Project 2
Housing Recommendations for Resiliency
ARC466-Architectural Design 4
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Group 3

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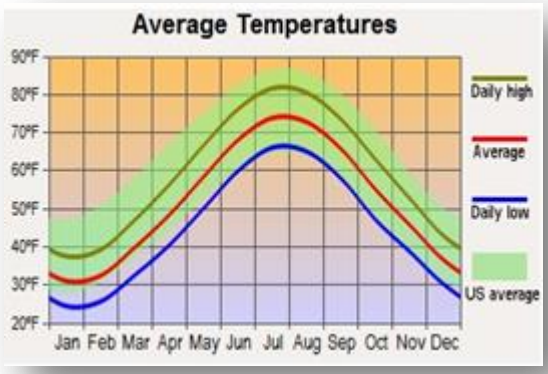
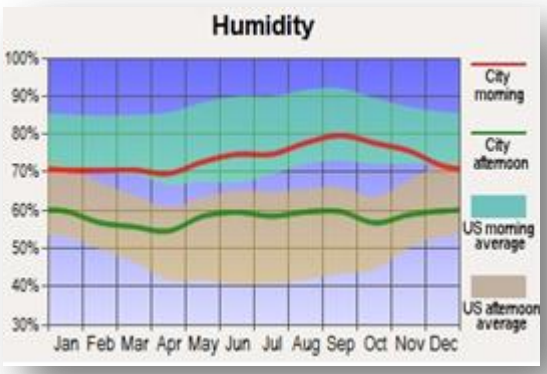
Summary

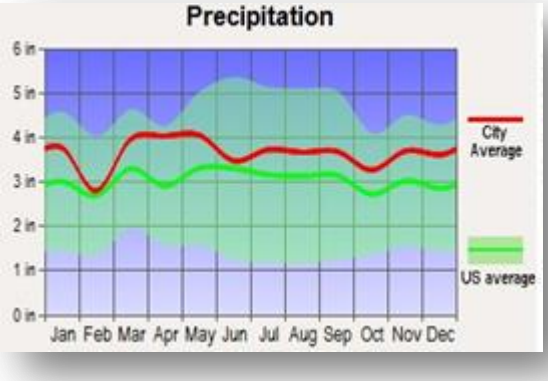
The purpose of this report is to develop ten recommendations that will assist in the process of building houses in southern Nassau County. Each developed dwelling unit must be resistant to future natural disasters such as hurricanes and various phenomena that cause flooding. In addition, this report will identify the adaptation of 5 innovative technologies that will enhance and reinforce the recommendations for resilient design features. Throughout the recommendation there are various conflicts between the new recommendations and the standards, but this conflict will be eliminated with the use of an alternate design or technical means. The recommendations are separated into ten categories based on Uniformat II. Foundations, Fire protection, electrical, Roof Construction, fenestration, plumbing, site, energy efficiency and exterior and interior finishes are the ten categories. After an in-depth look into the recommendations the five technologies are discussed, followed by the different conflicts caused by the recommendations.

