. 3.5, *Foundation Walls* and 8.1, *Enclosures and Breakaway Walls*.)

Pier (column): Pier foundations are recommended for A Zone areas where erosion potential and flood forces are small. This open foundation is commonly constructed with reinforced and grouted masonry units atop a concrete footing. Shallow pier foundations are extremely vulnerable to erosion and overturning if the footing depth and size are inadequate. They are also vulnerable to breakage. Fact Sheet No. 3.4, *Reinforced Masonry Pier Construction*, provides guidance on how to determine whether pier foundations are appropriate, and how to design and construct them.

Foundations for High-Elevation Coastal Areas

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

Moreover, both shallow and deep foundations will fail in such situations. Long-term solutions to the problem may involve better siting (see Fact Sheet No. 2.2, *Selecting a Lot and Siting the Building*), moving the building when it is threatened, or (where permitted and economically feasible) controlling erosion through slope stabilization and structural protection. Additionally FEMA 232, *Homebuilders' Guide to Earthquake Resistant Design and Construction*, provides information on foundation anchorage for hillside structures.

Foundations in V Zones with Ground Elevations Above the BFE

In some instances, coastal areas will be mapped on an NFIP Digital Flood Insurance Rate Map (DFIRM) as Zone V, but will have dunes or bluffs with ground elevations above the BFE shown on the DFIRM. During a design flood event, erosion of the bluffs and high dunes can be expected at these areas as well as waves and inundation. Therefore, the ground level can be expected to be lowered to a point that wave forces and loss of soil are a critical factor. The foundations for structures in these V Zone areas with high ground elevation are the same as V Zone areas with lower ground elevations. Deeply embedded pile or column foundations are still required in these areas, and solid or shallow foundations are still prohibited. The presence of a V Zone designation in these instances indicates that the dune or bluff is expected to erode during the base flood event and that V Zone wave conditions are expected after the erosion occurs. The presence of ground elevations above the BFE in a V Zone should not be taken to mean that the area is free from base flood and erosion effects.

Additional Resources

FEMA 550, *Recommended Residential Construction for the Gulf Coast: Building on Strong and Safe Foundations* (July 2006). (http://www.fema.gov/library/viewRecord.do?id=1853)

FEMA 549, *Hurricane Katrina in the Gulf Coast* (July 2006). (http://www.fema.gov/library/viewRecord.do?id=1857)

FEMA, NFIP Technical Bulletin 5, *Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas*, FIA-TB-5, Washington, DC, August 2008. (http://www.fema.gov/library/viewRecord.do?id=1718)

FEMA 232, *Homebuilders' Guide to Earthquake Resistant Design and Construction*, Washington, DC, February 2001 (http://www.fema.gov/library/viewRecord.do?id=2103)

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

American Society of Civil Engineers (ASCE). *Flood Resistant Design and Construction*, ASCE/SEI 24-05. (http://www.asce.org)

FOUNDATIONS 3

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

Pile Design and Installation

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 3.2

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

Key Factors

- Use a pile type that is appropriate for local conditions.
- Piles should resist coastal hazards such as high winds and flood loads in addition to withstanding erosion and scour. Erosion being the widespread loss of soil and scour being a localized loss of soil around a building or foundation element due to turbulent water movement.
- Have a registered engineer design piles for adequate layout, size, and length.
- Use installation methods that are appropriate for the conditions.
- Brace piles properly during construction.
- Make accurate field cuts, and treat all cuts and drilled holes to prevent decay.
- Have all pile-to-beam connections engineered, and use corrosion-resistant hardware (see Fact Sheet No. 1.7, C*oastal Building Materials*).

Pile Types

The most common pile types used are preservative treated wood, concrete, and steel. Contractors doing construction in coastal areas typically select preservative treated wood piles for pile foundations. They can be square or round in cross section. Wood piles are easily cut and adjusted in the field. Concrete and steel can also be used but are less common in residential construction. Concrete piles—may be an appropriate choice depending upon the pile capacity requirements and elevation needed by the design—are available in longer lengths and are usually installed by pile driving. Concrete piles tend to have higher strengths and are durable to many factors that are in the coastal environment when properly designed and detailed. Steel piles are rarely used because of potential corrosion problems.

Pile Size and Length

The foundation engineer is the one who determines pile size and length. Specified bearing and penetration requirements must be met. Round piles should have no less than an 8-inch tip diameter; square piles should have a minimum timber size of 8 by 8 inches. The total length of the pile is based on building code requirements [see the 2009 International Building Code (IBC) Section 1810 on deep foundations], calculated penetration requirements, erosion and scour potential, Design Flood Elevation (DFE), and allowance for cut-off and beam width (see Figure 1 and Table 1, which is an example of foundation design results). Substantial improvement in foundation performance can be achieved by increasing the minimum timber size for square piles to 12 by 12 inches or minimum tip diameter for round piles of 12 inches.

FOUNDATIONS 3

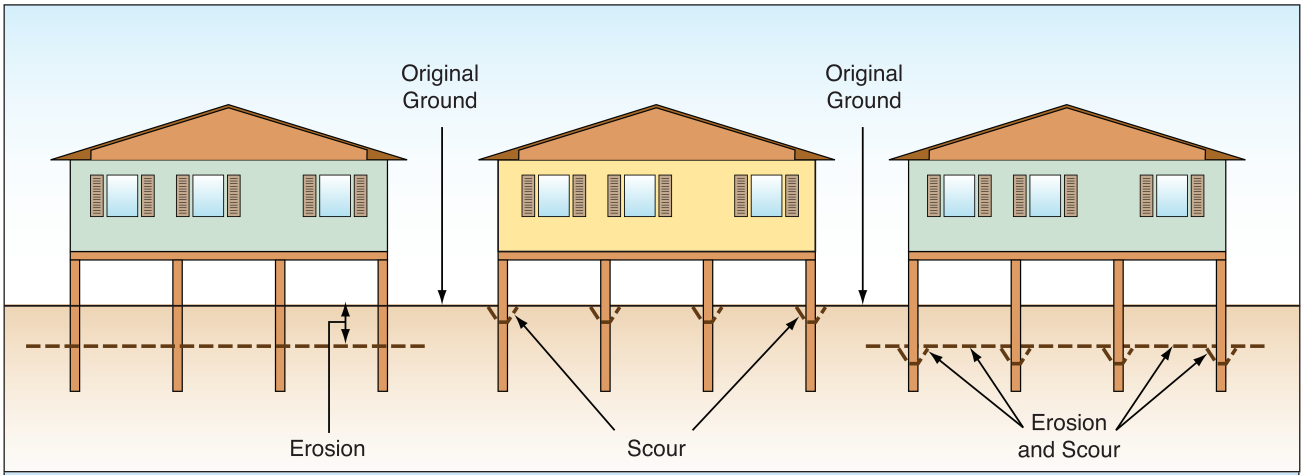


Figure 1. Distinguishing between coastal erosion and scour. A building may be subject to either or both, depending on the building location, soil characteristics, and flood conditions.

Table 1. Example foundation adequacy calculations for a two-story house supported on square timber piles and situated away from the shoreline, storm surge, and broken waves passing under the building, 130-mph basic wind speed per ASCE 7-05 (167-mph equivalent ASCE 7-10 basic wind speed for Risk Category II buildings), soil = medium dense sand. Shaded cells indicate the foundation fails to meet bending (P) and/or embedment (E) requirements.

Pile Embedment Before Erosion and Scour	Erosion and Scour Conditions	Pile Diameter, Ø		
		8 inch	10 inch	12 inch
10 feet	Erosion = 0, Scour = 0	P, E	E	OK
	Erosion = 0, Scour = 2.0Ø	P, E	E	E
	Erosion = 1, Scour = 2.5Ø	P, E	E	E
	Erosion = 1, Scour = 3.0Ø	P, E	E	E
	Erosion = 1, Scour = 4.0Ø	P, E	P, E	E
15 feet	Erosion = 0, Scour = 0	P	OK	OK
	Erosion = 0, Scour = 2.0Ø	P	OK	OK
	Erosion = 1, Scour = 2.5Ø	P	OK	OK
	Erosion = 1, Scour = 3.0Ø	P	OK	OK
	Erosion = 1, Scour = 4.0Ø	P, E	P, E	E
20 feet	Erosion = 0, Scour = 0	P	OK	OK
	Erosion = 0, Scour = 2.0Ø	P	OK	OK
	Erosion = 1, Scour = 2.5Ø	P	OK	OK
	Erosion = 1, Scour = 3.0Ø	P	OK	OK
	Erosion = 1, Scour = 4.0Ø	P	P	OK

Pile Layout

The foundation engineer and designer determine the pile layout together. Accurate placement and correction of misaligned piles is important. The use of a drive template for guiding the pile driving operation greatly increases the accuracy of the pile location and need for difficult remediation. A drive template is a temporary guide structure that is installed in a manner to restrict the lateral movement of the piles during driving. The pile template is reused for each row of piles to assure consistent spacing and alignment. Pile placement should not result in more than 50 percent of the pile cross section being cut for girder or other connections. Verify proper pile locations on drawings before construction and clarify any discrepancies. Layout can be done by a licensed design professional or surveyor, a construction surveyor, the foundation contractor, or the builder. The layout process must always include establishing an elevation for the finished first floor. Construction of the first-floor platform should not begin until this elevation is established (see Fact Sheet No. 1.4, *Lowest Floor Elevation*).

Installation Methods

Piles can be driven, augered, or jetted into place. The installation method will vary with soil conditions, bearing requirements, equipment available, and local practice. One common method is to initially jet the pile to a few feet short of required penetration, then complete the installation by driving with a drop hammer. Driving the pile even a few feet helps assure the pile is achieving some end-bearing capacity and some skin friction. Full depth driving where achievable provides for a pile foundation that has several advantages that merit consideration.

Pile Bracing

The engineer determines pile bracing layout. Common bracing methods include knee and diagonal bracing. Knee bracing is an effective method of improving the performance of a pile system without creating an obstruction to the flow of water and debris from a design event. Because slender bracing is susceptible to buckling, slender bracing should be considered as tension only. Bracing can become an obstruction, however, and increase a foundations exposure to wave and debris impact. Bracing is often oriented perpendicular to the shoreline so that it is not struck broadside by waves, debris, and velocity flow (see Figure 2). Temporary bracing or jacking to align piles and hold true during construction is the responsibility of the contractor.

It is recommended that pile bracing be used only for reducing the structure's sway and vibration for comfort. In other words, bracing should be used to address serviceability issues and not strength issues. The foundation design should consider the piles as being un-braced as the condition that may occur when floating debris removes or damages the bracing. If the pile foundation is not able to provide

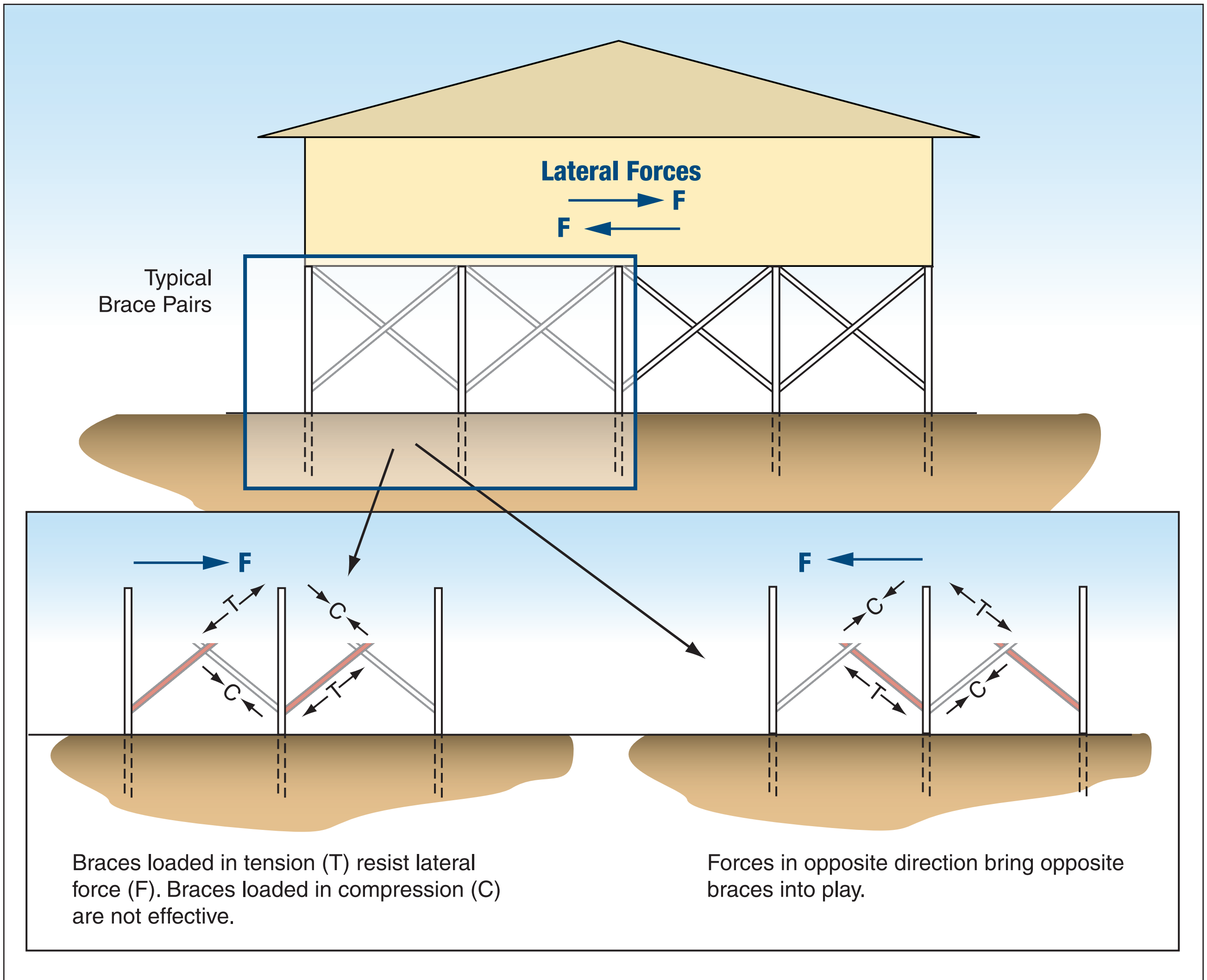


Figure 2. Diagonal bracing schematic.

the desired strength performance without bracing then the designer should consider increasing the pile size. Pile bracing should only be for comfort of the occupants, but not for stability of the home.

Field Cutting and Drilling

A chain saw is the common tool for making cuts and notches in wood piles. After making cuts, exposed areas should be field-treated with the proper wood preservative to prevent decay. This involves applying the preservative with a brush to the cut or drilled holes in the pile until no more fluid is drawn into the wood.

Connections

The connection of the pile to the structural members is one of the most critical connections in the structure. Always follow design specifications and use corrosion-resistant hardware. Strict attention to detail and good construction practices are critical for successful performance of the foundation (see Fact Sheet Nos. 1.7, *Coastal Building Materials*, and 3.3, *Wood-Pile-to-Beam Connections*).

Verification of Pile Capacity

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

Additional Resources

American Concrete Institute (ACI), 543R-00: *Design, Manufacture, and Installation of Concrete Piles* (Reapproved 2005), (http://www.concrete.org)

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

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

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

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

Southern Pine Council (SPC) (http://www.southernpine.com/about.shtml)

Timber Pile Council, American Wood Preservers Institute, *Timber Pile Design and Construction Manual*, (http://www.wwpinstitute.org/pdffiles/TimberPileManual.pdf)

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

NAHB RESEARCH CENTER

Wood Pile-to-Beam Connections

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

Key Issues

- Verify pile alignment and correct, if necessary, before making connections.
- Carefully cut piles to ensure required scarf depths.
- Limit cuts to no more than 50 percent of pile cross section.
- Use corrosion-resistant connectors and fasteners such as those fabricated from stainless steel, or connectors and fasteners with corrosion protection such as provided by hot-dip galvanized coating (see Fact Sheet No. 1.7, *Coastal Building Materials*).
- Accurately locate and drill bolt holes.
- Field-treat all cuts and holes to prevent decay.
- Use sufficient pile and beam sizes to allow proper bolt edge distances.

Built-up beams should be designed as continuous members and not be broken over the piles. Some homebuilders are using engineered wood products, such as glued laminated timber and parallel strand lumber, which can span longer distances without splices. The ability to span longer distances without splices eases installation and reduces fabrication costs.

Pile-to-beam connections must:

1. Provide required ***bearing*** area for beam to rest on pile.
2. Provide required ***uplift*** (tension) resistance.
3. Maintain beam in an ***upright*** position.
4. Be capable of resisting ***lateral*** loads (wind and seismic).
5. Be constructed with ***durable*** connectors and fasteners from corrosion-resistant materials or with corrosion protection in accordance with minimum requirements of the International Residential Code. The level of corrosion protection that can be expected will vary depending on the type of wood treatment and fastener type. Make sure the fastener is compatible with the wood variety selected for construction.

FOUNDATIONS 3

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

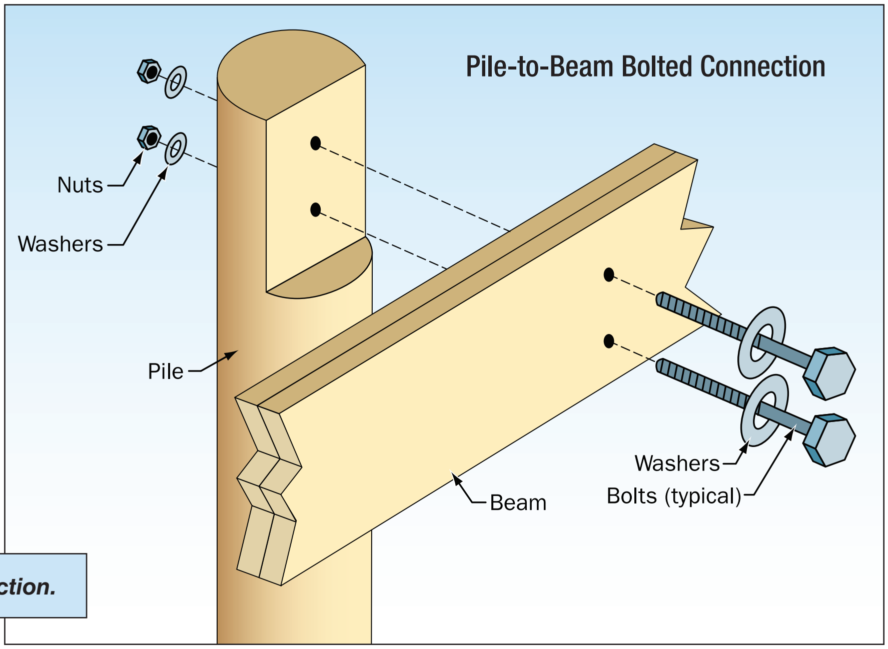
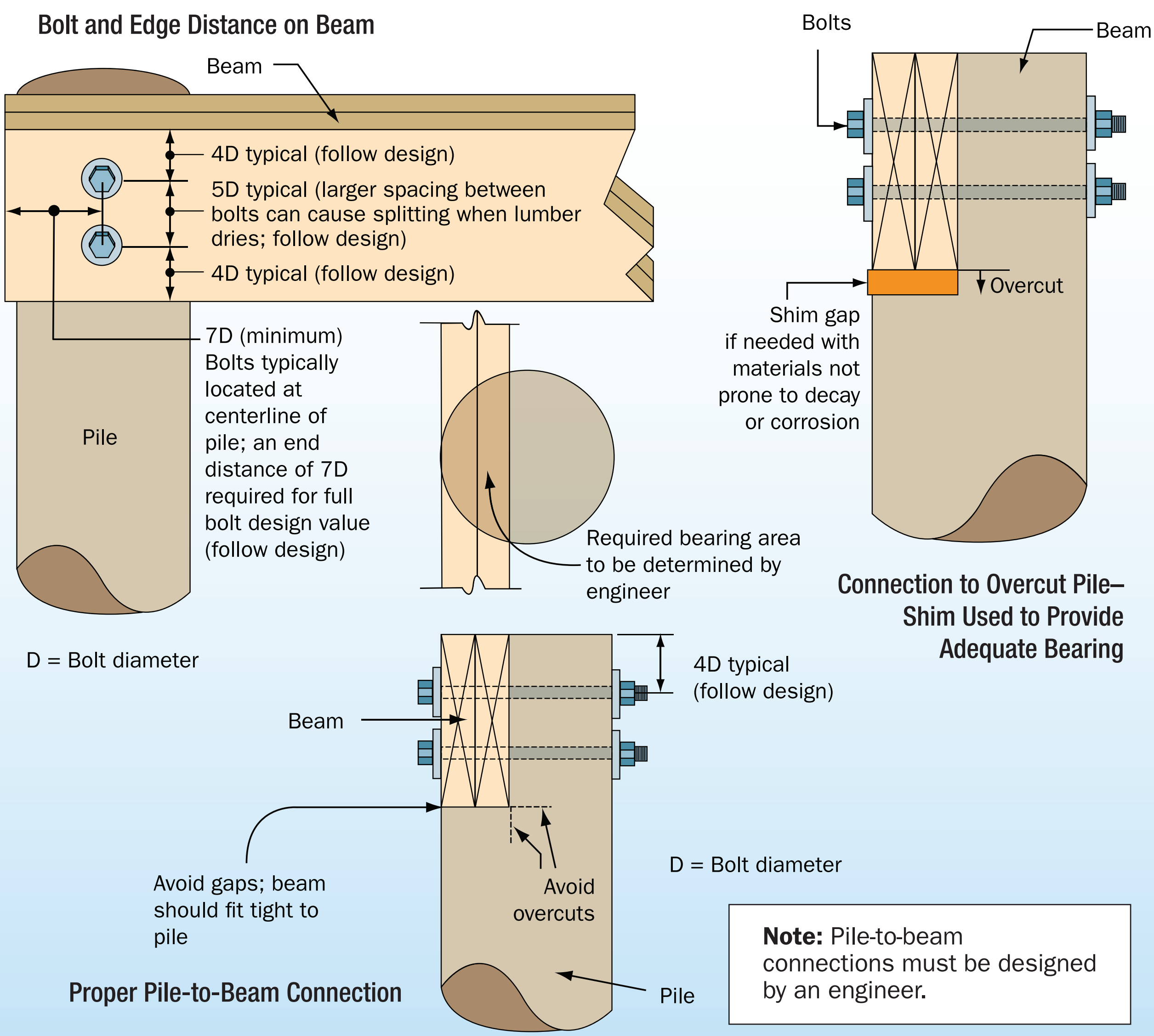


Figure 1. Pile-to-beam bolted connection.

Figure 2. Proper pile-to-beam bolted connection.



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

There are five possible solutions to fix the problem. (See figure 3 and details in figure 4):

Option 1 – beam cannot be shifted.

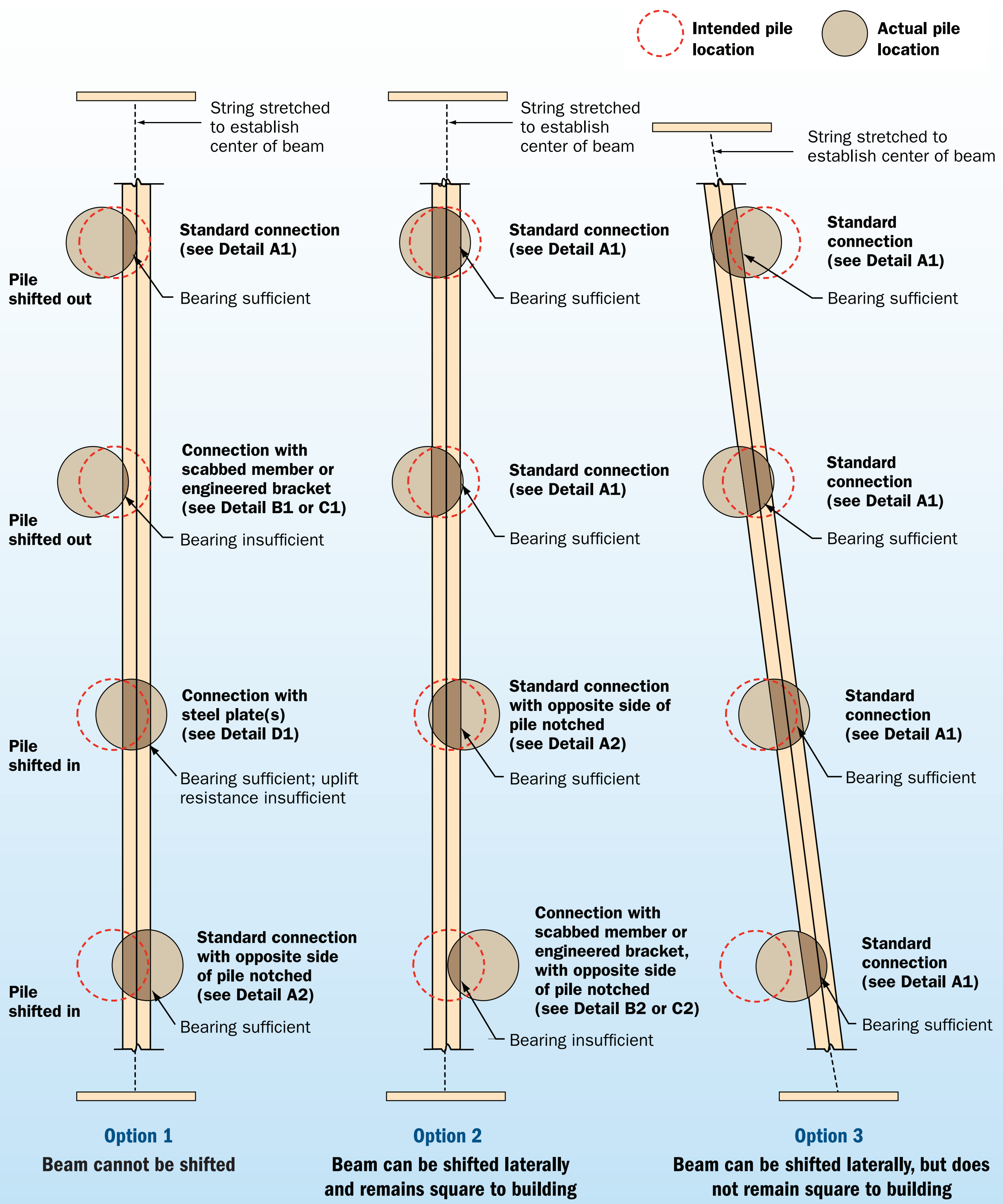
Option 2 – beam can be shifted laterally and remains square to building.

Option 3 – beam can be shifted laterally, but does not remain square to building.

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

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

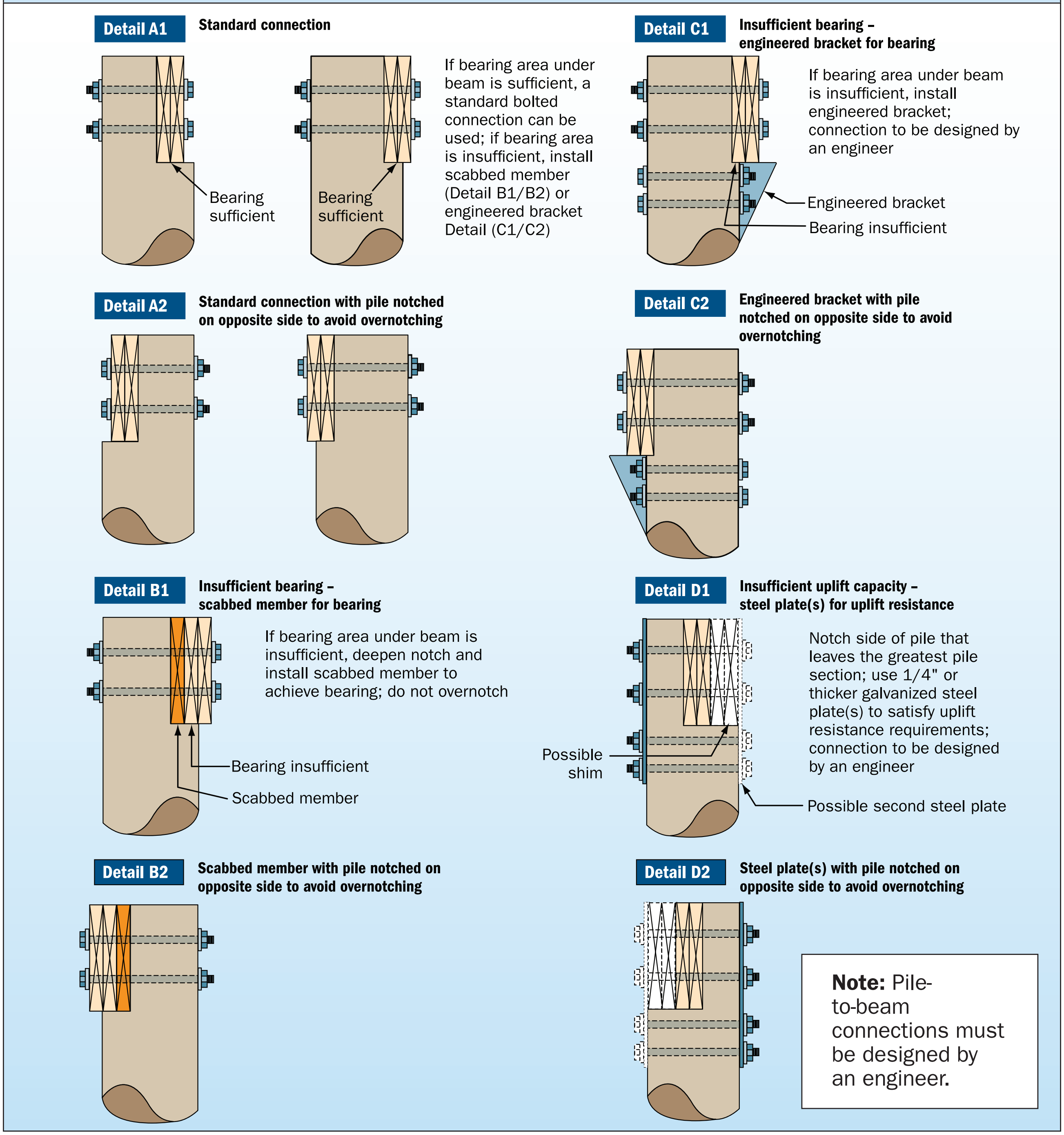
Figure 3. Connection of misaligned pile.



