2. Floodplain Management Regulations and Building Codes and Standards

Floodplain management regulations, along with building codes and standards, are adopted and enforced to regulate construction.

The floodplain management regulations applicable to the areas affected by Hurricane Katrina are discussed in Section 2.1. Section 2.2 presents the building codes and standards used to regulate construction specific to floods and wind.

2.1 Floodplain Management Regulations

All of the communities along the Mississippi Gulf Coast visited by the MAT participate in the NFIP and have adopted floodplain management regulations that meet or exceed minimum NFIP requirements. Up until 2000, these NFIP requirements generally were contained only in local floodplain management ordinances. Starting in 2000, however, flood-resistant provisions and floodplain management requirements began to be incorporated into the model building codes. The primary model building code in the United States is developed and maintained by the ICC. The ICC's family of codes, referred to as the "I-Codes," includes the IBC, the IRC, the

International Existing Building Code (IEBC), and a series of codes for mechanical, plumbing, fuel gas, and on-site sewage installations. The National Fire Protection Association (NFPA) has recently begun to produce a building code, the *Building Construction and Safety Code* (NFPA 5000). A notable recent addition is NFPA's *Model Manufactured Home Installation Standard* (NFPA 225, 2005 Edition), the first such standard to include provisions for installation in flood hazard areas.

Communities have two avenues for enforcing flood-resistant design and construction practices that are specific to buildings and structures: the floodplain management ordinance and the building code (see Figure 2-1). The ordinance includes all requirements necessary to participate in the NFIP. The IBC contains provisions that are specific to buildings (if adopted, Appendix G adds administrative provisions and requirements for most development other than buildings). To address the coordination between the ordinances and the I-Codes, communities may wish to refer to the document, *Reducing Flood Losses Through the International Codes*, available at <http://www.fema.gov/hazard/flood/pubs/fldlossesb.shtm>.

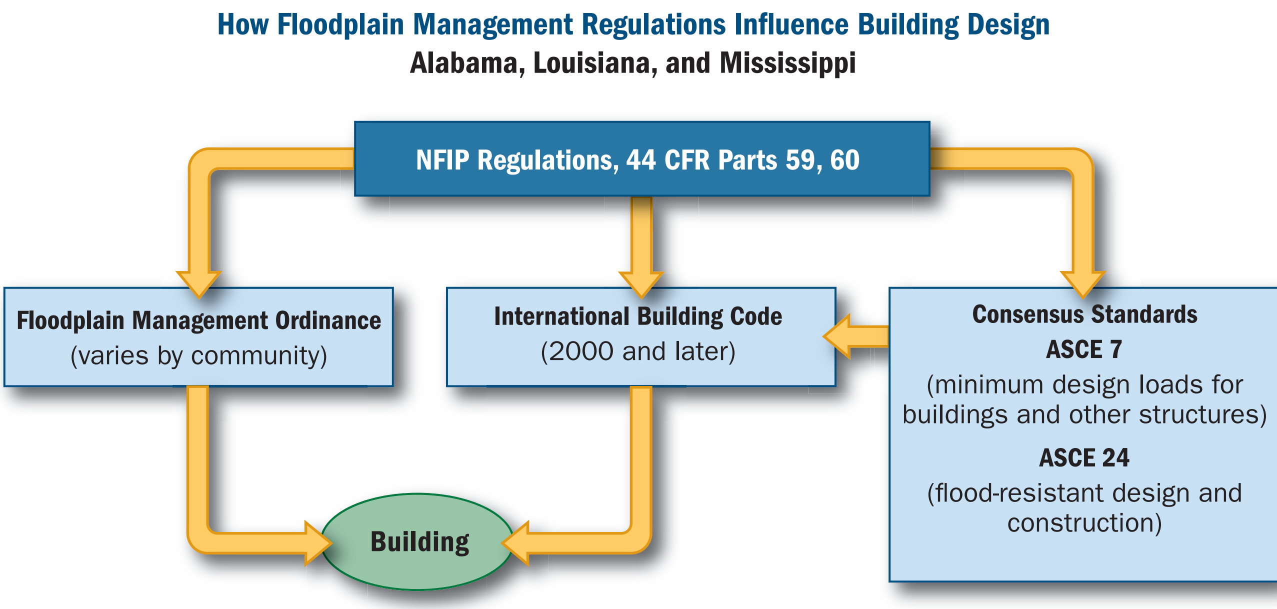

Figure 2-1.
Floodplain management regulations and building design in communities with adopted building codes

Many communities in Louisiana and Mississippi that were heavily impacted by Katrina's surge had not adopted model building codes prior to Hurricane Katrina; however, many communities had adopted a floodplain management ordinance.