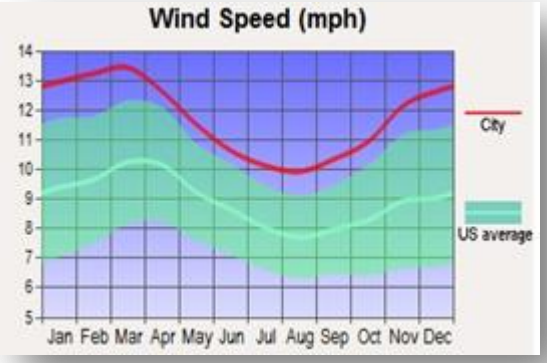
Environmental Key Issues

Very High Flood Risk
Very High Surge Risk
Very High Wind Speeds

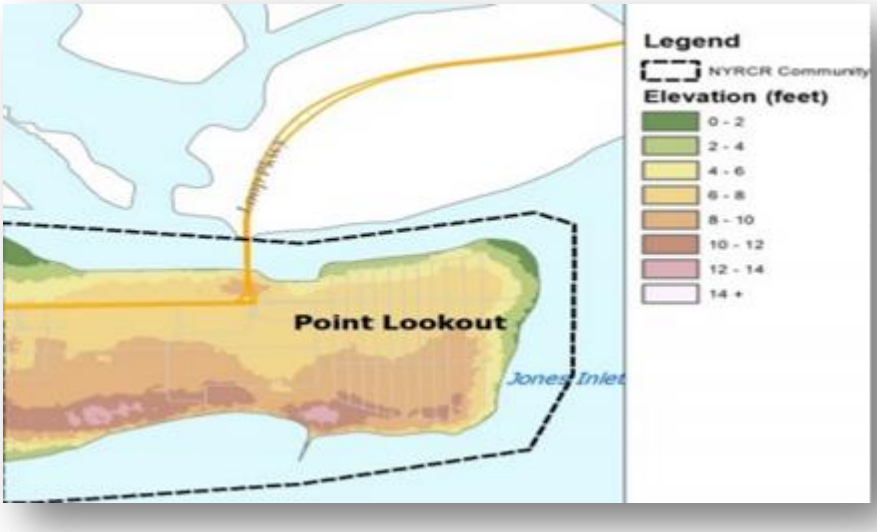


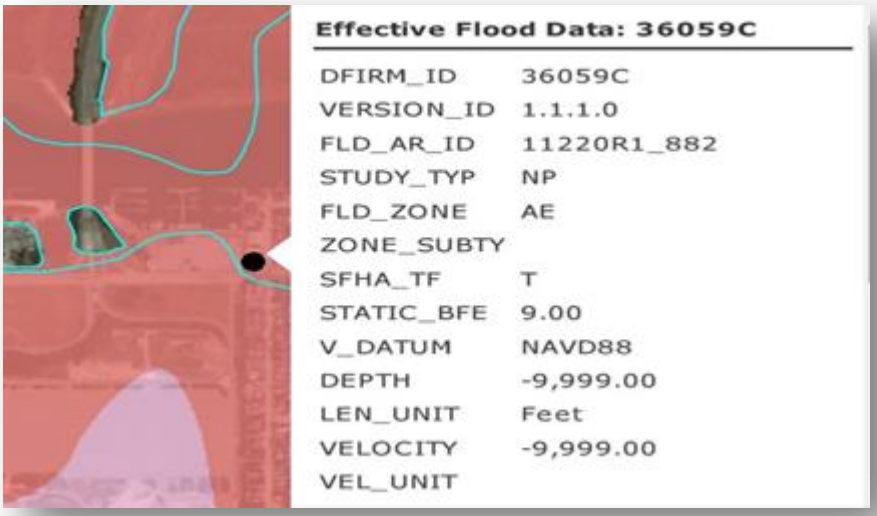




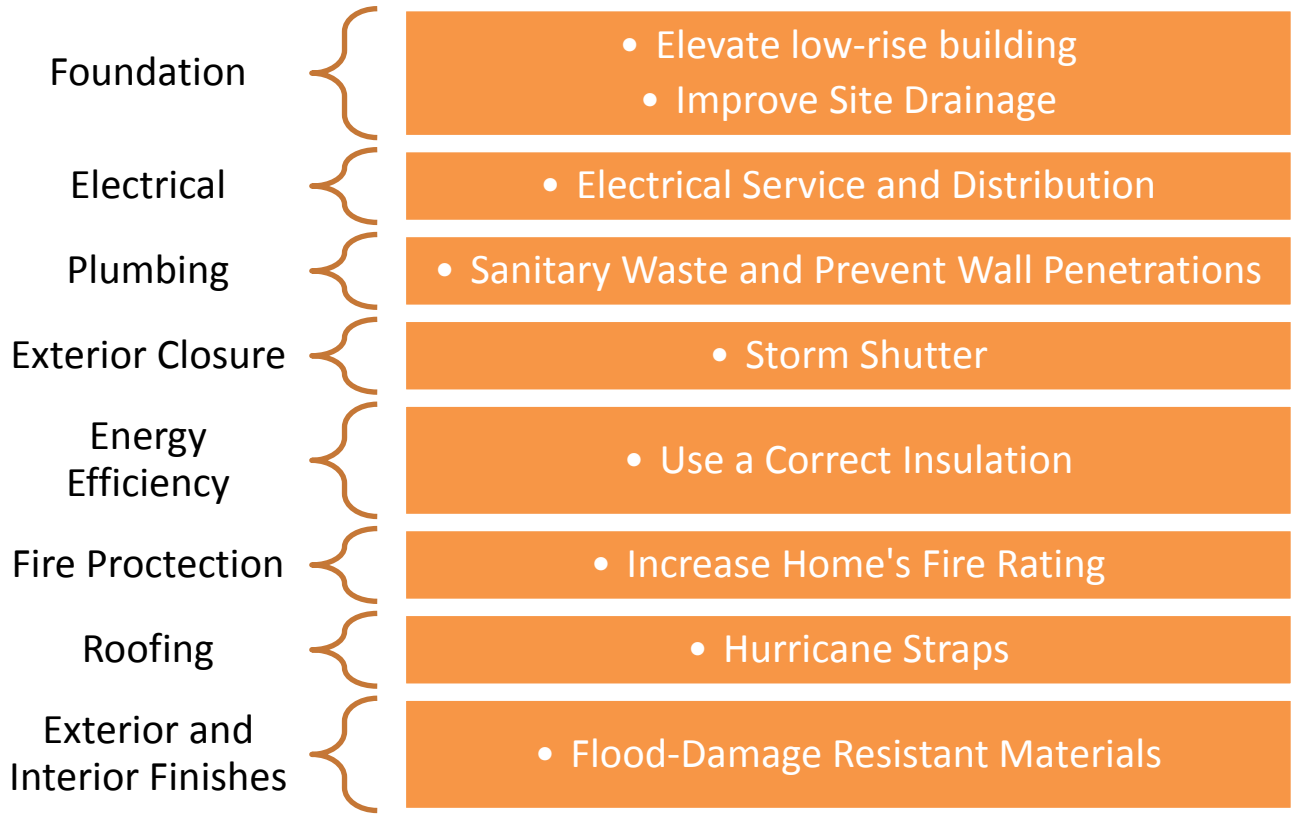


The site is located in Flood Zone AE.
Snowfall is about 27inches a year
Rainfall is about 42 inches a year
The highest temperature is reached in July.
The lowest temperature is reached in January.





List of Recommendations Based on ASTM UNIFORMAT II



Recommendation 1: Elevate low-rise building

Building floor elevation relative to the flood level has been one of the principal determinants of flood damage. Houses whose lowest floors were below the flood level were inundated at best or heavily damaged or destroyed by waves and debris at worst. One of the most common retrofitting methods is elevating a house to a required or desired Flood Protection Elevation (FPE). When a house is properly elevated, the living area will be above all but the most severe floods (such as the 500-year flood).

Local communities should ensure that existing low-rise buildings are elevated where possible and the foundations are replaced where needed. For example, in the case of a single-family dwelling for the community of Point Lookout, no building shall be greater in height than 2 1/2 stories, with a maximum height of 30 feet. In the case of a building other than a single-family dwelling, no building shall be greater than three stories or 45 feet in height, except a church.

Although numerous buildings were determined to have incurred Substantial Damage or were destroyed, many buildings sustained only minor structural damage. Even those buildings that do not meet the Substantial Damage threshold should be mitigated. At a minimum, these buildings should be brought to the current codes and standards for new construction adopted by the community. Where possible, a design professional may be able to assess an existing foundation and provide a design capable of withstanding future flood loads.

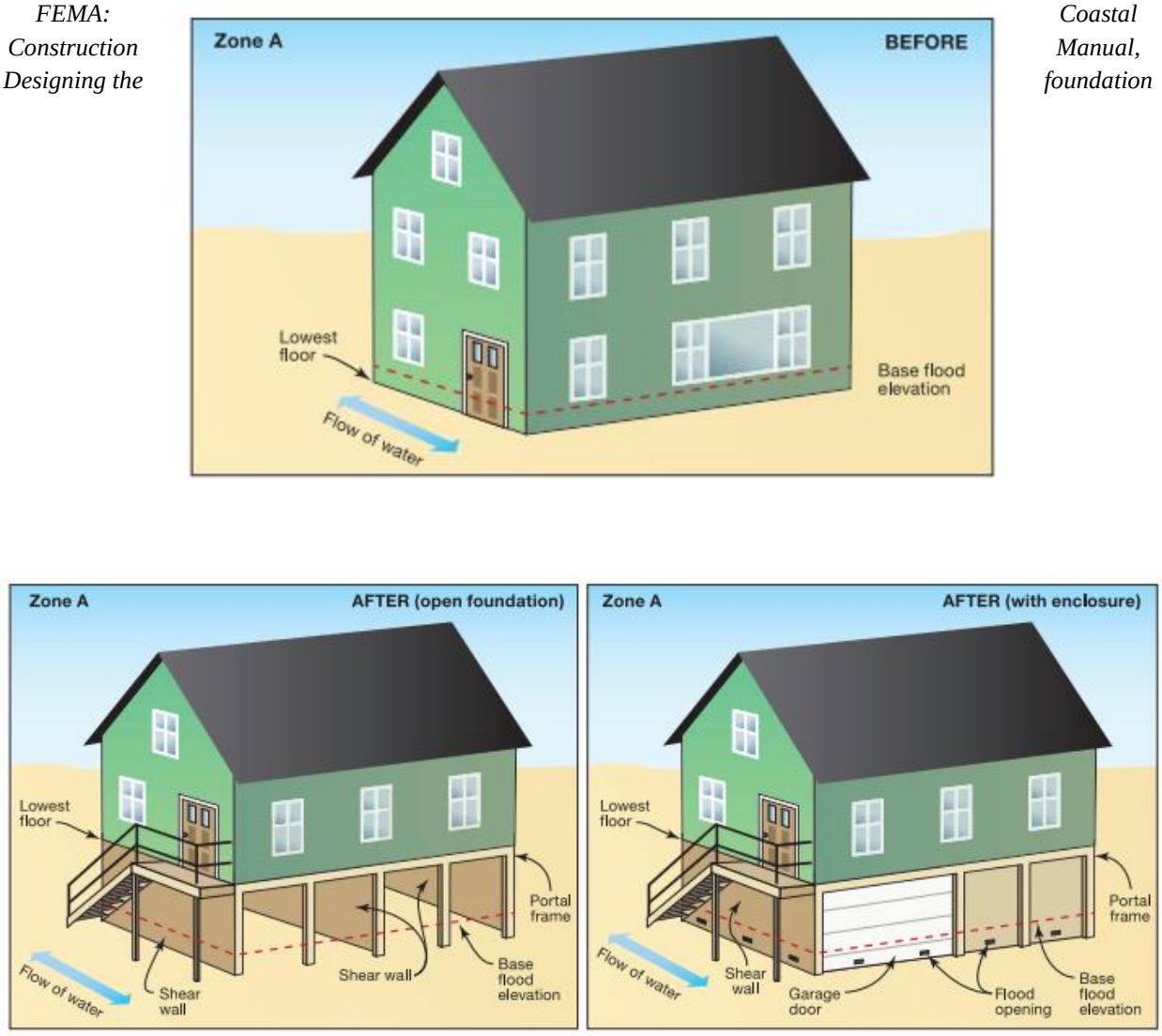
In order to raise a house, we recommend to Extended Foundation Walls. Frame, masonry veneer, and masonry houses can all be elevated on extended foundation walls. The technique used for houses on basement and crawlspace foundations differs from that used for houses on slab-on-grade foundations.