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

FOUNDATIONS 3

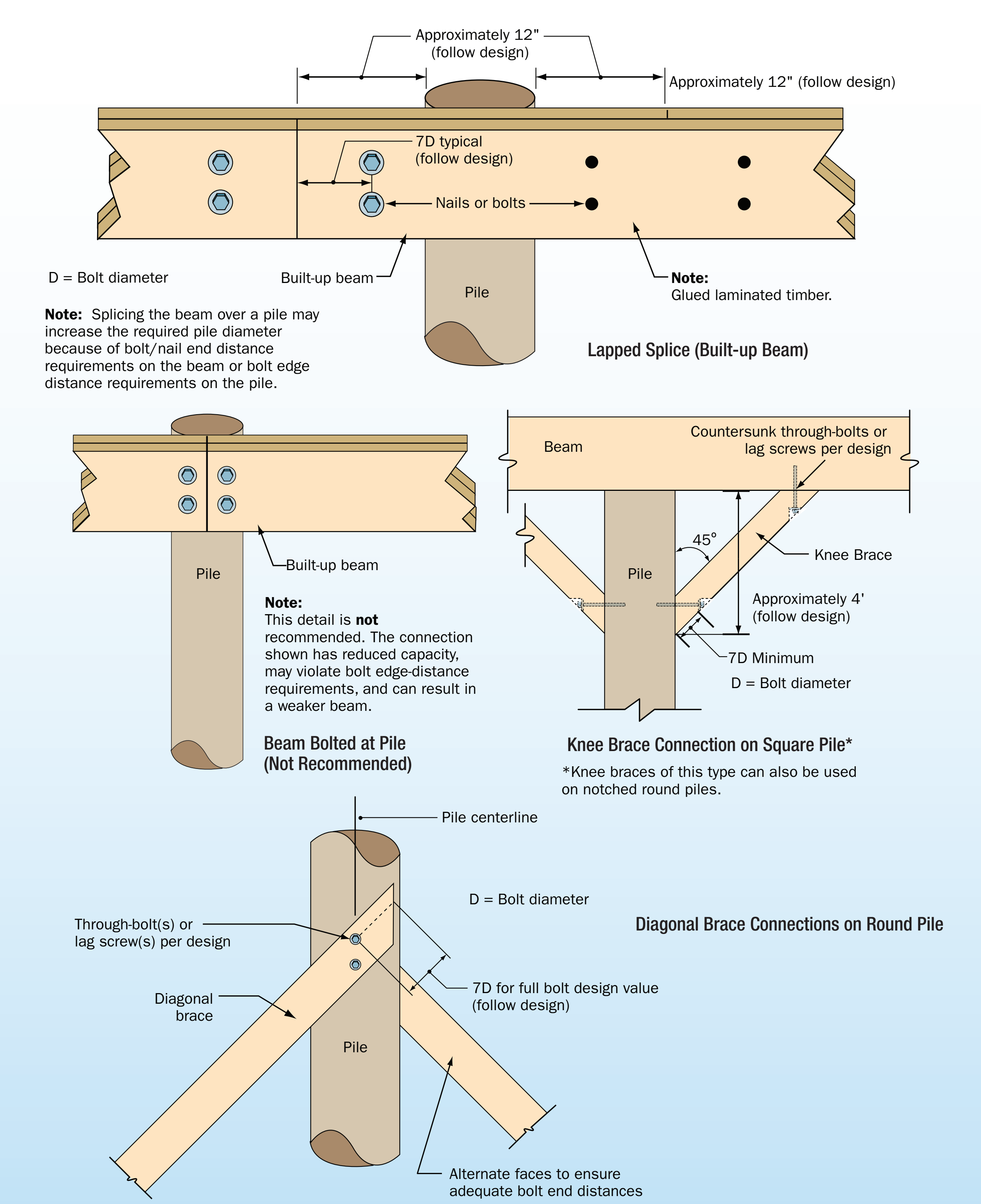
Figure 4. Connection details for misaligned piles.



Connections to misaligned piles (see drawings on figure 3 and details above)

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

Figure 5. Built-up beam connections, knee brace connections, and diagonal brace connections.



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

FOUNDATIONS 3

Additional Resources

American Wood Council (AWC) (http://www.awc.org)

American Institute of Timber Construction (AITC) (http://www.aitc-glulam.org)

Reinforced Masonry Pier Construction

Purpose: *To provide an alternative to piles in V Zones and A Zones in coastal areas where soil properties and other site conditions indicate that piers are an acceptable alternative to the usually recommended pile foundation. Examples of appropriate conditions for the use of piers are where rock is at or near the surface or where the potential for erosion and scour is low.*

Key Issues

- The footing must be designed for the soil conditions present. Pier foundations are generally not recommended in V Zones or in A Zones in coastal areas.
- The connection between the pier and its footing must be properly designed and constructed to resist separation of the pier from the footing and overturning due to lateral (flood, wind, debris) forces.
- The top of the footing must be below the anticipated erosion and scour depth.
- The piers must be reinforced with steel and fully grouted.
- The connection to the floor beam at the top of the pier must be through use of properly sized and detailed metal connectors.
- Special attention must be given to the application of mortar and the tooling of all the joints in order to help resist water intrusion into the pier core, where the steel can be corroded.
- Special attention must be given to corrosion protection of joint reinforcement, accessories, anchors, and reinforcement bars. Joint reinforcement that is exposed to weather or the earth shall be stainless steel, hot dipped galvanized, or epoxy coated. Wall ties, plates, bars, anchors, and inserts exposed to earth or weather shall also be stainless steel, hot dipped galvanized, or epoxy coated. Reinforcement bars shall be protected by proper use of masonry cover.

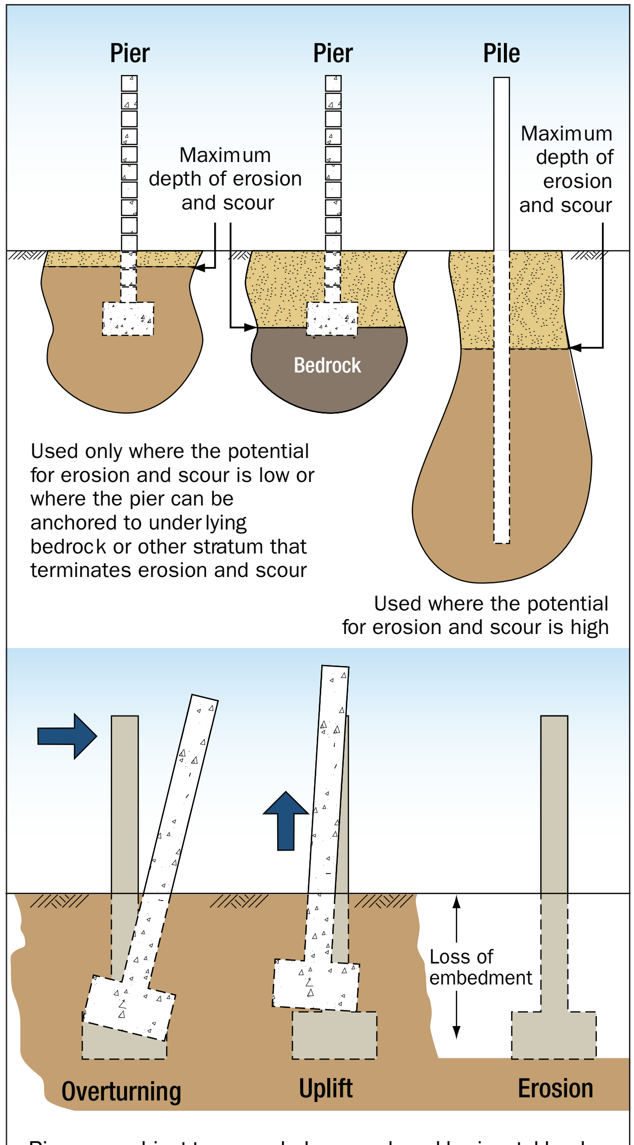


Figure 1. In coastal areas, masonry pier foundations are not recommended in V Zones with erodible soils, or in A Zones subject to waves and erosion — use pile foundations in these areas.

FOUNDATIONS 3

Piers vs. Piles

Pier foundations are most appropriate in areas where:

- Erosion and scour potential are low.
- Flood depths and lateral forces are low.
- Soil can help resist overturning of pier.

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

Figure 2. Pier breakage (Long Beach, Mississippi)

Good Masonry Practice

If a masonry pier is determined to be an appropriate foundation for a building, there are some practices that should be followed during construction of the piers.

- Masonry units and packaged mortar and grout materials should be stored off the ground and covered.
- Masonry work in progress must be well protected from exposure to weather.
- Mortar and grouts must be carefully batched and mixed. The 2009 International Building Code (IBC 2009) and 2009 International Residential Code (IRC) specify grout proportions by volume for masonry construction.
- Connectors should be selected that are appropriate for masonry to wood connection. It is important to maintain a sufficient load path from the building into the ground. The connectors and fasteners should be a corrosion-resistant material or have corrosion protection at least equivalent to that provided by coatings in accordance with the 2009 IRC. Connectors should be properly embedded or attached to the pier. Wood in contact with masonry pier should be naturally durable or preservative-treated. Figure 3 illustrates the importance of maintaining a proper load path between the pier and the building's beams.
- Properly sized steel reinforcing bars should be installed throughout the masonry piers. Piers should be fully grouted and steel reinforcing bars should not be left exposed to weather for excessive amounts of time prior to installation. Lap splices should be properly located and of sufficient length to meet the standard masonry industry details and requirements to sufficiently carry the loads imposed on the structure.
- Consider incorporating grade beams into the foundation in order to achieve greater structural stability in the pier system.
- If the design of the pier system or any details are unclear, contact a structural engineer or appropriate design professional to clarify the foundation details.

Pros and Cons of Grade Beams

Grade beams are horizontal structural members cast against the ground or "grade." Grade beams can be a useful foundation method in areas with limited potential for erosion and scour. The type of force resisted by grade beams varies by application, but can range from continuous vertical and horizontal loads to axial loads. The grade beams used in this example are used primarily for axial loads generated by stability demands of the piers. The grade beams should be placed below the elevation of anticipated eroded grade so that there is no effect on scour and erosion of the supporting soils.

The pros of using grade beams with pier foundations are that they:

- Provide vertical and lateral support.
- Are less prone to rotation and overturning.
- Transfer loads imposed on the elevated home and foundation to the ground below.

Some cons of using grade beams with pier foundations are that they:

- Are susceptible to erosion and scour if too shallow
- Can become obstructions during flood events and can increase scour

Are grade beams allowed in the V Zone?

Yes, although the NFIP states that the ***lowest horizontal structural member*** is to be constructed above the BFE, it is referring to the ***lowest horizontal structural member*** above ***erodible*** grade. Based on this, both grade beams, cross bracing and knee bracing are allowed by the NFIP. Grade beams can provide significant structural support to an open foundation system provided they are placed ***below the expected eroded surface***.

Figure 3. Failure of pier-to-beam connections due to wave and flood forces acting on the elevated building (Long Beach, Mississippi)

Additional Resources

American Concrete Institute, 2004, SP-66(04): *ACI Detailing Manual*. (http://www.concrete.org)

Concrete Reinforcing Steel Institute. *Placing Reinforcing Bars – Recommended Practices*, PRB-2-99. (http://www.crsi.org)

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

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

The Masonry Society. 2008. *Building Code Requirements for Masonry Structures*. TMS 402-08/ACI 530-08/ASCE 5-08. (http://www.masonrysociety.org)

The Masonry Society. 2008. *Specifications for Masonry Structures*. TMS 402-08/ACI 530.1 08/ASCE 6-08. (http://www.masonrysociety.org)

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

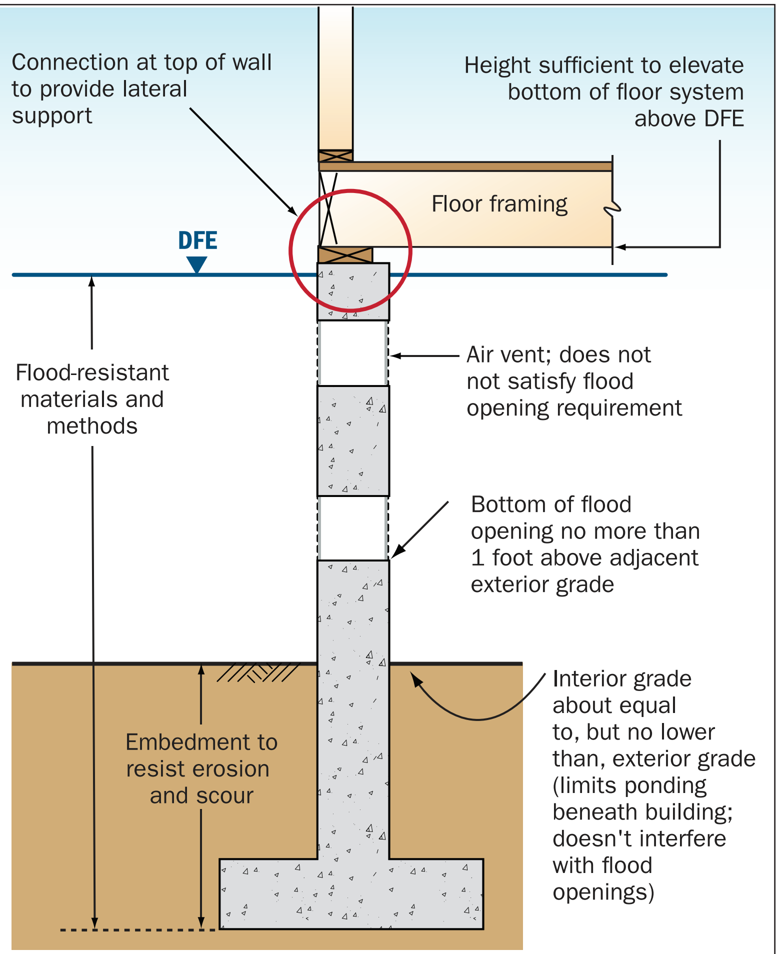
Foundation Walls

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION — Technical Fact Sheet No. 3.5

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

Key Issues

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



Foundation walls – flood-resistant design considerations

Foundation Walls – When Are They Appropriate?

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

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

FOUNDATIONS 3

Design Considerations for Foundation Walls

The design of foundation walls is covered by building codes and standards (e.g., Standard for Residential Construction in High-Wind Regions, ICC 600-2008, by the International Code Council). For flood design purposes, there are six additional design considerations: (1) embedment, (2) height, (3) materials and workmanship, (4) lateral support at the top of the wall, (5) flood openings and ventilation openings, and (6) interior grade elevation.

Embedment – The top of the footing should be no higher than the anticipated depth of erosion and scour (this basic requirement is the same as that for piers; see figure at right and Fact Sheet No. 3.4). If the required embedment cannot be achieved without extensive excavation, consider a pile foundation instead.

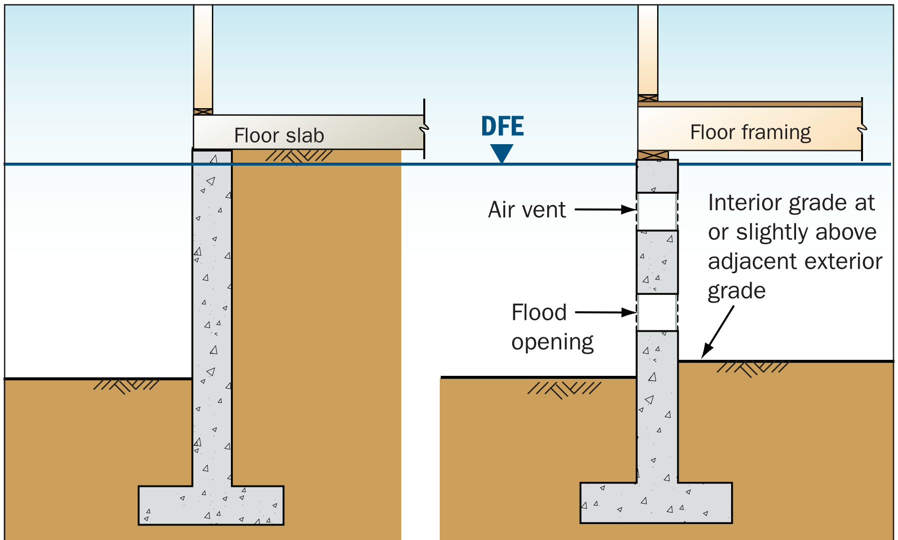
Height – The wall should be high enough to elevate the bottom of the floor system to or above the DFE (see Fact Sheet No. 1.4).

Materials and Workmanship – Foundation walls can be constructed from many materials, but masonry, concrete, and wood are the most common. Each material can be specified and used in a manner to resist damage due to moisture and inundation (see Fact Sheet No. 1.7). Workmanship for flood-resistant foundations is crucial. Wood should be preservative-treated for foundation or marine use (aboveground or ground-contact treatment will not be sufficient). Cuts and holes should be field-treated. Masonry should be reinforced and fully grouted (see Fact Sheet No. 4.2 for masonry details). Concrete should be reinforced and composed of a high-strength, low water-to-cement ratio mix.

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

Flood Openings and Ventilation Openings – Any area below the DFE enclosed by foundation walls must be equipped with openings capable of automatically equalizing the water levels inside and outside the enclosure. Specific flood opening requirements are included in Fact Sheet No. 8.1. Flood openings are not required for backfilled stemwall foundations supporting a slab. ***Air ventilation openings required by building codes do not generally satisfy the flood opening requirement***; the air vents are typically installed near the top of the wall, the flood vents must be installed near the bottom, and opening areas for air flow may be insufficient for flood flow.

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



Floor slab atop backfilled stemwall foundation

Floor joist system and crawlspace

3 FOUNDATIONS

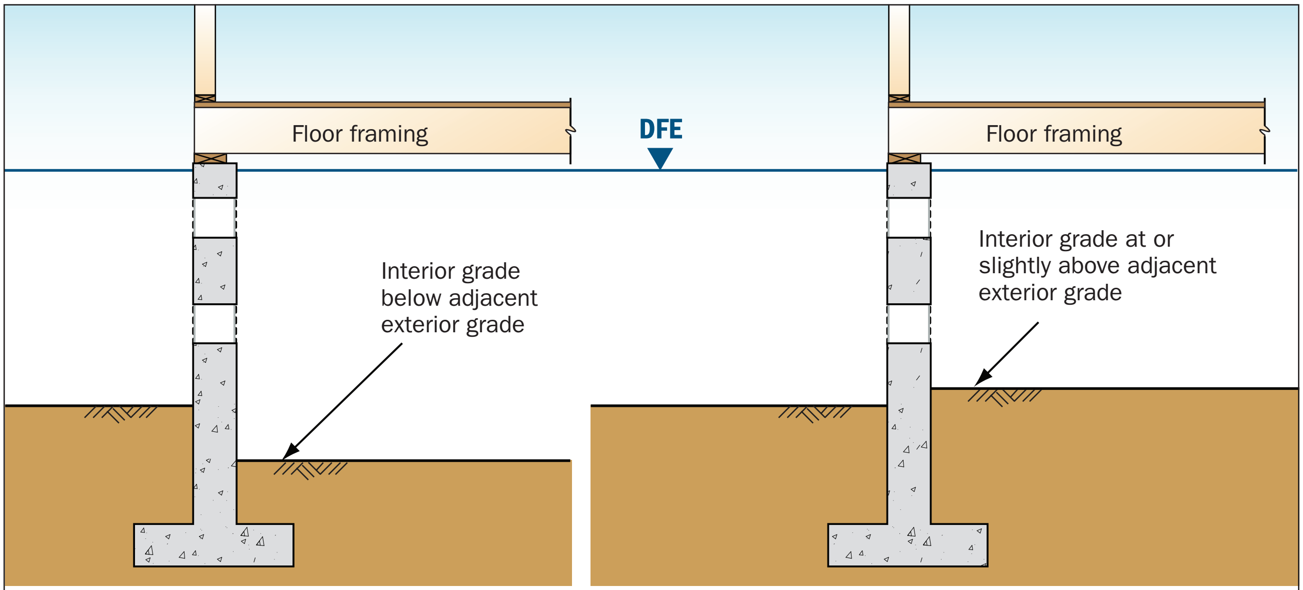
If a stemwall and floor slab system is used, the interior space beneath the slab should be backfilled with compacted gravel (or such materials as required by the building code). As long as the system can act monolithically, it will resist most flood forces. However, if the backfill settles or washes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

Additional Resources

FEMA. NFIP Technical Bulletin 1-08, *Openings in Foundation Walls and Walls of Enclosures.* 2008. (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

FEMA. NFIP Technical Bulletin 11-01, *Crawlspace Construction.* 2001. (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

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



Crawlspace construction: Interior grade elevation for Zone A not subject to breaking waves and erosion

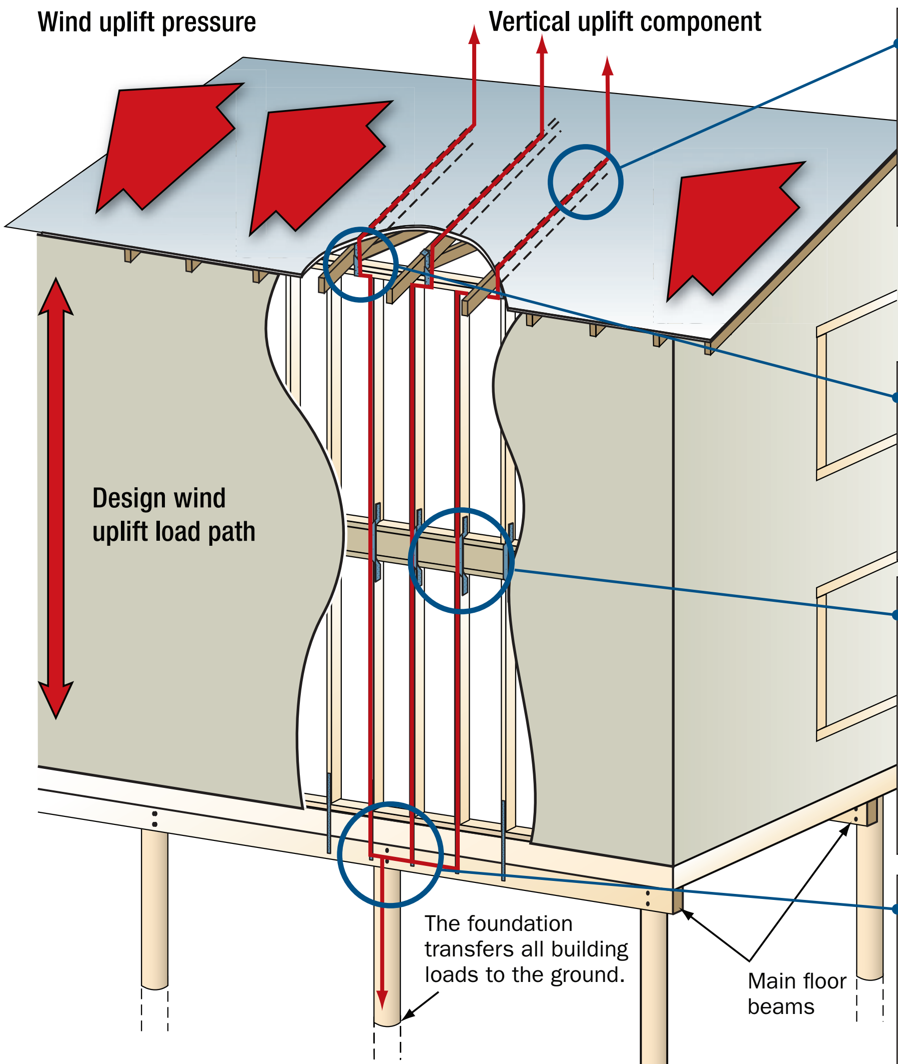
Developed in association with the National Association of Home Builders Research Center

Load Paths

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

Key Issues

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



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

LINK 1
High winds lift the roof upward. Roofing fasteners link the roof covering to the sheathing*, and sheathing fasteners link the sheathing to the roof framing members (see Fact Sheet No. 7.1).

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

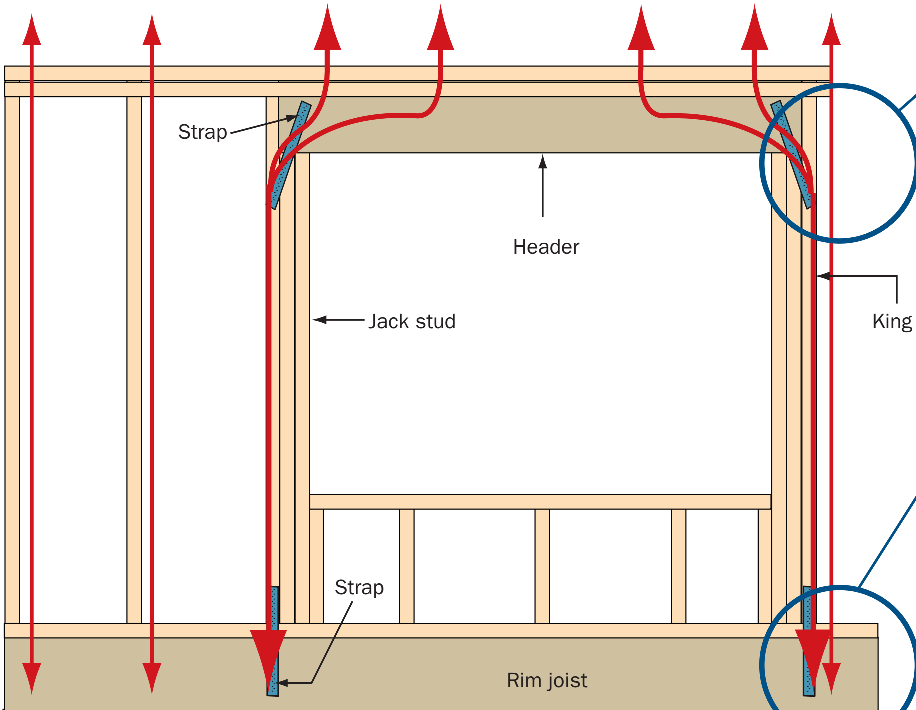
LINK 2
Accumulated roof load is routed through roof-to-wall connections. Special roof ties connect the roof framing to the bearing walls (see Fact Sheet No. 4.3).

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

LINK 4
The accumulated uplift force is transferred from the main floor beams to the pile foundation with special brackets or bolts (see Fact Sheet No. 3.3). Note: Some of this load is offset by the weight of the building.

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

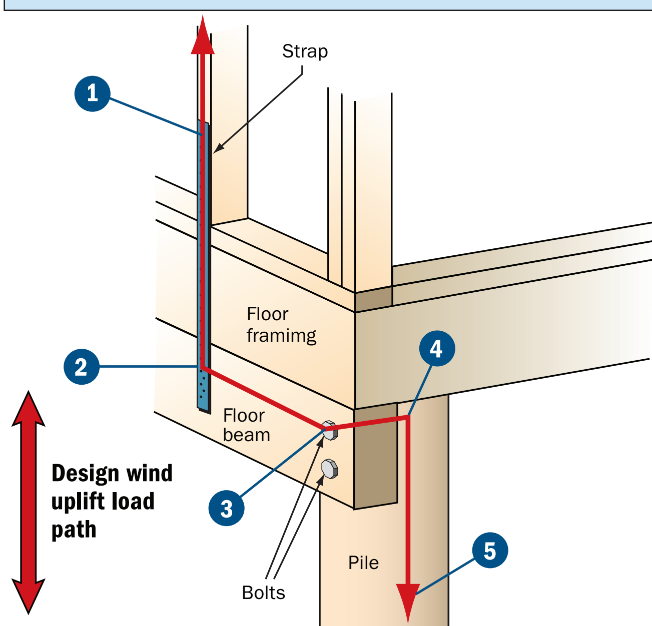
If a connection fails, an alternative load path will form. If the members and connections in the new load path have inadequate resistance, progressive failure can occur. Loads must be routed around openings, such as windows and doors. Accumulated loads on headers are transferred to the studs on the sides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



LINK
An adequate connection must be made between the header and the king stud in order for the load to continue down the path.

LINK
The bottom of a wall could have points of high uplift due to an accumulated load from above. Suitable hardware should be installed in the proper locations.

Load path around a window opening.



Load path through a pile connection.