Nine of the 14 Mississippi communities visited also participate in the NFIP's Community Rating System (CRS) program and range from Class 6 to Class 8 – an indication of efforts to move beyond the minimum requirements in the NFIP. In Louisiana, all six of the parishes visited participate in the NFIP, with four of the six parishes participating in the CRS program (ranging from Class 7 to Class 10). All but one incorporated jurisdiction visited by the MAT in Louisiana participate in the NFIP, with half participating in the CRS program (ranging from Class 8 to Class 9). In Alabama, the cities of Mobile and Dauphin Island and Baldwin County, which were the most impacted areas and visited by the MAT, all participate in the NFIP and the CRS program. Table 2-1 provides a detailed breakdown of NFIP and CRS participation by jurisdiction, along with the current effective date of the community's flood maps, if applicable (refer to Chapter 1, Figure 1-18, for locations of communities visited by the MAT).

COMMUNITY RATING SYSTEM

The NFIP's Community Rating System is a voluntary incentive program that recognizes community floodplain management activities that exceed the NFIP requirements. Classes range from 1 to 10, with 1 representing the most active and the most flood hazard-resistant communities. For CRS-participating communities, flood insurance premium rates are discounted in increments of 5 percent; i.e., a Class 1 community receives a 45 percent premium discount, while a Class 9 community receives a 5 percent discount (a Class 10 receives no discount). The CRS classes for communities are based on 18 creditable activities, organized under 4 categories: (1) Public Information, (2) Mapping and Regulations, (3) Flood Damage Reduction, and (4) Flood Preparedness. Of the more than 900 communities that participate in the CRS, over 90 percent have a rating of 7, 8, or 9 <http://www.fema.gov/business/nfip>.

It is worth noting that one jurisdiction in Louisiana that does not participate in the NFIP does not have any designated flood zones identified within its jurisdiction. There is no restriction on such a community participating in the NFIP if the community chooses to do so. Many communities without designated flood zones are still subject to flooding and benefit from NFIP membership.

Table 2-1. NFIP and CRS Participation in Visited Jurisdictions

Jurisdiction	NFIP Entry Date	Effective FIRM*	CRS Status (if applicable)
Alabama			
Baldwin County	1/12/1973	6/17/2002	9
Gulf Shores	7/4/1971	6/17/2002	9
Orange Beach	1/12/1973	6/17/2002	10
Mobile County	12/11/1970	7/6/1998	Non Participating
Dauphin Island	12/11/1970	7/6/1998	8
Mobile, City of	9/15/1972	7/6/1998	10
Escambia County	3/31/1998	10/27/1978	Non Participating
Atmore	6/24/1977	6/24/1977	8

Table 2-1. NFIP and CRS Participation in Visited Jurisdictions (continued)