The extension in the foundation house will be produced using an open foundation. It allows water to pass through the foundation of an elevated building, reducing the lateral flood loads the foundation must resist. An open foundation is designed and constructed to minimize the amount of vertical surface area that is exposed to damaging flood forces. Open foundations have the added benefit of being less susceptible than closed foundations to damage from flood-borne debris because debris is less likely to be trapped. Table 1 shows the recommended practices in different zones.

Table 1 . Foundation Styles in Coastal Areas

Foundation Style	Zone V	Coastal A Zone (LiMWA)	Zone A
Open/deep	Acceptable	Acceptable	Acceptable
Open/shallow	Not permitted	Acceptable[a]	Acceptable
Closed/shallow	Not permitted	Not recommended	Acceptable
Closed/deep	Not permitted	Not recommended	Acceptable

FEMA: Construction Designing the



Coastal Manual, foundation

Figure 1. *Before (2.5-story house at-grade) and after (1.5-story house with NFIP-compliant open foundation or compliant enclosure below the BFE) of a house in Zone A with the lower floor converted using a shear wall and portal frame foundation system. FEMA; Reducing Flood Risk and Flood Insurance Premiums for Existing Residential Buildings in Zone A.*

In Zone A, a possible alternative to replacing wood-framed walls with concrete or masonry is to modify the walls by using a combination of wood shear walls and a series of portal frames, moment frames, or other methods to create an open foundation or foundation shear walls with a compliant enclosure. Shear walls are walls that are designed to resist the lateral (side-to-side) forces imposed by floodwater, wind, and earthquakes. Shear walls should be oriented parallel to the direction of floodwater movement. The existing wood-framed walls may need to be modified so they can resist all lateral and vertical loads (due to gravity or uplift from the wind), and a registered design professional must evaluate whether the load capacity of the wall

needs to be increased by adding additional structural sheathing (e.g., plywood sheathing), additional studs, wood blocking, anchors, fasteners, or structural connectors. If shear walls are used and the area below the lowest floor is enclosed, the walls connecting the shear walls should not be structurally connected, and should be designed to fail under base flood conditions. An example of such a wall is described in FEMA Technical Bulletin 9, Design and Construction Guidance for Breakaway Walls below Elevated Coastal Buildings (2008). If the shear walls are completely enclosed, the walls must have flood openings that automatically equalize hydrostatic flood forces on exterior walls.

Building codes may also require that fire protection measures, such as use of gypsum board (drywall), be incorporated into the design. Walls below the BFE with gypsum board would have to be constructed using paperless gypsum board. The registered design professional should also inspect the concrete slab and footings to verify that they are capable of withstanding the loads that the shear walls will transfer to them.

Recommendation 2: Improve Site Drainage

Depending on the specific characteristics of a particular watershed, one method to lessen the impacts of flooding is to modify the stream or river channel. Modifying the channel attempts to provide a greater carrying capacity for moving floodwaters away from areas where damage occurs. Methods of drainage improvements include overflow channels, channel straightening, restrictive crossing replacements, and rainfall/runoff storage. Table 2 presents a summary of advantages and disadvantages for using drainage improvements as a mitigation measure.

Table 2 . Considerations for Using Drainage Improvement

Advantages	Disadvantages
▪ Can increase a stream's carrying capacity through overflow channels, channel straightening, restrictive crossing replacements, or rainfall/runoff storage. ▪ Minor projects may be fundable under FEMA mitigation grant programs.	▪ May help one area but create new problems upstream or downstream of the proposed improvements. ▪ Channel straightening increases the capacity to accumulate and carry sediment, thereby potentially adversely affecting the surrounding areas and the stream system's equilibrium. ▪ There can be difficulty in setting culverts of a sufficient size in a stream to convey the 100-year flood discharge, unless weir flow over the road surface is considered.

FEMA: Improve Site Drainage

Depth of Flood

The drainage improvement project is built to a certain flood protection level that may be exceeded by a larger flood event and thereby because more damage to the structure than might have occurred without the project.

Adverse Impact Downstream

A drainage improvement project, such as a channelized stream, can worsen flooding problems downstream because water is transported at a faster rate. Since the stream now has the capacity to carry more water, it will also have an increased capacity to accumulate and carry sediment. The additional sediment load may come from accelerated bank or stream bottom erosion.

Relative Costs

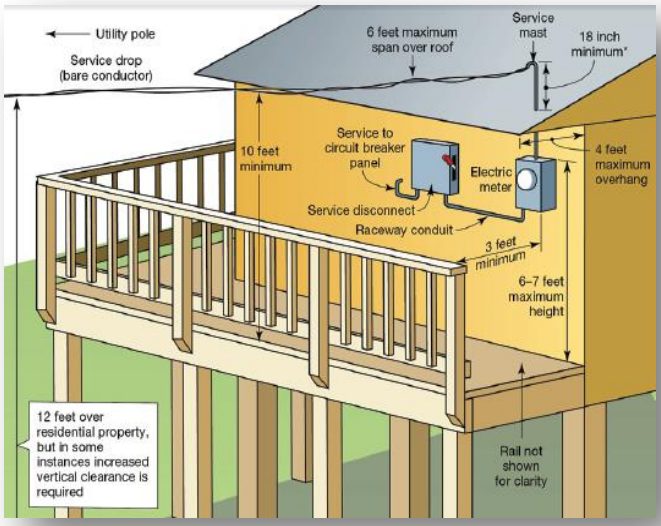
The relative cost ranking is based on the combination of the estimated costs for the drainage improvement project and a determination of cost-effectiveness.

Recommendation 3: Electrical Recommendation

The primary focus of this recommendation is to protect the electrical services that use less than 300 volts. In doing so the outing durations resulting from flooding conditions are minimized.

Key Issues

Flooding can damage utility meters, witches and many other electrical components. This can delay the recovery time and extend power outages. In order to prevent flood damage, it is required to place all electrical equipment above the base flood elevation.



National Electrical Code and Local Utility Requirements

The NEC prevents contact with conductors and energized lines. There must be clearance above the roofs, doors, windows, driveways and walking services such as stair landings, decks and balconies. All of these clearance requirements must be maintained when elevated above the flooding elevation.

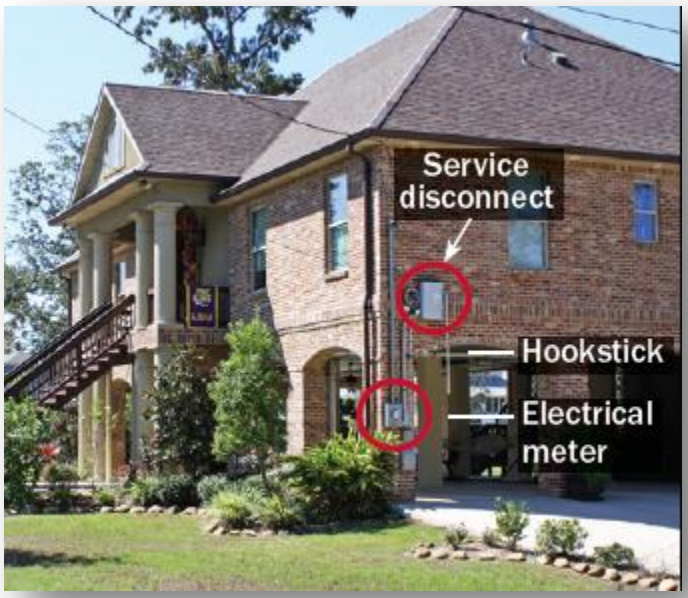
The power must be able to be disconnected in an event of a flood or the need for servicing. There are two possible ways this can be achieved.