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

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

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

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

NAHB RESEARCH CENTER

4 LOAD PATHS

Masonry Details

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

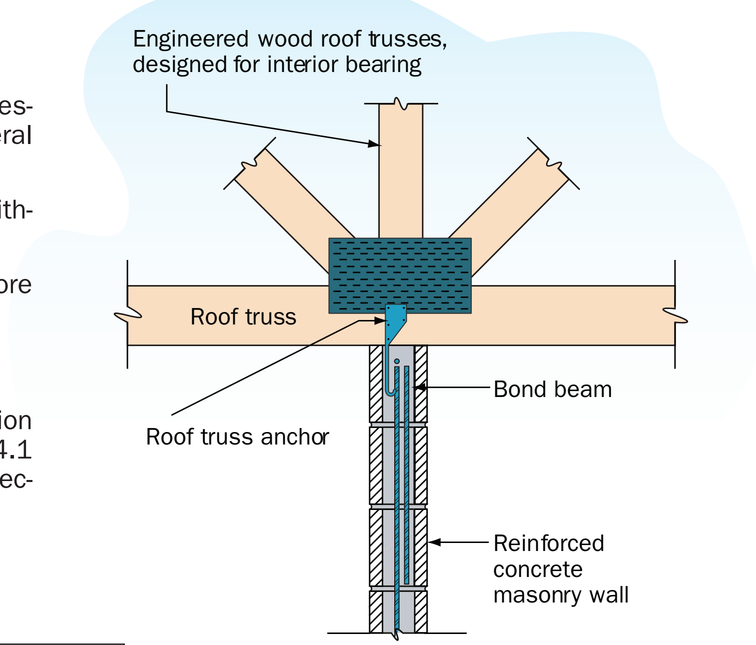
Key Issues

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

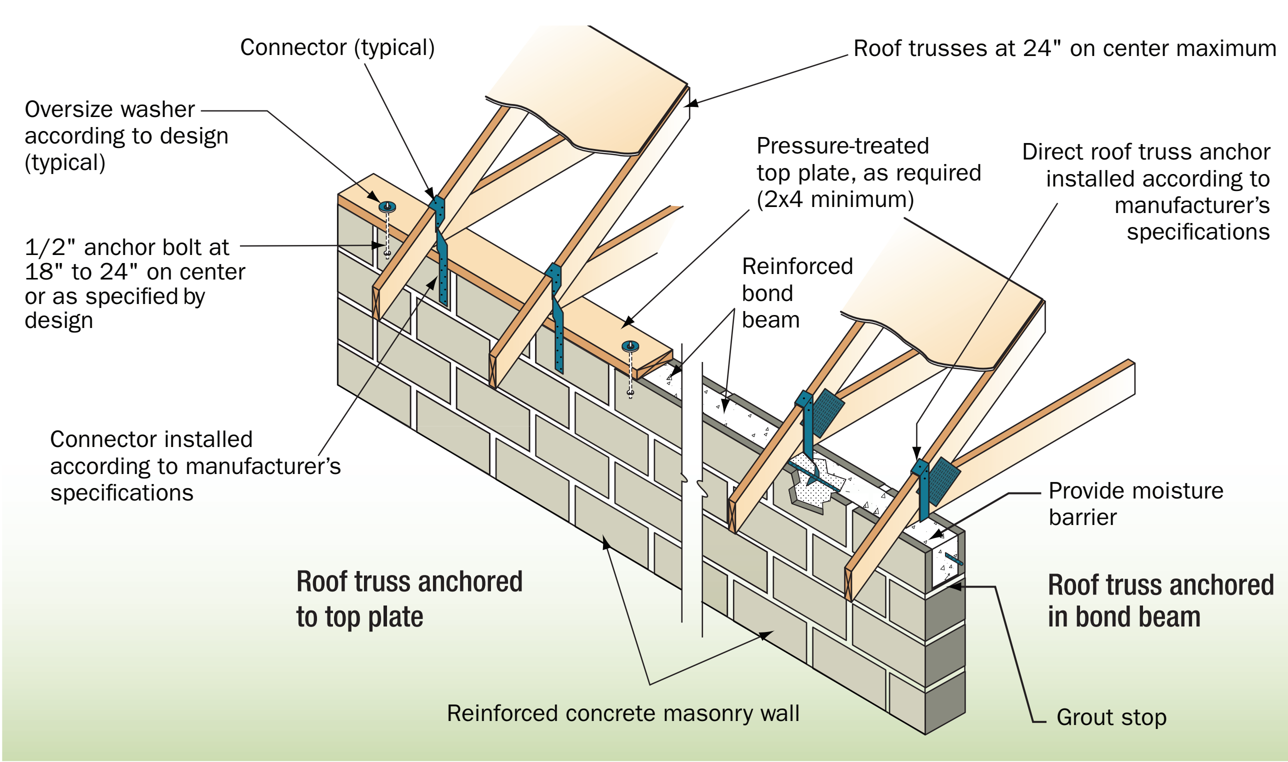
Load Paths

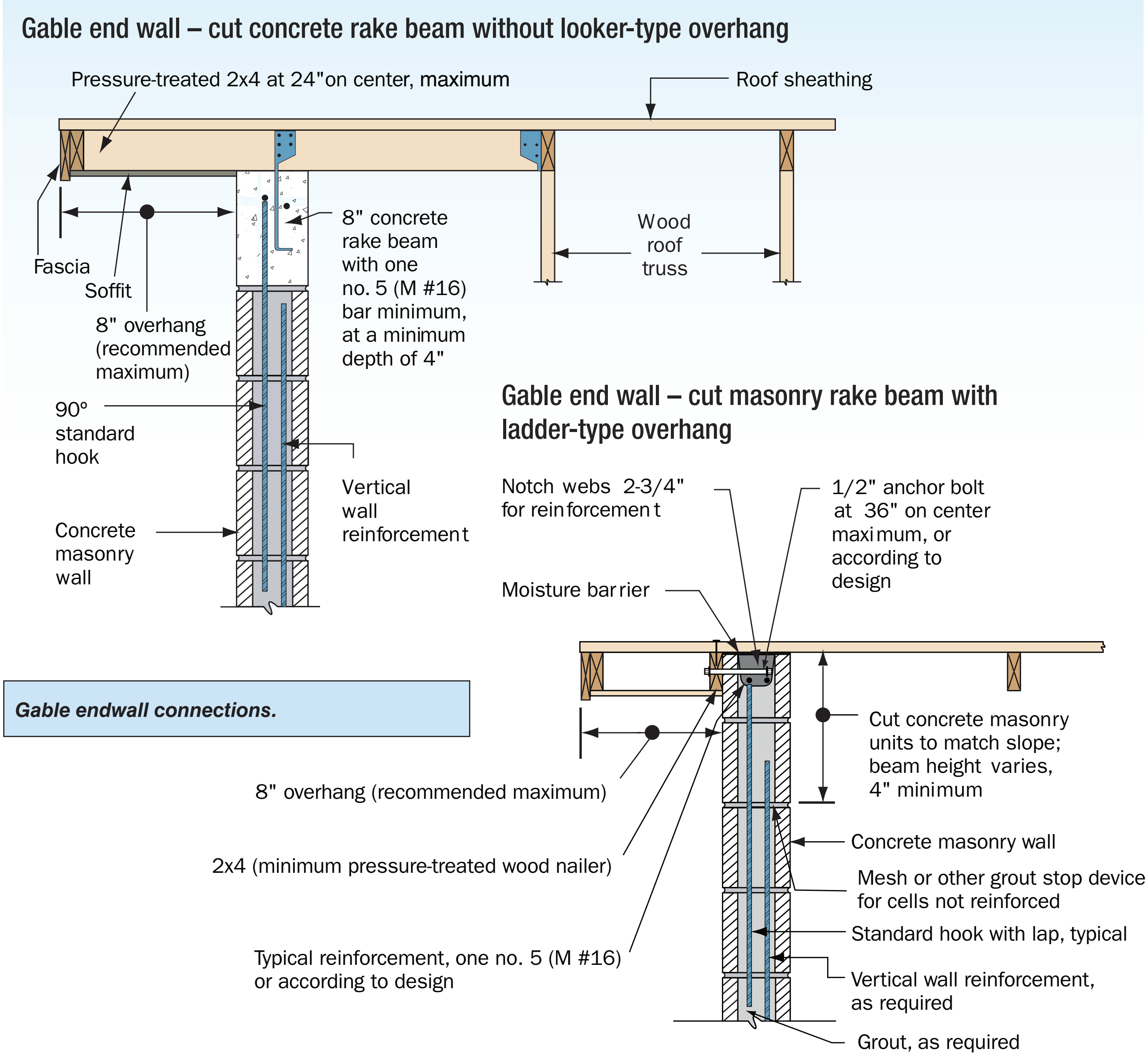
A properly connected load path from roof to foundation is crucial in coastal areas (see Fact Sheets Nos. 4.1 and 4.3). The following details show important connections for a typical masonry home.

Roof framing to interior masonry wall



Roof framing to masonry wall



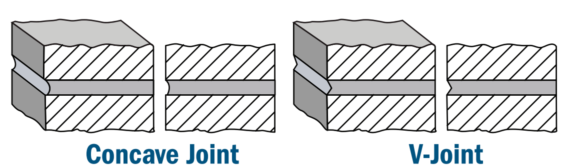


Gable endwall connections.

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

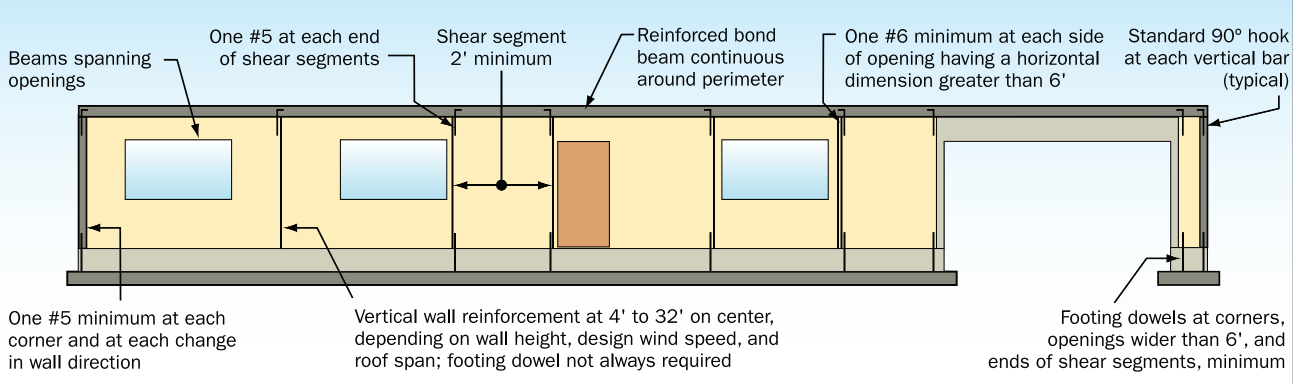
Quality depends on:

- **Proper storage of material –** Keep stored materials covered and off the ground.
- **Proper batching –** Mortar and grout must be properly batched to yield the required strength.
- **Good workmanship –** Head and bed joints must be well mortared and well tooled. Concave joints and V-joints provide the best moisture protection (see detail above). All block walls should be laid with full mortar coverage on horizontal and vertical face shells. Block should be laid using a “double butter” technique for spreading mortar head joints. This practice provides for mortar-to-mortar contact as two blocks are laid together in the wall and prevents hairline cracking in the head joint.



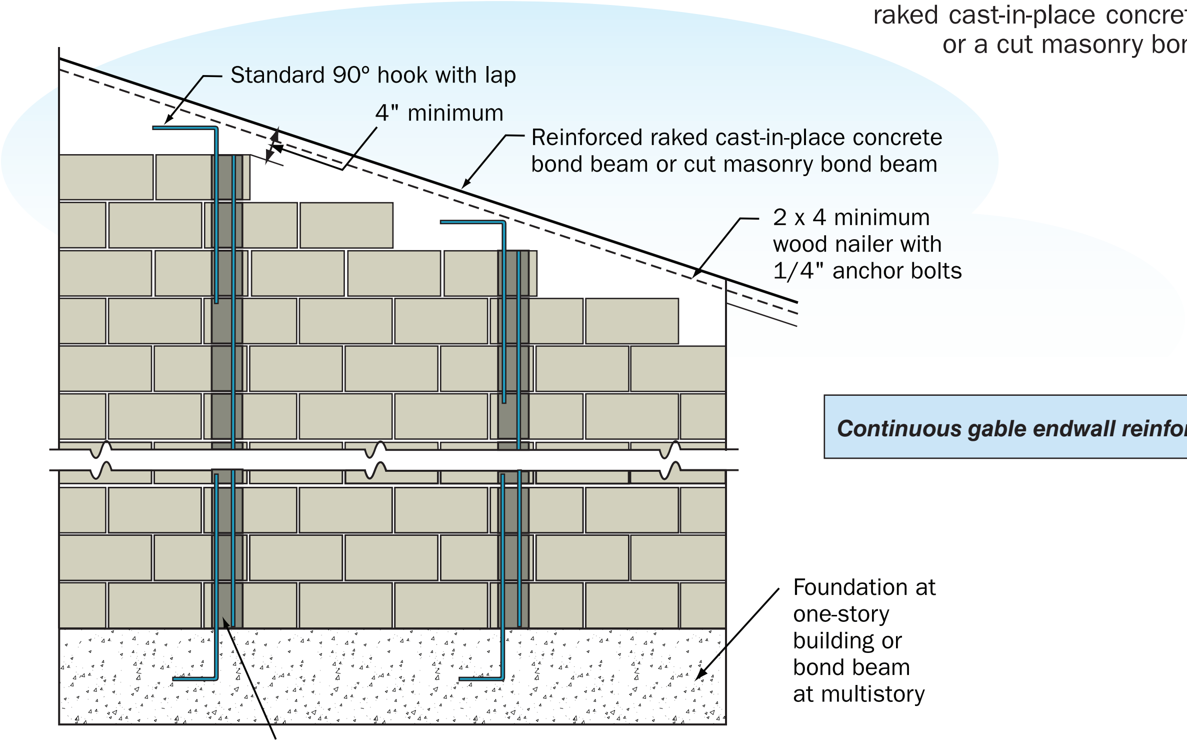
- **Protection of work in progress –** Keep work in progress protected from rain. During inclement weather, the tops of unfinished walls should be covered at the end of the workday. The cover should extend 2 feet down both sides of the masonry and be securely held in place. Immediately after the completion of the walls, the wall cap should be installed to prevent excessive amounts of water from directly entering the masonry.

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



Masonry reinforcement.

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



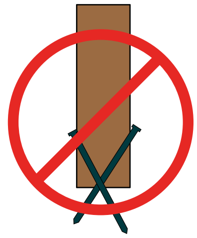
Continuous gable endwall reinforcement.

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

Use of Connectors and Brackets

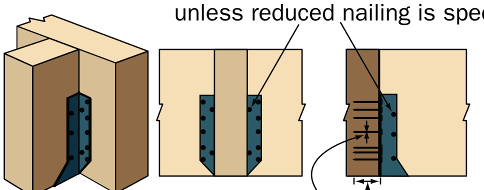
Purpose: *To highlight important building connections and illustrate the proper use of various types of connection hardware.*

Key Issues

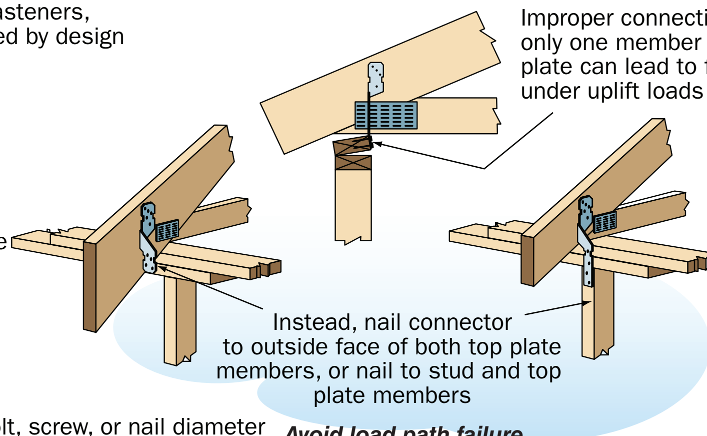


Never rely on toe-nailing for uplift connections in high-wind areas

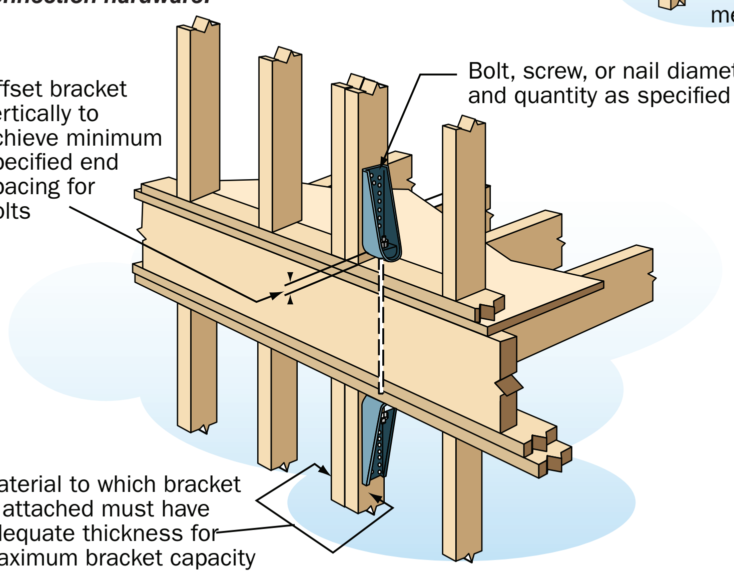
- In high-wind regions, special hardware is used for most framing connections. Toe-nailing is not an acceptable method for resisting uplift loads in high-wind regions.
- Hardware must be installed according to the manufacturer's or engineer's specifications.
- The correct number of the specified fasteners (length and diameter) must be used with connection hardware.
- Avoid cross-grain tension in connections.
- Metal hardware must be adequately protected from corrosion (see NFIP Technical Bulletin 8-96).
- Connections must provide a continuous load path (see Fact Sheet No. 4.1).



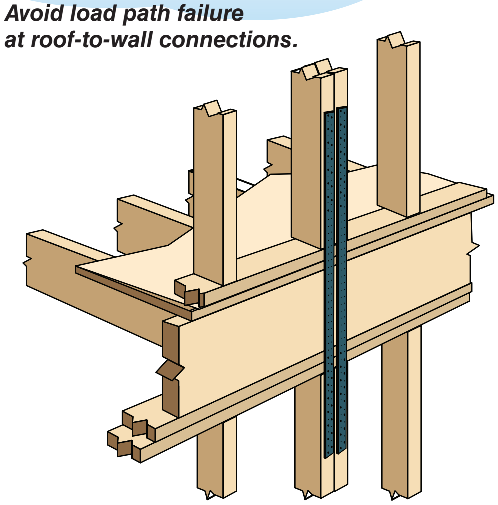
Proper fasteners must be used with connection hardware.



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

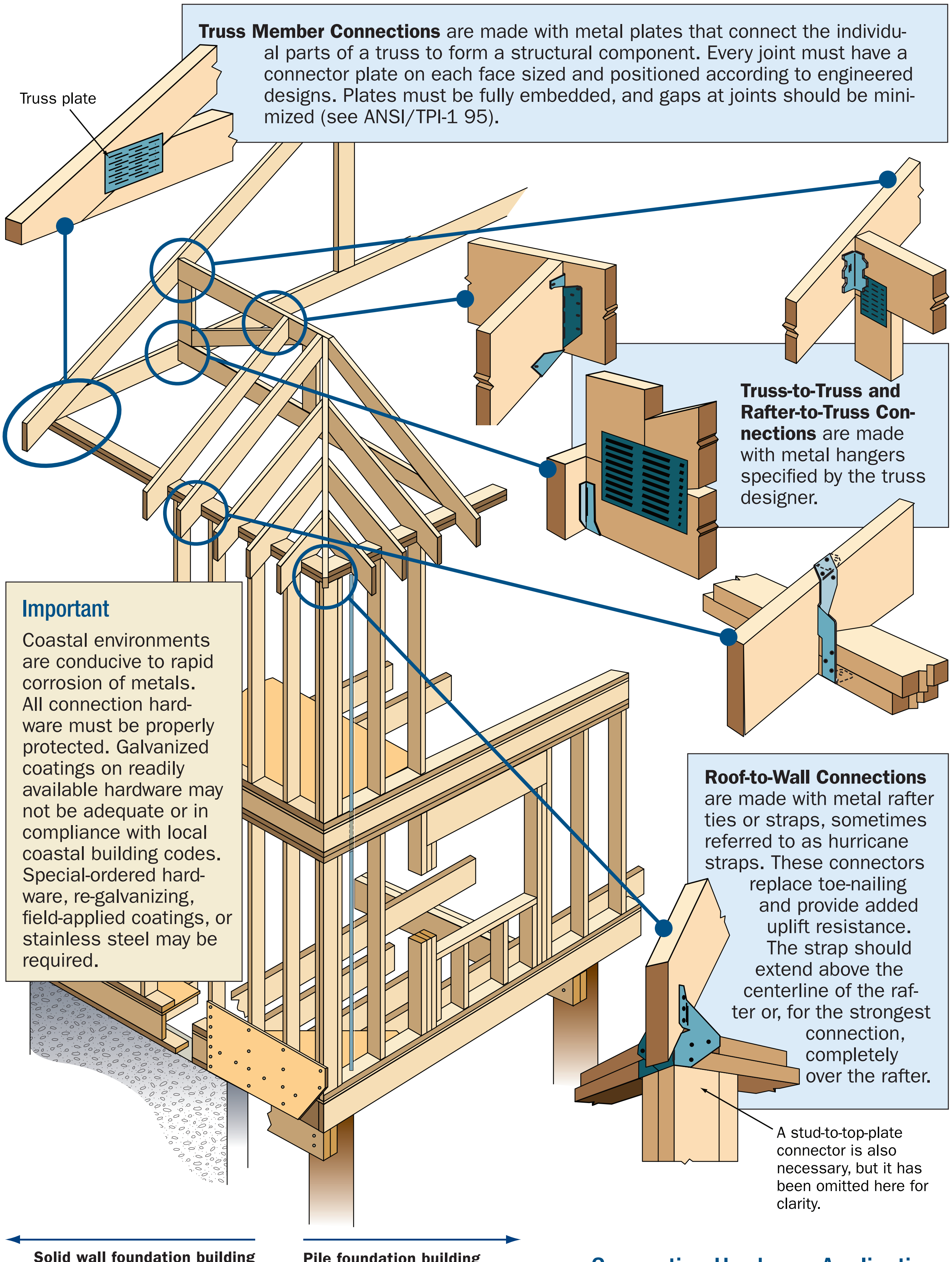


Proper bracket connection.



Proper strap connection.

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



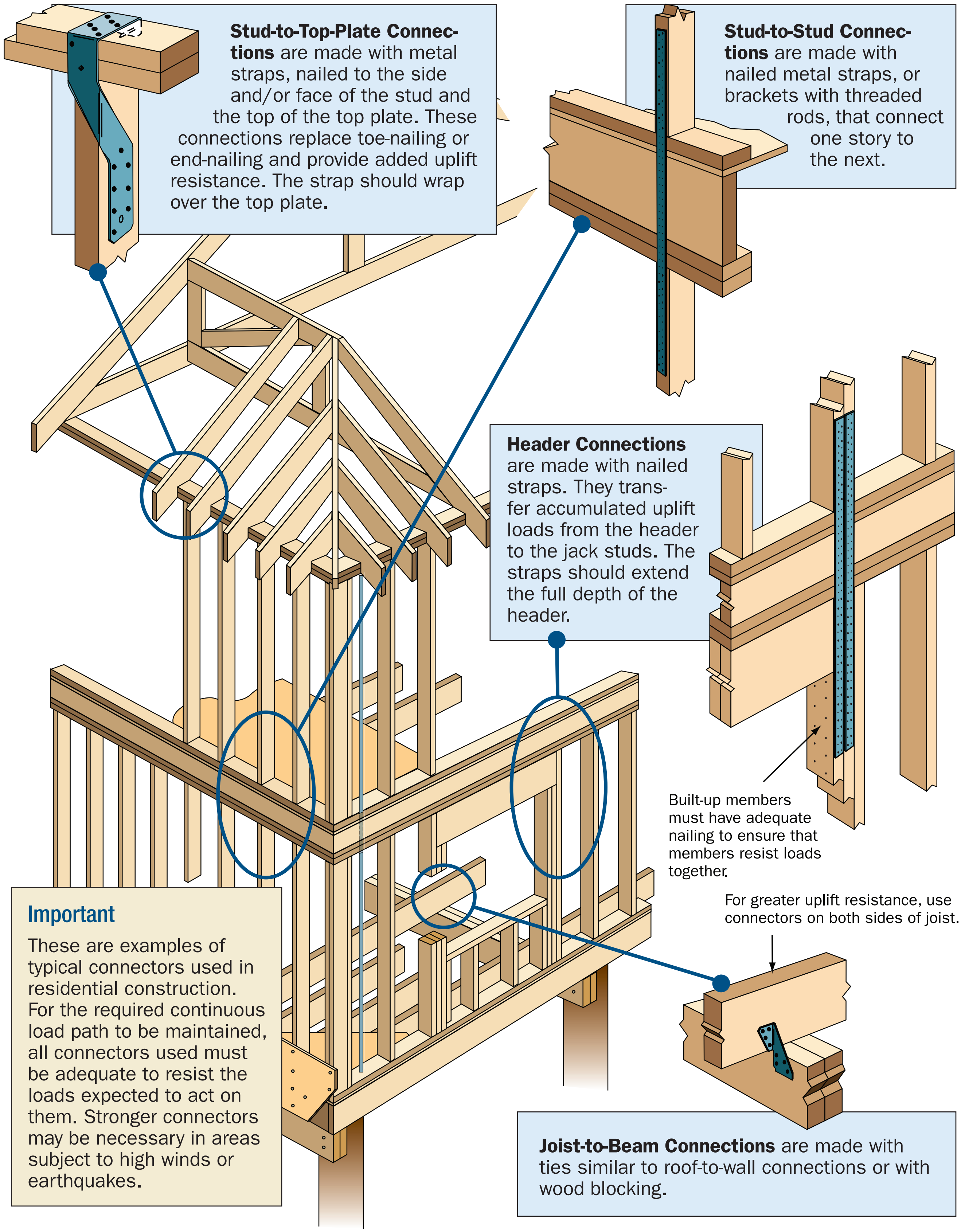
Truss-to-Truss and Rafter-to-Truss Connections are made with metal hangers specified by the truss designer.

Important

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

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

Connection Hardware Applications



Stud-to-Top-Plate Connections are made with metal straps, nailed to the side and/or face of the stud and the top of the top plate. These connections replace toe-nailing or end-nailing and provide added uplift resistance. The strap should wrap over the top plate.

Stud-to-Stud Connections are made with nailed metal straps, or brackets with threaded rods, that connect one story to the next.

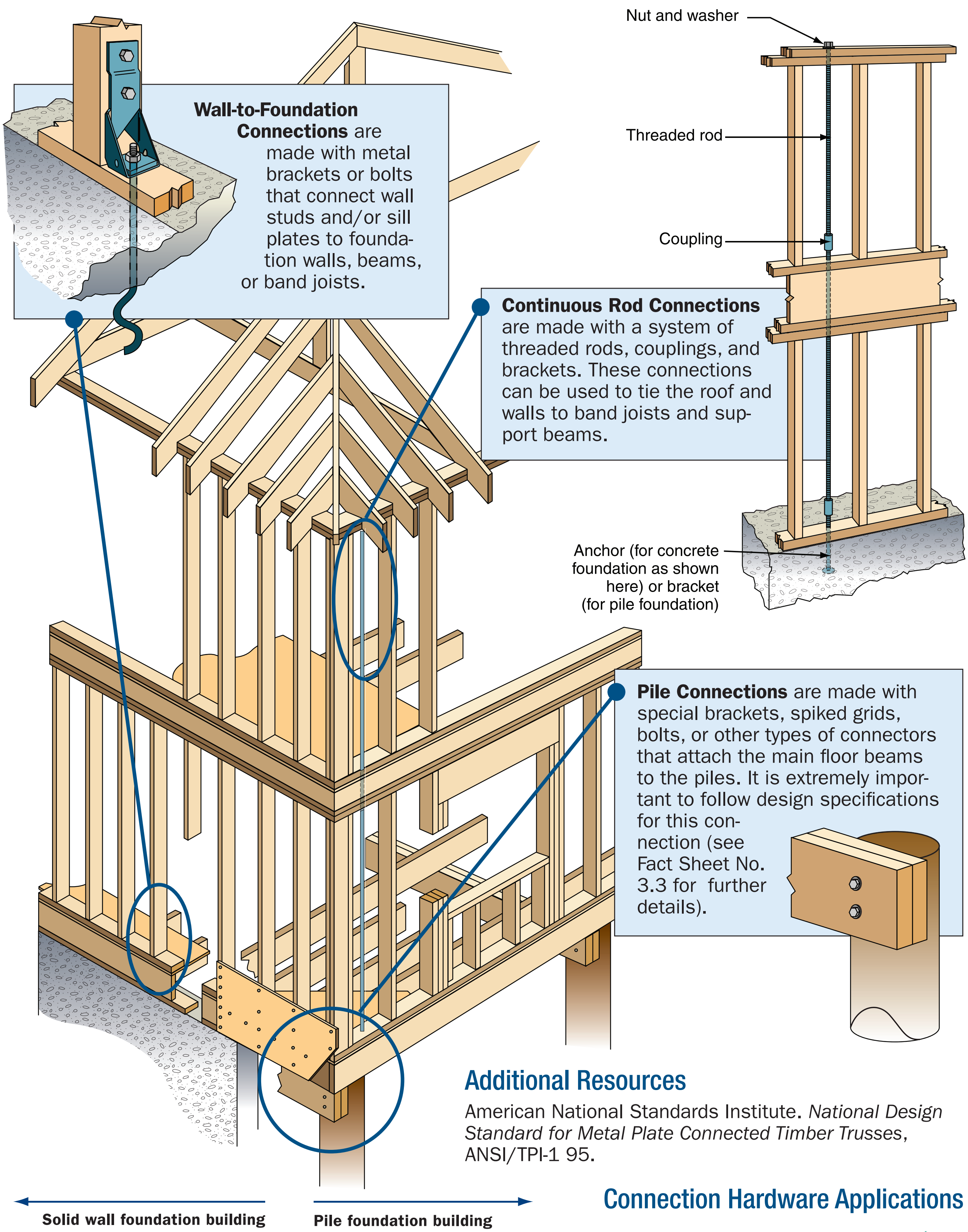
Header Connections are made with nailed straps. They transfer accumulated uplift loads from the header to the jack studs. The straps should extend the full depth of the header.

Important

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

Joist-to-Beam Connections are made with ties similar to roof-to-wall connections or with wood blocking.

Connection Hardware Applications



Additional Resources

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

Connection Hardware Applications

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

NAHB RESEARCH CENTER

4 LOAD PATHS

Housewrap

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

Key Issues

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

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

Purpose of Housewrap

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

When Should Housewrap Be Used?

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

Housewrap or Building Paper?

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

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

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

Product Attribute Rating		Poor – Fair – Good – Excellent	
Attribute	When it is Important	Product Performance	
		Building Paper	Housewrap
Air Permeability	Windy and cold climates	Fair	Good
Vapor Permeability	Hot, humid climates	Fair	Good
Water Resistance	Windy and rainy climates	Good	Excellent
Repels Moisture	High rainfall	Good	Good
Durability	Windy, with possible extended exposure	Fair	Good
Cost	Owner preference	Excellent	Fair

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

Installing Housewrap

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

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

Avoid These Common Problems

- **Incomplete wrapping**

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

- **Improper lapping**

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

- **Improper integration with flashing around doors and windows** – See Fact Sheet No. 6.1.
- **Relying on caulking or self-sticking tape to address improper lapping**

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

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

WALL SYSTEMS 5

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

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION — Technical Fact Sheet No. 5.2

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

Key Issues

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

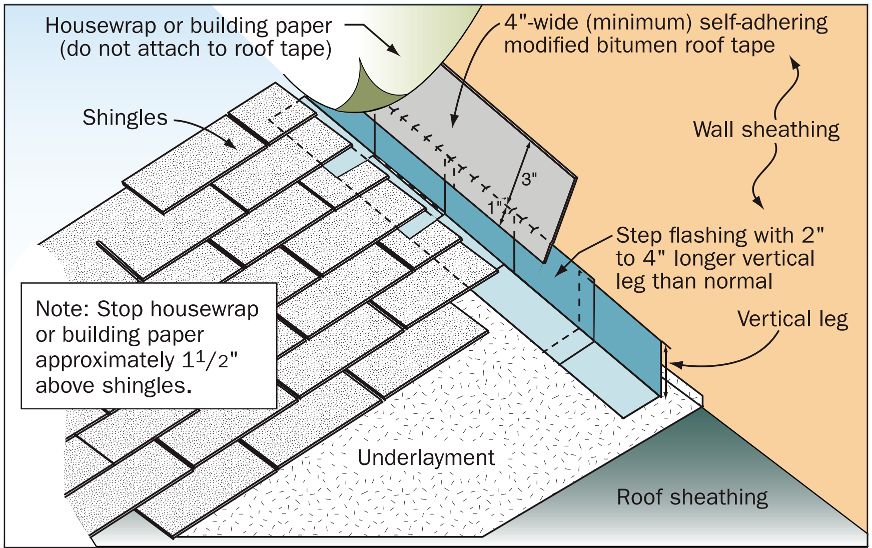


Figure 1. Roof/wall flashing detail.

Roof and Deck Flashing Recommendations for Coastal Areas

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

See Fact Sheet Nos. 7.2 and 7.3 for rake and eave details.

