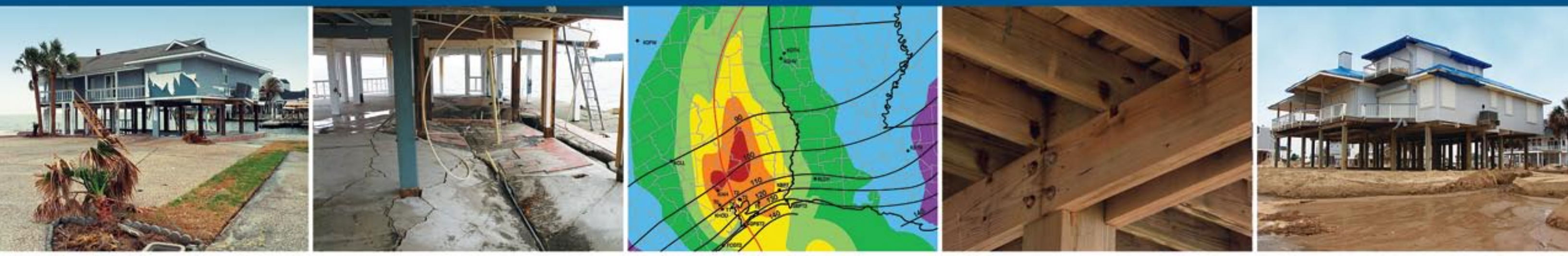

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HURRICANE IKE IN TEXAS & LOUISIANA

2 Floodplain Management Regulations, Building Codes, and Standards

Floodplain management regulations, building codes, and standards are adopted and enforced to regulate construction in at-risk areas.

The floodplain management regulations applicable to the areas affected by Hurricane Ike are discussed in Section 2.1. Section 2.2 presents the building codes and standards specific to floods and wind used to regulate construction. Section 2.3 discusses the Texas Windstorm Program. Section 2.4 discusses enhanced code construction.

2.1 Floodplain Management Regulations

National Flood Insurance Program regulations form the basis of a community's efforts to guide development in flood hazard areas. These regulations are incorporated into a community's floodplain management ordinance, and have been integrated into national consensus standards

(ASCE 7 and ASCE 24) and model building codes that are adopted by communities. Figure 2-1 illustrates the process by which NFIP regulations flow to an individual building.

All the Texas and Louisiana communities visited by the MAT participate in the NFIP, have adopted floodplain management regulations that meet or exceed minimum NFIP requirements, and are governed by minimum building and performance standards or a model building code (see Section 2.2), so the process outlined in Figure 2-1 applies. These communities have two avenues for enforcing flood-resistant design and construction practices: the floodplain management ordinance and the minimum standards/building code. To address the flood coordination issues between the floodplain management ordinance and the building standards/code, communities may wish to refer to FEMA 9-0372, *Reducing Flood Losses Through the International Codes: Meeting the Requirements of the National Flood Insurance Program* (December 2008).

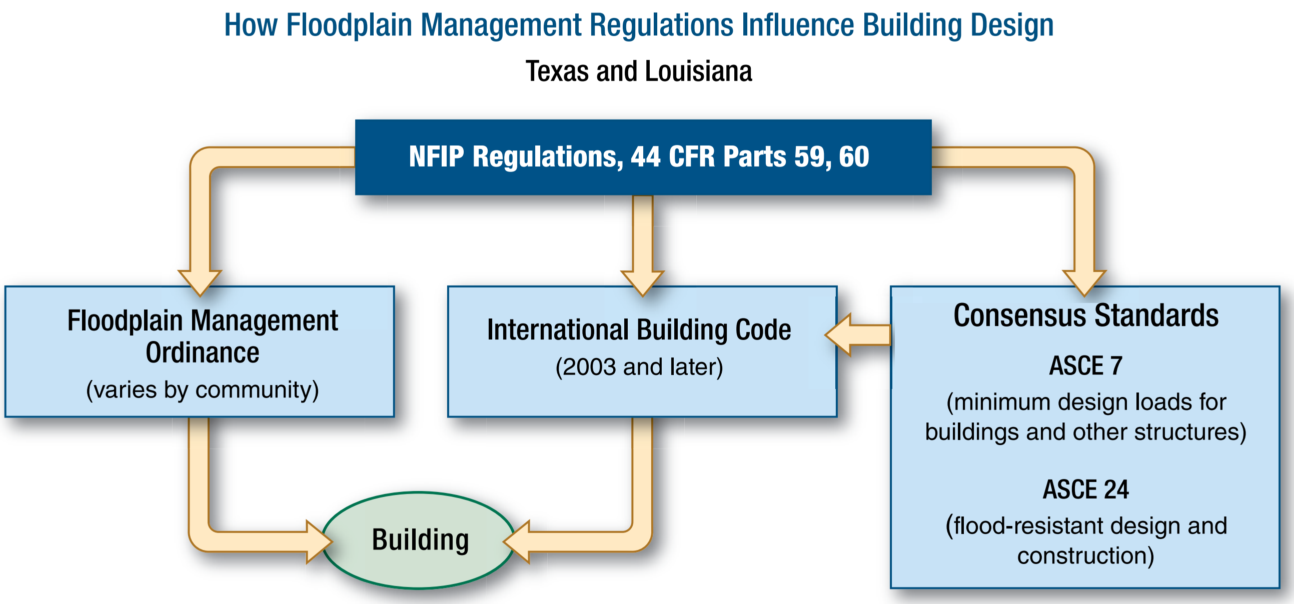


Figure 2-1. Floodplain management regulations and building design in communities with adopted building codes

2.1.1 Flood Studies and Flood Maps

FEMA and its mapping partners conduct FISs to create and update FIRMs. FIRMs identify areas of varying flood hazard as flood zones. Zones A and V comprise the area known as the SFHA. Locations designated as SFHAs have a 1-percent annual chance, or greater, of being inundated by flooding in any given year. The 1-percent annual chance flood is also referred to as the "base flood" or the "100-year flood." Areas that flood less frequently than the SFHA are also shown on FIRMs. The Shaded Zone X (old map designation Zone B) indicates the area that has between a 1-percent and 0.2-percent annual chance of flooding (this is commonly described as the area subject to flooding between the 100-year and 500-year floods). The Unshaded Zone X (old map designation Zone C) indicates the area that has less than a 0.2-percent annual chance of flooding.

FIRMs show BFEs in Zone V, and Advisory Base Flood Elevations (ABFEs) represent the minimum elevation to which the lowest floors of buildings must be elevated. When a community joins the NFIP and adopts its FIRM, the community is also adopting minimum building floor elevations and other floodplain standards required by the NFIP. Figure 2-2 shows the relationship between stillwater elevations, BFEs, and wave effects.

The FIRM zone designation and the BFE are critical factors in determining which requirements apply to a building and, as a result, how it is built. For example, the NFIP minimum requirements for buildings built in Zone V (Coastal High Hazard Areas) are:

1. Building must be elevated on pile, post, pier, or column foundations (refer to Section 3.1.1.1)
2. Building must be adequately anchored to the foundation (refer to Section 3.1.1.3)
3. Building must have the bottom of the lowest horizontal structural member supporting the lowest floor at or above the BFE (Figure 2-3)
4. Building design and method of construction must be certified by a design professional
5. The area below the BFE must be either free of obstructions or have breakaway construction in the form of non-supporting breakaway walls, lightweight open lattice or louvers, or insect screening (refer to Section 3.3.1)

In Zone A, the NFIP only requires that the top of the lowest floor of a building be at or above the BFE. There are no standards for foundations other than the general performance standard that the building be anchored to resist floatation, collapse, and lateral movement; any type of foundation that meets this performance standard is permitted by the NFIP. Also, in Zone A, the NFIP permits non-residential buildings to be floodproofed, with their walls made substantially impermeable to the passage of floodwater.

DESCRIPTION OF FLOOD ZONES

Zone V. The portion of the SFHA that extends from offshore to the inland limit of a primary frontal dune along an open coast, and any other area subject to high-velocity wave action (3 feet and higher) from storms or seismic sources. The FIRMs use Zones VE and V1-30 to designate these Coastal High Hazard Areas.

Zone A. The portion of the SFHA not mapped as Zone V. Although FIRMs depict Zone A in both riverine and coastal floodplains (as Zones A, AE, A1-30, and AO), the flood hazards and flood forces acting on buildings in those different floodplains can be quite different. In coastal areas, Zone A is subject to wave heights less than 3 feet and wave run-up depths less than 3 feet.

Coastal A Zone. The Coastal A Zone is an area within Zone A that is shown as an advisory layer on newer digital FIRMs (DFIRMs) using the Limit of Moderate Wave Action (LiMWA) line. Flood forces in the Coastal A Zone are not as severe as in Zone V, but are still capable of damaging or destroying buildings on shallow foundations. During base flood conditions, the potential for wave heights is greater than or equal to 1.5 feet, but less than 3.0 feet. For this reason, different design and construction standards are recommended (by the MAT and others) in the Coastal A Zone than in the riverine Zone A. Coastal A Zone provisions are included in ASCE 24-05 and ASCE 7-05, which are referenced by model building codes.

Shaded Zone X. Areas having between a 1-percent and 0.2-percent annual chance of flooding.

Unshaded Zone X. Areas with less than 0.2-percent annual chance of flooding.