- Main circuit breaker that is mounted with electrical service panel board is most commonly used to disconnect the service.
- Separate enclosed circuit breakers or separate fused disconnect switches mounted between the electrical meters and the electrical panel board.

Electrical Utility companies require the placement of electrical meters to be between 4-6 feet above the finished grade. This allows the utility workers to be able to read the meters and remove electrical meters from homes. Utilities must also have an exterior disconnection so that personnel can disconnect power without having to enter the structure.

The location of the electrical services therefore must be located in a position above potential floodwaters while also maintaining access to utility workers.

If not possible to locate the electrical equipment within 4-6 feet of grade, electrical equipment can be located with a larger distance to protect it from flooding. For example if the service is located 10 feet above grade than there must be a hook stick that allows it to be remote operated.



Other Considerations

All utilities that are located below the design flood elevation must be placed on the landward side of the house and be attached to foundation elements.

Meters, conduits and other electrical equipment shouldn't be attached to breakaway walls that may be damaged during flooding.

All components should be designed to drain water both above and below the design flood elevation.

Wall switches, receptacles and lighting components are usually interconnected using electrical junction boxes. In flood areas these boxes should be constructed of non-corrosive materials.

Any wiring rated for wet locations are permitted for insulation below flood elevations.

HVAC

In order for minimal damaging to HVAC systems they must be located above base flood elevation. Condensing units must be installed on platforms above the flood elevations and include restraints to resist flooding and wind loads.

Ductwork cannot be located in basements or crawl spaces and must be watertight.

Flood damage of electrical systems such as wires, switches, fuses and other electrical services can cause shock hazards and fires.

Recommendation 4: Plumbing Recommendation

Flood damage to the plumbing systems of a building such as pipes, septic tanks and on site wells can contaminate the water supply systems and cause a building to become inhabitable. Flooding can also cause the tanks to float and erosion to occur. Another major concern is waste backup.

Hazards

- **Back up-** When sewage backups into the building due to a surcharged sewer. This is caused by floodwaters entering a system, the failure of the pump station and the failure of the backup valve.

- **Physical Damage-** caused to the system components such as the pipes and tanks. The sources of damage are erosion, scour, collapse and infiltration of flood waters.
- **Contamination**- Caused by sewage and floodwaters mixing. This is a problem if someone comes into contact with the floodwaters.

There are two ways of preventing or eliminating these hazards.

- Prevent sewage back
- Prevent physical damage to system components.

On-site Sewage Storage Tank

A ready-made plastic or precast concrete tank that can store sewage temporarily during flooding conditions. When the flooding has receded the tank can be pumped out. The tank must be water tight and be able to resist buoyancy forces.

On-Site Sewage Effluent Ejector Pump

This can be used to force sewage around a closed check valve into a surcharged sewer. Sewage flows into a sump pit. When the level is high enough the pump is activated and then shuts off when the level is below a certain point.

- **Wall Penetrations-** A pipe penetration through a tank can be sealed using an expansive seal, sleeve, elastomeric seal or neoprene seal.
- **Septic Tank or Manhole cover**- A neoprene gasket must be applied and the septic tank cover must be bolted down.
- **Inspection Pipe**- The inspection pipe should have a watertight seal such as a screw on lid or the pipe should extend above the base flood elevation
- **Water Wells on Site**- They should be designed to with stand debris impact. Flood waters can erode and scour the soil around the well therefore leaving the well exposed to the debris. The well should be equipped with a water tight casing that extends from one foot above grade to twenty five feet below grade.

Recommendation 5: Storm Shutters

When it comes to storm shutters; there are three major types also known as panel systems. They are usually made of plywood, metal (aluminum or steel), or polycarbonate plastic. Lexan panels are transparent, and can be flat or have been heat-formed into a corrugated shape to increase impact resistance to the windows. Panels must be attached to the structure by screws in a direct mount or on tracks. When not in use, storm panels are stored in an easy to access location. Newly constructed homes sometimes have an assigned area for storage of storm panels.

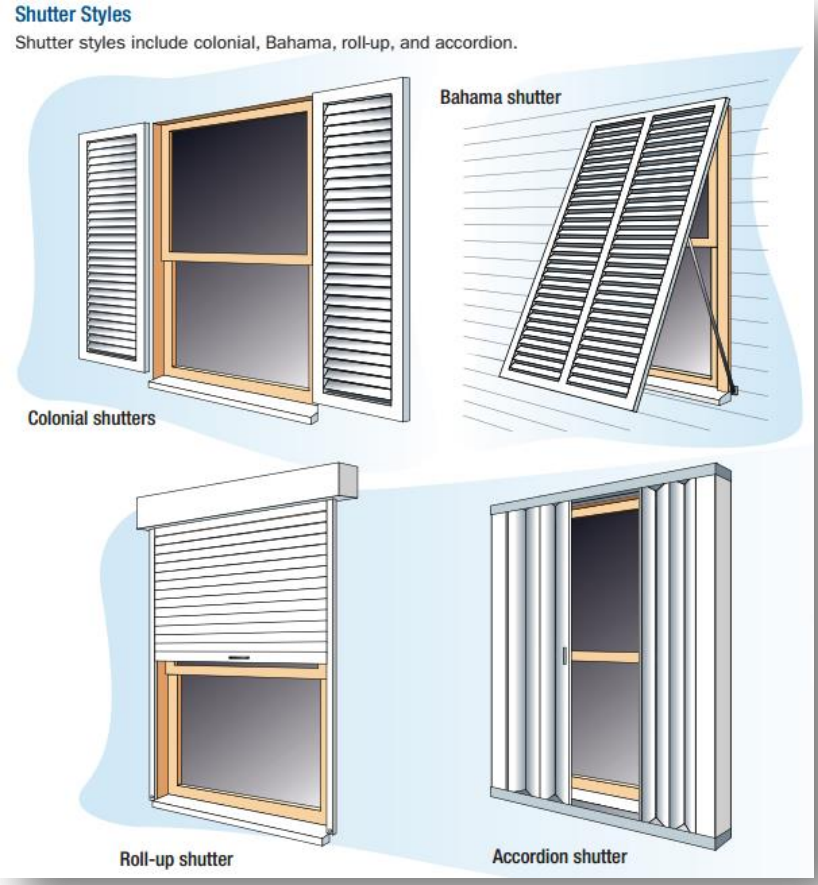
Another type of shutter is an accordion shutter. These shutters are made from interlocking vertical blades which slide into place horizontally on the track. They are used by pulling each curtain toward the middle of the track. This latches the curtains together and locks the handle in place.

The roll-up or rolling shutter contains a row of slats that form a curtain with both sides of the shutters attaching to the guide rails. The curtain is then rolled onto an axle. Rolling shutters can be used manually by gear, or by a pull strap that is mechanized. Motorized shutters can be operated by either a switch or remote and can be controlled either individually or in groups. If

the power goes out, the motorized shutters must be operated manually. You would need access to the motor or a pre-installed manual override. When in use, all hurricane shutters require special techniques for firefighters to gain access to the interior of a structure.