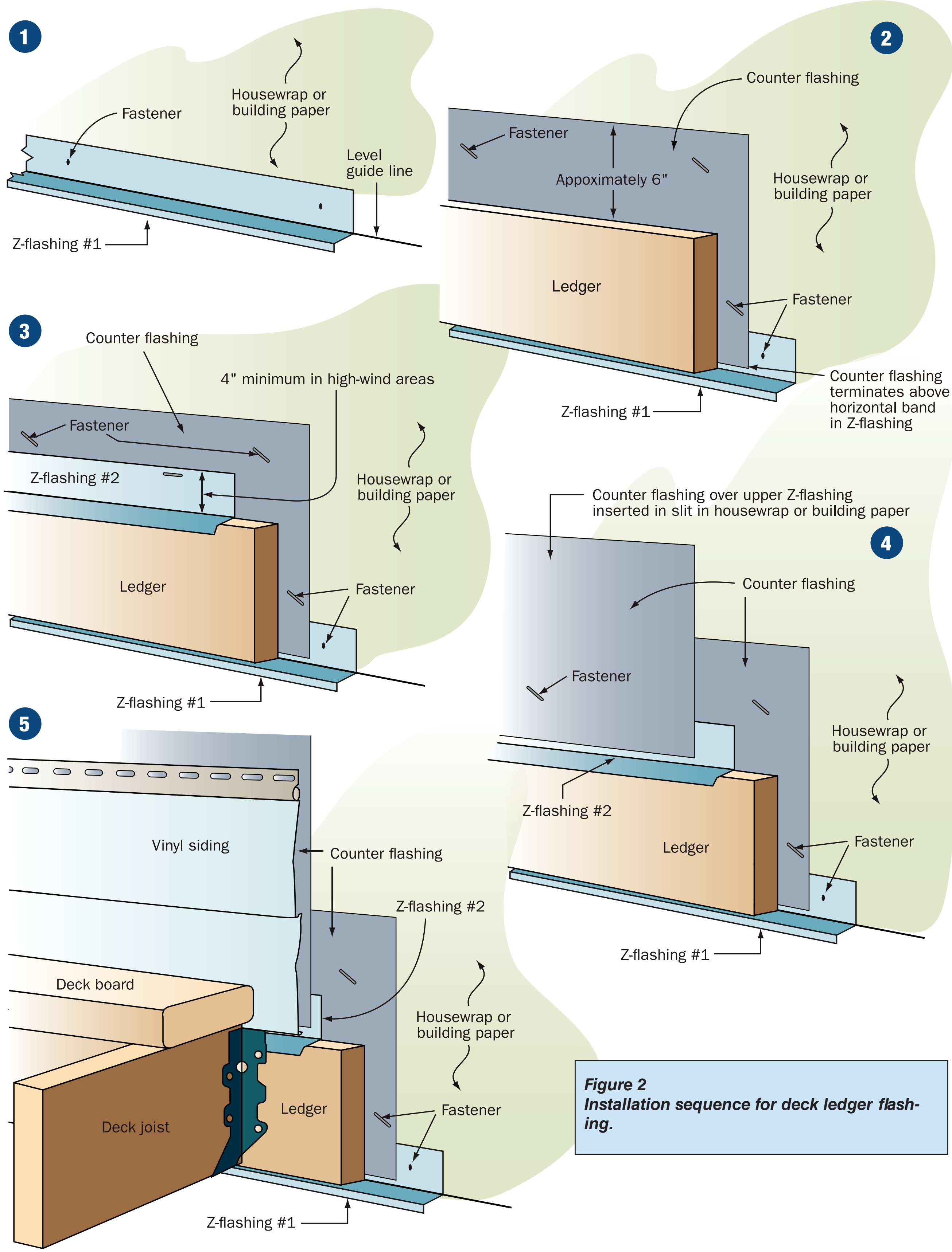


Figure 2
Installation sequence for deck ledger flashing.

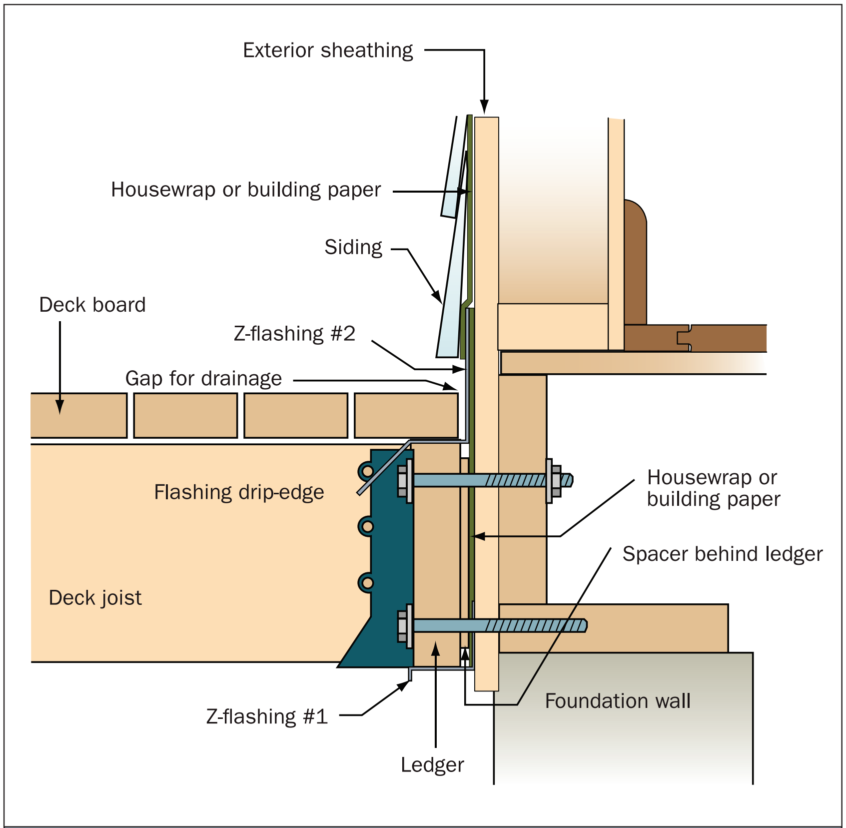


Figure 3 Deck ledger flashing.

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

Siding Installation in High-Wind Regions

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 5.3

Purpose: *To provide basic design and installation tips for various types of siding that will enhance wind resistance in high-wind regions (i.e., greater than 90 miles per hour [mph] basic [gust design] wind speed)[1].*

Key Issues

- Siding is frequently blown off walls of residential and non-residential buildings during hurricanes. Also, wind-driven rain is frequently blown into wall cavities (even when the siding itself is not blown off). Guidance for achieving successful wind performance is presented in the following.
- To avoid wind-driven rain penetration into wall cavities, an effective moisture barrier (housewrap or building paper) is needed. For further information on moisture barriers, see Fact Sheet No. 1.9, Moisture Barrier Systems. For further information on housewrap, see Fact Sheet No. 5.1, Housewrap.
- Always follow manufacturer's installation instructions and local building code requirements.
- Use products that are suitable for a coastal environment. Many manufacturers do not rate their products in a way that makes it easy to determine whether the product will be adequate for the coastal environment. Use only siding products where the supplier can provide specific information on product performance in coastal or high-wind environments.
- For buildings located within 3,000 feet of the ocean line, stainless steel fasteners are recommended.
- Avoid using dissimilar metals together.
- The installation details for starting the first (lowest) course of lap siding can be critical. Loss of siding often begins at the lowest course and proceeds up the wall (Figures 4 and 12). This is particularly important for elevated buildings, where the wind blows under the building as well as against the sides.
- When applying new siding over existing siding, use shims or install a solid backing to create a uniform, flat surface on which to apply the siding, and avoid creating gaps or projections that could catch the wind.
- Coastal buildings require more maintenance than inland buildings. This maintenance requirement needs to be considered in both the selection and installation of siding.

Moisture barrier (also known as a water-resistive barrier): In the context of residential walls, the moisture barrier is either housewrap or building paper (felt). The moisture barrier occurs between the wall sheathing and the siding. It is a dual-purpose layer that sheds water that gets through the siding and limits air flow through the wall. When properly sealed, housewrap is considered an air barrier. Although building paper provides some resistance to air flow, it is not considered an air barrier. Moisture barriers shed water, but they allow water vapor to pass through them.

For further guidance on principles, materials, and procedures for the design and construction of walls to make them resistant to water intrusion, see American Society for Testing and Materials (ASTM) E 2266, *Standard Guide for Design and Construction of Low-Rise Frame Building Wall Systems to Resist Water Intrusion*.

WALL SYSTEMS 5

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

Vinyl Siding

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

Windload Resistance

Vinyl siding is required by the International Building Code (IBC) and the International Residential Code (IRC) to comply with ASTM D 3679, *Standard Specification for Rigid Poly (Vinyl Chloride)* (PVC) Siding. Both the IBC and IRC require static pressure testing over solid wall surfaces capable of independently resisting the design wind pressures to approximate loading conditions that occur in 110-mph wind zone areas for a building up to 30 feet in height in Exposure B.[2] Most vinyl siding has also been tested for higher wind pressures and can be used in locations with a higher basic wind speed, greater building height, more open exposure, or some combination of these. While vinyl siding wind pressure ratings found in most product literature are based on tests of the vinyl over an approved sheathing capable of independently resisting the design wind pressures, methods of installation that rely on a combination of wind resistance provided by exterior wall sheathing, vinyl siding, and interior wall sheathing are available for some applications. The design wind pressure or wind speed for which these products are rated, as well as requirements for sheathing behind the vinyl siding are available from product literature, installation instructions, or listings of agencies such as the International Code Council (ICC) Evaluation Service.

- For design wind speeds greater than 110 mph per ASCE 7-05, or 139 mph per ASCE 7-10, or, building heights greater than 30 feet, or Exposure C, choose a siding product rated for those conditions or higher. The manufacturer's product literature or installation instructions should specify the fastener type, size and spacing, and any other installation details such as requirements for the sheathing materials behind the vinyl siding needed to achieve this rating.
- Products that have been rated for high winds typically have an enhanced nailing hem and are sometimes made from thicker vinyl (Figure 1). Thick, rigid panels provide greater wind resistance, withstand dents, and lie flatter and straighter against the wall. Optimum panel thickness should be 0.040 to 0.048 inches, depending on style and design. Thinner gauge vinyl works well for stable climates; thicker gauge vinyl is recommended for areas with high winds and high temperature changes.
- Position nails in the center of the nailing slot (Figure 2). To allow for thermal movement of the siding, do not drive the head of the nail tight against the nail hem (unless the hem has been specifically designed for this). Allow approximately 1/32 inch (which is about the thickness of a dime) clearance between the fastener head and the siding panel (Figure 3).
- Drive nails straight and level to prevent distortion and buckling in the panel.
- Do not caulk the panels where they meet the receiver of inside corners, outside corners, or J-trim. Do not caulk the overlap joints.
- Do not face-nail or staple through the siding.

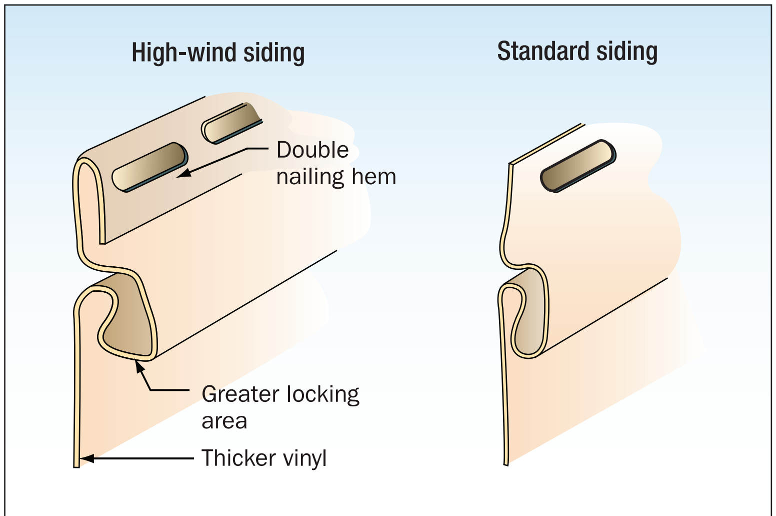


Figure 1. Features of typical high-wind siding and standard siding.

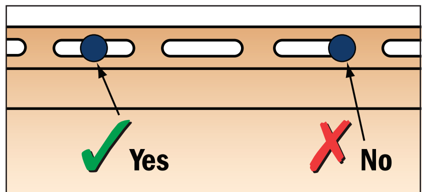


Figure 2. Proper and improper fastener locations.

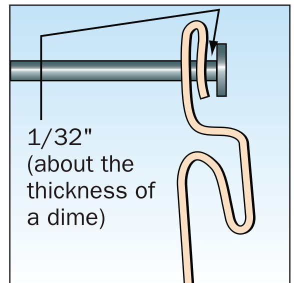


Figure 3. Allow 1/32" clearance between the fastener head and the siding panel.

2 The 110 mph wind speed is based on ASCE 7-05. If ASCE 7-10 is used, the equivalent wind speed is 139 mph for Risk Category II buildings.

- Use aluminum, galvanized steel, or other corrosion-resistant nails when installing vinyl siding. Aluminum trim pieces require aluminum or stainless steel fasteners.
- Nail heads should be 5/16 inch minimum in diameter. Shank should be 1/8 inch in diameter.
- Use the manufacturer-specified starter strip to lock in the first course; do not substitute other accessories such as a J-channel or utility trim (Figure 4) unless specified by the manufacturer. If the manufacturer specifies a particular strip for high-wind applications, use it. Make sure that the starter strip is designed to positively lock the panel, rather than just hooking over a bulge in the strip; field test the interlock before proceeding with the installation. Make sure that every course of siding is positively locked into the previous course (Figure 5). Push the panel up into the lock from the bottom before nailing rather than pulling from the top. Do not attempt to align siding courses with adjacent walls by installing some courses loosely.
- Make sure that adjacent panels overlap properly, about half the length of the notch at the end of the panel, or approximately 1 inch. Make sure the overlap is not cupped or gapped, which is caused by pulling up or pushing down on the siding while nailing. Reinstall any panels that have this problem.
- Use utility trim under windows or anywhere the top nail hem needs to be cut from siding to fit around an obstacle. Be sure to punch snap-locks into the siding to lock into the utility trim. Do not overlap siding panels directly beneath a window (Figure 6).
- At gable end walls, it is recommended that vinyl siding be installed over approved sheathing capable of independently resisting the full design wind pressures rather than over plastic foam sheathing or combinations of exterior foam sheathing and interior gable end sheathing except as provided for in the IRC Section R703.11.2. Figure 7 depicts the vulnerability of siding on gable end walls not properly sheathed with approved materials capable of independently resisting the full design wind pressures.
- Install vinyl siding in accordance with manufacturer's installation instructions and local building code requirements. Ensure product rating is appropriate for the intended application.
- It is recommended that vinyl siding installers be certified under the VSI Certified Installer Program sponsored by the Vinyl Siding Institute.

Figure 4. Utility trim was substituted for the starter strip and the bottom lock was cut off the siding. Siding was able to pull loose under wind pressure.

Figure 5. The siding panel was not properly locked into the panel below.

Figure 6. Proper detailing around windows and other obstacles is important. Use utility trim, punch snap-locks into siding, and do not overlap directly beneath a window.

Wood Siding

- Use decay-resistant wood such as redwood, cedar, or cypress. See the Sustainable Design section regarding certified wood.
- To improve longevity of paint, back-prime wood siding before installation.
- Carefully follow manufacturer's detailing instructions to prevent excessive water intrusion behind the siding.
- For attachment recommendations, see *Natural Wood Siding: Selection, Installation and Finishing*, published by the Western Wood Products Association.

This publication recommends an air gap between the moisture barrier and the backside of the siding to promote drainage and ventilation. Such a wall configuration is referred to as a rain screen wall. See the text box on page 5.

- Follow the installation details shown in Figures 8a and 8b. (Note: Although these details do not show a rain screen, inclusion of vertical furring strips to create a rain screen is recommended.)

Figure 7. The vinyl siding at this gable was installed over plastic foam insulation. Without wood sheathing, the wind pressures on the vinyl are increased. Also, if the siding blows away, the foam insulation is very vulnerable to blow-off. With loss of the foam insulation, wind-driven rain can freely enter the attic, saturate the ceiling insulation, and cause collapse of the ceiling.

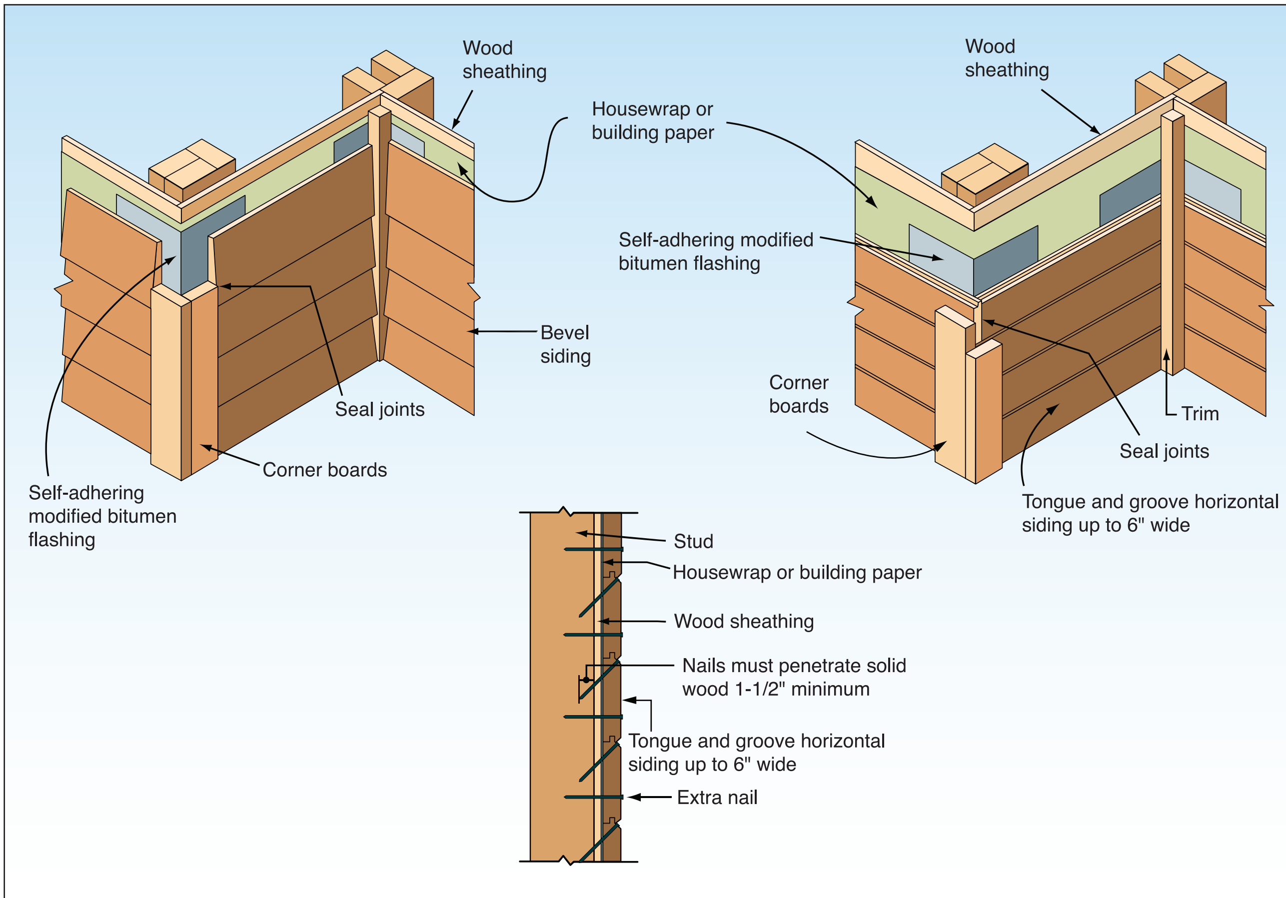


Figure 8a. Wood siding installation details.

5 WALL SYSTEMS

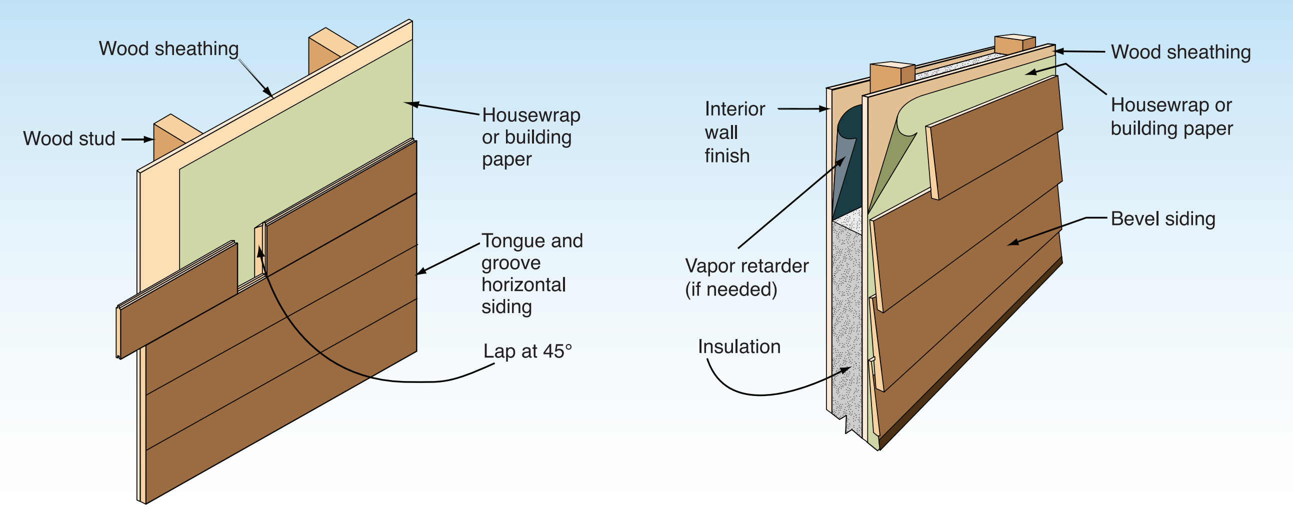


Figure 8b. Wood siding installation details.

Pressure-equalized rain screen wall system

In areas that experience frequent wind-driven rain and areas susceptible to high winds, it is recommended that a rain screen design be considered when specifying wood or fiber cement siding. (Typical vinyl siding products inherently provide air cavities behind the siding that facilitate drainage. Therefore, incorporation of vertical furring strips is normally not applicable to this type of wall covering.) A rain screen design is accomplished by installing suitable vertical furring strips between the moisture barrier and siding material (see Figure 9). The cavity facilitates drainage of water from the space between the moisture barrier and backside of the siding and it facilitates drying of the siding and moisture barrier.

Furring strip attachment: For 1 by 2 inches furring strips, tack strips in place and use siding nails that are 3/4 inch longer than would be required if there were no strips (to maintain the minimally required siding nail penetration into the studs). For thicker furring strips, an engineered attachment is recommended.

At the bottom of the wall, the cavity should be open to allow water drainage. However, the opening should be screened to avoid insect entry.

At the wall/soffit juncture, the top of the cavity can open into the attic space to provide inlet air ventilation, thereby, eliminating soffit vents and their susceptibility to wind-driven rain entry. If the rain screen cavity vent path is used instead of soffit vents, the depth of the cavity needs to be engineered to ensure that it provides sufficient air flow to ventilate the attic.

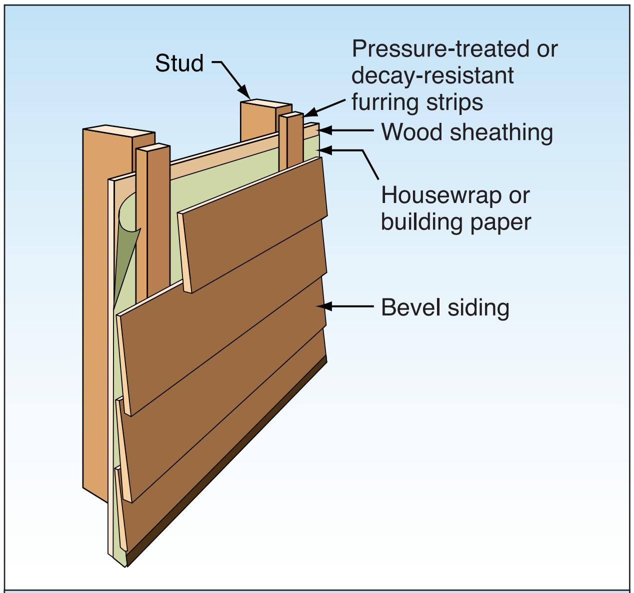


Figure 9. Pressure-equalized rain screen system.

Fiber Cement Siding

- Installation procedures are similar to those for wood siding, but require specialized cutting blades and safety precautions because of the dust produced during cutting with power tools. Manufacturer's installation recommendations should be strictly adhered to, and particular attention paid to the painting and finishing recommendations for a high-quality installation.
- Always seal field-cut ends according to the manufacturer's instructions. Properly gap the intersection between siding edges and other building components and fill the gap with sealant.

- Always consult and follow the manufacturer's installation requirements for the needed wind speed rating or design pressure (refer to the manufacturer's building code compliance evaluation report). Observe the manufacturer's fastener specifications, including fastener type and size, spacing, and penetration requirements. Do not over drive or under drive.
- At gable end walls, it is recommended that fiber cement siding be installed over wood sheathing rather than over plastic foam sheathing.
- Keep blind nails between 3/4 and 1-inch from the top edge of the panel (Figure 10). Be sure to drive nails at least 3/8 inch from butt ends, or use manufacturer-specified joiners.
- Face nailing (Figure 11) instead of blind nailing is recommended where the basic (design) wind speed is 100 mph or greater. If the local building code or manufacturer specifies face nailing at a lower wind speed, install accordingly.
- Do not leave the underside of the first course exposed or extending beyond the underlying material (Figure 12). Consider the use of a trim board to close off the underside of the first course.

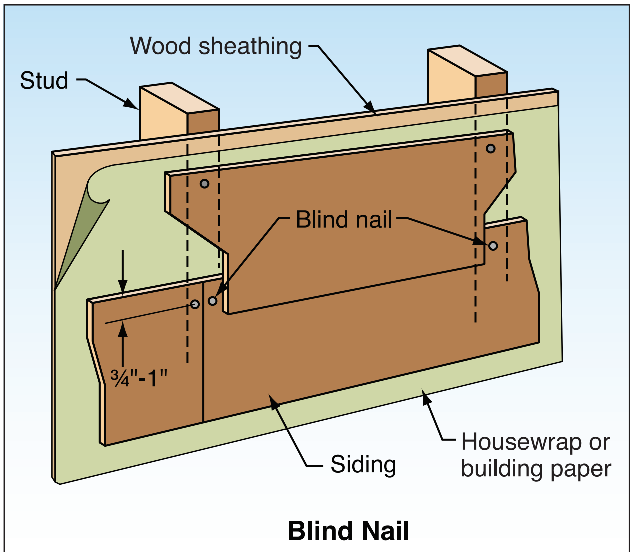


Figure 10. Blind nailing.

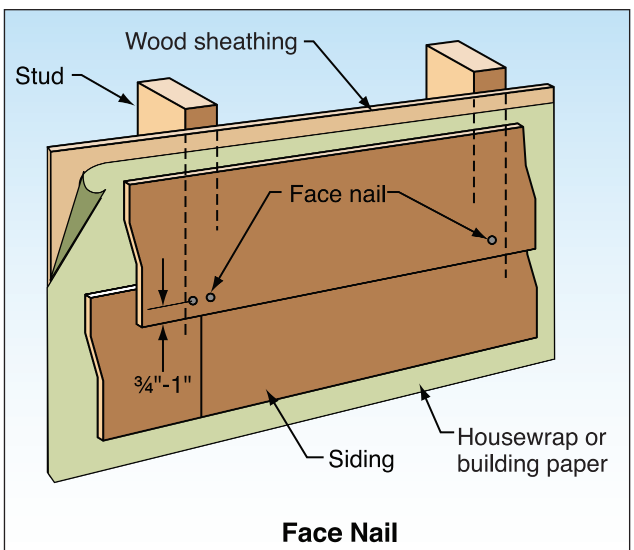


Figure 11. Face nailing.

Figure 12. Blind nailed siding installed with exposed gap at bottom (red circle) is vulnerable to failure.

Sustainable Design

Material selection for sustainable sources and durability

For wood products, it is best to select material that has been certified by a recognized program such as the American Tree Farm System® (ATFS), the Forest Stewardship Council (FSC) or the Sustainable Forestry Initiative® (SFI). Not only do these programs verify that wood is harvested in a more responsible fashion, but they also verify that the use of chemicals and genetic engineering of these products is avoided.

The following publications discuss sustainable aspects of vinyl siding:

A Dozen Things You Might Not Know That Make Vinyl Siding Green (available online at http://vinylsiding.org/greenpaper/090710_Latest_Revised_Green_paper.pdf).

Siding with the Environment (available online at http://www.vinylsiding.org/publications/final_Enviro_single_pg.pdf).

Energy Conservation and Air Barriers

Uncontrolled air leakage through the building envelope is often overlooked. The U.S. Department of Energy estimates that 40 percent of the cost of heating or cooling the average American home is lost due to uncontrolled air leakage. In warmer climates, it is a lower percentage of loss. An air barrier system can reduce the heating, ventilation, and cooling (HVAC) system size, resulting in reduced energy use and demand.

Uncontrolled air leakage can also contribute to premature deterioration of building materials, mold and moisture problems, poor indoor air quality, and compromised occupant comfort. When uncontrolled air flows through the building envelope, water vapor moves with it. Controlling the movement of moisture by air infiltration requires controlling the air pathways and/or the driving force.

To effectively control air leakage through the building envelope, an effective air barrier is required. To be effective, it needs to be continuous; therefore, air barrier joints need to be sealed and the barrier needs to be sealed at penetrations through it. The Air Barrier Association of America recommends that materials used as a component of a building envelope air barrier be tested to have an air infiltration rate of less than 0.004 cubic feet per minute (cfm)/square foot, assemblies of materials that form the air barrier be tested to have an air infiltration rate of less than 0.04 cfm/square foot, and the whole building exterior enclosure have an air infiltration rate of less than 0.4 cfm/square foot.

Air barrier: A component installed to provide a continuous barrier to the movement of air through the building envelope. Housewrap is a common air barrier material for residential walls. Although very resistant to airflow, housewrap is very vapor permeable and therefore is not suitable for use as a vapor retarder.

Vapor retarder: A component installed to resist diffusion of water vapor and provide a continuous barrier to movement of air through the building envelope. Polyethylene is a common vapor retarder material for residential walls. To determine whether or not a vapor retarder is needed, refer to the appropriate provisions of Chapter 14 of the 2009 IBC or Chapter 6 of the 2009 IRC. Also refer to the Moisture Control section of the NRCA Roofing and Waterproofing Manual, published by the National Roofing Contractors Association (NRCA) (http://www.nrca.net).

ASTM E 1677, *Standard Specification for an Air Retarder (AR) Material or System for Low-Rise Framed Building Walls:* This specification covers the minimum performance and acceptance criteria for an air barrier material or system for framed walls of low-rise buildings with the service life of the building wall in mind. The provisions contained in this specification are intended to allow the user to design the wall performance criteria and increase air barrier specifications to accommodate a particular climate location, function, or design of the intended building.

Air Barrier Systems Installed Behind Siding

Housewrap is the most common air barrier material for residential walls. To be effective, it is critical that the joints between sheets of housewrap be sealed as recommended by the manufacturer, and penetrations (other than fasteners) should also be sealed. At transitions between the housewrap and door and window frame, use of self-adhering modified bitumen flashing tape is recommended.

An air barrier should be installed over a rigid material, or it will not function properly. It also needs to be restrained from pulling off of the wall under negative wind pressures. For walls, wood sheathing serves as a suitable substrate, and the siding (or furring strips in a rain screen wall system) provide sufficient restraint for the air barrier.

At the base of the wall, the wall air barrier should be sealed to the foundation wall. If the house is elevated on piles, the wall barrier should be sealed to an air barrier installed at the plane of the floor.

If the building has a ventilated attic, at the top of the wall, the wall air barrier should be sealed to an air barrier that is installed at the plane of the ceiling.

If the building has an unventilated attic or no attic, at the top of the wall, the wall air barrier should be sealed to an air barrier that is installed at the plane of the roof (the roof air barrier may be the roof membrane itself or a separate air barrier element).

Siding Maintenance

For all siding products, it is very important to periodically inspect and maintain the product especially in a coastal environment. This includes recoating on a scheduled maintenance plan that is necessary according to the manufacturer's instructions and a periodic check of the sealant to ensure its durability. Check the sealant for its proper resiliency and that it is still in place. Sealant should be replaced before it reaches the end of its service life.

Additional Resources

American Tree Farm System®, ATFS (http://www.treefarmsystem.org/index.shtml).