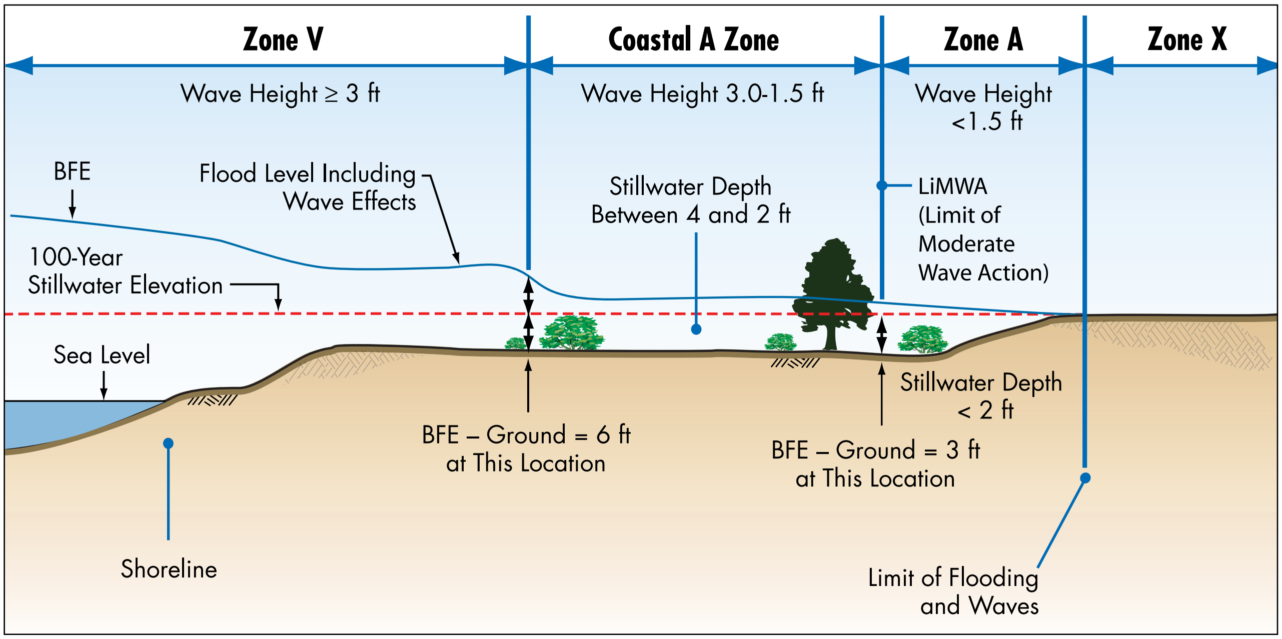
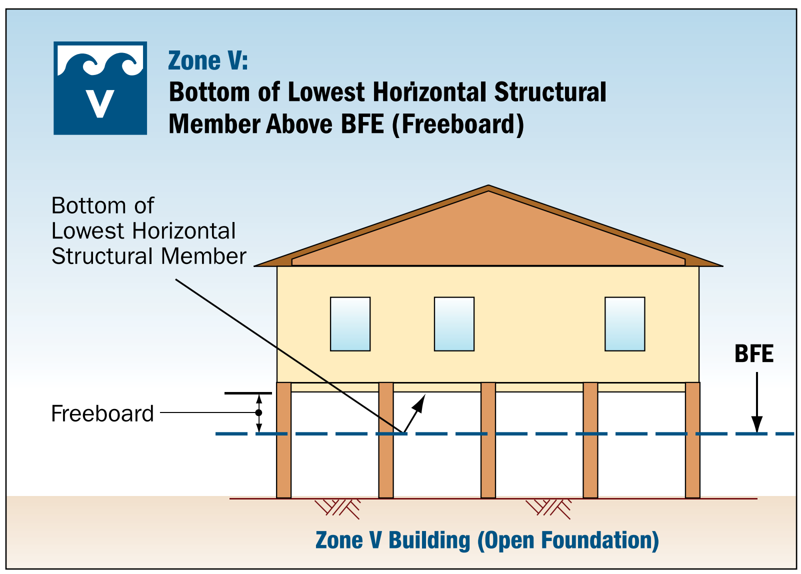


Figure 2-2. Relationship between the stillwater elevations, BFE, wave effects, and flood hazard zones

Figure 2-3.
Elevation of residential structures to the BFE is required in Zone V. The MAT recommends elevating higher, or adding freeboard (see Sections 2.1.1.3, 3.1.3, and 7.1.1).



For buildings built in Zones B, C, and X (areas of moderate or minimal hazard from the principal source of flood in the area), there are no NFIP building requirements, even for buildings built on barrier islands, because these buildings are outside the SFHA.

2.1.1.1 Accuracy of Flood Insurance Studies and Flood Insurance Rate Maps

It is important to note that the limits of the SFHA, the area over which floodplain management regulations apply, have changed over the past three decades as new FISs have been completed, BFEs have been changed, and new FIRMs have been issued. These changes affect the lowest building floor elevations mandated within the SFHA.

Any SFHA and BFE changes are generally the result of one or more of the following:

- **Changed conditions on the ground**
  - FISs and resulting FIRMs are based on physical, hydrologic, and hydraulic conditions existing at the time of the study. They do not anticipate or account for future changes in conditions (e.g., shoreline erosion, land subsidence, changed drainage patterns, etc.). Thus, as conditions change over time, the lateral and vertical extents of the base flood will deviate from those shown on the FIRM, and the FIRMs may no longer represent the best estimate of the SFHA and BFE.

> FEMA's *Community Status Book* provides the date of the effective FIS and FIRM for all mapped communities (http://www.fema.gov/fema/csb.shtm).
>
> The FIS and FIRMs can be viewed through the *Product Catalog* at FEMA's Map Service Center site. (http://msc.fema.gov/).

- **A longer period of record with which to characterize regional hurricane characteristics**
  - FISs and resulting FIRMs are based on the record of hurricanes at the time the study is conducted. Statistical distributions of important storm parameters (e.g., central pressure, radius to maximum winds, forward speed, direction, etc.) are developed from the record and are used as inputs to storm surge models. As time passes, more and more hurricanes occur that may not be represented in our statistics, and the FIRM becomes a less accurate predictor of the base flood.

- **New flood study models and procedures**
  - All FIRMs are generated using available topographic and land use data, and FEMA-approved study procedures and models. Those data, procedures, and models, however, are imperfect. They approximate the terrain and the physical processes that occur during a flood event. In an effort to improve map accuracy, FEMA, States, and communities now gather more accurate topographic and land use data than in years past. Also, FEMA has updated study procedures and models over the years to improve their ability to represent dune erosion, storm surge propagation, and wave effects. Taken together, improved terrain data and study methods used now yield more accurate BFE and SFHA estimates than in years past. However, even newer maps created with improved models and procedures have some uncertainty. This uncertainty can be addressed by adopting beyond-minimum flood-resistant design and construction practices, such as requiring freeboard (ASCE 24 is one source for guidance on freeboard).

> A new FIS for southwest Louisiana was just completed using the latest data, procedures, and models, and preliminary DFIRMs were released between January and November 2008 (see http://www.lamappingproject.com/).
> A new FIS for coastal Texas is now underway, and preliminary DFIRMs are expected to be released within a year.

2.1.1.2 Implication of FIRMs on Rebuilding and Building Safety

It is important to understand the limitations of FIRMs when considering reconstruction or new construction after a storm. The information described in Section 2.1.1.1 has the following implications for communities and homeowners:

- Since BFEs shown on future FIRMs may be higher, buildings constructed to elevations shown on Effective FIRMs may be constructed at elevations below those future BFEs.
- Buildings originally constructed outside the SFHA may be located within future SFHAs, but without the benefit of flood-resistant construction techniques.
- 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.

2.1.1.3 Higher Regulatory Standards

One of the most effective ways to compensate for future conditions, changed flood hazards, and floods exceeding the 1-percent annual chance flood level is to elevate buildings above the BFE shown on the FIRM at the time of construction. This practice is called "adding freeboard," and it not only reduces future flood damage, but results in significantly lower flood insurance premiums.

FREEBOARD

Some communities visited by the MAT require freeboard above the BFEs

- Texas Floodplain Management Association's freeboard survey is available at http://www.tfma.org/.
- The eight Louisiana parishes visited by the MAT have adopted freeboard consistent with Rita or Katrina Flood Recovery and ABFE maps (http://www.lamappingproject.com/).

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 Zone V house in 1 to 3 years; in a Zone A house, the payback period is approximately 6 years.

2.2 Building Codes and Standards

Model building codes have long included requirements for designers to identify anticipated environmental loads and load combinations, including wind loads, seismic loads, snow loads, and soil conditions. The 2000, 2003, and 2006 editions of the IBC and the International Residential Code (IRC), and the 2003 and 2006 editions of the National Fire Protection Association's (NFPA) *Building Construction and Safety Code* (NFPA 5000) are the first model codes to include comprehensive provisions that address flood hazards. These codes are consistent with the minimum provisions of the NFIP that pertain to the design and construction of buildings.

> **NOTE**
>
> The 2009 edition of the IRC will require 1 foot of freeboard in Zone V and the Coastal A Zone.

International Building Code

The IBC is a performance and prescriptive code that, for the most part, requires buildings and structures to be individually designed to meet the requirements of the code and various referenced standards. The two referenced standards (ASCE 7-05 and ASCE 24-05) that include provisions pertaining to flood hazards are briefly described in Sections 2.2.1.2 and 2.2.1.3. According to Mehta et al., (2007, pg. 32), in a performance code, the performance criteria of a component are specified instead of the material or the construction system. The performance criteria are based on the function of the component. The older and traditional types of building codes are prescriptive codes. Such codes give the prescription for construction systems, types of materials, and the devices to be used without permitting any alternatives.

International Residential Code

The IRC addresses environmental loads in a more prescriptive approach so that many one- and two-family houses can be built without individual designs prepared by architects and engineers.

Texas Statewide Residential Building Code

The statewide residential building codes in Texas are the 2000 IRC and the 1999 National Electrical Code (NEC). These, however, may be amended in local jurisdictions if they have updated the code provisions. The code that applies to an unincorporated area is the same code adopted by the county seat. If the county seat has not adopted an updated version of the code, then the 2000 IRC applies and code enforcement falls under the jurisdiction of the Texas Residential Construction Commission (TRCC).

Texas Residential Construction Commission

The TRCC develops and maintains building and performance standards for residential construction in Texas. These standards are not the same as a building code. A building code dictates how a builder must build a house. The building and performance standards apply to how a house must perform after it is built. The commission-adopted building and performance standards apply to residential construction that began in Texas on or after June 1, 2005. Residential construction completed before June 1, 2005, is governed by the standards applicable to the project at the time of the construction. The commission-adopted standards include compliance with the 2000 IRC and the 1999 NEC (TRCC, 2005).