Other types are the Bahamas and Colonials. Bahama shutters are mounted above the window creating shade when they are open, and when in use, they are brought down and secured over the window. Colonials are just like wooden shutters, but are made of aluminum. They hinge on the side of the windows and swing shut to protect the opening. Hurricane fabric coverings are a more modern, cheaper type of shutter.

Doors



If a door is broken open by the wind, it will most likely result in flooding and pressurization of the interior. Some doors that are classified as impact resistant are fiberglass doors, metal doors, patio doors, and mahogany doors. Impact resistant doors provide many advantages and benefits listed below:

- Permanent hurricane protection (no deployment is required in the event of a hurricane).
- Permanent security protection (enhanced protection against break-ins improves safety and loss of property).
- Temperature insulation (superior insulation saves energy, lowers cost and reduces loads on HVAC).
- Sound insulation (superior insulation against outside noise).
- Enhanced appearance (new doors improve the building's appearance).
- Improved property value (experts cite windows/doors upgrade as a top property investment due to improvement in protection & appearance).

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-	High	Easily opened and	Expensive. (It is important to find a motorized shutter that allows the shutter

Garage Doors

It is estimated that one inch of floodwater can cause around $7,800 worth of costly damage to your home. The garage doors are the easiest way for a lot of water to enter the house quickly. Hurricane/wind proof garage doors are a must if you are in a high risk area. The cheapest way to prevent your garage door from busting is by installing bracing kits to the garage door. You can buy them for around $500 and install them yourself. If you are buying a new garage door, you can pick up a hurricane/wind resistant garage door for about $800.

Recommendation 6: Energy Efficiency

The R-5 Thermal Shield is one inch of rigid foam insulation that can be added to a wall. This thermal shield is a continuous layer of insulation located on the outside of a wall underneath the siding. This minimizes thermal bridging which is helps save money. This R-5 thermal shield is one of the most cost effective ways to increase energy efficiency.

Use of a solar water heater is a great way to heat your home. Deltec panels resist up to 160mph winds. On average, after you install a solar water heater, your water heating bills drop around 50-80%. This system also qualifies for federal and state tax incentives and credits.

Recommendation 7: Increasing Home's Fire Rating

In home Fire Sprinkler

- Residential fire sprinklers are available in housing and can be concealed easily to make a sleek appearance.
- A fire sprinkler system costs $1.35 per square foot; this is less than many other items in a house such as carpet upgrades, paving stones and bathroom accessories.
- Fire sprinklers are environmentally friendly and can reduce fire damage by up to 71%, while also reducing the water usage to fight a fire by 91 percent.

- Only a high temperature fire can activate the sprinklers. Smoke caused by cigarette smoke or a fire place will not activate the sprinklers.

- Home fire sprinklers are effective in cold and warm climates. Instillation guidelines are put in place to prevent pipes from freezing.

Mineral Wool Insulation

Most insulation is fire-rated, but mineral wool is among the best.

- Can withstand heat in excess of 2,000 degrees F.
- Unlike fiberglass insulation, mineral wool does not melt when exposed to such high heat.
- Also improves wall & floor sound proofing

Electrical Box Fire Guards & Fire Barrier for Recessed Lights

- Cover guards for light switches and electrical outlets
- Designed to extinguish sparks caused by faulty wiring that can start fires.
- Protects against insulation fires caused by the build-up of heat around lights

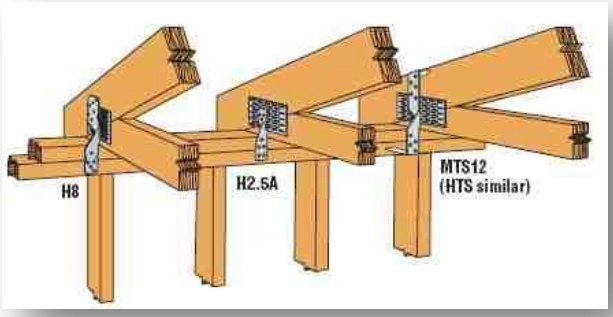
Type X Gypsum Board

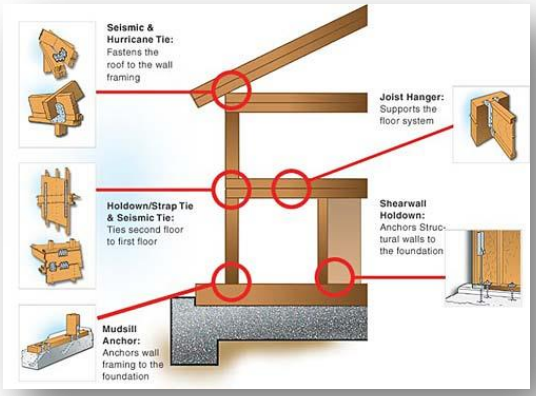
- Fire resistant drywall
- Specially treated with additives to further improve its fire-resistive qualities
- Available in a variety of lengths and widths.

Recommendation 8: Roof Protection

Hurricane Straps

- Tie attaches to roof tiles to keep them from blowing off a roof
- Aids to protect buildings from damage resulting from high wind.
- Provides continuous structural load path from the top of a building to foundation





Design Considerations

- A home with a square floor plan (or better a hexagonal or octagonal plan) with a multiple-panel roof (4 or more panels) was found to have reduced wind loads
- Roofs with multiple slopes such as a hip roof (4 slopes) perform better under wind forces than gable roofs (2 slopes). A 30-degree roof slope has the best results.
- Roof overhangs are subject to wind uplift forces which could trigger a roof failure. In the design of the hurricane-resistant home, the length of these overhangs should be limited to 20 inches.

Baffled Ridge & Soffit Vents

- Used to minimize the number of roof penetrations
- Prevents airflow and wind driven rain from entering attic

Recommendation 9 & 10: Exterior and Interior Finishes

Flood Damage-Resistant Material

"Flood [damage]-resistant material" is defined by the NFIP as "any building product [material, component or system] capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage." The term "prolonged contact" means at least 72 hours, and the term "significant damage" means any damage requiring more than cosmetic repair. "Cosmetic repair" includes cleaning, sanitizing, and resurfacing (e.g., sanding, repair of

joints, repainting) of the material. The cost of cosmetic repair should also be less than the cost of replacement of affected materials and systems.

Notes Regarding Classification of Materials

Materials Not Listed: Table 3 does not list all available structural materials and finish materials. For materials and products not listed, manufacturers' literature should be evaluated to determine if the product meets flood damage-resistance requirements. Materials and products that are not listed in Table 2 may be used if accepted by the local official.

Unacceptable Materials: Class 1, 2, and 3 materials are unacceptable for below-BFE applications for one or more of the following reasons:

- Normal adhesives specified for above-grade use are water soluble or are not resistant to alkali or acid in water, including groundwater seepage and vapor.
- The materials contain wood or paper products, or other materials that dissolve or deteriorate, lose structural integrity, or are adversely affected by water.
- Sheet-type floor coverings (linoleum, rubber tile) or wall coverings (wallpaper) restrict drying of the materials they cover.
- Materials are dimensionally unstable.
- Materials absorb or retain excessive water after submergence.