Forest Stewardship Council, FSC (http://www.fsc-info.org)

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

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

Sustainable Forestry Initiative® Program, SFI (http://www.sfiprogram.org)

Vinyl Siding Institute, VSI (http://www.vinylsiding.org)

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

Attachment of Brick Veneer in High-Wind Regions

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION — Technical Fact Sheet No. 5.4

Purpose: *To recommend practices for installing brick veneer that will enhance wind resistance in high-wind regions (i.e., greater than 90-miles per hour [mph] basic [gust design] wind speed).[1]*

Key Issues

- When not adequately attached, brick veneer is frequently blown off walls of residential and non-residential buildings during hurricanes (Figure 1). When brick veneer fails, wind-driven water can enter and damage buildings, and building occupants can be vulnerable to injury from windborne debris (particularly if walls are sheathed with plastic foam insulation or wood fiberboard instead of wood panels). Pedestrians in the vicinity of damaged walls can also be vulnerable to injury from falling veneer (Figure 2).
- Common failure modes include tie (anchor) corrosion (Figure 3), tie fastener pull-out (Figure 4), failure of masons to embed ties into the mortar (Figure 5), and poor bonding between ties and mortar and mortar of poor quality (Figure 6).
- Ties are often installed before brick laying begins. When this is done, ties are often improperly placed above or below the mortar joints. When misaligned, the ties must be angled up or down in order for the ties to be embedded into the mortar joints (Figure 7). Misalignment not only reduces embedment depth, but also reduces the effectiveness of the ties because wind forces do not act parallel to the ties themselves.
- Corrugated ties typically used in residential veneer construction provide little resistance to compressive loads. Use of compression struts would likely be beneficial, but off-the-shelf devices do not currently exist. Two-piece adjustable ties (Figure 8) provide significantly greater compressive strength than corrugated ties and are, therefore, recommended. However, if corrugated ties are used, it is recommended that they be installed as shown in Figures 9 and 10 in order to enhance their wind performance.

1 The 90 mph speed is based on ASCE 7-05. If ASCE 7-10 is being used, the equivalent wind speed trigger is 115 mph for Risk Category II buildings.

Figure 1. Failed brick veneer over plywood. Many of the ties are still attached to the substrate, but several of the tie fasteners pulled out of the substrate and the ties are embedded in the collapsed veneer. Estimated wind speed: 107 miles per hour (peak gust, Exposure C, at 33 feet).

Figure 2. The upper portion of the brick veneer at this apartment building collapsed. Pedestrian and vehicular traffic in the vicinity of the damaged wall are vulnerable to injury and damage if remaining portions of the wall were to collapse during subsequent storms.

WALL SYSTEMS 5

Figure 3. Significant tie corrosion caused the brick at a fire station to fail, even though the building is not near the coast. Note that metal is missing for half of the width of the tie at two locations (red arrows). The left end of the tie was still embedded into a concrete masonry unit back-up wall. The right end is where the tie failed in tension, thus leaving a portion of the tie embedded in the collapsed brick.

Figure 4. This tie remained embedded in the mortar joint while the smooth-shank nail pulled out from the stud.

Figure 5. These four ties were never embedded into the mortar joint.

- Buildings that experience veneer damage typically do not comply with current building codes. Building code requirements for brick veneer have changed over the years. Model codes prior to 1995 permitted brick veneer in any location, with no wind speed restrictions. Also, some older model codes allowed brick veneers to be anchored with fewer ties than what is required by today's standards.

The Masonry Society's (TMS) 402/American Concrete Institute 530/American Society of Civil Engineers (ASCE) 5 *Building Code Requirements and Specifications for Masonry Structures* (TMS 402) is the current masonry standard referenced by model building codes. The 2009 International Residential Code (IRC) and the 2009 International Building Code (IBC) references the 2008 edition of TMS 402, which is the latest edition.

TMS 402 addresses brick veneer in two manners: rational design and a prescriptive approach. Nearly all brick veneer in residential and low-rise construction follows the prescriptive approach. The first edition of TMS 402 limited the use of prescriptive design to areas with a basic wind speed of 110 mph or less. The 2008 edition of TMS 402 extended the prescriptive requirements to include a basic wind speed of 130 mph, but limits the veneer wall area per tie that can be anchored with veneer ties to 70 percent of that allowed in lower wind speed regions. The 2008 edition requires rational design approaches in locations where the basic wind speeds exceed 130 mph.

Some noteworthy distinctions exist in the requirements for anchored brick veneer between the 2005 and the 2008 editions of TMS 402. For lower wind speed regions (110 mph and below), TMS 402-05 limited the vertical spacing of ties to 18 inches; the 2008 edition allows vertical ties to be spaced up to 25 inches, provided the wall area of veneer anchored per tie does not exceed 2.67 square feet. In TMS's high-wind regions (over 110 mph and up to 130 mph), both editions of the code limit vertical spacing to 18 inches. TMS 402-08 also limits the space between veneer anchored with corrugated ties and the wall sheathing to 1 inch. This is to avoid compression failures in the corrugated ties when they are exposed to positive pressures.

- The following Brick Industry Association (BIA) Technical Notes provide guidance on brick veneer: Technical Notes 28 – Anchored Brick Veneer, Wood Frame Construction; Technical Notes 28B – Brick Veneer/Steel Stud Walls; and Technical Notes 44B – Wall Ties. Although these Technical Notes provide attachment recommendations, the recommendations are inadequate because they are not specific for high-wind regions.

Construction Guidance

The brick veneer wall system is complex in its behavior. There are limited test data on which to draw. The following guidance is based on professional judgment, wind loads specified in ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures,* fastener strengths specified in the American Forest and Paper Association's (AF&PA's) National Design Specification (NDS) for Wood Construction, and brick veneer standards contained in TMS 402-08. In addition to the general guidance given in BIA Technical Notes 28 and 28B, the following guidelines are recommended:

Tie Spacing: The ability for Brick Ties and Tie Fasteners to function properly is highly dependent on horizontal and vertical spacing of ties. Horizontal spacing of ties will often coincide with stud spacing of either 16-inch or 24-inch on center (see Table 1) because tie fasteners are required to be installed directly into framing. Spacing of ties horizontally and vertically must not exceed a) spacings which will overload the tie or tie fastener based on a tributary area of wind pressure on the brick veneer, or b) prescriptive limits on spacing of ties. More information on horizontal and vertical tie spacing is available in Table 1.

Tie Fasteners: 8d (0.131" diameter) ring-shank nails are recommended instead of smooth-shank nails. A minimum embedment of 2 inches into framing is suggested.

Ties: For use with wood studs, two-piece adjustable ties are recommended. However, where corrugated steel ties are used, use 22-gauge minimum, 7/8 by 6 inches, complying with American Society for Testing and Materials (ASTM) A 366 with a zinc coating complying with ASTM A 153 Class B2. For ties for use with steel studs, see BIA Technical Notes 28B – Brick Veneer/Steel Stud Walls. Stainless steel ties should be used in areas within 3,000 feet of the coast.

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

Note: In areas that are also susceptible to high seismic loads, brick veneer should be evaluated by an engineer to ensure that it can resist seismic and wind design loads.

Sustainability

Brick veneer can offer a very long service life, provided the ties are not weakened by corrosion. To help ensure that brick veneer achieves its long life potential, in addition to properly designing and installing the ties, stainless steel ties are recommended.

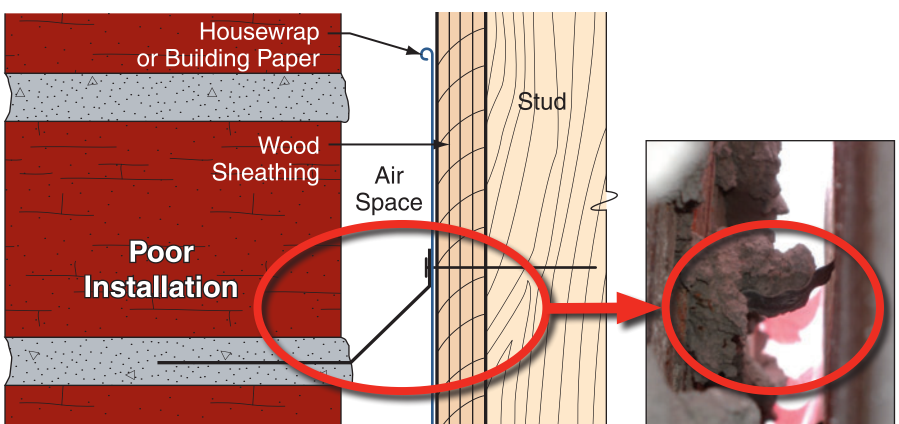


Figure 7. Misalignment of the tie reduces the embedment and promotes veneer failure.

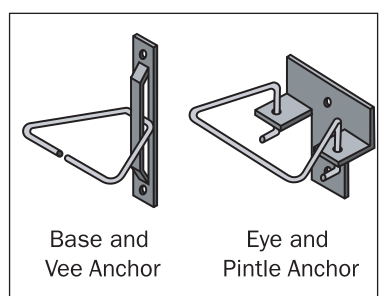


Figure 8. Examples of two-piece adjustable ties.

Tie Installation

- Install ties as the brick is laid so that the ties are properly aligned with the brick coursing. Alternatively, instead of installing ties as the brick is laid, measure the locations of the brick coursing, snap chalk lines, and install ties so that they are properly aligned with the coursing, and then install the brick.
- Install brick ties spaced based on the appropriate wind speed and stud spacing shown in Table 1. In areas where the 2006 Edition of the IBC or IRC are adopted, install brick veneer ties as noted in Table 1 but with a maximum vertical spacing of no more than 18 inches to satisfy the requirements of TMS 402-05.
- Locate ties within 8 inches of door and window openings and within 12 inches of the top of veneer sections.
- Bend the ties at a 90-degree angle at the nail head in order to minimize tie flexing when the ties are loaded in tension or compression (Figure 9).
- Embed ties in joints so that mortar completely encapsulates the ties. Embed a minimum of 1 1/2 inches into the bed joint, with a minimum mortar cover of 5/8 inch to the outside face of the wall (Figure 10).

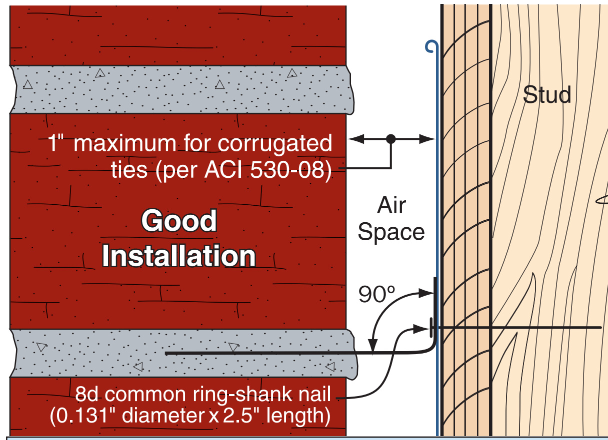


Figure 9. Bend ties at nail heads.

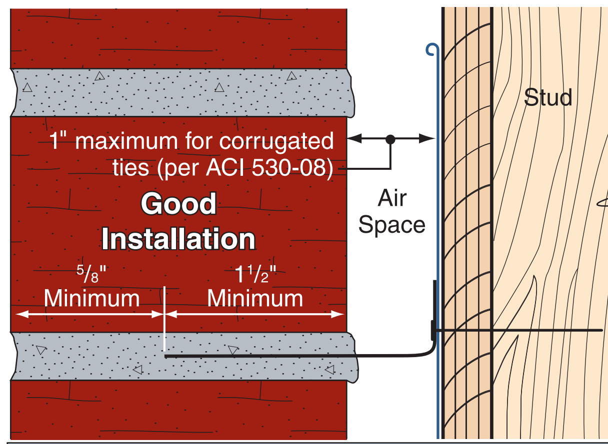


Figure 10. Tie embedment.

Table 1. Brick Veneer Tie Spacing

Wind Speed (mph) (3–Second Peak Gust)	Wind Pressure (psf)	Maximum Vertical Spacing for Ties (inches)	
		16" stud spacing	24" stud spacing
90	–19.5	24[a,b]	16[a]
100	–24.1	24[a,b]	16[a]
110	–29.1	20½ [b]	13½
120	–34.7	17	NA[c]
130	–40.7	15	NA[c]
140	–47.2	13	NA[c]
150	–54.2	11	NA[c]

Notes:

1. The tie spacing is based on wind loads derived from Method 1 of ASCE 7-05, for the corner area of buildings up to 30' high, located in Exposure B with an importance factor (I) of 1.0 and no topographic influence. For other heights, exposures, or importance factors, engineered designs are recommended.
2. Spacing is for 2½" long 8d common (0.131" diameter) ring-shank fasteners embedded 2" into framing. Fastener strength is for wall framing with a Specific Gravity G=0.55 with moisture contents less than 19 percent and the following adjustment factors, C_t=0.8; and C_D, C_M, C_{eg}, and C_{tn}=1.0. Factored withdrawal strength W'=65.6#.
3. The brick veneer tie spacing table is based on fastener loads only and does not take into account the adequacy of wall framing, sheathing, and other building elements to resist wind pressures and control deflections from a high-wind event. Prior to repairing damaged brick veneer, the adequacy of wall framing, wall sheathing, and connections should be verified by an engineer.

a Maximum spacing allowed by ACI 530-08.

b In locales that have adopted the 2006 IBC/IRC, the maximum vertical spacing allowed by ACI 530-05 is 18".

c 24" stud spacing exceeds the maximum horizontal tie spacing of ACI 530-08 prescribed for wind speeds over 110 mph.

Additional Resources

Brick Industry Association (BIA). (http://www.gobrick.com)

- Technical Notes 28 – Anchored Brick Veneer, Wood Frame Construction
- Technical Notes 28B – Brick Veneer/Steel Stud Walls
- Technical Notes 44B – Wall Ties

Window and Door Installation

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 6.1

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

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

Key Issues

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

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

ASTM E 2112

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

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

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

Specific Considerations

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

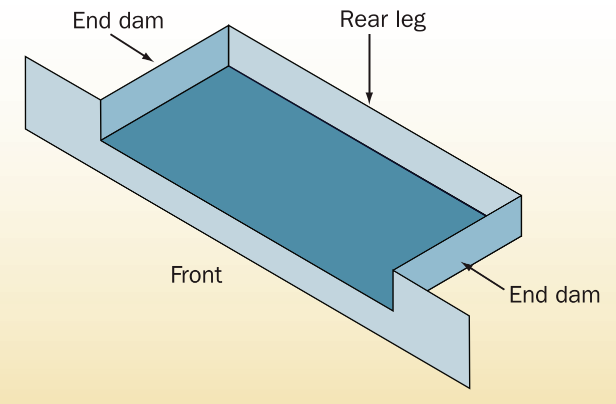


Figure 1. Pan Flashing

6 OPENINGS

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

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

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

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

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

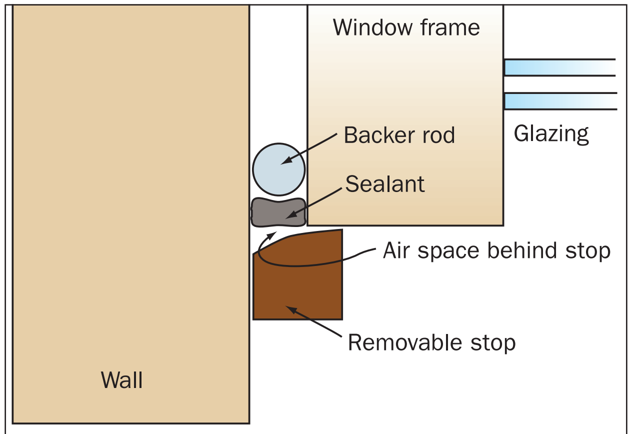


Figure 2. Protection of sealant with a stop.

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

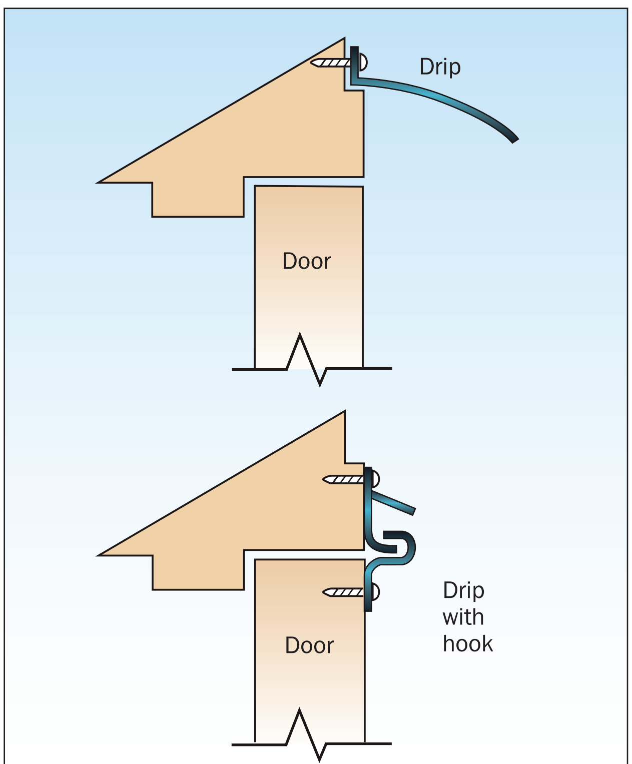


Figure 4. Drip at door head and drip with hook at head

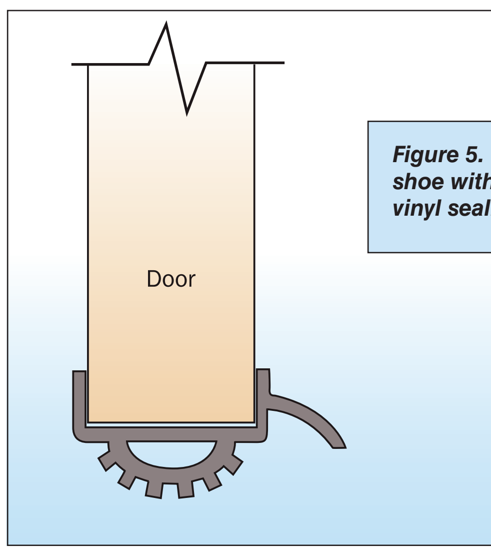


Figure 5. Door shoe with drip and vinyl seal.

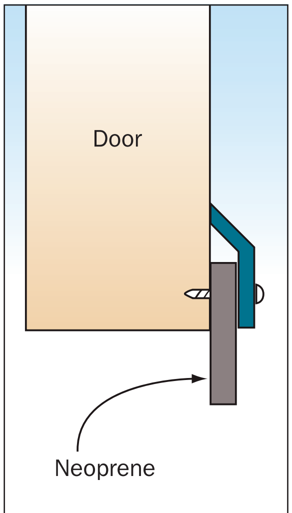


Figure 6. Neoprene door bottom sweep.

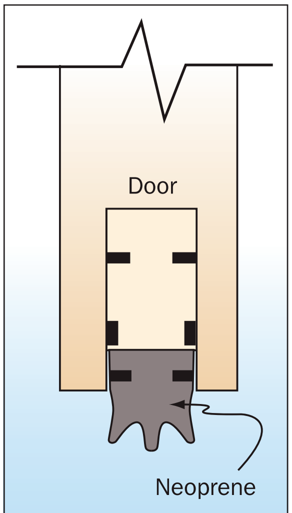


Figure 7. Automatic door bottom.

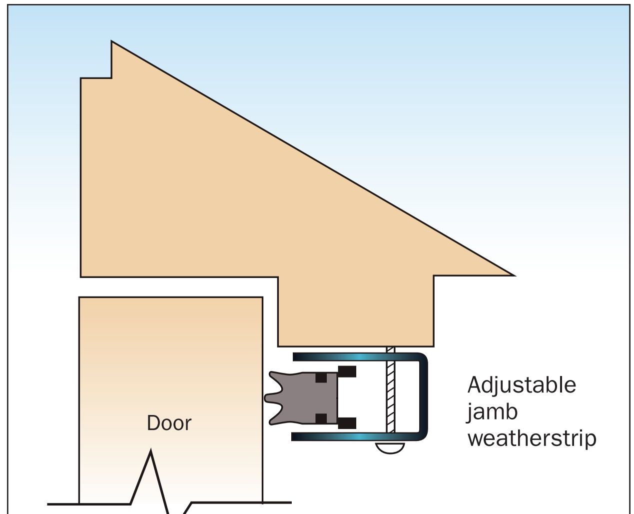


Figure 8. Adjustable jamb/head weatherstripping.

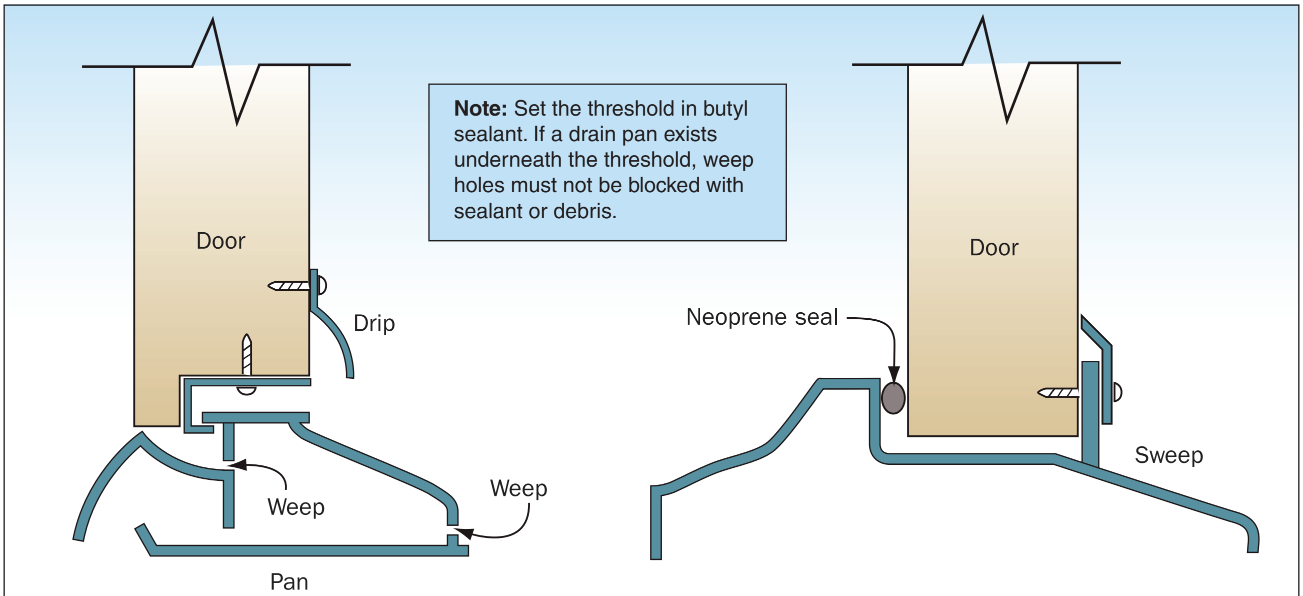


Figure 9. Threshold

Additional Resources

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

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

Protection of Openings– Shutters and Glazing

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

Opening Requirements in Codes and Standards

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

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

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

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

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

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

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

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

Anchorage

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

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

6 OPENINGS

Shutters

Why Are Storm Shutters Needed?

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

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

Where Are Storm Shutters Required and Recommended?

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

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

What Types of Shutters Are Available?

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

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

OPENINGS 6

Shutter Styles

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

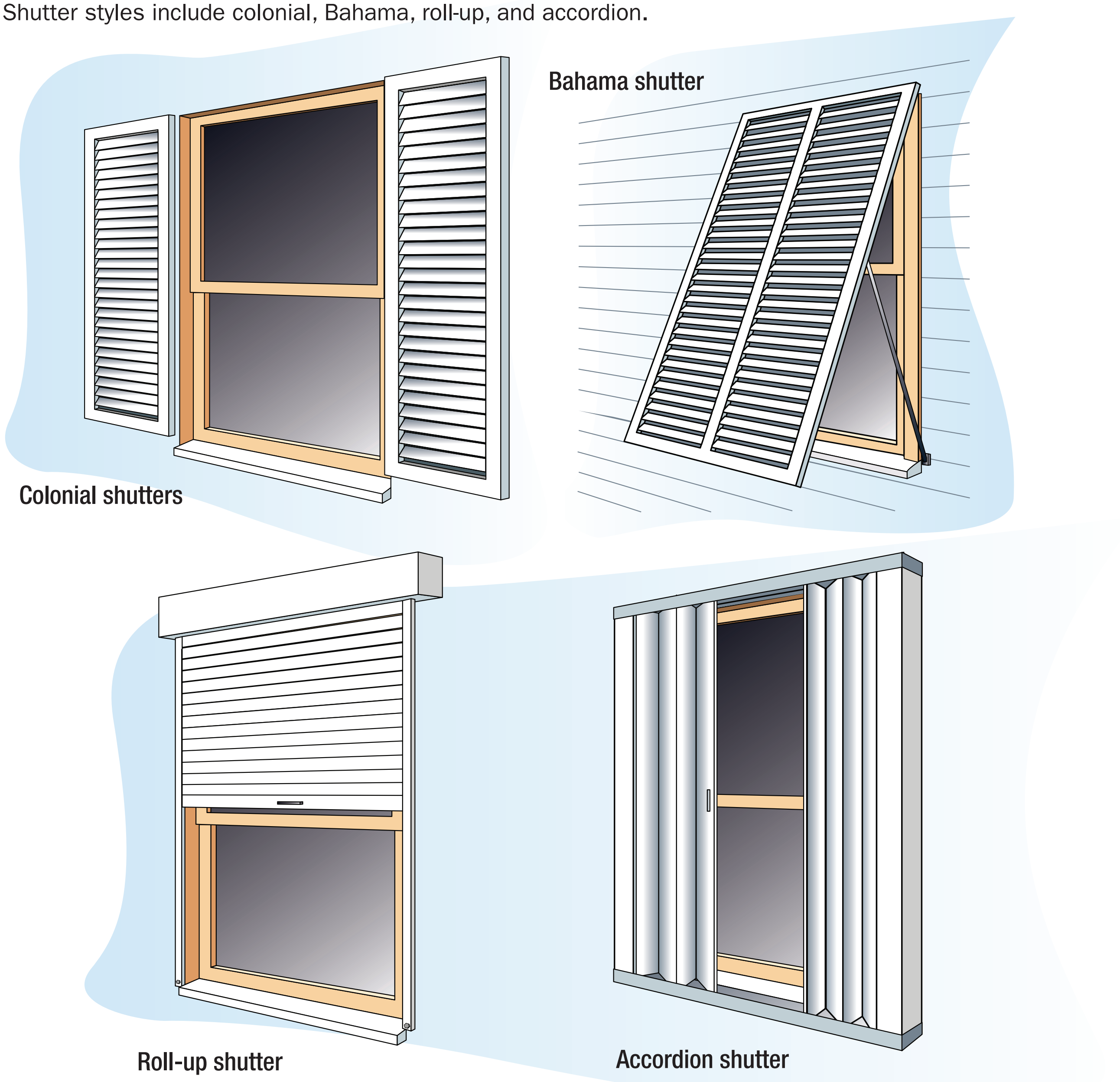
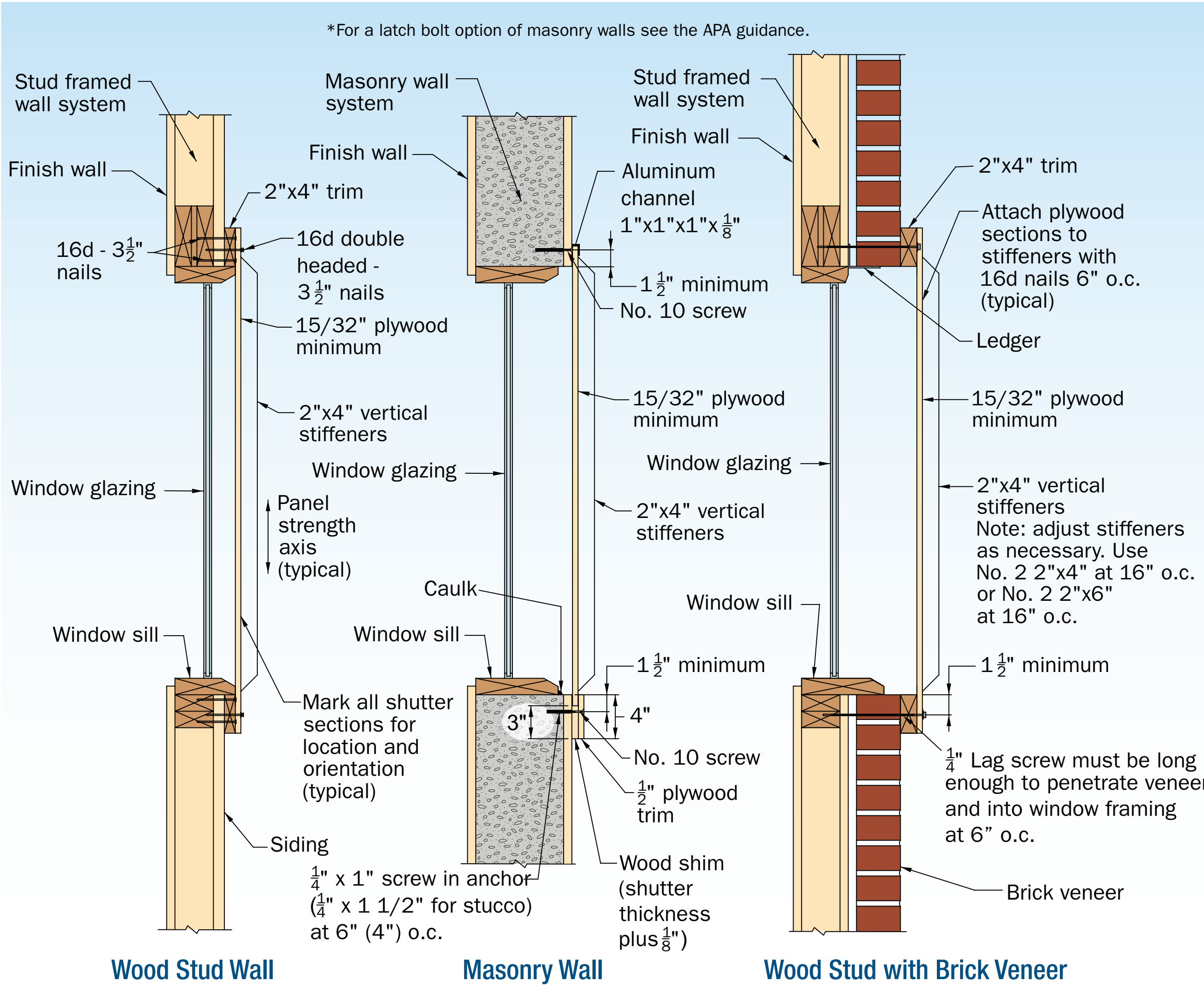


Figure 3. Colonial shutters, Bahama style shutters, Roll-up style shutters, and Accordion style shutters.



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

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

Shutter Type Cost Advantages

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

Are There Special Requirements for Shutters in Coastal Areas?