In August 2008, the Texas Sunset Advisory Commission, which was created in 1977 by the Legislature to identify and eliminate waste, duplication, and inefficiency in government agencies, called for the TRCC to be abolished and stated that its "current regulation of the residential construction industry is fundamentally flawed and does more harm than good" (Dallas Business

Journal, 2008). On September 1, 2008, in response to the Sunset Advisory Commission, the TRCC began enforcing an amendment to the Texas Register that had been previously approved in February 2008. This amendment requires the enforcement of the IRC for residential construction completed by builders and remodelers in unincorporated areas or in areas not subject to municipal inspections to have a minimum of three inspections: 1) a foundation inspection; 2) a framing, mechanical, and delivery systems inspection; and 3) a final inspection.[1] This three-step process provides inspection by a qualified third-party architect, engineer, or building official and is intended to ensure compliance with the requirements of the IRC. However, unincorporated areas of Texas are not required to complete plan review, residential building design review, or building inspection by a State or county building official.

Louisiana Statewide Uniform Construction Code

The Louisiana Legislature enacted Act 12 of the 2005 First Extraordinary Session to provide for a State uniform construction code to govern new construction, reconstruction, and additions to previously constructed homes in 11 coastal parishes. Act 12 mandated adoption of the latest editions of the IBC and IRC (subject to some amendments by the State) and created the Louisiana Statewide Uniform Construction Code Council (LSUCCC) to update statewide code as new editions of the IBC and IRC are published.[2]

2.2.1 Flood Requirements

The following discussion provides information regarding flood requirements in building codes and the national consensus standards that are incorporated into the codes. The flood-related code provisions discussed generally apply in Louisiana and Texas.

2.2.1.1 Flood Requirements in the IBC and IRC

IBC. The IBC applies to multi-family buildings (with a few exceptions) and to non-residential buildings. In the terminology of the NFIP, the IBC is used for engineered structures. The 2006 IBC addresses flood loads and flood-resistant construction primarily in Section 1612, Flood Loads, which refers to the consensus standards ASCE 7-05 and ASCE 24-05 (refer to Section 2.2.1.2 and 2.2.1.3 for information on ASCE). Most of the mandatory flood provisions are contained in Section 1612, but others occur in the code related to the lowest floor elevation inspection, flood-resistant materials, accessibility, ventilation, and elevators (IBC 2006). Flood loads and load combinations are specified in Section 1605, Load Combinations (IBC 2006). The designer must identify the pertinent, site-specific characteristics and then use ASCE 7-05 to determine the pertinent specific loads and load combinations. In effect, it is similar to a local floodplain ordinance that requires determination of the environmental conditions (location of building with respect to mapped flood hazard area, effective BFE, and flood depth) and then specifies certain conditions that must be met during design and construction. The body of the IBC, together with Appendix G, Flood-Resistant Construction, addresses all of the key building and development requirements of the NFIP. If communities participate in the NFIP, they should

1 http://www.trcc.state.tx.us/policy/FAQs_2.asp#countyinspections

2 See http://www.dps.louisiana.gov/lsuccc/codes.html for the latest Louisiana code information

coordinate their floodplain ordinances with the I-Codes (both IBC and IRC) to ensure that all requirements are addressed.

IRC. The scope of the IRC is more limited than the IBC. The IRC applies to one- and two-family dwellings and to some townhouses. In the terminology of the NFIP, the IRC is used for residential structures. The IRC addresses flood-resistant construction primarily in Section R324, Flood-Resistant Construction, although provisions for mechanical and plumbing installations are included in other pertinent sections of the 2006 IRC.

It is important that communities coordinate their ordinances with the I-Codes (both IBC and IRC) to ensure that all requirements are addressed. A crosswalk of the NFIP regulations and the I-Code provisions is provided in FEMA 9-0372.

IBC/IRC Commonalities. There are some commonalities between the IBC and the IRC as they relate to NFIP:

- **Both** specify information related to SFHAs that are to be included in permit applications and shown on plans.
- **Both** specify that an inspection is required upon placement of the lowest floor, including basement, and prior to further vertical construction, at which time the building official is to require submission of documentation, prepared and sealed by a registered design professional or surveyor, of the elevation of the lowest floor, including the basement.

2.2.1.2 Flood Requirements in ASCE 7-05

The ASCE develops and maintains the consensus standard for ASCE 7-05 (2005b). Since the 1995 edition, ASCE has included flood load provisions. The provisions have changed with each succeeding edition. ASCE 7-98 is a referenced standard in the 2000 and 2003 editions of the IBC, and the 2006 edition of the codes refers to ASCE 7-05.

Design loads used by the 2003 IBC are taken from ASCE 7-02. The following sections of ASCE 7-05 deal with flood:

- Section 2.3, Combining Factored Loads Using Strength Design, and Section 2.4, Combining Nominal Loads Using Allowable Stress Design, include load combinations for Zone V and Coastal A Zone.
- Chapter 5, Flood Loads, covers hydrostatic, hydrodynamic, wave, and impact loads. Load criteria for breakaway walls are included in Section 5.3.3.

The standard requires designers to determine if a site is susceptible to erosion (general lowering of the ground surface) or scour (localized lowering due to interaction of waves and currents with a building element).

In recognition of the growing awareness that wave heights between 1.5 feet and 3.0 feet (the latter being the lower cutoff used to delineate FEMA's Zone V) cause considerable damage, ASCE 7-05 incorporates the concept of the Coastal A Zone.

The 2006 edition of the IRC does not refer to ASCE 7-05 for flood loads because the code is a prescriptive code that, for the most part, does not require individual designs for buildings that are built in compliance with the provisions of the code. However, for buildings located in Zone V, individual designs for buildings must be prepared and sealed by a registered design professional.

2.2.1.3 Flood Requirements in ASCE 24-05

The ASCE develops and maintains the consensus standard for ASCE 24-05, *Flood Resistant Design and Construction* (2005a). The first edition of ASCE 24 was published in 1998 and is referenced in the 2000 and 2003 editions of the IBC. The 2005 edition of ASCE 24 is a major revision and expansion of the standard, and is referenced by the 2006 IBC.

ASCE 24-05 specifies minimum requirements for flood-resistant design and construction of buildings and structures located in flood hazard areas, including floodways, Coastal High Hazard Areas, and other high-risk flood hazard areas, such as alluvial fans, flash flood areas, mudslide areas, erosion-prone areas, and high velocity areas. It applies to new structures and substantial repair or improvement of existing structures that are not designated as historic structures. Basic design requirements address flood loads and load combinations, elevation of the lowest floor, foundation requirements and geotechnical considerations, use of fill, and anchoring and connections. As a function of the type of flood hazard area, enclosures are to have breakaway walls or meet requirements for flood openings (prescriptive or engineered).

For buildings in coastal high hazard areas (Zone V) and Coastal A Zone, ASCE 24-05 includes specifications for the design of pile, post, pier, column, and shear wall foundations. Considerable detail is specified for pilings as a function of pile types and connections.

Additional sections of ASCE 24-05 include the following elements: materials, dry and wet floodproofing, utility installations, building access, and miscellaneous construction (decks, porches, patios, garages, chimneys and fireplaces, pools, and above- and below-ground storage tanks).

Section 1612.4 of the 2006 IBC states, "The design and construction of buildings and structures located in flood hazard areas, including flood hazard areas subject to high velocity wave action, shall be in accordance with ASCE 24."

The 2006 IRC does not refer to ASCE 24-05 because the code is a prescriptive code that, for the most part, does not require individual designs for buildings that are built in compliance with the provisions of the code. The exceptions for Zone V buildings (which do require design) were listed above. Communities must, therefore, reference ASCE 24-05 directly to apply its provisions to residential buildings. However, Section R324 of the 2006 IRC, Flood-Resistant Construction, states that buildings in floodways shall be designed in accordance with the IBC, thereby mandating use of ASCE 24-05 for buildings in floodways as shown on the FIRMs. Also, the 2009 IRC will allow use of ASCE 24-05 as an alternative to certain provisions of the IRC.

2.2.1.4 Flood Requirements in Texas

Flood requirements in Texas are specified at the community level. There are no additional State-mandated flood standards. The Texas Water Development Board[3] is the State coordinating agency for the NFIP.

2.2.1.5 Flood Requirements in Louisiana

Flood requirements in Louisiana are specified at the community level. There are no additional State-mandated flood standards. The Louisiana Department of Transportation and Development (LADOTD)[4] is the State coordinating agency for the NFIP, and produced a *Louisiana Floodplain Management Desk Reference* summarizing floodplain management in the State (LADOTD, 2008).

2.2.2 Wind Requirements

Wind speeds and wind damage were more significant in Texas than Louisiana. The wind investigation and analysis was primarily limited to Texas. The following discussion provides information regarding wind requirements in codes and information about code adoptions in Texas and Louisiana.

2.2.2.1 Wind Requirements in the IBC

The methodology required for calculating wind loads in the 2006 IBC is that prescribed in Chapter 6 of ASCE 7-05. Using ASCE 7-05 for determining wind loads ensures that designers are using state-of-the-art methodology to calculate wind loads. In addition to improved load computations, ASCE 7-05 also provides performance and testing requirements for windborne debris protection of glazing in compliance with ASTM E 1886, *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*, and ASTM E 1996, *Standard Specification for Performance of Exterior Windows, Glazed Curtain Walls, Doors, and Storm Shutters Impacted by Windborne Debris in Hurricanes.*

2.2.2.2 Wind Requirements in Texas

Texas counties and municipalities have the authority to adopt a building code of their choosing. Historically, in the State of Texas, the codes of choice were the Standard Building Code (SBC) and the Uniform Building Code (UBC), with the SBC being the preferred code in the coastal counties. With the advent of the I-Codes in 2000, most counties had adopted the IRC and the IBC prior to Hurricane Ike. As of September 1, 2008, the TRCC requires unincorporated areas within counties to comply with the 2000 IRC, at a minimum. If a county seat has adopted an updated version of the IRC code, that code applies to the unincorporated areas within the county. Table 2-1 lists those counties affected by Ike and their adopted codes.