Impact of Material Combinations: In some cases, the combination of acceptable structural and finish materials can negatively impact the classification of individual materials

Classification of Flood Damage-Resistant Materials

NFIP	Class	Class Description
ACCEPTABLE	5	Highly resistant to floodwater[1] damage, including damage caused by moving water.[2] These materials can survive wetting and drying and may be successfully cleaned after a flood to render them free of most harmful pollutants.[3] Materials in this class are permitted for partially enclosed or outside uses with essentially unmitigated flood exposure.
	4	Resistant to floodwater[1] damage from wetting and drying, but less durable when exposed to moving water.[2] These materials can survive wetting and drying and may be successfully cleaned after a flood to render them free of most harmful pollutants.[3] Materials in this class may be exposed to and/or submerged in floodwaters in interior spaces and do not require special waterproofing protection.
UNACCEPTABLE	3	Resistant to clean water[4] damage, but not floodwater damage. Materials in this class may be submerged in clean water during periods of flooding. These materials can survive wetting and drying, but may not be able to be successfully cleaned after floods to render them free of most[3] harmful pollutants.
	2	Not resistant to clean water[4] damage. Materials in this class are used in predominantly dry spaces that may be subject to occasional water vapor and/or slight seepage. These materials cannot survive the wetting and drying associated with floods.
	1	Not resistant to clean water[4] damage or moisture damage. Materials in this class are used in spaces with conditions of complete dryness. These materials cannot survive the wetting and drying associated with floods.

FEMA Flood Damage-Resistant Materials Requirements Technical Bulletin 2 / August 2008.
Notes:
1. Floodwater is assumed to be considered "black" water; black water contains pollutants such as sewage, chemicals, heavy metals, or other toxic substances that are potentially hazardous to humans.
2. Moving water is defined as water moving at low velocities of 5 feet per second (fps) or less. Water moving at velocities greater than 5 fps may cause structural damage to building materials.
3. Some materials can be successfully cleaned of most of the pollutants typically found in floodwater. However, some individual
Pollutants such as heating oil can be extremely difficult to remove from uncoated concrete. These materials are flood damage resistant except when exposed to individual pollutants that cannot be successfully cleaned.
4. Clean water includes potable water as well as "gray" water; gray water is wastewater collected from normal uses (laundry, bathing, food preparation, etc.).

Table 3 lists structural materials and finish materials commonly used in construction of floors, walls, and ceilings. For the purpose of this Technical Bulletin, structural materials and finish materials are defined as follows:

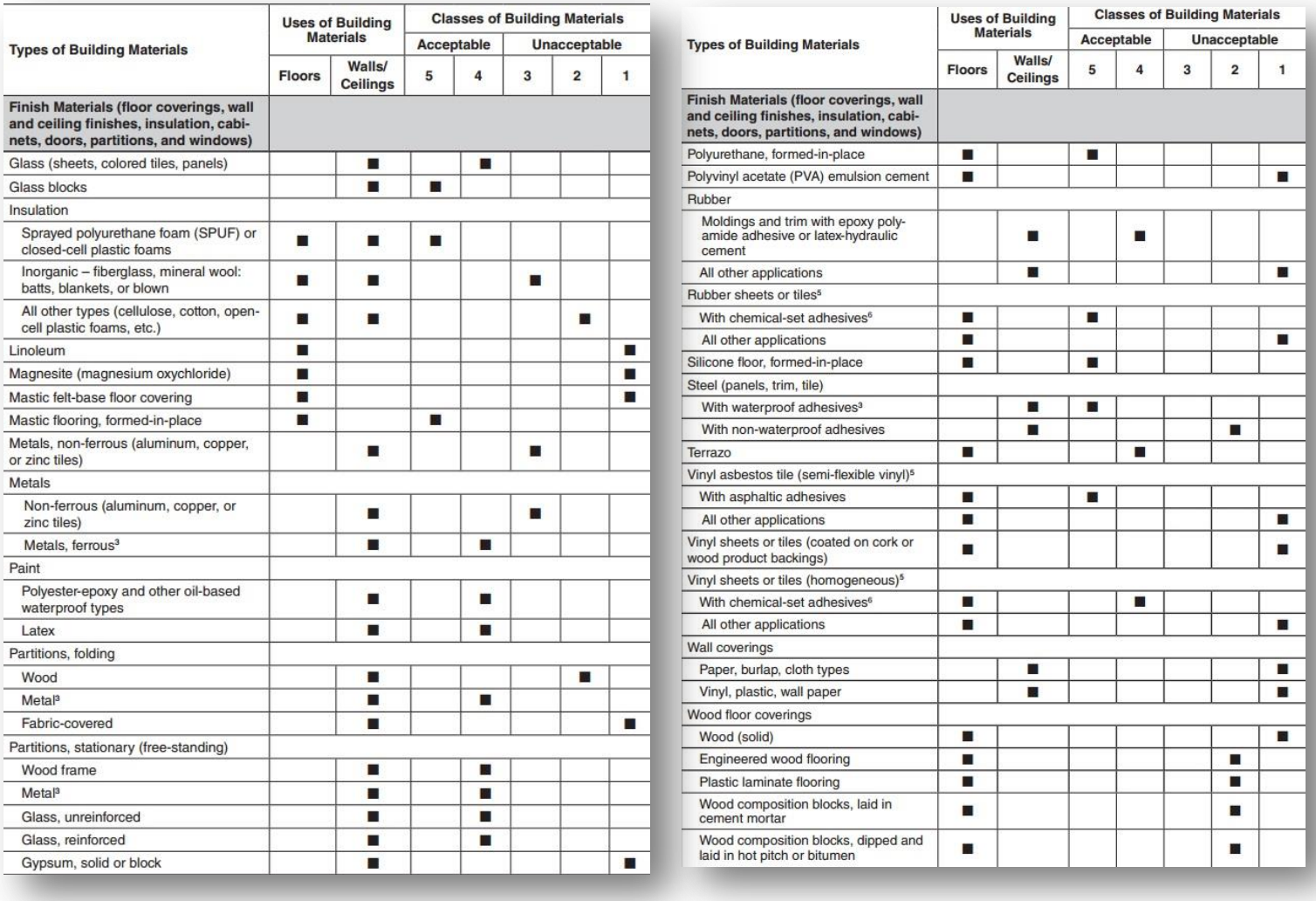
- Structural materials include all elements necessary to provide structural support, rigidity, and integrity to a building or building component. Structural materials include floor slabs, beams, subfloors, framing, and structural building components such as trusses, wall panels, I-joists and headers, and interior/exterior sheathing.
- Finish materials include all coverings, finishes, and elements that do not provide structural support or rigidity to a building or building component. Finish materials include floor coverings, wall and ceiling surface treatments, insulation, cabinets, doors, partitions, and windows.

Table 3. Types, Uses and Classes of Building Materials

Types of Building Materials	Uses of Building Materials		Classes of Building Materials				
			Acceptable		Unacceptable		
	Floors	Walls/ Ceilings	5	4	3	2	1
Structural Materials (floor slabs, beams, subfloors, framing, and interior/exterior sheathing)							
Preservative-treated, Borate[2]	■	■	■				
Exterior grade/Exposure1 (WBP – weather and boil proof)	■	■		■			
All other types	■	■					■
Recycled plastic lumber (RPL)							
Commingled, with 80-90% polyethylene (PE)	■		■				
Fiber-reinforced, with glass fiber strands	■		■				
High-density polyethylene (HDPE), up to 95%	■		■				
Wood-filled, with 50% sawdust or wood fiber	■				■		
Stone							
Natural or artificial non-absorbent solid or veneer, waterproof grout	■	■	■				
All other applications		■				■	
Structural Building Components							
Floor trusses, wood, solid (2x4s), de-cay-resistant or preservative-treated	■	■		■			
Floor trusses, steel[3]	■		■				
Headers and beams, solid (2x4s) or plywood, exterior grade or preservative-treated		■		■			
Headers and beams, OSB, exterior grade or edge-swell resistant		■				■	
Headers and beams, steel[3]		■	■				
I-joists	■					■	
Wall panels, plywood, exterior grade or preservative-treated		■		■			
Wall panels, OSB, exterior grade or edge-swell resistant		■				■	
Wall panels, steel[3]		■		■			