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

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

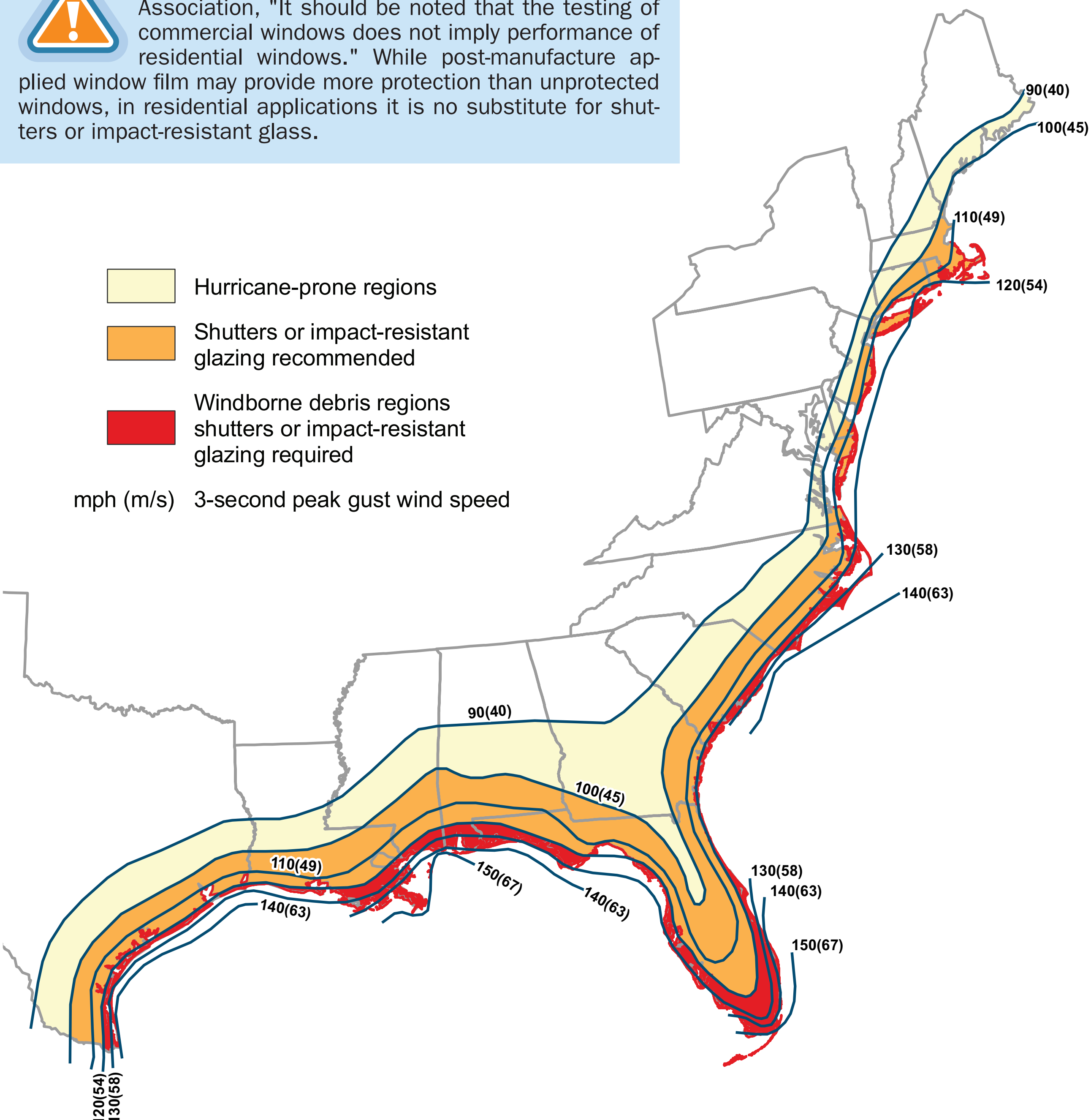


Figure 5. An illustration of the ASCE 7-05 wind speed contours and windborne debris region. See ASCE 7-05 Figure 6-1 for wind load design.

Windborne debris resistant glazing

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

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

Garage Doors

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

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

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

Additional Resources

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

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

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

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

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

American Society for Testing and Materials:

ASTM E1886, *Performance of Exterior Windows, Curtain Walls, Doors, and Storm Shutters Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials*

ASTM E1996, *Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors and Impact Protective Systems Impacted by Windborne Debris in Hurricane*

ASTM E2112, *Standard Practice for Installation of Exterior Windows, Doors and Skylights*

ASTM E330, *Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference*. (http://www.astm.org)

Door and Access Systems Manufacturers Association:

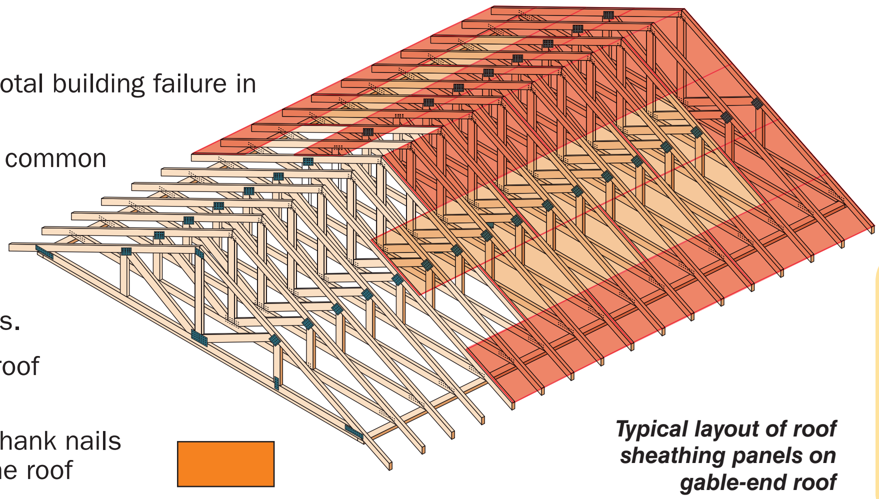
DASMA 108, *Standard Method for Testing Sectional Garage Doors: Determination of Structural Performance Under Uniform Static Air Pressure Difference*

Roof Sheathing Installation

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

Key Issues

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

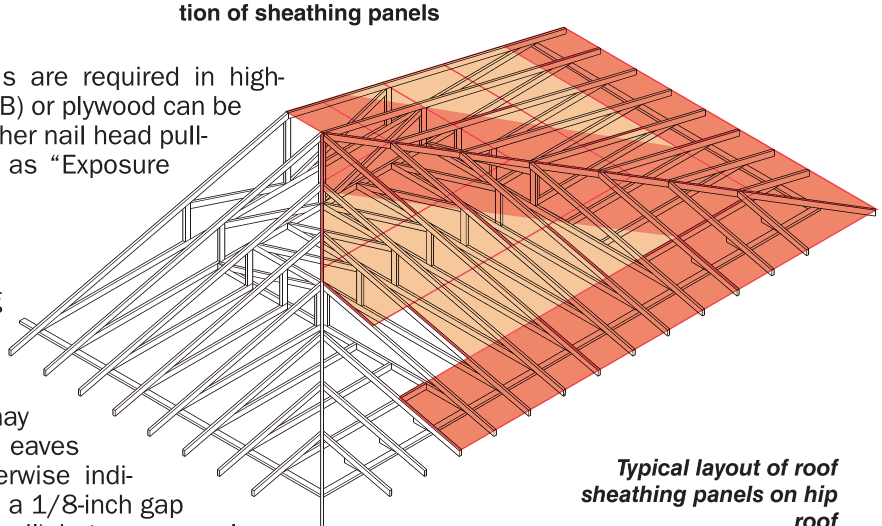


Most critical area for connection of sheathing panels

Typical layout of roof sheathing panels on gable-end roof

Sheathing Type

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



Typical layout of roof sheathing panels on hip roof

Sheathing Layout

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

Fastener Selection

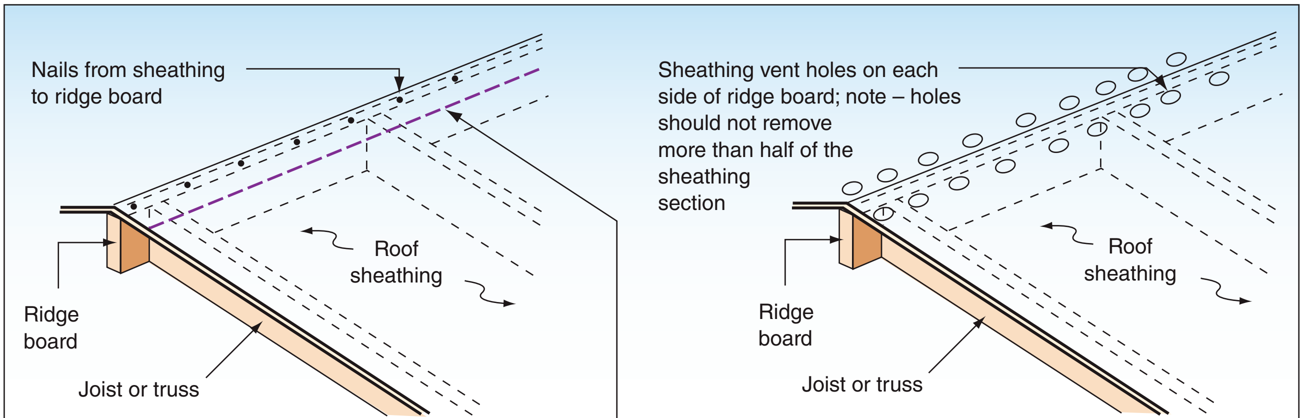
An 8d nail (2.5 inches long) is the minimum size nail to use for fastening sheathing panels. Full round heads are recommended to avoid head pull-through. Deformed-shank (i.e., ring- or screw-shank) nails are required near ridges, gables, and eaves in areas with design wind speeds over 110 mph (3-second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

Fastener Spacing

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

Ridge Vents

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



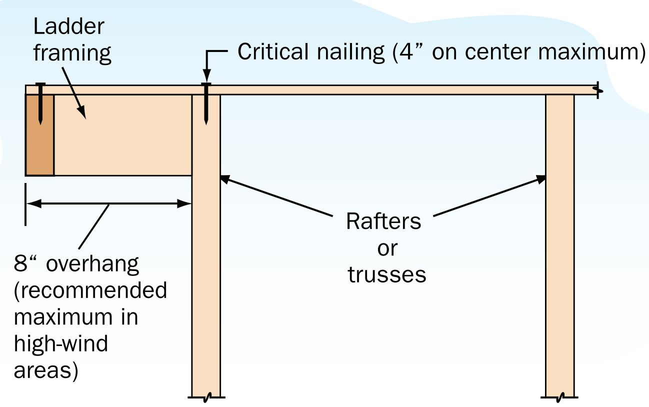
NOTE: If roof sheathing is cut and removed to achieve an air slot, continuity and diaphragm action are affected.

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

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

Ladder Framing at Gable Ends

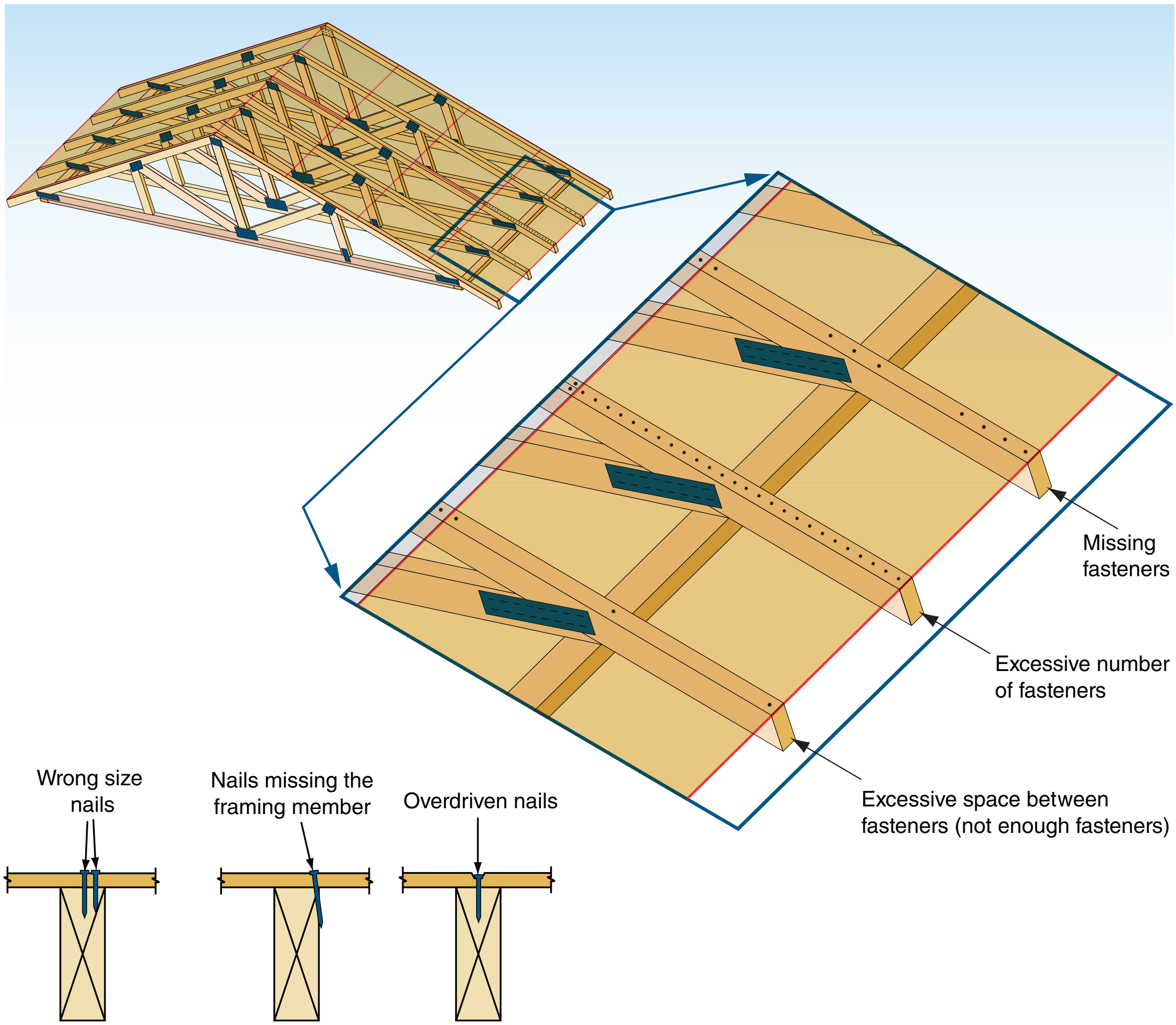
Use extra care when attaching a ladder-framed extension to a gable end. Many homes have been severely damaged by coastal storms because of inadequate connections between the roof sheathing and the gable truss. The critical fasteners occur at the gable-framing member, not necessarily at the edge of the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



Ladder framing at gable ends.

Common Sheathing Attachment Mistakes

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



Additional Resources

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

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

Roof Underlayment for Asphalt Shingle Roofs

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

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

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

ROOFING 7

Key Issues

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

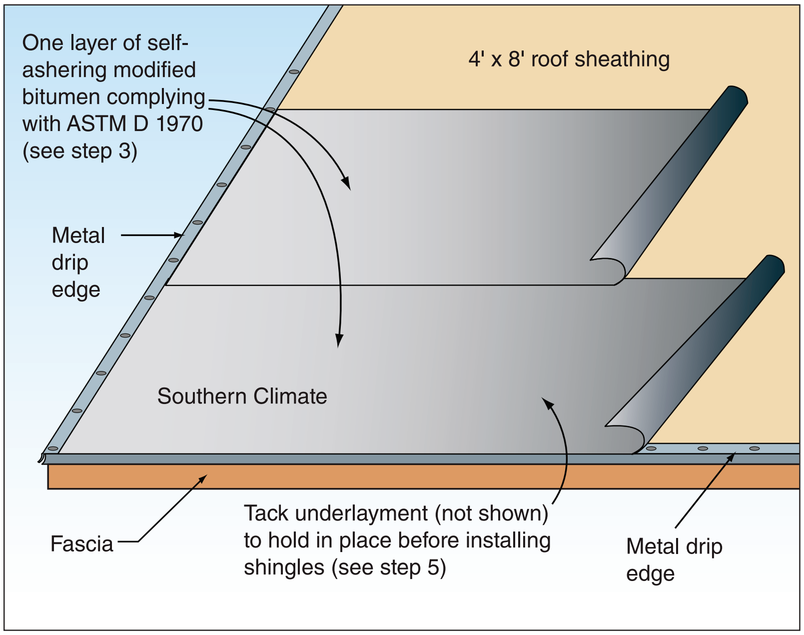
Note: This fact sheet provides general guidelines and recommended enhancements for improving upon typical practice. It is advisable to ***consult local building requirement***s for type and installation of underlayment, particularly if specific enhanced underlayment practices are required locally.

Sheathing Installation Options

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

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

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



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

5. **Apply a single layer of ASTM D 226 Type I (#15) or ASTM D 4869 Type II felt.** Tack underlayment to hold in place before installing shingles.

6. **In northern climates**, after step 2, install self-adhering modified bitumen tape (4 inches wide, minimum) over sheathing joints; seal around deck penetrations with roof tape. Roll tape with roller.

7. **Apply a single layer of ASTM D 226 Type II (#30) or ASTM D 4869 Type IV felt. Attach per steps 8 and 9. Then install a single layer of self-adhering modified bitumen per steps 3 and 4, followed by installation of the shingles.**

8. Secure felt with low-profile, capped-head nails or thin metal disks ("tincaps") attached with roofing nails.

9. Fasten at approximately 6 inches on center along the laps and at approximately 12 inches on center along two rows in the field of the sheet between the side laps.

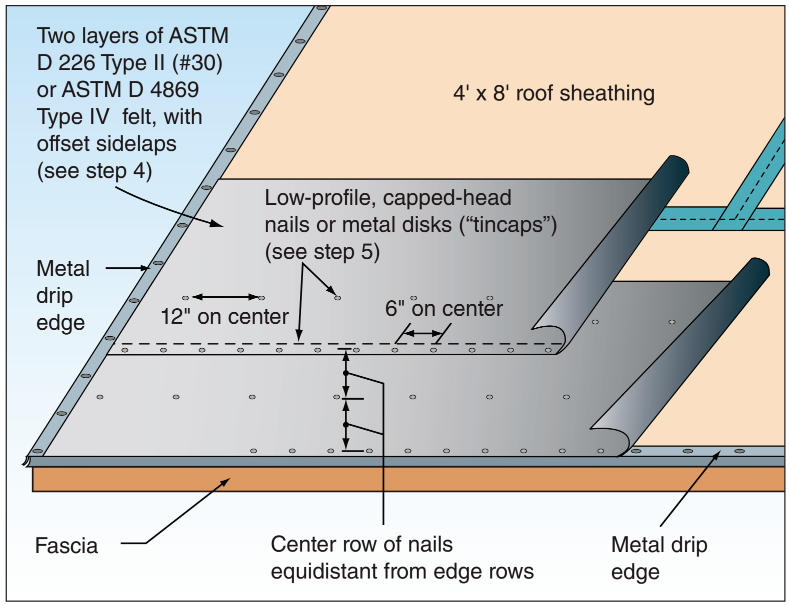
Installation Sequence – Option 2[2]

1. Before the roof covering is installed, have the deck inspected to verify that it is nailed as specified on the drawings.

2. Broom clean deck before taping. If the sheathing is OSB, check with the OSB manufacturer to determine if a primer needs to be applied before installing self-adhering modified bitumen products.

3. Install self-adhering modified bitumen tape (4 inches wide, minimum) over sheathing joints; seal around deck penetrations with roof tape. Roll tape with roller.

4. **Apply two layers of ASTM D 226 Type II (#30) or ASTM D 4869 Type IV felt with offset side laps.**



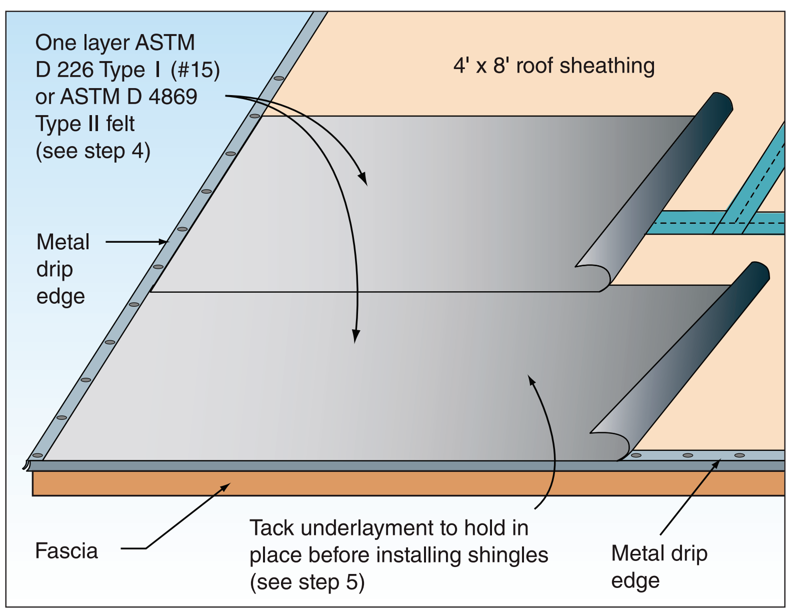
5. Secure felt with low-profile, capped-head nails or thin metal disks ("tincaps") attached with roofing nails.

6. Fasten at approximately 6 inches on center along the laps and at approximately 12 inches on center along a row in the field of the sheet between the side laps.

Installation Sequence – Option 3[2,3]

1. Before the roof covering is installed, have the deck inspected to verify that it is nailed as specified on the drawings.

2 Broom clean deck before taping. If the sheathing is OSB, check with the



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

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

7 ROOFING

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

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

General Notes

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

Additional Resources

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

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

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

Asphalt Shingle Roofing for High Wind Regions

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

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

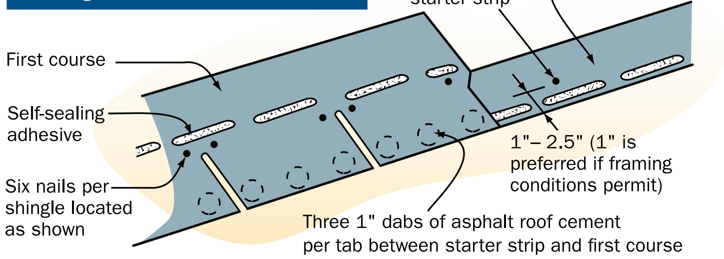
Key Issues

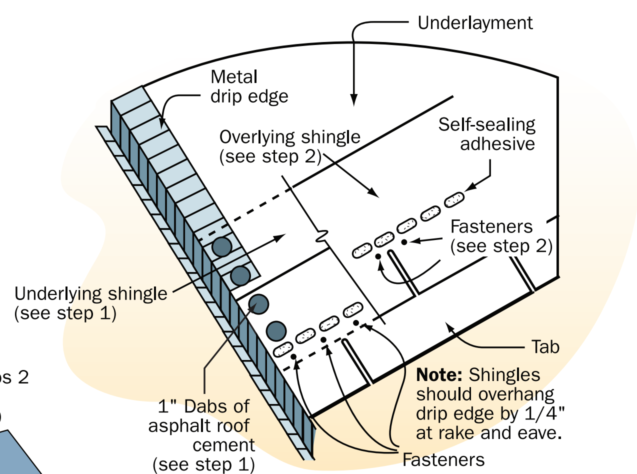
- Special installation methods are recommended for asphalt roof shingles used in high-wind, coastal regions (i.e., greater than 90-mph gust design wind speed).
- Use wind-resistance ratings to choose among shingles, but do not rely on ratings for performance.
- Consult local building code for specific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

Construction Guidance

1. Follow shingle installation procedures for enhanced wind resistance.

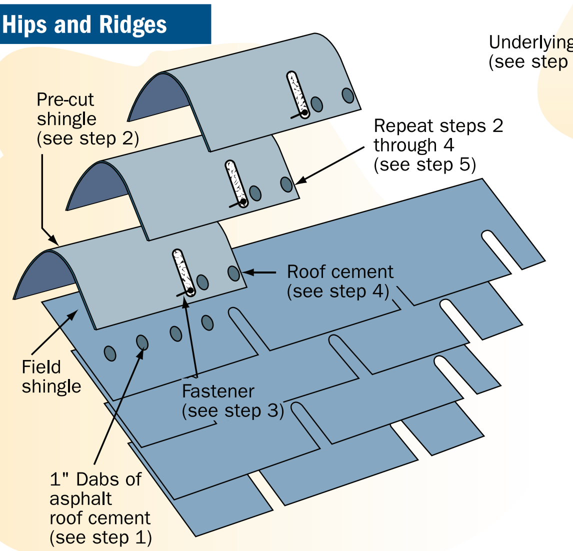
Shingle Installation at Eaves





Shingle Installation at Hips and Ridges

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



Enhanced shingle securement

Shingle Installation at Rakes

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

12/10

2. Consider shingle physical properties.

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

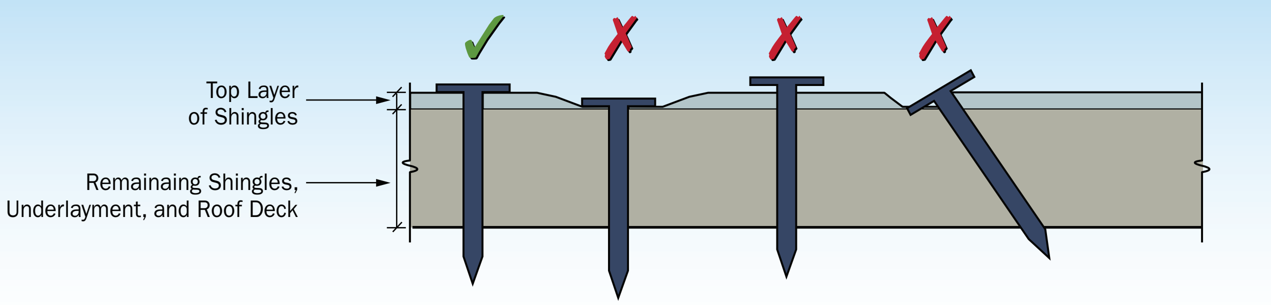
1. Design wind speed based on 3-second peak gust.
2. ASTM D 3462 specifies a minimum fastener pull-through resistance of 20 lb at 73° F. If a higher resistance is desired, it must be specified.

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

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

Fastener Guidelines

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



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

Weathering and Durability

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

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

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

Wind-Resistance Ratings

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

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

Tile Roofing for High Wind Regions

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

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

Key Issues

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

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

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

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

Corner and perimeter enhancements: Uplift loads are greatest in corners, followed by the perimeter, and then the field of the roof (see Figure 1 on page 2). However, for simplicity of application on smaller roof areas (e.g., most residences and smaller commercial buildings), use the attachment designed for the corner area throughout the entire roof area.

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

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

Classification of Buildings

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

ROOFING 7

7 ROOFING

Design and Construction Guidance

1. Uplift Loads

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

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

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

2. Uplift Resistance

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

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

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

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

3. Hips and Ridges

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

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

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

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

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

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

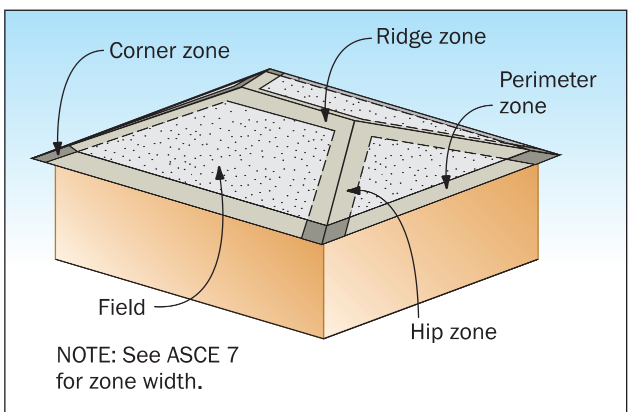


Figure 1. For critical and essential facilities, clip all tiles in the corner, ridge, perimeter, and hip zones.

5. Quality Control

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

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

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

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

Minimizing Water Intrusion Through Roof Vents in High-Wind Regions

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

Key Issues

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

The Unvented Attic

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

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

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

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

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

Mitigation Guidance

Soffit Vents

Key Issues

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

Figure 1. Missing soffit material.

Proper Installation

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

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

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

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

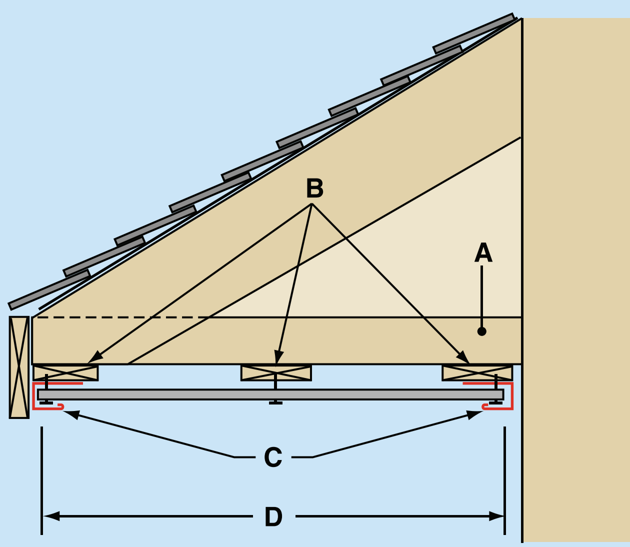


Figure 2. Key soffit installation points.

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

Checking Soffit Material Installation

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

Remedial Measures

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

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

Figure 4. Applying dabs of sealant.

Figure 5. Screws through wall channel.

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

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

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

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

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

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

Ridge Vents

Key Issues

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

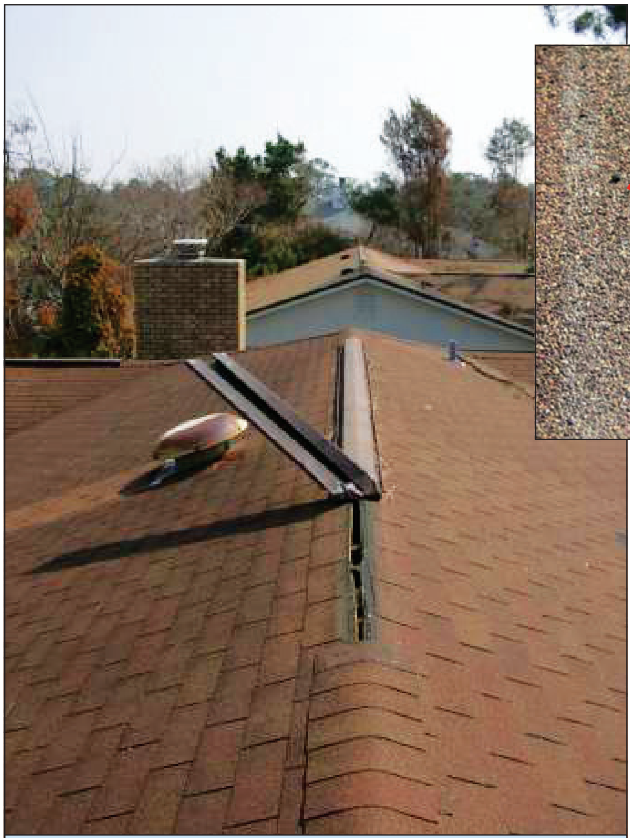


Figure 8. *This metal ridge vent was attached with widely spaced roofing nails.*

Slotting the Deck

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

Checking Ridge Vents and Their Installation

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

Remedial Measures

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

Figure 9. Gable end vent.