3 http://www.twdb.state.tx.us/wrpi/flood/nfip.htm
4 http://www8.dotd.la.gov/lafloods/

Table 2-1. Codes in Effect at the Time of Hurricane Ike for Impacted Counties and Cities in Texas

County	City	Building Codes*, **
Brazoria County		
	Surfside Beach	2003 IBC and IRC
Chambers County		
	Baytown	2006 IBC and IRC
Galveston County		
	Clear Lake Shores	2003 IBC and IRC
	City of Galveston	2003 IBC and IRC
	Jamaica Beach	2006 IBC and IRC
	Village of Tiki Island	2000 IBC and IRC
	Kemah	2003 IBC and IRC
	Texas City	2003 IBC and IRC
	League City	2000 IBC and IRC
Harris County		
	Houston	2000 IBC and IRC
	La Porte	2003 IBC and IRC
	Deer Park	2003 IBC and IRC
	Seabrook	2003 IBC and IRC
	Shoreacres	2000 IBC and IRC (2006 IBC and IRC adopted after Hurricane Ike)
Jefferson County		
	Beaumont	1997 SBCCI
	Port Arthur	2006 IBC and IRC
	Port Neches	2003 IBC and IRC
Orange County		
	Bridge City	2006 IBC
	Orange	2003 IBC and IRC

Notes:

* IBC – International Building Code
IRC – International Residential Code
SBCCI – Southern Building Code Congress International

** The current adopted code should be verified before construction or rebuilding activities commence.

All versions of IBC specify higher wind speeds for coastal Texas counties than any of the previous editions of the SBC. Therefore, variation exists in the design wind speeds for areas throughout those counties for buildings previously constructed to the SBC standard. The 1985 SBC modified the required speeds to match those in the American National Standards Institute (ANSI) A58.1-1982 standard, the predecessor to the ASCE 7, but rejected the inclusion of the new methods and coefficients for calculation pressures included in the ANSI standard. The wind speed map remained unchanged for all subsequent editions of SBC, including the last edition in 1999. The maps used by the 2003 IBC are taken directly from ASCE 7-02. The 3-second gust wind speeds cited in the 2003 IBC for Galveston, Chambers, and Harris Counties increased significantly from those cited in the 1997 SBC. Table 2-2 summarizes the progression over time of the basic design wind speeds for those counties. The map shown in Figure 2-4 includes an overlay of design wind speed contours for the portion of the Texas and Louisiana coast affected by Hurricane Ike and was taken directly from the 2003 IBC/ASCE 7-05. The colored swaths provide a graphical representation of the percentage difference between Hurricane Ike's peak 3-second gusts compared to these design speeds. This map clearly indicates that Hurricane Ike's winds were less than the required design wind speeds for buildings in this region.

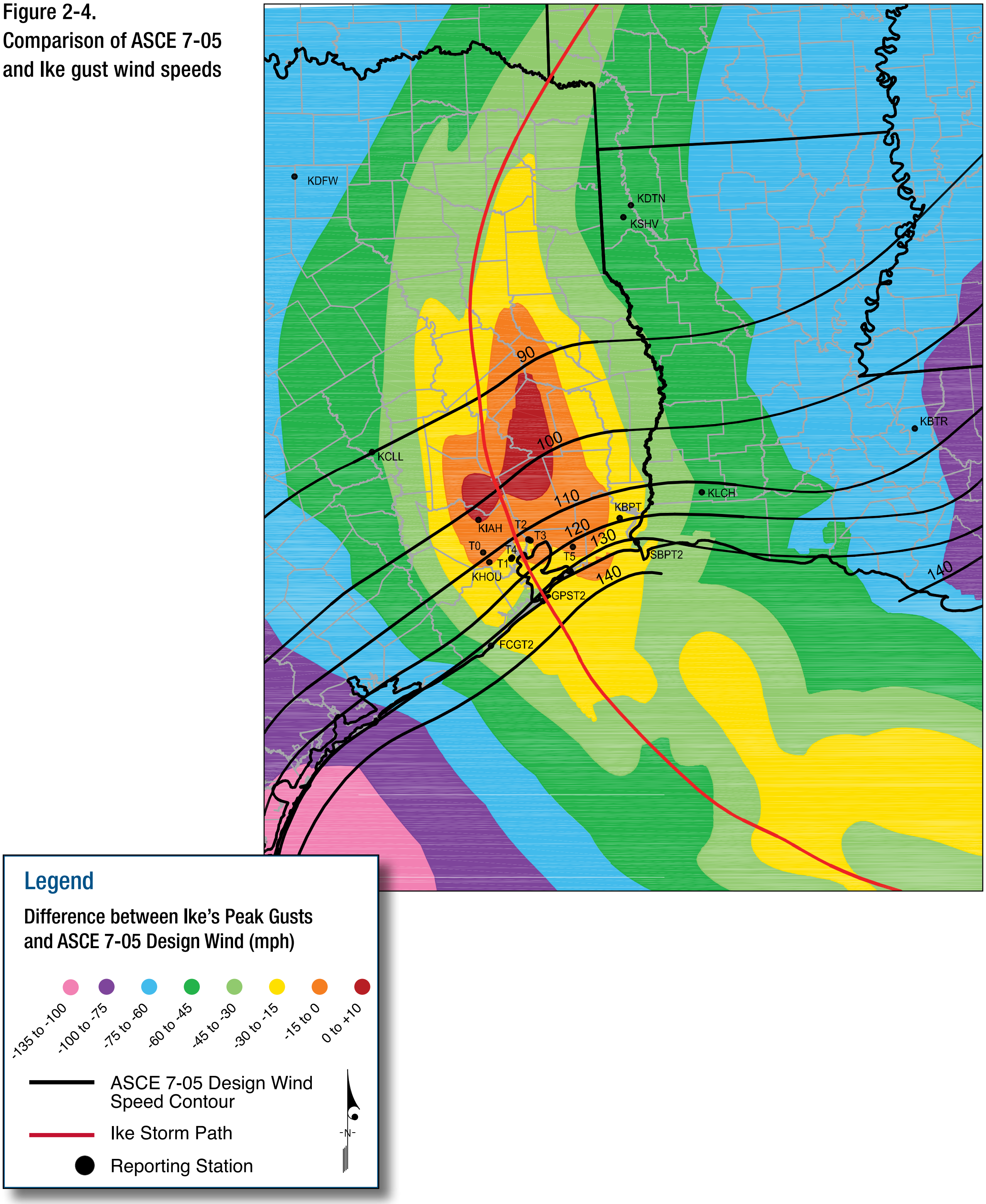
Table 2-2. Approximate Range of Basic Design Wind Speeds in the Coastal Counties Visited by the MAT (3-Second Gust, Exposure C, at 33 Feet Above Ground)

County	SBC 1985 Edition*	SBC 1997 Edition*	2006 IBC and ASCE 7-02 and Later
Galveston	115–120 mph	110–120 mph	120–130 mph
Chambers	110–115 mph	110–115 mph	110–125 mph
Harris	100–110 mph	100–110 mph	100–110 mph

* Code wind speeds reported as fastest-mile wind speeds in the Standard Building Code (SBC) were converted to 3-second gust for comparison. The lower values correspond to the edge of the county farthest from the coast, and the higher values correspond to the coastal value or the edge of the county closest to the coast.

IBC = International Building Code
ASCE = American Society of Civil Engineers

Figure 2-4.
Comparison of ASCE 7-05 and Ike gust wind speeds



Example of Design Load Changes Over Time

The SBC expressed wind speeds in terms of the "fastest mile," whereas the IBC and ASCE 7 measures maximum wind speeds as "3-second gusts" (refer to text box). Table 2-3 presents a summary of the design wind pressures on wall and roof areas for a typical residence in the City of Galveston, and compares the wind pressures with respect to the 1985 SBC fastest mile measurement, the 1997 SBC 3-second gust (converted from fastest mile) measurement using an ASCE 7-95 design solution and the current adopted 2006 IBC 3-second gust measurement. The IBC calculations are based on a home less than 33 feet tall and located near the water in Exposure C. The required design pressures are given for both a building's structure (referred to in codes and standards as the main wind force resisting system or MWFRS) and for a building's envelope (referred to as components and cladding, or C&C). The 1985 SBC uses the terminology of "Parts and Portions" (P&P) in lieu of the current ASCE 7 terminology of C&C. The 1985 SBC design coefficients did not address pressures for MWFRS corners or P&P coefficients for roof and corner edges. Though the 1985 SBC references and allows the use of the ANSI standard (ANSI A58.1-1982), the new design load standard and predecessor of ASCE 7 of that time, the City of Galveston did not adopt the ANSI standard.

COMPARING BASIC DESIGN WIND SPEEDS

Current codes and standards (2006 IBC and ASCE 7-05) standardize wind speed measurement as the 3-second gust. This differs from the fastest-mile wind speed measure that was previously used by the SBC, as well as the wind speed measure of 1-minute sustained that is used in the Saffir-Simpson Hurricane Scale and referenced by the NHC. The Saffir-Simpson Hurricane Scale was presented in Table 1-2. The table below provides a comparison of wind speeds for 3-second gust, fastest mile, and 1-minute sustained.

Wind Speed Comparison (in miles per hour)

*$V_{3\text{-second gust}}$	85	90	100	110	120	130	140	150
*$V_{\text{fastest-mile}}$	70	75	80	90	100	110	120	130
**$V_{\text{sustained}}$	67	71	79	87	95	102	110	118

* 3-second gust and fastest mile based on 2003 IBC table 1609.3.1.

** 1-minute sustained based on the Engineering Sciences Data Unit gust factor curve.

Table 2-3. Design Loads for a Typical Single-Family Residence in the City of Galveston, Galveston County, TX

Description	SBC 1985 Edition	SBC 1997 Edition (ASCE 7-95 Solution)	2006 IBC and ASCE 7-05
Basic Design Wind Speed	100 mph (fastest-mile, f_m)	120 mph (f_m converted to 3-second gust)	130 mph (3-second gust)
Wind Design Pressures on Exterior Walls (psf)			
As MWFRS:			
Windward	+19/+14	+29/+16	+30/+17
Leeward	-12/-7	-20/-8	-21/-9
Net Horizontal	+31	+37	+39
As C&C:			
Middle	+26/-26	+36/-41	+39/-43
Corner	*	+36/-49	+39/-51
Wind Design Pressures on Roof (4:12 slope) (psf)			
As MWFRS:			
Windward	-22/-18	-18/-5	-23/-10
Leeward	-17/-12	-20/-8	-23/-11
As C&C:			
Middle	*	+16/-53	+27/-64
Corner	*	+16/-55	+23/-80
Overhang Middle	-36	-73	-75
Overhang Corner	*	-83	-127

Definitions:
SBC = Standard Building Code
ASCE = American Society of Civil Engineers
IBC = International Building Code
mph = miles per hour
psf = pounds per square foot
MWFRS = Main Wind Force Resisting System
C&C = Components and Cladding

Notes:
The sampled residence is 40 feet by 40 feet, elevated on 10 pilings, with a total roof eave height of 20 feet. The roof is gable with the winds calculated normal to the roof ridge line. The roof slope is a 4:12 pitch. Calculations use the SBC and ASCE 7 method for buildings of all heights. Wind speeds were selected from the 50-year Mean Recurrence Maps from the respective code or standard. Calculations are based on Exposure C wind speeds measured at 33 feet (10 meters) above ground level.