Types of Building Materials	Uses of Building Materials		Classes of Building Materials				
			Acceptable		Unacceptable		
	Floors	Walls/ Ceilings	5	4	3	2	1
Structural Materials (floor slabs, beams, subfloors, framing, and interior/exterior sheathing)							
Asbestos-cement board		■	■				
Brick							
Face or glazed		■	■				
Common (clay)		■		■			
Cast stone (in waterproof mortar)		■	■				
Cement board/fiber-cement board		■	■				
Cement/latex, formed-in-place	■			■			
Clay tile, structural glazed		■	■				
Concrete, precast or cast-in-place	■	■	■				
Concrete block[1]		■	■				
Gypsum products							
Paper-faced gypsum board		■			■		
Non-paper-faced gypsum board		■		■			
Greenboard		■				■	
Keene's cement or plaster		■			■		
Plaster, otherwise, including acoustical		■				■	
Sheathing panels, exterior grade		■			■		
Water-resistant, fiber-reinforced gypsum exterior sheathing		■		■			
Hardboard (high-density fiberboard)							
Tempered, enamel or plastic coated		■				■	
All other types		■					■
Mineral fiberboard		■					■
Oriented-strand board (OSB)							
Exterior grade	■	■				■	
Edge swell-resistant OSB	■	■				■	
All other types	■	■					■
Particle board	■						■
Plywood							
Marine grade	■	■	■				
Preservative-treated, alkaline cop-per quaternary (ACQ) or copper azole (C-A)	■	■		■			

Types of Building Materials	Uses of Building Materials		Classes of Building Materials				
			Acceptable		Unacceptable		
	Floors	Walls/ Ceilings	5	4	3	2	1
Structural Materials (floor slabs, beams, subfloors, framing, and interior/exterior sheathing)							
Wood							
Solid, standard, structural (2x4s)		■		■			
Solid, standard, finish/trim		■			■		
Solid, decay-resistant[4]	■	■	■				
Solid, preservative-treated, ACQ or C-A		■		■			
Solid, preservative-treated, Borate[2]		■		■			
Finish Materials (floor coverings, wall and ceiling finishes, insulation, cabinets, doors, partitions, and windows)							
Asphalt tile[5]							
With asphaltic adhesives	■				■		
All other types	■						■
Cabinets, built-in							
Wood		■				■	
Particle board		■					■
Metal[3]		■		■			
Carpeting	■						■
Ceramic and porcelain tile							
With mortar set	■	■		■			
With organic adhesives	■	■				■	
Concrete tile, with mortar set	■		■				
Corkboard		■				■	
Doors							
Wood, hollow		■				■	
Wood, lightweight panel construction		■				■	
Wood, solid		■				■	
Metal, hollow[3]		■		■			
Metal, wood core[3]		■		■			
Metal, foam-filled core[3]		■		■			
Fiberglass, wood core		■		■			
Epoxy, formed-in-place	■		■				



Types of Building Materials	Uses of Building Materials		Classes of Building Materials				
			Acceptable		Unacceptable		
	Floors	Walls/ Ceilings	5	4	3	2	1
Finish Materials (floor coverings, wall and ceiling finishes, insulation, cabinets, doors, partitions, and windows)							
Glass (sheets, colored tiles, panels)		■		■			
Glass blocks		■	■				
Insulation							
Sprayed polyurethane foam (SPUF) or closed-cell plastic foams	■	■	■				
Inorganic – fiberglass, mineral wool: batts, blankets, or blown	■	■			■		
All other types (cellulose, cotton, open-cell plastic foams, etc.)	■	■				■	
Linoleum	■						■
Magnesite (magnesium oxychloride)	■						■
Mastic felt-base floor covering	■						■
Mastic flooring, formed-in-place	■		■				
Metals, non-ferrous (aluminum, copper, or zinc tiles)		■			■		
Metals							
Non-ferrous (aluminum, copper, or zinc tiles)		■			■		
Metals, ferrous[3]		■		■			
Paint							
Polyester-epoxy and other oil-based waterproof types		■		■			
Latex		■		■			
Partitions, folding							
Wood		■				■	
Metal[3]		■		■			
Fabric-covered		■					■
Partitions, stationary (free-standing)							
Wood frame		■		■			
Metal[3]		■		■			
Glass, unreinforced		■		■			
Glass, reinforced		■		■			
Gypsum, solid or block		■					■

Types of Building Materials	Uses of Building Materials		Classes of Building Materials				
			Acceptable		Unacceptable		
	Floors	Walls/ Ceilings	5	4	3	2	1
Finish Materials (floor coverings, wall and ceiling finishes, insulation, cabinets, doors, partitions, and windows)							
Polyurethane, formed-in-place	■		■				
Polyvinyl acetate (PVA) emulsion cement	■						■
Rubber							
Moldings and trim with epoxy polyamide adhesive or latex-hydraulic cement		■		■			
All other applications		■					■
Rubber sheets or tiles[5]							
With chemical-set adhesives[6]	■		■				
All other applications	■						■
Silicone floor, formed-in-place	■		■				
Steel (panels, trim, tile)							
With waterproof adhesives[3]		■	■				
With non-waterproof adhesives		■				■	
Terrazo	■			■			
Vinyl asbestos tile (semi-flexible vinyl)[5]							
With asphaltic adhesives	■		■				
All other applications	■						■
Vinyl sheets or tiles (coated on cork or wood product backings)	■						■
Vinyl sheets or tiles (homogeneous)[5]							
With chemical-set adhesives[6]	■			■			
All other applications	■						■
Wall coverings							
Paper, burlap, cloth types		■					■
Vinyl, plastic, wall paper		■					■
Wood floor coverings							
Wood (solid)	■						■
Engineered wood flooring	■					■	
Plastic laminate flooring	■					■	
Wood composition blocks, laid in cement mortar	■					■	
Wood composition blocks, dipped and laid in hot pitch or bitumen	■					■	

FEMA Flood Damage-Resistant Materials Requirements Technical Bulletin 2 / August 2008.

Notes*:
1 Unfilled concrete block cells can create a reservoir that can hold water following a flood, which can make the blocks difficult or impossible to clean if the floodwaters are contaminated.
2 Borate preservative-treated woods meet the NFIP requirements for flood damage-resistance; however, the borate can leach out of the wood if the material is continuously exposed to standing or moving water.
3 Not recommended in areas subject to salt-water flooding.
4 Examples of decay-resistant lumber include heart wood of redwood, cedar, and black locust. Refer to Section 2302 of the
International Building Code® (IBC®) and Section R202 of the International Residential Code® (IRC®) for guidance.
5 Using normally specified suspended flooring (i.e., above-grade) adhesives, including sulfite liquor (lignin or "linoleum paste"), rubber/asphaltic dispersions, or "alcohol" type resinous adhesives (culmar, oleoresin).
6 Examples include epoxy-polyamide adhesives or latex-hydraulic cement.
* In addition to the requirements of TB 2 for flood damage resistance, building materials must also comply with any additional requirements of applicable building codes. For example, for wood products such as solid 2x4s and plywood, applicable building code requirements typically include protection against decay and termites and will specify use of preservative-treated or decay resistant wood for certain applications. Applications that require preservative-treated or decay-resistant species include wood in contact with the ground, wood exposed to weather,

wood on exterior foundation walls, or wood members close to the exposed ground. In some cases, applicable building code requirements (such as those in ASCE 24-05 and IRC 2006) do not reflect updated guidance in TB 2 and specify that all wood used below the design flood elevation be preservative-treated or naturally decay-resistant regardless of proximity to ground or exposure to weather.