Gable End Vents

Key Issues

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

Remedial Measures

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

Figure 10. Shuttered gable end vent.

Off-ridge Vents

Key Issues

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

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

Checking Off-Ridge Vent Installations

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

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

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

Remedial Measures

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

Gable Rake Vents

Key Issues

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

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

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

Remedial Measures

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

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

Turbines

Key Issues

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

Checking Turbines and Their Installation

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

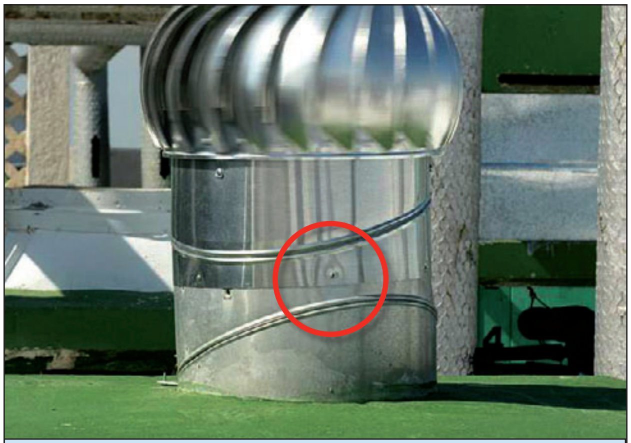


Figure 13. This turbine head is attached to the standpipe with dimple punches. Sheet metal screws should be added to strengthen the connection.

Remedial Measures

Loose standpipes should be securely anchored to the roof sheathing. If the standpipe is attached to the roof sheathing with long, thin nails, it may be possible to improve the anchorage by cinching the nails (bending them over against the underside of the roof sheathing). However, if they are short and/or thick, trying to bend them over may cause more harm than good. Some homeowners have had covers made that can be installed from the inside of the attic over the

ROOFING 7

hole where the standpipe is installed. This will be easiest if the standpipe is larger than the hole and the cover can be attached to the sheathing in an area where the fasteners cannot be driven through the roof cover. Otherwise, it will be important to ensure that the fasteners are short enough that they will not extend through the roof sheathing and damage the roof cover.

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

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

Figure 14. Plastic wrapped turbines.

Metal Roof Systems in High-Wind Regions

Purpose: *To describe practices for designing and installing metal roof systems that will enhance wind resistance in high-wind regions (i.e., greater than 90 miles per hour [mph] basic [gust design] wind speed).[1]*

Key Issues

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

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

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

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

ROOFING 7

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

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

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

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

Metal Roofing Options

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

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

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

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

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

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

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

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

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

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

Construction Guidance

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

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

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

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

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

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

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

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

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

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

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

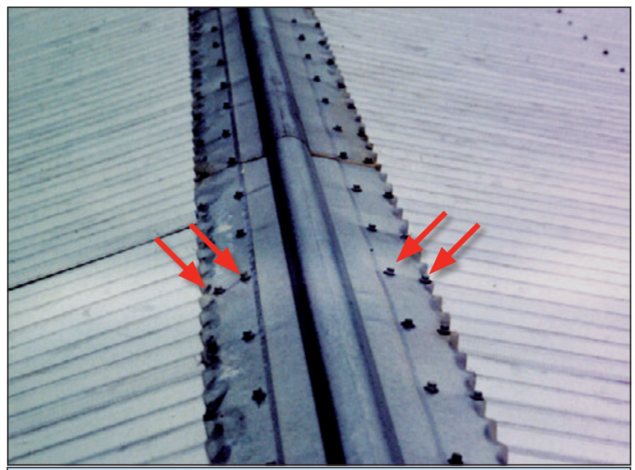


Figure 8. The ridge flashing on these corrugated metal panels had two rows of fasteners on each side of the ridge line.

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

Additional Resources

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

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

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

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

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

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

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

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

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

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

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

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

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

Enclosures and Breakaway Walls

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 8.1

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

Key Issues

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

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

WARNING

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

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

ATTACHMENTS 8

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

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

What is an Enclosure?

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

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

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

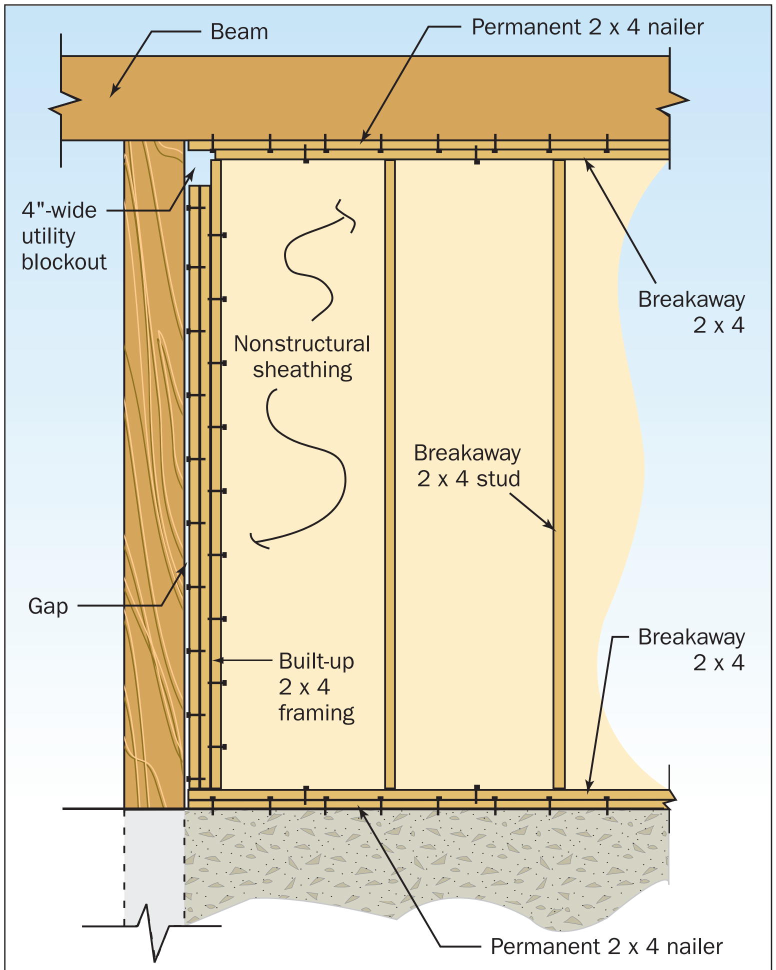


Figure 3. An example of an NFIP-compliant breakaway wall constructed of preservative treated or decay resistant lumber.

Breakaway Walls

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

8 ATTACHMENTS

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

Obstruction Considerations

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

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

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

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

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

Flood Openings

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

A Zone opening requirements are as follows:

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

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

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

Other Considerations

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

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

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

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

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

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

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

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

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

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

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

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

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

Additional Resources

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

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

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

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

Decks, Pools, and Accessory Structures

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

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

Key Issues

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

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

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

Decks

Requirements

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

ATTACHMENTS 8

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

Recommendations

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

Access Stairs and Elevators

Requirements

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

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

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

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

Recommendations

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

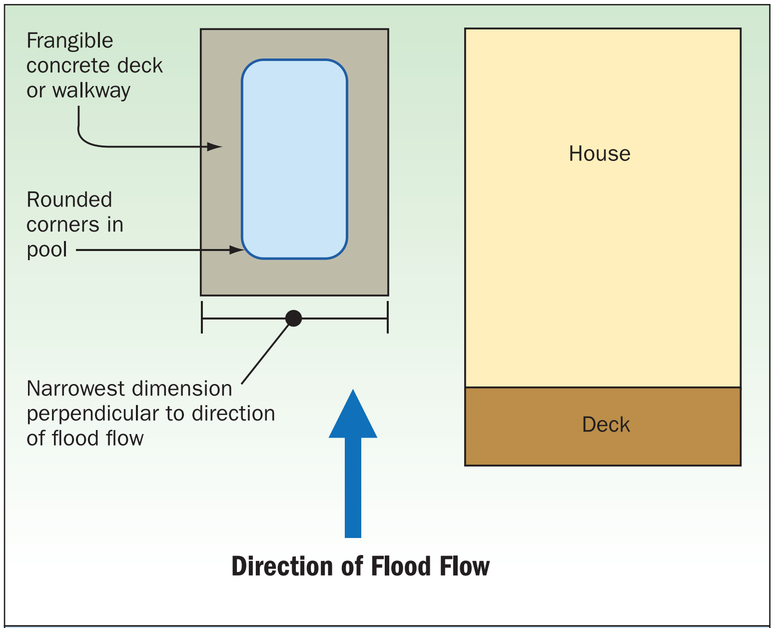
Swimming Pools

Requirements

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

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

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



Siting and design recommendations for swimming pools in coastal areas.

Recommendations

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

Accessory Buildings

Requirements

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

Recommendations

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

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

Small accessory building anchored to resist wind forces.

Additional Resources

FEMA. NFIP Technical Bulletin 2-08, *Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas*. (http://www.fema.gov/library/viewRecord.do?id=1580)

FEMA. NFIP Technical Bulletin 4-10, *Elevator Installation for Buildings Located in Special Flood Hazard Areas*. (http://www.fema.gov/library/viewRecord.do?id=1717)

FEMA. NFIP Technical Bulletin 5-08, *Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas*. (http://www.fema.gov/library/viewRecord.do?id=1718)

Protecting Utilities

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

Key Issues:

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

Electrical lines and box dislocated by hurricane forces.

Coastal Hazards That Damage Utility Equipment

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

Common Utility Damage in Coastal Areas

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

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

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

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

Basic Protection Methods

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

Elevation

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

Component Protection

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

NFIP Utility Protection Requirements

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

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

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

ATTACHMENTS 8

Utility Protection Recommendations

Electrical

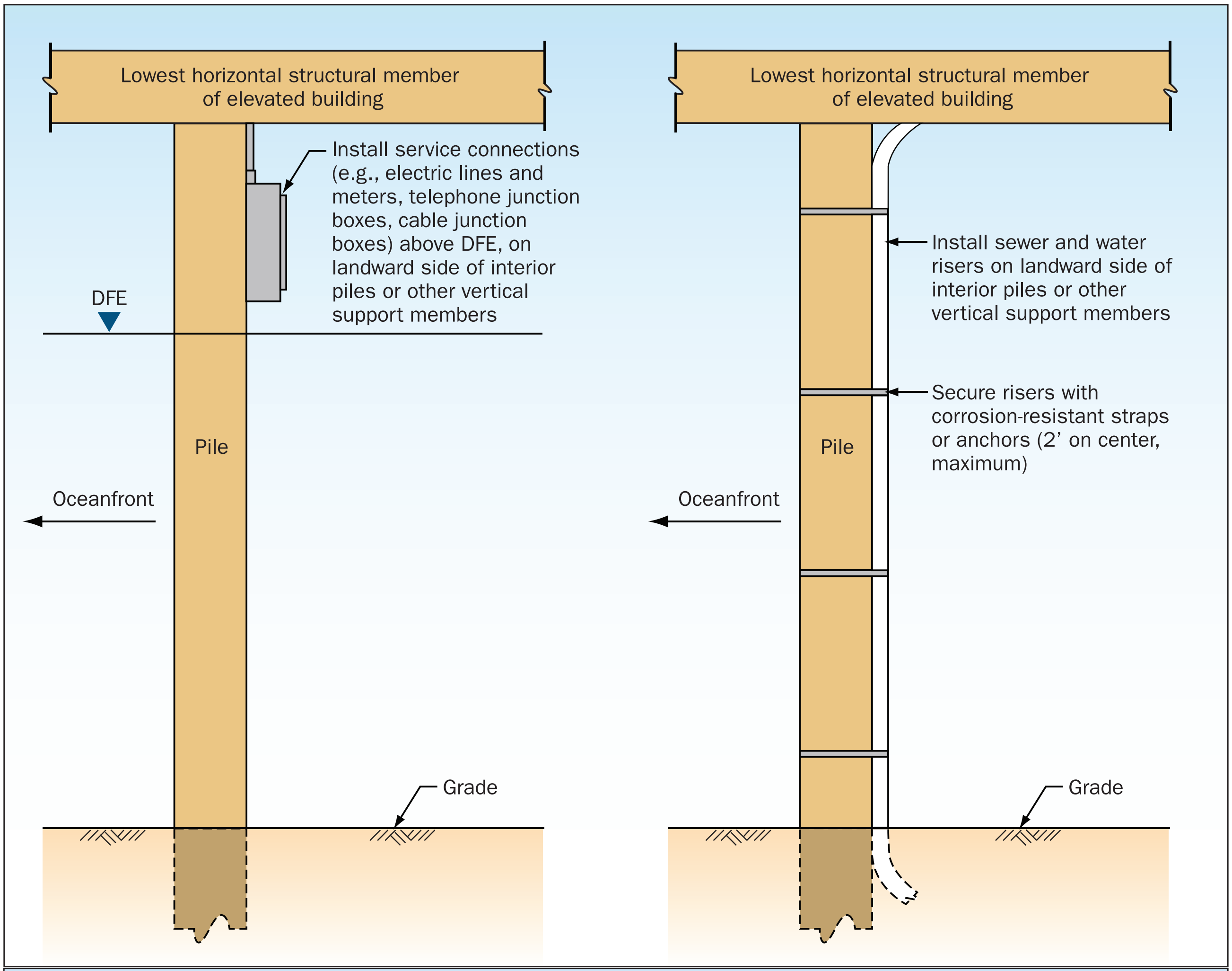
- Limit switches, wiring, and receptacles below the DFE to those items required for life safety. Substitute motion detectors above the DFE for below-DFE switches whenever possible. Use only ground-fault-protected electrical breakers below the DFE.
- Install service connections (e.g., electrical lines,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

Water/Sewage

- Attach plumbing risers on the landward side of interior piles or other vertical support members.
- When possible, install plumbing runs inside joists for protection.
- Never attach plumbing runs to breakaway walls.

HVAC

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



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

Fuel

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

Elevated air conditioning compressors.

Additional Resources

American Society of Civil Engineers. *Flood Resistant Design and Construction* (SEI/ASCE 24-05). (http://www.asce.org)

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

FEMA. *Protecting Building Utilities From Flood Damage*. FEMA 348. November 1999. (http://www.fema.gov/library/viewRecord.do?id=1750)

ATTACHMENTS 8

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

Repairs, Remodeling, Additions, and Retrofitting – Flood

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION Technical Fact Sheet No. 9.1

Purpose: *To outline National Flood Insurance Program (NFIP) requirements for repairs, remodeling, and additions, and opportunities for retrofitting in coastal flood hazard areas; to provide recommendations for exceeding those minimum requirements.*

Key Issues

- Existing buildings that sustain substantial damage or that are substantially improved (see box on page 3) will be treated as new construction and must meet the community's current flood-resistant construction requirements (e.g., lowest floor elevation, foundation, and enclosure requirements).
- Work on post-Flood Insurance Rate Map (FIRM)[1] existing buildings that are not substantially damaged or substantially improved (see box on page 3) must meet the community's flood-resistant construction requirements that were in effect when the building was originally constructed.
- Work on pre-FIRM[1] existing buildings that are not substantially damaged or substantially improved (see box on page 3) is not subject to NFIP flood-resistant construction requirements.
- With some minor exceptions (e.g., code violations and historic buildings), substantial damage and substantial improvement requirements apply to all buildings in the flood hazard area, whether or not a flood insurance policy is in force.
- Buildings damaged by a flood and covered by flood insurance may be eligible for additional payments through the Increased Cost of Compliance (ICC) policy provisions. Check with an insurance agent and the authority having jurisdiction (AHJ) for details.
- Repairs and remodeling—either before or after storm damage—provide many opportunities for retrofitting homes and making them more resistant to flood damage.

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

Rules governing the applicability of NFIP new construction requirements to existing buildings are confusing to many people; this fact sheet and Fact Sheet No. 1.2, Summary of Coastal Construction Requirements and Recommendations for Flood Effects provide guidance on the subject.

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

- **Value of damage/work–** whether the cost of repairs to the damaged building triggers substantial damage or substantial improvement regulations (see page 3).
- **Nature of work–** whether the work involves an expansion of the building, either laterally or vertically (an addition), or an enclosure of space below the Base Flood Elevation (BFE), or the demolition and reconstruction of an existing building, or the relocation of an existing building.

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

REPAIRS 9

1 Pre-FIRM is defined as a building for which construction or substantial improvement occurred on or before December 31, 1974, or before the effective date of the initial Flood Insurance Rate Map (FIRM) for the community. Post-FIRM is defined as a building for which construction or substantial improvement occurred after December 31, 1974, or on or after the effective date of the initial Flood Insurance Rate Map (FIRM) for the community.

2 This fact sheet and Fact Sheet No. 2 recommend meeting current NFIP/community requirements in these instances.

12/10

- **Pre-FIRM or post-FIRM building–** different requirements may apply to pre-FIRM existing buildings.
- **Flood zone–** different requirements may apply in V Zones and A Zones (this includes both the Coastal A Zone and A Zone).

Two other factors may need to be considered (consult the AHJ regarding whether and how these factors apply):

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

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

Code Compliance

Definitions from the International Code Council Model Building Codes

ADDITION: An extension or increase in floor area or height of a building or structure.

ALTERATION: Any construction or renovation to an existing structure other than repair or addition that requires a permit. Also, a change in a mechanical system that involves an extension, addition or change to the arrangement, type or purpose of the original installation that requires a permit.

REPAIR: The reconstruction or renewal of any part of an existing building for the purpose of its maintenance.

2009 International Residential Code Requirements for Additions, Alterations or Repairs

R102.7.1 Additions, alterations or repairs. Additions, alterations, or repairs to any structure shall conform to the requirements for a new structure without requiring the existing structure to comply with all of the requirements of this code, unless otherwise stated. Additions, alterations or repairs shall not cause an existing structure to become unsafe or adversely affect the performance of the building.

What Is Substantial Damage?

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

What Is Substantial Improvement?

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

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

Substantial Damage and Substantial Improvement

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

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

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

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

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

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

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

Additions

Additions increase the square footage or external dimensions of a building. They can be divided into *lateral additions, vertical additions, and enclosures of areas below existing buildings.* When considering additions, it is important to consider that changes to the shape of the building may impact the potential damages to the house. A lateral addition may change the way flood waters travel around the structure and potentially create obstructions for flood-borne debris that may require additional foundation modifications. Vertical additions may also impose greater loads on the existing structure. A qualified design professional should evaluate the loading to the entire structure to see if additional structural modifications are required in order to maintain the structure's ability to sustain flood loading.

Lateral Additions

- If a *lateral addition* constitutes a substantial improvement to a V Zone building, *both the addition and the existing building must comply* with the effective base flood elevation, foundation, and other flood requirements for new V Zone construction (see Figure 1).

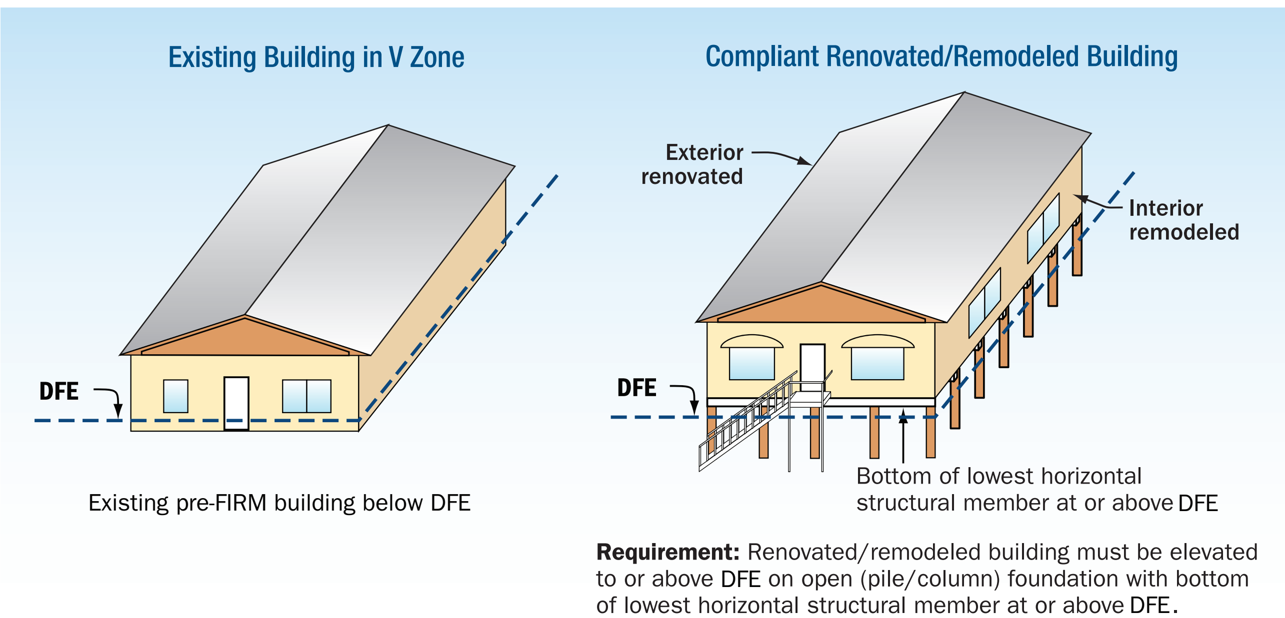


Figure 1. Substantial improvement: Renovated/remodeled building in a V Zone.

- If a lateral addition constitutes a substantial improvement to an A Zone building, only the addition must comply with the current floor elevation, foundation, and other flood requirements for new construction, as long as the alterations to the existing building are the minimum necessary.[3] *Minimum alterations necessary* means the existing building is not altered, except for cutting an entrance through the existing building wall into the addition, and except for the minimum alterations necessary to tie the addition to the building. If more extensive alterations are made to the existing building, it too must be brought into compliance with the requirements for new construction.
- If a lateral addition to a pre-FIRM building does not constitute a substantial improvement, neither the addition nor the existing building must be elevated. However, the HBGCC recommends that both the existing building and the addition be elevated to, or above, the current DFE, in a manner consistent with current NFIP requirements for new construction, and using a V Zone-type foundation in V Zones and in Coastal A Zones.
- If a lateral addition to a post-FIRM building does not constitute a substantial improvement, the addition must be elevated in accordance with the flood requirements in effect at the time the building was originally constructed, even if the BFE and flood hazard have changed over time. The HBGCC recommends that both the existing building and the addition be elevated to, or above, the current DFE, in a manner consistent with current NFIP requirements for new construction, and using a V Zone-type foundation in V Zones and in Coastal A Zones (see Figure 2).

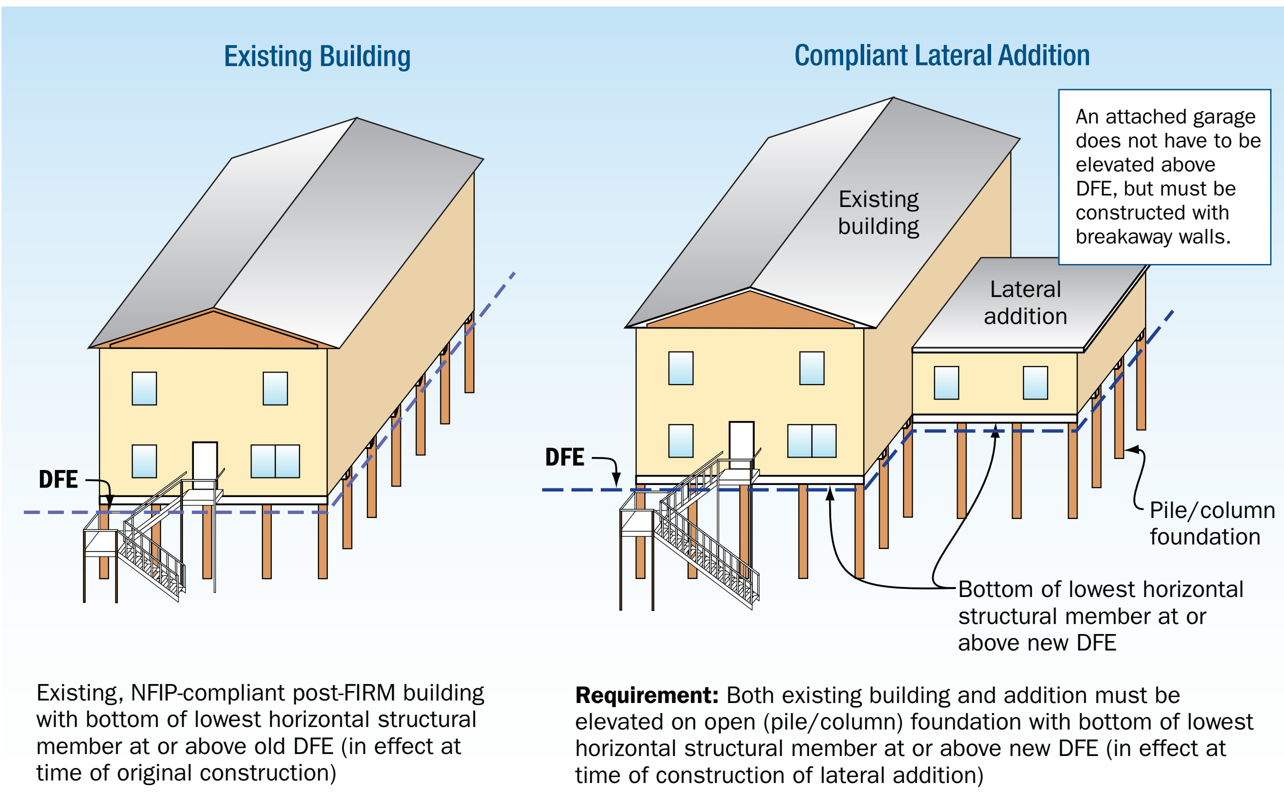


Figure 2. Substantial improvement: Lateral addition to a pre-FIRM building in a V Zone.

3 However, the HBGCC recommends that both the existing building and the addition be elevated to, or above, the current DFE, in a manner consistent with current NFIP requirements, and using a V Zone-type foundation in Coastal A Zones.

Vertical Additions

- If a vertical addition to a V Zone or A Zone building constitutes a substantial improvement, both the addition and the existing building must comply with the effective base flood elevation, foundation, and other flood requirements for new construction (see Figure 3).

- If a vertical addition to a pre-FIRM V Zone or A Zone building does not constitute a substantial improvement, neither the addition nor the existing building must be elevated or otherwise brought into compliance with NFIP requirements. However, the HBGCC recommends that both the addition and the existing building be elevated to, or above, the current DFE in a manner consistent with current NFIP requirements for new construction, and using a V Zone-type foundation in V Zones and in Coastal A Zones (see Figure 3). The HBGCC also recommends strongly against using any space below the current BFE for habitable uses (uses permitted by the NFIP are parking, storage, and building access).

- If a vertical addition to a post-FIRM V Zone or A Zone building does not constitute a substantial improvement, the addition must be designed and constructed in accordance with the flood requirements in effect at the time the building was originally constructed. However, BFEs and flood zones change over time as areas are remapped. The HBGCC recommends that both the addition and the existing building be elevated to, or above, the current DFE in a manner consistent with current NFIP requirements for new construction, and using a V Zone-type foundation in V Zones and in Coastal A Zones. The HBGCC also recommends strongly against using any space below the current BFE for habitable uses (uses permitted by the NFIP are parking, storage, and building access).

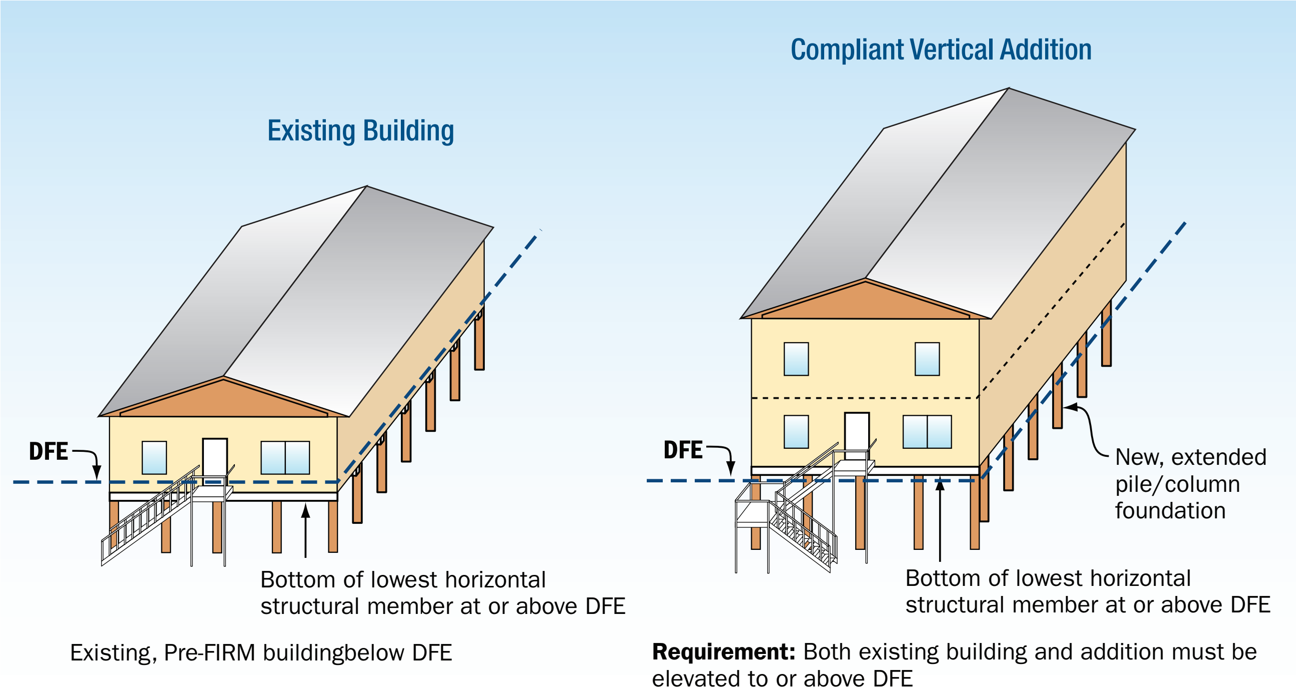


Figure 3. Substantial improvement: Vertical addition to a pre-FIRM building in a V Zone.

Enclosures of Areas Below Existing Buildings

Enclosures below existing buildings are treated like vertical additions.

Existing NFIP requirements: (1) do not enclose and convert to habitable use any space below the BFE under any circumstances, and (2) construct only breakaway enclosures below existing buildings in V Zones and in Coastal A Zones. HBGCC recommendation: in V Zones and Coastal A Zones the area below the BFE should be built free of obstruction. Use open lattice, screening, or breakaway walls. For requirements concerning enclosures below elevated buildings see Fact Sheet 8.1. It should be noted that enclosures built with breakaway walls below the BFE may result in increased insurance premiums when compared to an open foundation.

Reconstruction of a Destroyed or Razed Building

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

Moving an Existing Building

When an existing building (pre-FIRM or post-FIRM, V Zone or A Zone) is moved to a new location or site, the work is considered "new construction" and if the relocated building is in the SFHA, it must be installed so as to comply with NFIP requirements.

Materials

When constructing in coastal environments, carefully consider what construction materials to select. The NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements* (August 2008), provides valuable information regarding the applicability of various construction materials in a coastal environment. For additional information, see Fact Sheet 1.7, Coastal Building Materials. Following a storm event, repairs should not be started until the problem is properly evaluated and materials are selected that will entirely remedy the damage. All costs of repairs should be identified and quantified prior to starting repairs.