* Load considerations and pressure coefficients not included in the SBC 1985 Edition.

1. The pressure calculations under each code for both MWFRS and C&C were calculated using building design coefficients that provide the maximum wind pressure for that area on the building surface.
2. Previous and current U.S. building codes and ASCE standards do not address pressures on the underside of floors for open elevated structures.
3. Positive pressure values indicate pressure acting inward toward building surfaces. Negative value pressures indicate pressures acting outward from building surfaces.
4. The building was considered to be an enclosed structure subject to positive and negative internal pressures and the values tabulated represent the maximums per evaluated area.
5. Numbers divided by a slash (/) represent the effect of positive and negative pressure coefficients.
6. The net horizontal pressures consider the addition of the positive windward pressures and negative leeward pressures with the internal pressures canceled.

2.2.2.3 Wind Requirements in Louisiana

Prior to Hurricane Katrina, Louisiana communities had various building and residential codes, and, in many communities, no codes at all. The State Uniform Construction Code, which took effect on January 1, 2004, required only that communities choosing to enforce a code use the 2000 IBC. Many larger cities and parishes adopted the IBC, but many other communities had not adopted the IBC, and were still enforcing various editions of the SBC. There were no State-level provisions relating to residential building codes. When adopted, the form and guidance provided by these residential codes varied widely, including various editions of the IRC, SBC, and Council of American Building Officials (CABO) codes. This lack of a residential code, or use of older versions of the residential codes, is often an indicator that the residential buildings in the areas were designed and constructed without the guidance and criteria of the newer hazard-resistant codes.

After Hurricane Katrina, the Louisiana State Legislature passed Act 12 on November 29, 2005, requiring enforcement of the IBC and IRC statewide. It also created the Louisiana State Uniform Construction Code Council, whose purpose is to "... review and adopt the state uniform construction code, provide for training and education of code officials, and to accept all requests for amendments to the code, except the Louisiana State Plumbing Code." The provisions of the newly revised State Uniform Construction Code were to be implemented in phases. The new law contained emergency provisions requiring Calcasieu, Cameron, Iberia, Jefferson, Lafourche, Orleans, Plaquemines, St. Bernard, St. Tammany, Terrebonne, and Vermilion Parishes to enforce all wind and flood mitigation requirements prescribed by the 2003 IBC and IRC, as modified and amended by Section 301.2.1.1(2) to replace SBCCI *Standard for Hurricane-Resistant Construction* (SBCCI SSTD 10-99) with the *Guidelines for Hurricane-Resistant Residential Construction* as published by the IBHS in 2005.

2.2.3 HUD Manufactured Housing Design Standards

The design and construction of manufactured homes have been governed at the Federal level by the U.S. Department of Housing and Urban Development (HUD) since the National Manufactured Housing and Construction Safety Standards Act was passed in 1974.

Beginning in 1976, the Manufactured Home Construction and Safety Standards, Title 24 of the Code of Federal Regulations (CFR) Part 3280, established the minimum requirements for the construction, design, and performance of a manufactured home. HUD, rather than States or communities, determines the manufacturing standards for manufactured homes. However, States and communities determine where manufactured housing can be sited and what permits and inspections are required for installation and occupancy of manufactured housing.

Currently, the HUD standards define a manufactured home as a dwelling unit, transportable in one or more sections, that, when erected on site, is of at least 320 square feet in size, with a permanent chassis to ensure the initial and continued transportability of the home. In the traveling mode, a manufactured home is 8 feet or more in width or 40 feet or more in length.

In August 1992, when Hurricane Andrew hit southern Florida, over one-third of all site-built houses were substantially damaged and almost all manufactured homes were destroyed within the area affected by the hurricane. As a direct consequence, HUD developed improved wind-resistance requirements for the hurricane-prone coastal areas of the United States. Published as a Final Rule in the Federal Register (59 FR 2456 [1994]), these changes introduced more stringent requirements in high wind areas and defined three separate wind zones: Zone I, Zone II, and Zone III.

For wind Zones II and III, this rule also designates higher wind loads. Specifically, the updated HUD standard requires that the manufactured home, each of its wind-resisting parts, and its C&C materials be designed by a professional engineer or architect to resist either the design wind loads for Exposure C specified in ANSI/ASCE 7-88, *Minimum Design Loads for Buildings and Other Structures*, for a 50-year recurrence interval or those tabulated in 24 CFR Part 3280. Zone II homes must be designed to resist a fastest-mile wind speed of 100 mph; Zone III homes must be designed to resist a 110 mph fastest-mile wind speed. Zone I homes are not specifically associated with a design wind speed, but rather are designed to resist minimum horizontal and vertical wind pressures.

In addition, the rule requires that each manufactured home have a support and anchoring or foundation system that, when properly designed and installed, will resist overturning and lateral movement (sliding) of the manufactured home, as imposed by the respective design loads.

Please note that the September 1985 edition of FEMA 85, *Manufactured Home Installation in Flood Hazard Areas*, is currently under revision and is tentatively scheduled to be released later in 2009.

Manufactured home regulations and standards are continuously being developed. The following list summarizes some of the more recent regulations and standards that have been passed or developed:

- The HUD Manufactured Housing Installation Standard, 24 CFR Part 3285, was issued in October 2007 and became effective October 20, 2008. This standard is part of an installation program that includes: (1) installation standards, (2) training and licensing manufactured home installers, and (3) inspecting manufactured home installations. The HUD program will be mandated for any State that does not have its own program that includes all three of the previously described components. To be exempted, a State must have adopted standards that equal or exceed the protection provided by HUD's program.[5]
- The NFPA currently maintains three documents on the subject of manufactured housing: (1) NFPA 501, *Standard on Manufactured Housing*, a consensus document on the design and construction of manufactured homes (NFPA, 2005b); (2) NFPA 501A, *Standard for Fire Safety Criteria for Manufactured Home Installations, Sites and Communities* (NFPA, 2009b); and (3) NFPA 225, *Model Manufactured Home Installation Standard*, a consensus document that governs the installation of manufactured homes (NFPA, 2009a). The 2005 edition of NFPA 501 has wind-related requirements based upon ASCE 7-02. The 2009 edition of

5 More information on the development of this new program can be found at http://www.hud.gov/offices/hsg/ramh/mhs/mhip.cfm

NFPA 225 has wind provisions consistent with ASCE 7-05 and flood provisions consistent with the NFIP. The latest edition of NFPA 225 also contains new prescriptive flood- and wind-resistant foundation designs.

2.2.3.1 Manufactured Housing in Texas

The Manufactured Housing Division of the Texas Department of Housing and Community Affairs adopted amendments to Texas Administrative Code (TAC), Chapter 80, Sections 80.2, 80.21, and 80.22, related to installation standards of the manufactured housing program. These amendments comply with the Federal Installation Standards (24 CFR Part 3485) that became effective January 1, 2009.

The Texas codes require that all new manufactured homes be installed by a licensed installer in accordance with the home manufacturer's approved installation instructions. The installer of a new manufactured home is responsible for the proper preparation of the site where the manufactured home will be installed.

The codes require that all used manufactured homes be installed by a licensed installer to resist overturning and lateral movement of the home and in accordance with instructions appropriate for the wind zone where the home is to be installed as per the home manufacturer's installation instructions; the State's generic standards set forth in Sections 80.22 through 80.25 of Chapter 80; the instructions for a stabilization system registered with the Department in accordance with Section 80.26 of Chapter 80; or the instructions for a special stabilization system.

2.2.3.2 Manufactured Housing in Louisiana

The State of Louisiana has adopted the Manufactured Home Installation Standards – Final Rule contained in 24 CFR Part 3285 for the installation of new manufactured homes. In the Final Rule, all new manufactured homes must be installed to the new standard at the initial installation. The manufacturer's instructions apply where the manufacturer's approved instructions meet or exceed this standard and do not take the home out of compliance.

Prior to initial installation of a new manufactured home, the installer is responsible for determining whether the manufactured home site lies wholly or partially within a flood hazard area (24 CFR 3285.102). If the property where the home is to be installed is located within a flood zone, 24 CFR Part 3285 requires the installation to satisfy the NFIP. The Final Rule at 24 CFR Part 3285 also requires that manufacturer's installation instructions specifically state whether they are appropriate for homes placed in SFHAs or not.

For existing homes, Louisiana follows the Louisiana Revised Statutes (R.S.) 51:912.21. In the absence of manufacturer's installation instructions, homes must be placed in accordance with R.S. 51:912.21 through 51:912.31. Louisiana statutes require the landowner to be responsible for proper site preparation. The statutes also require that the grade under the home be cleaned of all vegetation and organic material, and sloped to properly drain. All grass and organic material must be removed and the pier foundation placed on stable soil or compacted fill. The statutes also specify minimum requirements for the pads or footers supporting the piers. In floodprone areas, the foundation is required to comply with the requirements set forth in FEMA 85, M*anufactured Home Installation in Flood Hazard Areas* (FEMA, 1985).

2.2.4 Galveston Residential Hurricane Resistance Study, 1990

During the last decade, new information has been learned about the effects of hurricane wind and flooding, and this knowledge has been incorporated into building codes and construction practices. In 1990, a study titled *Effectiveness of Building Codes and Construction Practice in Reducing Hurricane Damage to Non-Engineered Construction* was conducted by James R. McDonald, PhD, P.E. of the TTU Institute for Disaster Research and Billy Manning, P.E. of SBCCI. The scope of work was to examine the history of the wind and flood design provisions of the City of Galveston, TX, building code and to determine the effectiveness of building codes and construction practices in reducing hurricane damage to non-engineered construction. Thirty-one single-family residences constructed under various eras of building code authority were examined. The information collected included terrain exposure, floor elevation, construction practices, quality of workmanship and materials, state of repair, insurance coverage, and damage from previous hurricanes. The MAT's review and investigation of some of the buildings analyzed in the 1990 Galveston study provides insight into an important question: whether the continued observed vulnerability of buildings from hurricanes results from an incomplete understanding of design or construction issues or the lack of incorporating these design and construction practices into new construction and retrofit buildings.