Fasteners and Connectors

Table 3 does not specifically address fasteners and connectors. However, it is clear that the performance of buildings that are exposed to flooding is, at least in part, a function of the fasteners and connectors used to put the components together. When preservative-treated woods are used, particular attention is required for fasteners and connectors because some treatments are more corrosive than others, which could shorten the service life of the fasteners and connectors.

This Technical Bulletin, consistent with ASCE 24 and the International Code Series, recommends that stainless steel or hot-dip galvanized fasteners and connectors be used below the BFE in both inland (noncorrosive) and coastal (corrosive) areas. In coastal environments where airborne salts contribute to corrosion, it is recommended that corrosion-resistant fasteners and connectors be used throughout the building where they may be exposed.

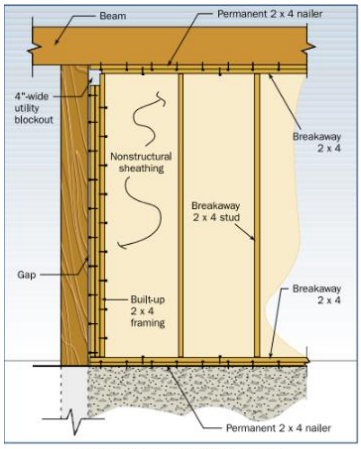
Tool Base Technologies

Technological advances and practices have been designed to further protect homes near coastal regions. The first place that needs to be flood resistant is the basement or crawl space. Sump pumps will help to direct water away from entering the basement/crawlspace and it help protect the foundation. It is installed under the foundation with an opening towards the basement floor. It has a pipe that leads to gravel outside of the foundation and pump connected to a tank that collects the water. The pump capacity is dependent on the hourly inflow rate of water and the distance it is pumped away from the foundation. There is another perforated pipe that is connected to the tank. This pipe collects all of the ground water and channels it to a central point in the tank called the sump crock. From there the water gets pumped and directed towards sewers or storm drains. Sump pumps are easy to install and cost about $100. In the case of a power outage, the sump pump can be battery operated or ran by a motor in normal cases.

Another advancement that may help is called Hydro Lock System. This is a factory built foundation system that uses steel foundation that locks other parts of the house into the crawl space or basement, providing axial support. This steel system can be put together rather quickly as half a day, as opposed to building a foundation system on site. The walls are precut for windows and doors and then thermally sealed. This system has a resistance rating of 10 and can have more insulation added to adhere to building codes. Also it can be sustainable against high winds, water, and harmful gasses because it uses interlocking, wielding system that connects the foundation to upper floors as one complete piece.

As far as protection from debris entering the home through a door or window, there are impact resistance features that you can install to help protect your homes outer shell. Obviously, there are hurricane shutters, which should be included in any circumstance. Another option is impact resistance doors and garage doors and single car openings. They are test and rated on

their resistance to winds and debris. The doors are more resistant because of the materials they use and the way it is connected to the overall structure. Windows on the other hand are double coated and have a higher glazing rate. Some windows are solar control low E, which helps keep air and water out and keep insulated heat.



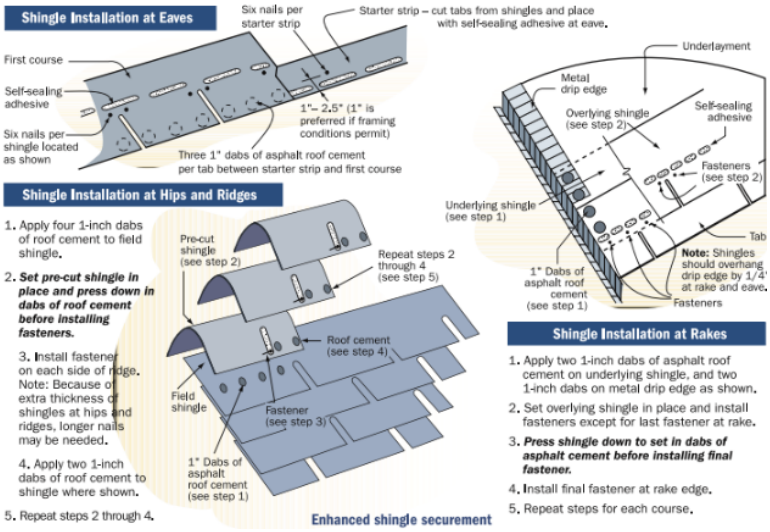
Recommended breakaway wall construction.

During a flood, water needs to be able to flow freely without any obstructions in the way to harm the structure of your house or anything else. The technology that would help water flow underneath your house is called breakaway walls. It is the walls that are under base flood elevation, that doesn't provide any structural support. They are mostly used as a garage, building access or storage. The walls must be able to break away heavy wind load and collapse under 20psf. Also with the installation of breakaway walls there must also be flood openings, which also helps water enter and exit the lower elevation of the structure. Flood openings must be located on 2 of the walls opposite from each other. It should be sized as 1 square inch of flood opening per square foot of enclosed area.

Roof construction is very important during coastal construction. To prevent winds from damaging roof, there are specific instructions for installing asphalt shingles. They are precut so that pieces fit together snug and are nailed in by ¾ inch nails. This kind of roof installment ensures roof safety.

Conflicts

The conflict involving the use of piles to raise the building is how to protect those piles from an elevated water level, debris and corrosion. As seen there are various materials that can be used for the piles such as concrete, wood and steel. All of these have their advantages and disadvantages. To protect these piles from the weather and other factors it's recommended to use protective coatings to resist corrosion and even use walls to protect them from incoming debris.



The conflict with the second recommendation of erosion control structures is how to protect those structures such as bulk head and walls. As seen during hurricane sandy many of these structures failed and even caused more damage by doing so. The solution to this problem is to maintain these structures and construct these protective barriers with the appropriate height and width.

The electrical conflict is present when raising the electrical utilities above the base flood elevation. This causes the problem of how to access the electrical service disconnect in the case of an emergency. This is solved by the use of a hook stick to access the raised disconnect.

The conflict that arises from the fenestration recommendation is the types of storm shutters that should be used. While using the bahama shutter uplift will occur and could easily tear the shutters of the house. The solution to this problem is to not use this type of storm shutter or if they are being used make sure they are closed during a storm and locked down to prevent uplift.

Ten Most Important Guidelines

1. **Elevate low-rise building:** Raise the building to prevent damage to interior finishes and reduce the amount of water damage.
2. **Improve Site Drainage:** Modifying the channel attempts to provide a greater carrying capacity for moving floodwaters away from areas when flooding or damage occurs.
3. **Electrical Recommendation:** Raise all electrical equipment above the base flood elevation but also create a way to access to these utilities. If electric service disconnect is raised off grade, use a hook stick to shut of the power.
4. **Plumbing Recommendation:** Protect the plumbing equipment such as the various tanks by sealing all connections and securing the tanks to resist buoyancy forces. Also prevent waste backup by using a sewage effluent ejector pump.
5. **Use Storm Shutter:** Protect windows from being damaged. When using bahama shutters make sure shutters are closed and locked down during a storm to prevent up lift.
6. **Improve Energy Efficiency:** To make the house more energy efficient add one inch of rigid foam to the wall. This continuous layer of insulation is located under the siding and minimizes the thermal bridge.
7. **Increase Home's Fire Rating:** To increase the fire protection of the building use residential fire sprinklers to reduce fire damage by up to 71%.
8. **Roof Protection:** Use hurricane straps on all the roof joists and reduce overhangs to prevent roof uplift during high wind conditions.
9. **Exterior Finishing:** Use exterior flood resistant material to prevent water damage during direct and prolonged water contact.
10. **Interior Finishing:** Use interior flood resistant material to prevent interior water damage during direct and prolonged water contact.

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