Jurisdiction	NFIP Entry Date	Effective FIRM*	CRS Status (if applicable)
Louisiana			
Jefferson Parish	10/1/1971	3/23/1995	7
Grand Isle	10/30/1970	3/23/1995	Non Participating
Gretna	6/18/1971	3/23/1995	8
Lafitte	10/1/1971	3/23/1995	Non Participating
Kenner	6/25/1971	3/23/1995	8
Lafourche Parish	4/17/1985	5/4/1992	10
Orleans Parish	8/3/1970	3/1/1984	8
Plaquemines Parish	5/1/1985	9/30/1993	Non Participating
St. Bernard Parish	3/13/1970	6/30/1999	Non Participating
Chalmette	Non Participating	Non Participating	Non Participating
St. Tammany Parish	4/23/1971	4/21/1999	9
Madisonville	12/2/1980	3/16/1983	Non Participating
Mandeville	9/28/1979	4/4/1983	8
Slidell	12/16/1980	4/21/1999	9
Mississippi			
Hancock County	9/9/1970	8/18/1992	Non Participating
Bay St. Louis	9/11/1970	11/16/1983	7
Waveland	9/11/1970	11/16/1983	6
Harrison County	6/15/1978	10/4/2002	8
Biloxi	9/11/1970	3/15/1984	7
D'Iberville	11/14/1988	8/04/1998	Non Participating
Gulfport	9/11/1970	10/4/2002	8
Long Beach	9/11/1970	5/4/1988	8
Pass Christian	5/26/1970	8/19/1987	6
Jackson County	4/3/1978	4/16/1993	Non Participating
Gautier	11/13/1986	8/18/1992	8
Moss Point	9/18/1970	9/4/1987	Non Participating
Ocean Springs	9/18/1970	8/18/1992	8
Pascagoula	9/18/1970	3/15/1984	Non Participating

SOURCE: NFIP, CRS

Under Executive Order 11988, Federal agencies shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural beneficial values served by floodplains in carrying out its responsibilities for the following:

1. acquiring, managing, and disposing of Federal lands and facilities;
2. providing Federally undertaken, financed, or assisted construction and improvements; and
3. conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

2.1.1 Flood Studies and Flood Maps

FEMA conducts Flood Insurance Studies (FISs) to develop the data upon which FIRMs are based. FEMA provides printed copies of FISs and FIRMs to participating communities. FIRMs identify areas of varying flood hazard as flood zones. Zones A and V comprise a special area known as the Special Flood Hazard Area (SFHA). The SFHAs are expected to be inundated by the flood event with a 1-percent probability of being equaled or exceeded in any given year. This flood is also referred to as the base flood or 100-year flood. Within these special flood hazard areas are areas that may experience more frequent but less severe flooding. One of the goals of the MAT was to investigate failures from flooding to buildings located both inside and outside the SFHAs, as shown on the effective FIRMs.

SFHAs labeled as Zone AE (as well as A1-30, VE, and V1-30) have been studied by detailed methods and show Base Flood Elevations (BFEs), which are the minimum elevations to which lowest floors, as defined by the NFIP, are required to be elevated.[1] SFHAs labeled as Zone VE are along coasts and are subject to additional hazards due to storm-induced velocity wave action (the BFE in Zone V is the top of the wave crest). BFEs derived from detailed hydraulic analyses are shown within

DESCRIPTION OF FLOOD ZONES

V Zones. 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.

A Zones. The portion of the SFHA not mapped as a V Zone. Although FIRMs depict A Zones 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, A Zones are subject to wave heights less than 3 feet and wave run-up depths less than 3 feet.

Coastal A Zones. Though not shown on FIRMS, Coastal A Zones are referenced in ASCE 24-05 and ASCE 7-05. This is an area within the SFHA, landward of a V Zone, where flood forces in A Zones in coastal areas are not as severe as in V Zones, but are still capable of damaging or destroying buildings on shallow foundations. During the base flood conditions, the potential for breaking wave heights shall be greater than or equal to 1.5 feet. For this reason, different design and construction standards are recommended (by the MAT and others) in Coastal A Zones that are different than those used in Riverine A Zones.

1 A Zone BFEs apply to the top of the lowest floor elevation; V Zone BFEs apply to the bottom of the lowest horizontal structural member. In A Zones, the lowest floor is to be elevated to or above the BFE; in V Zones, the bottom of the lowest horizontal structural member is to be elevated to or above the BFE.

DESCRIPTION OF FLOOD ZONES (continued)

A1-30. Areas of 100-year flood; BFEs and flood hazard factors are determined.

AO. Areas of 100-year shallow flooding where depths are between 1 and 3 feet.

AH. Shallow flooding SFHA.

A99. An area inundated by 100-year flooding, for which no BFEs have been determined. This is an area to be protected from the 100-year flood by a Federal flood protection system under construction.