Ten code eras were identified, beginning with the first Galveston code adoption in 1914 and ending with the effective code at the time the study was conducted. The codes concurrent with the Galveston study were the SBC (1985 edition with the 1986 revisions, published by SBCCI) and the 1971 Texas Catastrophe Property Insurance Association (TCPIA) wind load provisions. The TCPIA wind code applied to the first two tiers of counties along the Gulf Coast of Texas, including Galveston (refer to Section 2.3.2 for more information). In order to obtain extended-coverage insurance, a building owner had to have certification that the property met the TCPIA requirements.

The locations of the houses investigated in the Galveston study are shown in Figure 2-5. The newest house, number 3289, was still under construction at that time, which allowed for a thorough investigation of building connections and construction quality. The remaining 30 houses had been constructed prior to the study, and the building connections could not be thoroughly examined. Attics were inspected and the type of rafter-to-wall connections noted, either toe-nailed or hurricane clips. Of the 31 houses, seven were observed to have hurricane clip connections. A roof uplift resistance analysis was run on each house based upon the observed quality of construction, the roof anchorage, rafter size and spacing, and the roof decking. Those results were then compared to the current Galveston code, SBC, and ASCE 7-88 uplift forces associated to the same assigned wind speed of 96 mph, fastest-mile (117 mph, 3-second gust).

The City of Galveston adopted the NFIP's FIRMs on May 7, 1971. Based on the results of a wave analysis that FEMA conducted for the City, the FIRMs were revised in 1983 and remained current

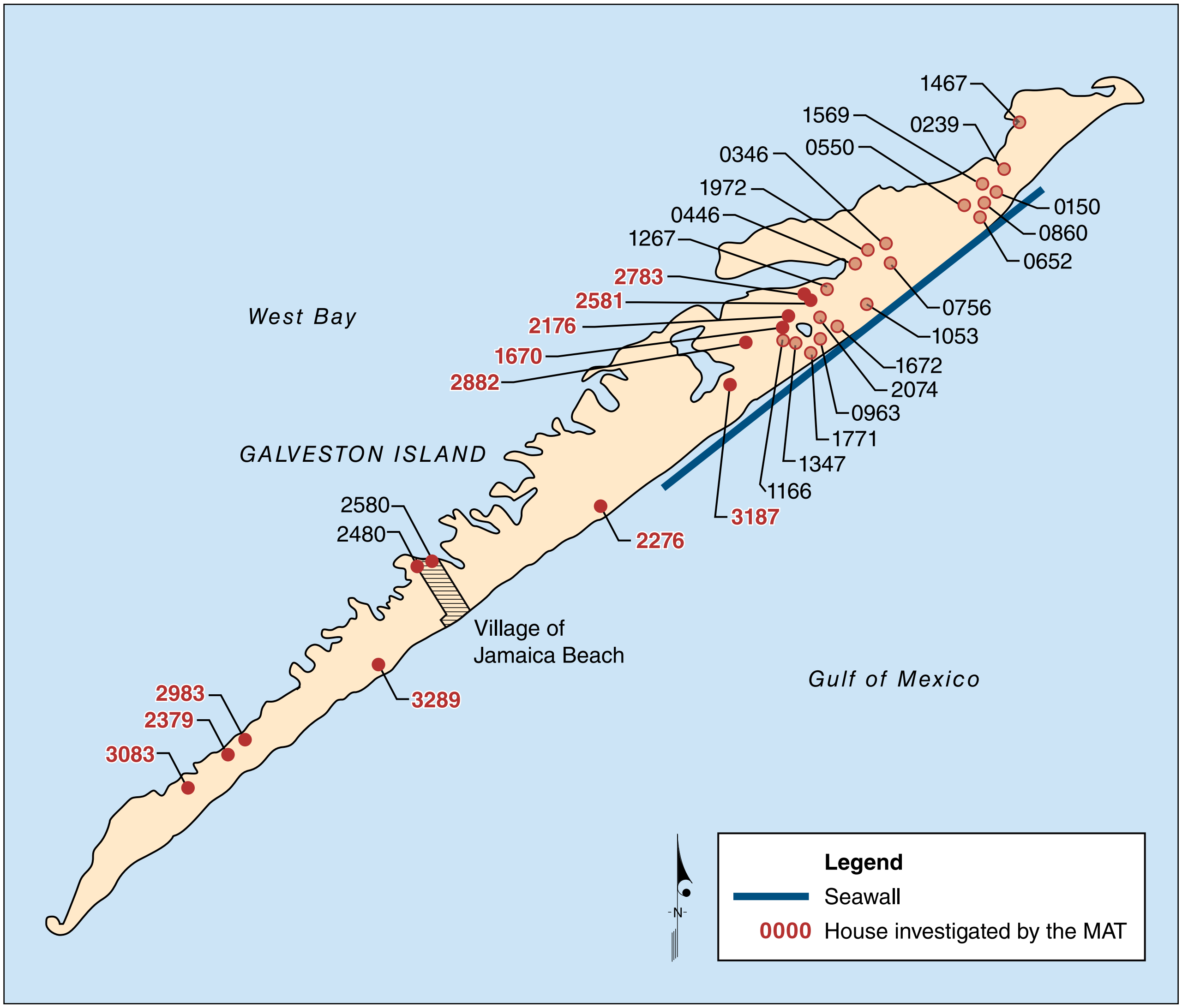


Figure 2-5.
Galveston Island houses investigated for the 1990 report that were visited by the MAT in 2008 after Hurricane Ike

at the date of the 1990 Galveston study. As a part of the investigation of susceptibility of the 31 houses for flooding and surge damage, the following information was recorded for each:

- Flood zone
- BFE
- Elevation of lowest floor
- Distance to water
- Closest body of water
- Foundation type
- Connections of elevated structure

PRE-FIRM AND POST-FIRM BUILDINGS

For insurance rating purposes, a pre-FIRM building was constructed or substantially improved on or before December 31, 1974, or before the effective date of the initial FIRM of a community, whichever is later. Most pre-FIRM buildings were constructed without taking the flood hazard into account.

A post-FIRM building was constructed or substantially improved after December 31, 1974, or after the effective date of the initial FIRM, whichever is later. For a community that participated in the NFIP when its initial FIRM was issued, post-FIRM buildings are the same as new construction and must meet the NFIP's minimum floodplain management standards.

The observations included in the Galveston study noted that many of the houses constructed pre-FIRM were constructed at or within 1 foot of the mapped BFE. All of the houses constructed post-FIRM were sited above the BFE and appeared to have more substantial pile foundations than the older residences, and had more substantial anchorage between the piles, girders, and floor joists.

The overwhelming conclusions of the Galveston study regarding wind resistance were that most wood-framed residences did not meet the performance criteria of building codes and roof-to-wall connections were not designed or analyzed for resistance to wind uplift forces. Other conclusions were that the practice of using toe-nailed connections is unsatisfactory, and that hurricane clips can provide the needed resistance, but their selection must be based upon the calculated forces. Other factors that contribute to large uplift forces include building width, eave height, roof angle, and overhang dimension.

Additionally, the Galveston study concluded that the wind load provisions of the building code current at the time of investigation failed to meet the then current criteria of ASCE 7-88. The study further concluded that houses constructed since the adoption of the NFIP in 1971 utilizing flood-resistant construction and BFE elevations should perform to NFIP expectations; however, the practice of installing non-breakaway walls below the BFE in Zones V and Coastal A Zones were in violation of the NFIP and jeopardized the houses' structural resistance to flood loads.

2.2.4.1 Ike MAT Observations of Houses in the 1990 Galveston Study

The MAT chose to investigate 12 of the 31 houses included in the 1990 Galveston study located nearest the coastline and not protected by the seawall. Eleven of these houses were still standing after Hurricane Ike, but suffered varying degrees of damage (Figure 2-5). Number 2276, located on the Gulf side of Bermuda Drive, had been washed away by the storm. Number 3289, located in Indian Beach in a Zone V, is approximately 200 feet from the Gulf (Figure 2-6). This house had been under construction during the preparation of the Galveston study, thereby allowing the investigators to survey the building construction and connections. The Galveston study reported deficiencies for this house, including non-breakaway elements below the BFE and a roof uplift resistance greater than the local building code, but less than ASCE requirements. The MAT observed that the first floor was 2 feet above the BFE (17 feet) with significant pilings (12-inch by 12-inch) to girder connections and hurricane clips; however, many clips were corroded and broken (Figure 2-6 inset), as would be expected in this location. Refer to NFIP Technical Bulletin 8-96, *Corrosion Protection for Metal Connectors in Coastal Areas* (August 1996).