Repairs

Correction of only the apparent surface damage can lead to unaddressed or overlooked problems beneath the surface that can potentially cause major issues with the structural stability of the building. Proper inspections of damage often not only require demolition or removal of the physically damaged building component, but also removal of associated exterior cladding. Wind-driven rain for example can lead to compromised connections and the decaying or rotting of building materials that may not be visible without further investigation.

Insurance Consequences

Designers and owners should know that the work described previously may have insurance consequences, especially if not completed strictly in accordance with NFIP requirements.

In general, most changes to an existing building that result from less-than-substantial damage, or that do not constitute substantial improvement, will not change the status from pre-FIRM to post-FIRM. However, it is required that substantially improved or substantially damaged buildings be brought into compliance. NFIP flood insurance policies on those buildings are written using rates based on elevation. In most cases, the premium will decrease when a pre-FIRM building is substantially improved and brought into compliance. The building becomes a post-FIRM building and premiums are calculated using elevation rates. Failure to comply with the substantial damage or substantial improvement requirements will result in a building's status being changed and in higher flood insurance premiums. For example:

- If an NFIP-compliant enclosure built with breakaway walls is added below a post-FIRM V Zone building, the building will no longer be rated as "free of obstructions." Flood insurance premiums on these buildings will be higher. If the enclosure is not compliant with all NFIP requirements, higher premiums will result.
- If work on an existing V Zone building constitutes a substantial improvement, the building will be rated on a current actuarial basis. Any pre-FIRM designation will be lost and current post-FIRM rates will be used.
- If an NFIP-compliant lateral addition constituting a substantial improvement is made to a pre-FIRM A Zone building and no changes were made to the existing building, the building will retain its pre-FIRM designation and rating. However, if the addition does not comply with all requirements, or if more than the minimum alteration necessary was made to the existing building, the building and addition's lowest floor must be elevated to or above the BFE. The building including the addition will be rated with post-FIRM actuarial rates.

Retrofit and Remodeling Opportunities

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

- Improving ***floor-framing-to-beam*** connections whenever they are accessible (see Fact Sheet 4.1, *Load Paths* and Fact Sheet 4.3, *Use of Connectors and Brackets* for additional information).
- Improving ***beam-to-pile connections*** whenever they are accessible (see Fact Sheet 3.3, *Wood-Pile-to-Beam Connections* for additional information).
- Periodically checking and inspecting ***flood openings*** to make sure that they are not blocked and functioning properly. If the house is older, check to make sure that flood openings are sized correctly. Consult NFIP Technical Bulletin 1, *Openings In Foundation Walls and Walls of Enclosures* (August 2008) for proper flood opening guidance. Also see Fact Sheet 3.5, *Foundation Walls* for additional information.
- At any time deficient ***metal connectors*** are found, they should be replaced with stainless steel connectors or metal connectors with proper corrosion protection, such as hot-dip galvanized steel (see Fact Sheet 1.7, *Coastal Building Materials* for additional information).
- When ***HVAC equipment*** is replaced, the replacement equipment selected should incorporate a more corrosion-resistant design—so that it will last longer in a coastal environment—and should be elevated to, or above, the DFE. The equipment should be adequately anchored to resist wind and seismic loads (see Fact Sheet 8.3, *Protecting Utilities* for additional information).
- Improving ***utility attachments*** when the outside equipment is replaced or relocated (see Fact Sheet 8.3, *Protecting Utilities* for additional information).
- To minimize the effects of corrosion, carbon steel ***handrails*** can be replaced at any time with vinyl-coated, plastic, stainless steel, or wood handrails. Wood handrails may require frequent treatment or painting and appropriate fasteners must be used (see Fact Sheet 1.7, *Coastal Building Materials* for additional information). Carbon steel handrails may also be painted with a zinc-rich, vinyl, or epoxy paint appropriate for exposed wet and salt-spray environments. Regardless of the product used, proper maintenance is always necessary in order to ensure a safe handrail.
- Consider ***sewer backflow preventer*** valves if they are not currently part of the building's plumbing. The installation should be done by a licensed plumber.
- If the current water heater is at, or below, the DFE, consider switching to a tankless water heater. A tankless water heater will take up less space and can be mounted to a wall due to its small size. In addition to allowing the user to mount it higher than a traditional water heater, it may also result in reduced energy costs.
- Older structures should consider elevation as a possible retrofit or mitigation opportunity. Older pre-FIRM structures can be at significant risk to flooding events. In coastal environments, even a little additional elevation can result in improved flood resistance. Costs can vary greatly depending on the type of foundation. It is important when considering an elevation project to consult a design professional before considering how much elevation and the appropriate foundation type. A contractor experienced with the elevation of buildings should be used for the actual lifting of the house. It is common for the house to require other structural work to the interior and exterior following the elevation. Before undertaking an elevation, consider the elevation process, which usually results in the structure being set on top of a foundation that is more level than the original foundation. This process can result in cosmetic cracking as the structure's foundation settles again and may require additional work to get the structure's aesthetics back to a pre-elevation appearance.

Additional Resources

FEMA. 2010. *Substantial Improvement/Substantial Damage Desk Reference*. FEMA P-758. http://www.fema.gov/library/viewRecord.do?id=4160

FEMA. 2005. *Coastal Construction Manual*, Chapter 14. FEMA 55. (http://www.fema.gov/library/viewRecord.do?id=1671)

Florida Department of Community Affairs. 2000. *A Local Official's Guide to Implementing the National Flood Insurance Program in Florida.* (See Chapter 6). (http://www.floridadisaster.org/Mitigation/NFIP/NFIPStudyCourse/Appendix%20E%20-%20FL%20Handbook.pdf)

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

Repairs, Remodeling, Additions, and Retrofitting – Wind

HOME BUILDER'S GUIDE TO COASTAL CONSTRUCTION — Technical Fact Sheet No. 9.2

Purpose: *To outline requirements and "best practice" recommendations for repairs, remodeling, and additions, and propose opportunities for retrofitting in coastal high-wind areas.*

Key Issue

- Repairs and remodeling– either before or after storm damage– provide many opportunities for retrofitting homes and making them more resistant to storm damage (see Figure 1).

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

Code Compliance

Definitions from the International Code Council (ICC) Model Building Codes

Addition: An extension or increase in floor area or height of a building or structure.

Alteration: Any construction or renovation to an existing structure other than repair or addition that requires a permit. Also, a change in a mechanical system that involves an extension, addition, or change to the arrangement, type, or purpose of the original installation that requires a permit.

Repair: The reconstruction or renewal of any part of an existing building for the purpose of its maintenance.

Factors That Determine Whether and How Existing Buildings Must Comply With Current Building Code Requirements

When undertaking repairs, remodeling, additions, or improvements to an existing building, there are two basic factors that determine whether and how the existing building must comply with building code requirements for new construction.

- ***Value of damage/work–*** whether the value of the building damage and/or work qualifies as substantial damage or substantial improvement under NFIP regulations (see text box).

International Residential Code (IRC) Requirements for Additions, Alterations or Repairs

R102.7.1 Additions, alterations or repairs. Additions, alterations, or repairs to any structure shall conform to the requirements for a new structure without requiring the existing structure to comply with all of the requirements of this code, unless otherwise stated. Additions, alterations, or repairs shall not cause an existing structure to become unsafe or adversely affect the performance of the building.

REPAIRS 9

- **Nature of work–** whether the work involves an expansion of the building, either laterally or vertically (an addition), or the demolition and reconstruction of an existing building, or the relocation of an existing building.

Two other factors occasionally come into play (consult the authority having jurisdiction [AHJ] regarding whether and how these factors apply):

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

Substantial Damage and Substantial Improvement

It is not uncommon for existing coastal buildings to be modified or expanded over time, often in conjunction with the repair of storm damage. *All repairs, remodeling, improvements, additions, and retrofitting to buildings must be made in conformance with existing building code requirements pertaining to substantial improvement and substantial damage.*

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

- All ***structural items and major building components*** (e.g., foundations; beams; trusses; sheathing; walls and partitions; floors; ceilings; roof covering; windows and doors; brick, stucco, and siding; attached decks and porches).
- ***Interior finish elements*** (e.g., tile, linoleum, stone, carpet; plumbing fixtures; gypsum wallboard and wall finishes; built-in cabinets, bookcases and furniture; hardware).
- ***Utility and service equipment*** (e.g., HVAC equipment; plumbing and wiring; light fixtures and ceiling fans; security systems; built-in appliances; water filtration and conditioning systems).
- Market value of ***all labor and materials*** for repairs, demolition, and improvements, including management, supervision, overhead, and profit (do not discount volunteer or self-labor or donated/discounted materials).

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

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

What Is Substantial Damage?

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

What Is Substantial Improvement?

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

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

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

Additions

Additions increase the square footage or external dimensions of a building. They can be divided into *lateral additions, vertical additions,* and *enclosures* of areas below *existing buildings*. When considering additions, it is important to consider that changes to the shape and roof line of the structure may impact the potential damages to the house. A lateral addition may change the number of openings, the way wind travels around the structure, or create a large open space that may require additional bracing.

Vertical additions may also impose greater loads on the existing structure. A qualified design professional should evaluate the loading to the entire structure to see if additional structural modifications are required in order to maintain the structure's ability to sustain high-wind loading.

Lateral Additions

- If a *lateral addition* constitutes *a substantial improvement to a building*, both the addition and the existing building must comply with the current wind loading requirements. The foundation, walls, and roof may need to be altered in order to comply with wind loading requirements.

Vertical Additions

- If a *vertical addition* to a building constitutes a substantial improvement, both the *addition and the existing building must comply* with the current wind loading requirements. The foundation, walls, and roof may need to be altered in order to comply with wind loading requirements. Vertical additions may apply significantly higher loadings to the foundation and first story, it is important to consider all of the framing and foundation modifications that need to be made (see Figure 2). Vertical additions may require the use of a geotechnical engineer and soil borings may be needed prior to design.

Materials

When constructing in coastal environments, carefully consider what construction materials to select. For additional information, see Fact Sheet 1.7, *Coastal Building Materials*. Wind events can cause damage to several parts of the structure. Often the damage will consist of not only wind related damage, but also water intrusion. Following a storm event, repairs should not be started until the problem is properly evaluated and materials are selected that will entirely remedy the damage.

Repairs

Correction of the apparent surface damage can lead to unaddressed or overlooked problems that can cause major issues with the structural stability of the building. Inspections often not only require demolition or removal of the physically damaged building component, but also removal of associated exterior cladding. Wind-driven rain can lead to compromised connections and decaying or rotting building materials that may not be visible without more investigation.

The repair of interior finishes damaged by wind-driven rain should be carefully considered. Coastal buildings are often subjected to high-wind events, which many times are accompanied by wind-driven rain. The wind pushes water through small openings in doors and windows. This does not suggest improper functioning of the door or window, but this is more the result of the pressures these openings are subjected to during high-wind events. Interior surfaces such as walls, floor, and cabinets may be subjected to water on a regular basis. These building components may require finishes that will resist repeated water contact.

Repairs may present an excellent opportunity to upgrade the house. Additional connectors for maintaining a load path, additional moisture barriers, and installation of wind-resistant components are some possible options. The section on "Retrofit and Remodeling Opportunities" will outline some options to consider when undergoing repairs.

Figure 2. Vertical addition to a home damaged by Hurricane Fran. Preexisting 1-story home became the second story of a home elevated to meet new foundation and floor elevation requirements.

Retrofit and Remodeling Opportunities

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

- When the ***roof covering*** is replaced, the attachment of the sheathing to the trusses or rafters can be checked, and additional load path connectors can be installed as necessary. The Technical Fact Sheets located in Category 7 of this publication provide details on how to improve the roof system's ability to resist wind and water intrusion. The common elements of a roof system should be carefully evaluated in order to address opportunities to improve the load path and water resistance of the system. The most common repair necessary following a storm event is the roof covering. When reroofing, tear-off is recommended instead of re-covering. Although some

REPAIRS 9

jurisdictions allow for reroofing, this method may prevent the identification of more serious inadequacies in the system and result in more catastrophic failures in the next event. A roof covering project should be viewed as an opportunity to evaluate the strength of the roof sheathing. With the removal of the roof covering, a careful inspection of the sheathing should be conducted to look for darkened areas or areas subjected to water damage. If detected, these areas should be replaced. The thickness of the roof sheathing should be inspected to verify that it is of a sufficient thickness to resist the design wind speeds for your area. Also, consult the information in Fact Sheet 7.1, *Roof Sheathing Installation*, in order to improve roof system connections. Replacement of roof coverings also may provide opportunities to evaluate the adequacy of rafter or truss to wall system connections and install hurricane/seismic connectors. Information on these connections can be found in Fact Sheet 4.1, *Load Paths* and Fact Sheet 4.3, *Use of Connectors and Brackets*.

- If ***siding*** or ***roof sheathing*** has to be replaced, hurricane/seismic connectors can be installed at the rafter-to-wall or truss-to-wall connections, the exterior wall sheathing attachment can be checked, and structural sheathing can be added to shearwalls. Adding wall-to-foundation ties may also be possible. Verify that all exterior sheathing (wall and roof) is approved for use on exterior surfaces. Verify that fasteners are indeed connecting the exterior sheathing to the framing. See Fact Sheet 4.1, *Load Paths* and Fact Sheet 4.3, *Use of Connectors and Brackets* for additional information.

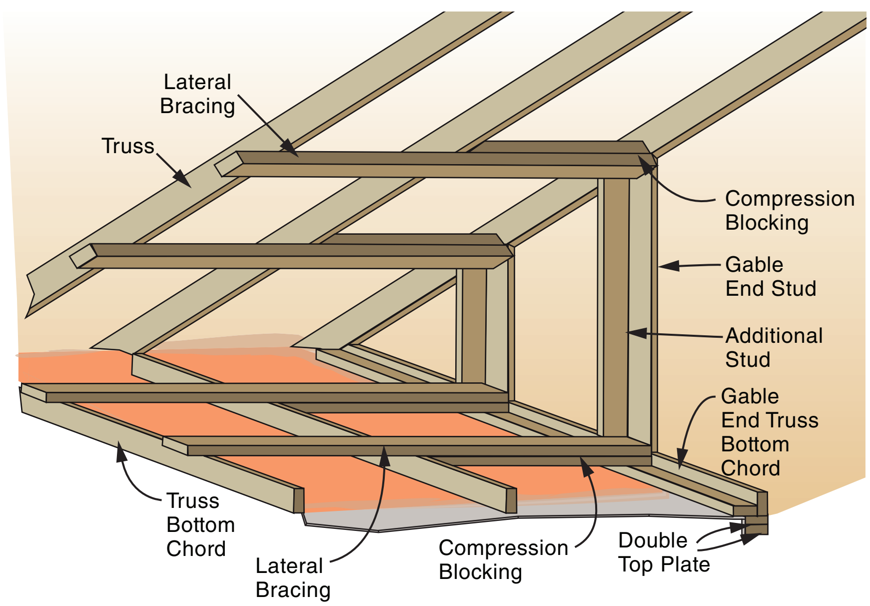


Figure 3. Typical gable end wall bracing retrofit example.

- ***Gable ends*** can be braced in conjunction with other retrofits or by themselves. The illustration in Figure 3 shows a typical gable end wall bracing system. These improvements are typically inexpensive, allow the loads imposed on the gable end walls to be distributed through multiple roof trusses or rafters, and assist in distributing the wind loads on the gable ends. Additional guidance for gable ends can be found in the *Gable End Retrofit Guide – Florida Division of Emergency Management*.

- Exterior ***siding*** attachment can be improved with more fasteners at the time the exterior is recoated. See Fact Sheet 5.3, *Siding Installation in High-Wind Regions* for additional information.

- ***Window, door,*** and ***skylight*** reinforcement and attachment can be improved whenever they are accessible. Following a high-wind event, windows and doors should be checked for leaks. The framing should be checked for cracked paint or discolored paint. If the doors and windows are not shutting correctly, then this may indicate that the framing around the window or door suffered water damage. Check for worn areas where paint or caulking is missing and investigate for water damage or intrusion. Repair any water-damaged areas immediately. Framing should be inspected to verify that it is sufficiently attached to the wall system to provide sufficient protection. Improperly framed windows and doors have been found forced from their framing. See Fact Sheet 6.1, *Window and Door Installation* for additional information.

- When ***windows*** and ***doors*** are replaced, glazing and framing can be used that is impact-resistant and provides greater UV protection. The windows and doors must meet wind-resistance standards and be installed in accordance with the manufacturer's installation instructions for high wind. Fasteners should be long enough to attach the window or door to wall framing around the opening. Fasteners should be spaced no greater than 16 inches unless otherwise stated by the manufacturer's recommended installation instructions. See Fact Sheet 6.2, *Protection of Openings–Shutters and Glazing*, for additional information on protecting openings. Verify that doors meet ASTM E330 and DASMA 108 and that windows meet ASTM E1886 and E1996 or Miami-Dade TAS 201, 202 and 203.

- ***Soffits*** should be inspected following high-wind events to determine whether structural upgrades are necessary. Soffit failures are common during storms and damage is often experienced in attics due to water being blown in through open soffits. Proper attachment is the most common problem noted with soffit failures. Wood backing or supports should be installed in order to provide a structural member to attach the soffit panels to. If it is not possible to install wood supports, the soffit should be secured at 12-inch intervals on each side in order to limit its ability to flex during high-wind events. See Fact Sheet 7.5, *Minimizing Water Intrusion through Roof Vents in High-Wind Regions* for additional information.
- Hurricane ***shutters*** can be added at any time (see Fact Sheet 6.2, *Protection of Openings– Shutters and Glazing*). Shutter systems should be purchased and installed well before a storm event. It is important to take the time necessary to verify that hangers and attachment systems are properly anchored to the structural system of the building. Shutter systems should be anchored to the building and maintain the load path of the building.
- ***Floor-framing-to-beam connections*** can be improved whenever they are accessible. See Fact Sheet 4.1, *Load Paths* and Fact Sheet 4.3, *Use of Connectors and Brackets* for additional information.
- ***Beam-to-pile connections*** can be improved whenever they are accessible. See Fact Sheet 3.3, *Wood Pile-to-Beam Connections* for additional information.
- At any time, deficient ***metal connectors*** should be replaced with stainless steel connectors or metal connectors with proper corrosion protection such as hot-dip galvanized steel. See Fact Sheet 1.7, *Coastal Building Materials* for additional information.
- When ***HVAC equipment*** is replaced, the replacement equipment should be more durable so that it will last longer in a coastal environment. It should also be elevated at, or above, the Base Flood Elevation (BFE) and adequately anchored to resist wind and seismic loads. See Fact Sheet 8.3, *Protecting Utilities* for additional information.
- ***Utility attachment*** can be improved when the outside equipment is replaced or relocated. See Fact Sheet 8.3, *Protecting Utilities* for additional information.
- In the ***attic space***, at any time, *straps* should be added to rafters across the ridge beam, straps should be added from rafters to wall top plates, and gable end-wall framing should be braced. In addition, the uplift resistance of the roof sheathing can be increased through the application of APA AFG-01 or ASTM 3498 (see additional resources for more information) rated structural *adhesive* at the joints between the roof sheathing and roof rafters or trusses. The adhesive should be applied in a continuous bead and extended to the edges of the roof (where some of the highest uplift pressures occur). At the last rafter or truss at gable ends, where only one side of the joint is accessible, wood strips made of quarter-round molding may be embedded in the adhesive to increase the strength of the joint. For more information about the use of adhesive, see the “Additional Resources” section.
- The addition of ***air admittance valves (AAV)*** on all plumbing fixtures can reduce the need for roof penetrations required for conventional venting systems. The reduction in roof penetrations will reduce roof maintenance and reduce the number of openings available for water penetration. AAVs are not allowed in all jurisdictions, so verify with a licensed plumber that they are allowed in the jurisdiction where the house is being constructed.
- At any time, ***garage doors*** should be reinforced or replaced with new wind- and debris-resistant doors. There are some reinforcement kits available to provide both vertical and horizontal reinforcement of the garage door. If the garage door requires replacement, then select one that meets the design wind-speed requirements for your area. See Fact Sheet 6.2, *Protection of Openings– Shutters and Glazing*, for additional guidance on protecting openings and garage door guidance.
- To minimize the effects of corrosion, ***metal light fixtures*** can be replaced at any time with fixtures that have either wood or vinyl exteriors. However, wood may require frequent treatment or painting. See Fact Sheet 1.7, *Coastal Building Materials* for additional information.
- To minimize the effects of corrosion, carbon steel ***handrails*** can be replaced at any time with vinyl-coated, plastic, stainless steel, or wood handrails. Wood handrails may require frequent treatment or painting and appropriate fasteners must be used (see Fact Sheet 1.7, C*oastal Building Materials* for additional information). Carbon steel handrails may also be painted with a zinc-rich, vinyl, or epoxy paint appropriate for exposed wet and salt-spray environments. Regardless of the product used, proper maintenance is always necessary in order to ensure a safe handrail.

Additional Resources

APA – The Engineered Wood Association, 2001, *APA Specification* AFG-01.

ASTM, *Standard Specification for Adhesives for Field-Gluing Plywood to Lumber Framing for Floor Systems,* 2003, ASTM 3498-03.

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

FEMA, *Substantial Improvement /Substantial Damage Desk Reference* FEMA P-758, 2010, (http://www.fema.gov/library/viewRecord.do?id=4160)

FEMA, *Coastal Construction Manual*, FEMA-55, 2005, (http://www.fema.gov/library/viewRecord.do?id=1671)

Florida Department of Community Affairs, *A Local Official's Guide to Implementing the National Flood Insurance Program* in Florida, 2000, (http://www.floridadisaster.org/Mitigation/NFIP/NFIPStudyCourse/Appendix%20E%20-%20FL%20Handbook.pdf)

Florida Division of Emergency Management, *Gable End Retrofit Guide*. (http://www.floridadisaster.org/hrg)

References and Resources

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

References

A Dozen Things You Might Not Know That Make Vinyl Siding Green (http://vinylsiding.org/greenpaper/090710_Latest_Revised_Green_paper.pdf)

American Concrete Institute. *ACI Detailing Manual*. SP-66(04). 2004. (http://www.concrete.org)

American Concrete Institute. *Building Code Requirements for Structural Concrete and Commentary.* ACI 318-02. (http://www.concrete.org)

American Concrete Institute. *Design, Manufacture, and Installation of Concrete Piles.* ACI 543R-00. Reapproved 2005. (http://www.concrete.org)

American Forest and Paper Association. *National Design Specification for Wood Construction.* (http://www.afandpa.org)

American Institute of Timber Construction. (http://www.aitc-glulam.org)

American Institutes for Research. *Evaluation of the National Flood Insurance Program's Building Standards.* 2006. (http://www.fema.gov/library)

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

American National Standards Institute. *National Design Standard for Metal Plate Connected Wood Truss Construction.* ANSI/TPI-1 95.

American Society of Civil Engineers. *Minimum Design Loads for Buildings and Other Structures.* ASCE/SEI 7-05. (http://www.asce.org)

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

American Society of Civil Engineers. *Flood Resistant Design and Construction.* ASCE/SEI 24-05. (http://www.asce.org)

American Society for Testing and Materials. *Standard Practice for Application of Self-Adhering Modified Bituminous Waterproofing*. ASTM D6135-05. 2005. (http://www.astm.org)

American Society for Testing and Materials. *Standard Practice for Installation of Exterior Windows, Doors and Skylights.* ASTM E2112-07. (http://www.astm.org)

American Society for Testing and Materials. *Standard Specification for Round Timber Piles.* ASTM D25-99. 2005. (http://www.astm.org)

American Society for Testing and Materials. *Standard Specification for Adhesives for Field-Gluing Plywood to Lumber Framing for Floor Systems.* ASTM D3498-03. 2003. (http://www.astm.org)

American Society for Testing and Materials. *Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes.* ASTM E1996-09. (http://www.astm.org)

American Society for Testing and Materials. *Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials.* ASTM E1886-05. (http://www.astm.org)

American Society for Testing and Materials. *Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference.* ASTM E330-02. 2010. (http://www.astm.org)

American Forest Foundation, Inc. *American Tree Farm System.* (http://www.treefarmsystem.org/index.shtml)

American Wood Council. (http://www.awc.org)

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

APA, The Engineered Wood Association. *APA Specification AFG-01*. 2001. (http://www.apawood.org)

APA, The Engineered Wood Association. *Hurricane Shutter Designs Set 5 of 5. Hurricane Shutter Designs for Woodframe and Masonry Buildings.* (http://www.apawood.org)

Brick Industry Association. (http://www.gobrick.com)

Clemson University, Department of Civil Engineering and South Carolina Sea Grant Extension Program. *Not Ready to Re-Roof? Use Structural Adhesives to Strengthen the Attachment of Roof Sheathing and Holding onto Your Roof – A Guide to Retrofitting Your Roof Sheathing Using Adhesives*. (http://www.haznet.org/haz_outreach/outreach_factsheets.htm)

Coastal Contractor Magazine. Low Country Rx: Wet Floodproofing. Drainable, Dryable Assemblies Made With Water-tolerant Materials Help Speed Recovery From Deeper Than-expected Floods, by Ted Cushman. July 2006. (http://www.coastalcontractor.net/cgi-bin/issue.pl?issue=9)

Concrete Reinforcing Steel Institute. *Placing Reinforcing Bars – Recommended Practices.* PRB-2-99. (http://www.crsi.org)

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

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

Door and Access Systems Manufacturers Association. *Standard Method for Testing Sectional Garage Doors and Rolling Doors: Determination of Structural Performance Under Uniform Static Air Pressure Difference.* ANSI/DASMA 108-2005.

FEMA. *Above the Flood: Elevating Your Floodprone House.* FEMA 347. 2000. (http://www.fema.gov/library)

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

FEMA. *Coastal Construction Manual – Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas.* FEMA 55. 2005. (Ordering information at: http://www.fema.gov/pdf/plan/prevent/nhp/nhp_fema55.pdf)

FEMA. *Design Guide for Improving Critical Facility Safety from Flooding and High Winds.* FEMA 543. 2007. (http://www.fema.gov/library)

FEMA. *Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds: Providing Protection to People and Buildings.* FEMA 577. 2007. (http://www.fema.gov/library)

FEMA. *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures.* FEMA 259. January 1995. (http://www.fema.gov/library)

FEMA. *Flood Insurance Manual.* October 2010, January 2011. (http://www.fema.gov/business/nfip/manual.shtm)

FEMA. FloodSmart, the Official Site of the NFIP. (http://www.floodsmart.gov)

FEMA. *Homebuilders' Guide to Earthquake Resistant Design and Construction.* FEMA 232. 2001. (http://www.fema.gov/library)

FEMA. *Homeowner's Guide to Retrofitting, Six Ways to Protect Your House From Flooding.* FEMA 312. 1998. (http://www.fema.gov/library)

FEMA. Map Service Center. (http://www.msc.fema.gov)

FEMA. *Mitigation Assessment Team Report, Hurricane Charley in Florida: Building Performance Observations, Recommendations, and Technical Guidance.* FEMA 488. 2005. (http://www.fema.gov/library)

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

FEMA. *Mitigation Assessment Team Report, Hurricane Ivan in Alabama and Florida: Building Performance Observations, Recommendations, and Technical Guidance.* FEMA 489. 2005. (http://www.fema.gov/library)

FEMA. *Mitigation Assessment Team Report, Hurricane Katrina in the Gulf Coast: Building Performance Observations, Recommendations, and Technical Guidance.* FEMA 549. 2006. (http://www.fema.gov/library)

FEMA. NFIP Elevation Certificate and Instructions. (http://www.fema.gov/pdf/nfip/elvcert.pdf)

FEMA. NFIP Forms. (http://www.fema.gov/business/nfip/forms.shtm)

FEMA. NFIP Technical Bulletin 1-08, *Openings in Foundation Walls and Walls of Enclosures*. 2008. (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

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

FEMA. NFIP Technical Bulletin 4-10, *Elevator Installation.* 2010. (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

FEMA. NFIP Technical Bulletin 5-08, *Free-of-Obstruction Requirements.* 2008. (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

FEMA. *NFIP Technical Bulletin 8-96, Corrosion Protection for Metal Connectors in Coastal Areas.* 1996. (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

FEMA. NFIP Technical Bulletin 9-08, *Design and Construction Guidance for Breakaway Walls.* 2008. (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

FEMA. NFIP Technical Bulletin 10-01, *Ensuring that Structures Built on Fill In or Near Special Flood Hazard Areas are Reasonably Safe From Flooding.* 2001. (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

FEMA. NFIP Technical Bulletin 11-01, *Crawlspace Construction*. 2001. (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

FEMA. *Protecting Building Utilities From Flood Damage.* FEMA 348. 1999. (http://www.fema.gov/library)

FEMA. Protecting Manufactured Homes from Floods and Other Hazards. FEMA P-85. 2009. (http://www.fema.gov/library)

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

FEMA. *Reducing Flood Losses Through the International Code Series.* 2006 I-Codes with 2007 Supplement. (http://www.fema.gov/library)

FEMA. S*ubstantial Improvement/Substantial Damage Desk Reference.* FEMA P-758. 2010. (http://www.fema.gov/library)

Florida Department of Community Affairs. *A Local Official's Guide to Implementing the National Flood Insurance Program in Florida*. 2000. (http://www.floridadisaster.org/Mitigation/NFIP/NFIPStudyCourse/Appendix%20E%20-%20FL%20Handbook.pdf)

Florida Division of Emergency Management. *Hurricane Retrofit Guide.* (http://www.floridadisaster.org/hrg)

Florida Roofing, Sheet Metal and Air Conditioning Contractor's Association, Inc. *Concrete and Clay Roof Tile Installation Manual.* (http://www.floridaroof.com)

Forest Stewardship Council. (http://www.fsc-info.org)

Information about product testing and approval process for Miami-Dade County, Florida. (http://www.miamidade.gov/BuildingCode/home.asp)

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

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

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

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

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

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

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

National Roofing Contractors Association. *The NRCA Waterproofing Manual.* (http://www.nrca.net)

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

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

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

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

Professional Roofing. NRCA Analyzes and Tests Metal, by James R. Kirby and Bala Sockalingam. 2003. (http://www.professionalroofing.net/article.aspx?id=266)

The Journal of Light Construction. (http://www.jlconline.com)

The Masonry Society. *Building Code Requirements for Masonry Structures.* TMS 402-08/ACI 530-08/ASCE 5-08. 2008. (http://www.masonrysociety.org)

The Masonry Society. *Specifications for Masonry Structures.* TMS 402-08/ACI 530.1 08/ASCE 6-08. 2008. (http://www.masonrysociety.org)

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

Siding with the Environment (http://www.vinylsiding.org/publications/final_Enviro_single_pg.pdf).Southern Pine Council. (http://www.southernpine.com/about.shtml)

SFI Inc. Sustainable Forestry Initiative.® (http://www.sfiprogram.org)

Technical Notes 28 – Anchored Brick Veneer, Wood Frame Construction

Technical Notes 28B – Brick Veneer/Steel Stud Walls

Technical Notes 44B – Wall Ties

Timber Pile Council, American Wood Preservers Institute. Timber Pile Design and Construction Manual. (http://www.wwpinstitute.org/pdffiles/TimberPile-Manual.pdf)

U.S. Department of Housing and Urban Development. *Durability by Design, A Guide for Residential Builders and Designers.* 2002. (http://www.huduser.org/publications/destech/durdesign.html)

Vinyl Siding Institute. (http://www.vinylsiding.org)