Zones X, B, and C. These zones identify areas outside of the SFHA. Zone B and shaded Zone X identify areas subject to inundation by the flood that has a 0.2 percent probability of being equaled or exceeded during any given year. This flood is often referred to as the 500-year flood. Zone C and unshaded Zone X identify areas above the level of the 500-year flood. The NFIP has no minimum design and construction requirements for buildings in Zones X, B, and C.

For NFIP flood zone definitions, refer to 44 CFR 59.1.

For an explanation of zone designations, please refer to the FIRM for your community.

the V Zones. (Zone VE is used on new and revised maps in place of Zones V1-V30.) Mandatory flood insurance purchase requirements apply in all SFHAs. Figure 2-2 shows the relationship between the stillwater elevation, wave effects, BFEs, and the zone designations. Further discussion of flood zones, including Coastal A Zones, can be found in Section 3.1.

The zone designation and the BFE are critical factors in determining what requirements apply to a building and, as a result, how it is built. NFIP regulations provide minimum building requirements for structures built in each of the zones; when a community joins the NFIP[2] and adopts its FIRM, the community is also adopting minimum floodplain standards. Some examples of the NFIP minimum requirements for buildings built in Zone VE (Coastal High Hazard Areas) are:

- The building must be elevated on pile, post, pier, or column foundations.
- The building must be adequately anchored to the foundation.
- The building must have the bottom of the lowest horizontal structural member at or above the BFE.
- The building design and method of construction must be certified by a design professional.
- The area below the BFE must be free of obstructions; if enclosed, the enclosure must be made of breakaway walls that are designed and certified to give way under certain flood loads.

ADVISORY BASE FLOOD ELEVATIONS

FEMA established Advisory BFEs after Hurricane Katrina to help expedite the rebuilding process in areas that were most severely impacted by coastal flooding. Communities are not required to adopt the advisory maps, but when the official maps are completed, adoption will be required. See Section 11.1 for further details on flood-related recommendations.

Web site for Advisory BFEs: <http://www.fema.gov/hazard/flood/recoverydata/index.shtm>

[2] Additional information on the National Flood Insurance Program can be found at <http://www.fema.gov/plan/prevent/fhm/hm_nfip.shtm>.

In Zone AE, the NFIP has the following requirements:

- The top of the lowest floor of a building must be at or above the BFE; however, there are no specific design standards or certification requirements for foundations other than the general performance standard that the building must be anchored to resist flotation, collapse, and lateral movement.
- Unfilled foundation walls below the BFE must have openings to allow for the automatic inflow and outflow of floodwaters to equalize hydrostatic pressure and prevent wall failures.