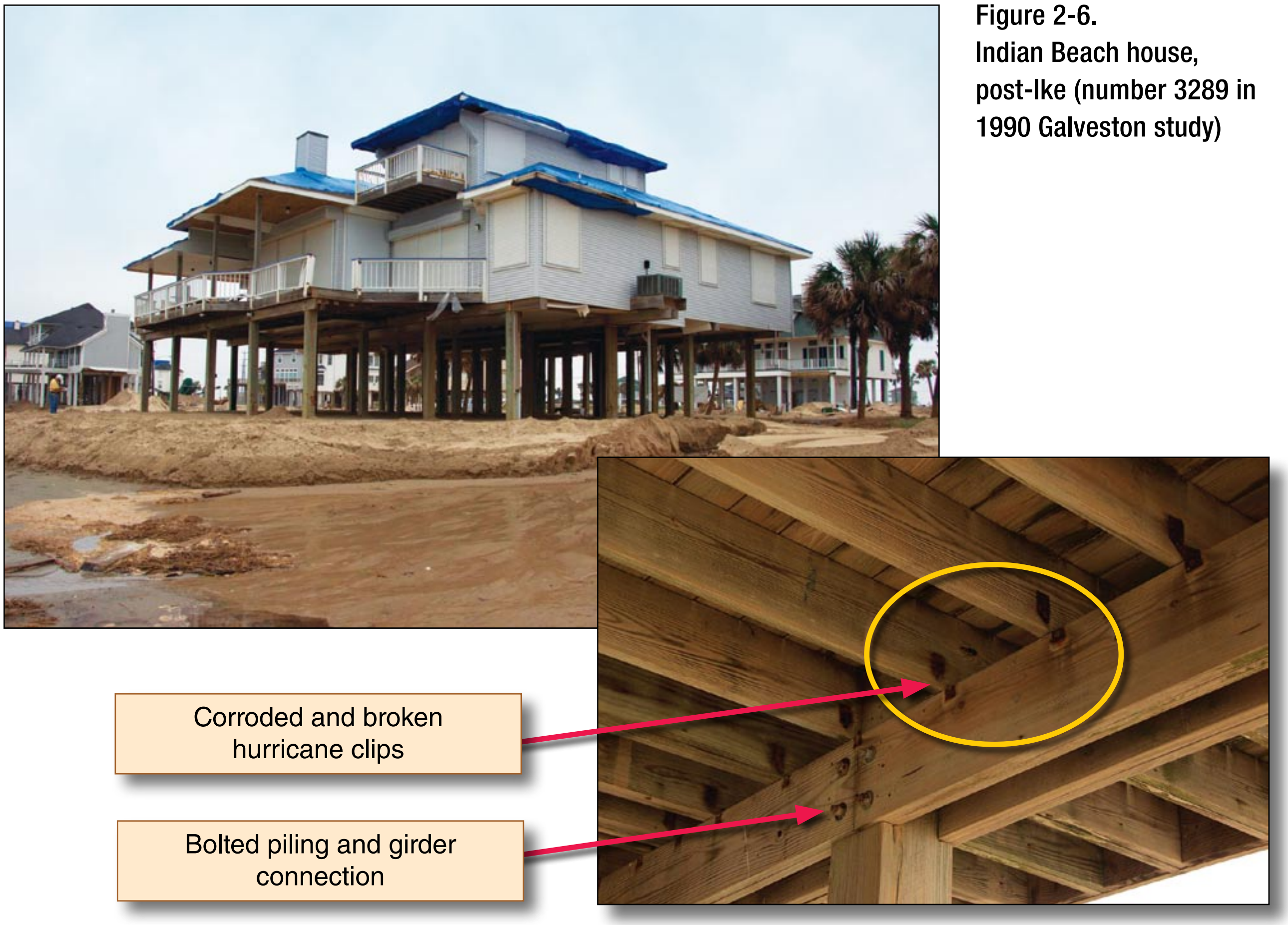


Figure 2-6.
Indian Beach house, post-Ike (number 3289 in 1990 Galveston study)

During Hurricane Ike, the house suffered substantial wind damage to the asphalt shingles, vinyl siding, and soffits. The Galveston study identified the lack of shuttering for the house openings as a weakness. At the time of Hurricane Ike, the house openings were fully shuttered.

Number 3083, constructed in 1983, is located in Zone A in Point San Luis on a canal that opens to the West Bay (Figure 2-7). According to the Galveston study, this house's identified weaknesses included overhangs greater than 4 feet, pile spacing greater than 12 feet, and walls or enclosures below the BFE that were not of breakaway construction. During Ike, the house was inundated by approximately 8 feet of water with waves that destroyed the majority of the first floor walls.

Number 2480 is located on the West Bay in Zone A in Jamaica Beach with a Category C wind exposure (Figure 2-8). The Galveston study identifies the hurricane clips and bolted structural connections as strengths and the non-breakaway wall structures as a primary weakness. The house experienced both wind and flood damage during Hurricane Ike. Wind damaged vinyl siding and roof shingles on the north and west exposure of the house, an indicator of "backside" (north-to-south) winds. Flooding and waves undermined the concrete paving below the house and tore out ceilings, stairs, and wall structures below the first floor (Figure 2-9).

Figure 2-7.
Point San Luis house (number 3083 in 1990 Galveston study)

Figure 2-8.
Jamaica Beach house on the West Bay with "backside" wind damage (number 2480 in 1990 Galveston study)

Figure 2-9.
First floor walls removed and floor slab undermined by flooding and waves at this Jamaica Beach house (number 2480 in 1990 Galveston study)

2.2.4.2 MAT Summary of Findings Regarding the Galveston Study

The Galveston study concludes that the wind load provisions of the building code current at the time of investigation failed to meet the then current provisions of ASCE 7-88. The study further concluded that houses constructed since the adoption of the NFIP in 1971 utilizing flood-resistant construction and BFE elevations should perform to NFIP expectations; however, the practice of installing non-breakaway walls below the BFE in Zones V and Coastal A Zones were in violation of the NFIP and jeopardized the houses' structural resistance to flood loads. The Galveston study rated each house for wind and water resistance based upon the collected data.

The Galveston study assigned ratings to each house regarding performance for wind resistance and flood/wave resistance. The average rating in the study for the 12 houses sampled by the MAT was an "expected Poor Performance for wind resistance and a Good Performance for resistance to flood and wave loads." Hurricane Ike was not a design wind speed event and wind damage to the houses was relegated to loss of asphalt shingles, siding, and soffit materials; therefore, a reasonable comparison of the Galveston study wind expectations could not be measured.

Of the 12 houses visited by the MAT, Numbers 3289 and 2276 were the only houses located in Zone V. Number 3289 lost non-breakaway walls and Number 2276 was washed away by the storm. The other 10 houses were Zone A units with first floors located at or above the BFE. Four of these houses were slabs-on-grade and experienced flooding, while the other six houses were elevated and experienced breakaway and non-breakaway wall damage below the BFE, along with the loss of garage doors and ceiling finishes. The MAT's observations of the resistance of the sampled houses to flood and wave loads indicate a "Poor Rating" in comparison to the Galveston study's "Expected Good Performance."

2.3 Texas Windstorm Program

Hurricanes periodically strike the Texas Gulf coast. The City of Galveston was flattened in 1900 by the Great Galveston Hurricane, the deadliest ever recorded in the State, killing approximately 8,000 people. Another massive storm, Hurricane Carla, killed 43 people and caused approximately $2 billion in property damage (in 2009 dollars) when it came ashore near Galveston in August of 1961. Hail storms, tornadoes, and floods subject other parts of the State to catastrophe, but only hurricanes have caused levels of devastation that demanded action by the State legislature. Because of the level of devastation caused along the Texas coast by previous hurricanes and prompted by Hurricane Celia (which caused significant damage to coastal areas near Corpus Christi in 1970), the TCPIA—a "Cat Pool" of insurers—was created by the Texas Legislature in 1971. The Cat Pool was renamed the Texas Windstorm Insurance Association (TWIA) in 1997. All insurers that write property insurance in Texas are required to become members of TWIA. Excess funds collected from premiums and investments are deposited in the Texas Catastrophe Reserve Trust Fund (CRTF) to pay for excess losses. According to a report on the TWIA, prepared by the Texas Department of Insurance (TDI) in October 2008, the current balance of the CRTF is zero as a result of losses from Hurricanes Rita (2005), Dolly (2008), and Ike (2008) (Insurance, 2008).

TWIA operates under the authority of Chapter 2210 of the Texas Insurance Code. TWIA is a pool intended to serve as an "insurer of last resort" for individuals needing windstorm and hail insurance on buildings that are located in the first tier of coastal counties along the 367-mile Texas Gulf Coast; see Table 2-4 and Section 2.3.3.

Table 2-4. Texas Counties covered by TWIA

Aransas	Brazoria	Calhoun
Cameron	Chambers	Galveston
Jefferson	Kenedy	Kleberg
Matagorda	Nueces	Refugio
San Patricio	Willacy	

Along with those counties indicated, TWIA also provides windstorm and hail coverage in certain specifically designated communities in Harris County that are east of State Highway 146. These communities include Pasadena, Morgan's Point, Shoreacres, Seabrook, and La Porte.

2.3.1 Texas Department of Insurance

When the TCPIA was established in 1971, the Texas Legislature adopted the TCPIA Building Code for Windstorm Resistant Construction, which was based on the wind load provisions of the 1971 SBC. The damage caused by Hurricane Alicia in 1983 revealed that applicable building codes were not being enforced. As a result, the Windstorm Inspection Program at the TDI was created by the Texas Legislature, effective January 1, 1988. The TDI was charged with the following responsibilities:

- Certify to TWIA that buildings are constructed to the adopted windstorm code and therefore insurable against windstorm and hail losses

- Provide inspection services and process windstorm forms
- Though not part of the original charge, but as an integral part of the windstorm program, evaluate and list building products for compliance with the building specifications adopted by the TDI

2.3.2 Basic Tenets of the Texas Windstorm Code

In 1989, the TDI began using the Windstorm Resistant Construction Guide, which was based on the SBC, as amended May 8, 1973, in addition to using the 1971 TCPIA Building Code for Windstorm Resistant Construction. In 1998, the TDI began using the TWIA (formerly TCPIA) Building Code for Windstorm Resistant Construction, which was updated to be based on ASCE 7-93. In 2003, the TDI adopted the 2000 IRC and the 2000 IBC. This was followed by the adoption of the 2003 IRC and 2003 IBC in 2005, and most recently, the adoption of the 2006 IRC and 2006 IBC in 2008.