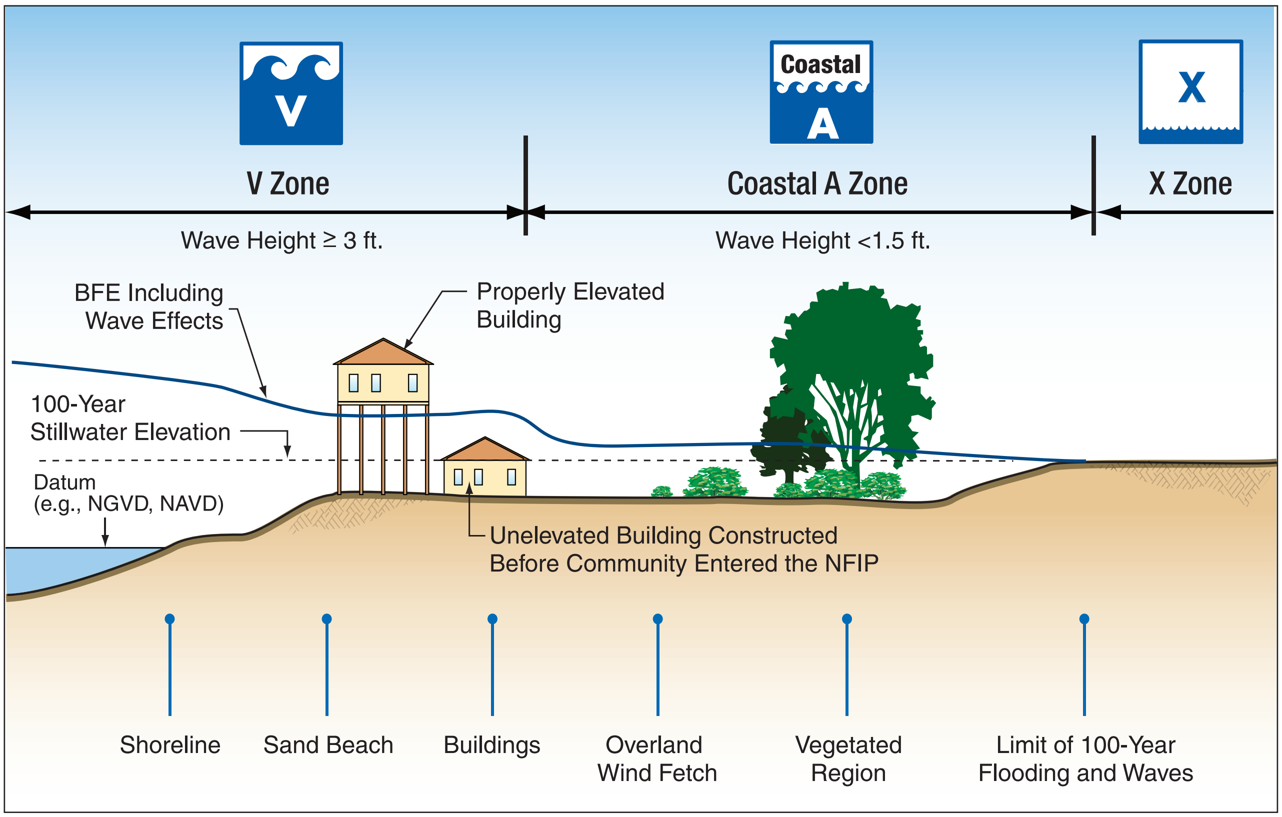

Figure 2-2.
Illustration of the relationship between the stillwater elevations, BFE, and wave effects

SOURCE: FEMA 55, *COASTAL CONSTRUCTION MANUAL*

For buildings constructed in Zones X, B, and C (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 of the SFHA.

In Louisiana, many buildings were constructed behind levees that were intended to protect them from the 100-year flood. Areas that were protected by the levees are shown by various zone designations, depending upon the unique flood hazard for that specific area. Zone designations for these areas may fall into one of the following designations: A1-30, AO, or A99 (see pages 2-5 and 2-6). As an example of the variations of the BFE for areas impacted by Hurricane Katrina, the BFE outside the levee was 14 feet in some areas; however, inside some areas protected by the levee, the BFE was 1.5 feet.[3] In many areas impacted by Hurricane Katrina, the mapped BFE was below mean sea level (msl). In some areas, the BFE was as low as -4.5 feet NGVD.[4] As a result of levee failures, widespread flood damage to residential neighborhoods occurred throughout the New Orleans area. Flood depths observed in residential buildings, for example, reached more than 8 feet in some cases, with the largest flood depths observed on the north side of New Orleans near Lake Ponchartrain, the Lower Ninth Ward, and Chalmette. A more detailed discussion of the issues in the New Orleans area can be found in Chapter 8.

2.1.2 Higher Regulatory Standards

One of the goals of the MAT was to investigate building failures from flooding (principally, waves and storm surge) inside and outside the SFHAs shown on the effective FIRMs. One issue the MAT identified during its investigation was that almost all the communities visited only enforce minimum flood-resistant design and construction standards; few have adopted more stringent requirements.

2.1.3 Mississippi – Relating Observed Flood Damage to the FIRMs

Along the Mississippi Gulf Coast, many newer buildings, apparently constructed in compliance with the minimum requirements of the NFIP per the effective FIRMs for each community, failed due to storm surge and wave crest elevations far in excess of BFEs (refer to Figure 2-4). Water marks and building damage thresholds throughout the region, especially in Hancock and Harrison Counties, show that storm surge/wave crest elevations exceeded 23 feet and were as high as 25 to 30 feet NGVD in some areas along the shore, while BFEs shown on the effective FIRMs were generally 11 to 15 feet NGVD.