Since 1998, the first tier counties, referred to as Designated Catastrophe areas, have been divided into three zones, referred to as Inland (II), Inland (I), and Seaward, by the TDI. The delineation between Inland (II) and Inland (I) is primarily roadways, city limits, and county lines. The delineation between Inland (I) and Seaward is the Intracoastal Waterway. The TDI also adopts wind speed requirements for each of the three zones. Figure 2-10 illustrates the three zones, as well as the current wind speed requirements adopted for each zone. The TDI has adopted amendments, called Texas Revisions, for each edition of the IRC and the IBC that have been adopted by the TDI. The Texas Revisions to the 2006 IRC and 2006 IBC include the following:

- Defines requirements for windborne debris protection as follows:
  - Inland (II) – no protection required
  - Inland (I) – all glazed openings to be protected
  - Seaward – all exterior openings (windows, doors, skylights, and garage doors) to be protected
- In accordance with IRC Section R301, Design Criteria, and IBC Section 1609, Wind Loads, the provisions of the IBHS *Guidelines for Hurricane Resistant Residential Construction* (IBHS, 2005) were added as an option for the designer and builder.
  - Regarding asphalt roof shingles, in accordance with Sections R905.2, Requirements for Roof Coverings, of the 2006 IRC and Section 1504, Performance Requirements, of the 2006 IBC, the TDI allows for shingles that have passed the ASTM D 3161, *Standard Test Method for Wind-Resistance of Asphalt Shingles*, Class F to be installed on roofs

NOTE

For more information about the Texas Department of Insurance, visit http://www.tdi.state.tx.us/wind/.

located in the Inland (II), the Inland (I), and the Seaward zones. In addition, the TDI permits the use of asphalt shingles that have passed ASTM D 7158, *Standard Test Method for Wind Resistance of Sealed Asphalt Shingles*, Class H to be installed in the Inland (I) and the Seaward zones. The TDI maintains a list of asphalt shingle products that have passed these criteria on their Windstorm Program Web.[6]

- The TDI requires building products to be tested to and comply with the test standards and criteria specified in the IRC, the IBC, and the Texas Revisions. Products that meet these criteria are evaluated by the TDI and listed on their Windstorm Program Web site. The TDI also evaluates and lists some types of building products that have passed test criteria used by Dade County, FL.

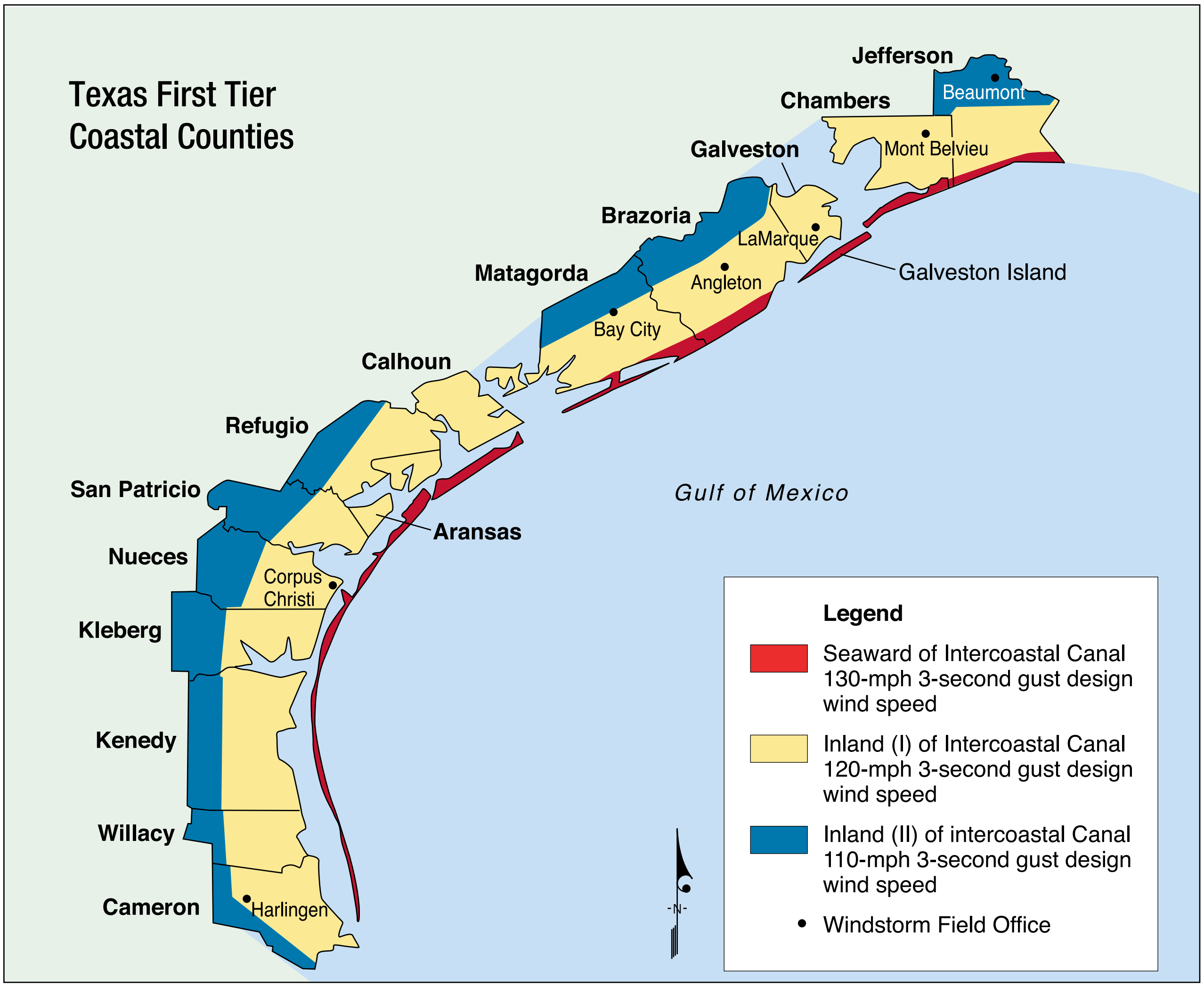


Figure 2-10. Texas Windstorm Designated Catastrophe Areas

SOURCE: http://www.tdi.state.tx.us/wind

6 www.tdi.state.tx.us/wind/geninfo.html

2.3.3 Texas Windstorm Program – Insights and Opinions

The TDI Windstorm Program has evolved from using prescriptive codes and construction criteria with minimal requirements for high wind construction to adopting nationally recognized codes, such as the IRC and IBC. Properties that are constructed in accordance with the building specifications adopted by the TDI are eligible for insurability against wind hazards. However, numerous challenges continue for the windstorm program to remain solvent and for buildings to reliably resist hurricane wind forces. Some of these challenges and concerns include:

- TWIA losses in excess of a certain threshold will negatively impact the general revenue of the State of Texas. Numerous proposals are currently before the State Legislature to address this problem.
- The windborne debris criteria adopted by TDI address the opening protection for residences in the Seaward and Inland I zones, 130 mph and 120 mph wind zones, respectively. Ike's winds were less than design levels, and therefore windborne debris was basically relegated to flying asphalt shingles, roof aggregate, and wall cladding materials. However, MAT observations from other hurricane events have found that windborne debris frequently perforates windows, doors, garage doors, as well as the building envelope (walls and roof), thereby allowing the entrance of water that damages home finishes and contents. Furthermore, debris impacts on large openings can allow wind to enter the home, thereby producing internal pressurization failures. The MAT observed that some homeowners shuttered the windward facing seaward side of their home and left the leeward side unprotected. The TDI should consider adopting windborne debris protection for all zones in the Designated Catastrophe Area, including the Inland II zone (110 mph), in accordance with the ASCE 7-05/IRC 2003 guidelines that require opening protection within 1 mile of the coastal mean high water line where the basic wind speed is equal to or greater than 110 mph. Glazing or opening protection should be compliant with ASTM E 1886 and ASTM E 1996 as the impact testing criteria. This opening protection should be provided for all sides of the home, irrespective of the predominant wind direction or the expected direction of threat.
- Although Hurricane Ike was not a design wind event, significant losses of asphalt shingles (which were the predominate type of residential roof covering in the areas impacted by Hurricane Ike) were observed by the MAT (see Section 3.2.1.1). Asphalt shingles are affordable and available for use in areas with design wind speeds of 90, 120, and 150 mph. When asphalt shingles are used, TDI should consider requiring the use of shingles complying with ASTM D 7158 Class G shingles in Inland (I) and Inland (II) zones, and Class H shingles in the Seaward zone.

2.4 Enhanced Code Construction

Several terms have been used to describe construction that exceeds minimum building code requirements, with two of the more common terms being "Code-Plus" and "Fortified."

- The Federal Alliance for Safe Homes (FLASH), Blueprint for Safety™ program, has published a *Contractors Field Manual*, whose glossary[7] defines "Code-Plus" as: "Additional measures are taken to build to higher standards or loads than the minimum required by code requirements. This adds strength and protection to the building" (FLASH, 2002).
- The IBHS has developed a *Fortified . . . for safer living*® program that specifies design, construction, and landscaping guidelines to increase a new house's resistance to natural catastrophes, including hurricanes. After completing certain documentation, verification, and inspection steps, a builder is permitted to advertise a house as a "Fortified" house (IBHS, 2008).[8]
- Many FEMA documents, such as FEMA 55, *Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas* (June 2000) and FEMA 499, *Home Builders Guide to Coastal Construction* Technical Fact Sheet Series (August 2005), recommend best practices for design and construction that exceed minimum requirements of the NFIP and/or building code. These best practices include elevating a house to an elevation higher than the FIRM specifies (this practice is called "adding freeboard"); using an open foundation where a solid foundation may be permitted; and using different, additional, or stronger building components than the code calls for.

This Hurricane Ike MAT report refers to the above types of construction collectively as *enhanced code construction*. The exact meaning may vary geographically, because different States and communities have adopted and amended different building codes, or different editions of those codes, and thus have different minimum design and construction requirements.

One of the most important aspects of enhanced code construction for consumers and communities to recognize is that the mere designation or advertising of a building as being enhanced code construction does not necessarily mean the building will survive a hurricane or other severe event without damage. The MAT observed some enhanced code houses in Galveston County, TX, with flaws that led to building damage during Hurricane Ike, sometimes under less than design conditions.

Consumers and communities should also keep in mind that the criteria used to designate enhanced code construction evolve over time, and a house that satisfied enhanced code criteria at one point in time (and was truthfully claimed to be enhanced code construction) may not meet today's criteria.

7 http://www.blueprintforsafety.org/glossary.php

8 See the Builder's Guide at http://disastersafety.org/text.asp?id=builder_guide for more details

One important aspect of enhanced code construction in coastal areas is designing and constructing buildings to withstand flood levels above the BFE. Accomplishing this will require the addition of freeboard (see Section 7.1.1), strengthening foundations, and using flood damage-resistant materials above the lowest floor. A Hurricane Ike Recovery Advisory, *Designing for Flood Levels Above the BFE* (see Appendix D), is available to assist communities, design professionals, builders, and consumers.