The following three examples (Figures 2-3 through 2-5) show residential buildings in three Mississippi communities that relate observed flood damage to the FIRMs.

2.1.4 Louisiana – Relating Observed Flood Damage to the FIRMs

In many areas observed by the MAT, water levels were well above mapped BFEs due to levee failure, most notably in Orleans, St. Bernard, Plaquemines, and Jefferson Parishes. Flooding caused severe damage to both pre-FIRM and post-FIRM buildings, with flood depths in various neighborhoods ranging to more than 8 feet above the lowest floor (refer to Figure 2-6).

The two-part New Orleans levee/floodwall system was certified by the USACE as providing at least 100-year flood protection in accordance with the NFIP requirements. Due to this certification, the FIRMs for the area, which are the basis for the flood insurance and floodplain management, did not reflect direct flooding from the Gulf of Mexico, Lake Pontchartrain, or the Mississippi River. The FIRMs did reflect some internal flooding in the areas protected by the levee/floodwall system; the source of this flooding was not a levee/floodwall breach, but rainfall

[3] The 1.5-foot BFE referenced here is to account for rain within the area protected by the levee.

[4] NGVD is the national datum used by the NFIP. NGVD is based on msl.

EXAMPLE: BUILD SAFE! 13.1 FEET MSL PASCAGOULA ELEVATION STANDARD

PASCAGOULA, MISSISSIPPI

Following Hurricane Georges in 1998 (a storm that heavily impacted Jackson County), the City of Pascagoula, as an example of one community that has enforced more than minimum standards, established higher elevations requiring new construction be built to 13.1 feet msl. In some cases, this represented up to a 5-foot increase above mapped BFEs. As a result of this local decision to enforce higher standards, buildings impacted by Hurricane Katrina that were built to this elevation suffered less flood damage than older housing units built to previous requirements. In order to increase public awareness surrounding the program, homes built to the new standard were identified with a sign that read, "Build Safe! 13.1' msl Pascagoula Elevation Standard." One specific example of this success was also the first application of Increased Cost of Compliance funds in the State of Mississippi. Funded out of the Hazard Mitigation Grant Program (HMGP) at a 75 percent Federal share, Increased Cost of Compliance funds provided part of the 25 percent non-Federal match. Elevation allowed this house to survive Hurricane Katrina. The estimated flood depth from Katrina was approximately 1 foot above the regulatory lowest floor and reportedly caused only minor damage to the house. According to the effective FIRM at the time of Hurricane Katrina, the building is located in Zone AE with a BFE of 11 feet. For more information on Increased Cost of Compliance refer to http://www.fema.gov/business/nfip/icc.shtm.

Figure 2-3.
This elevation project was designed to the higher elevation standard of 13.1 feet msl adopted by the City of Pascagoula. Note the "Build Safe!" public awareness sign posted in the front yard of the house following the completion of the project. The estimated flood depth of 1 foot above the floor is shown by the red line.

EXAMPLE: COLUMN-ELEVATED HOUSE
PASS CHRISTIAN, MISSISSIPPI

One surviving building located on Shadowlawn Avenue in Pass Christian, Mississippi, is situated, according to the effective FIRM at the time of Hurricane Katrina, in Zone A with a BFE of 13 feet. The parking slab of this building is at 14.7 feet NGVD, with the bottom of the floor beams at 22 feet NGVD. The homeowner, a structural engineer who also designed and built the structure, based the elevation of the house on the storm surge caused by Hurricane Camille in 1969. The MAT observed the remains of other buildings that had been located along Shadowlawn Avenue within approximately 1,000 feet of East Beach Boulevard (Highway 90). All of the houses surrounding this surviving building had been destroyed by surge, waves, and debris. The estimated surge/wave damage elevation inside the surviving house was +/- 29 feet NGVD (4 feet above elevated first floor slab). Although the flood line was around 7 feet above the bottom of the floor beams, there was no structural damage because of the robustness of the structural system, which consists of a reinforced concrete frame with insulated concrete form walls.

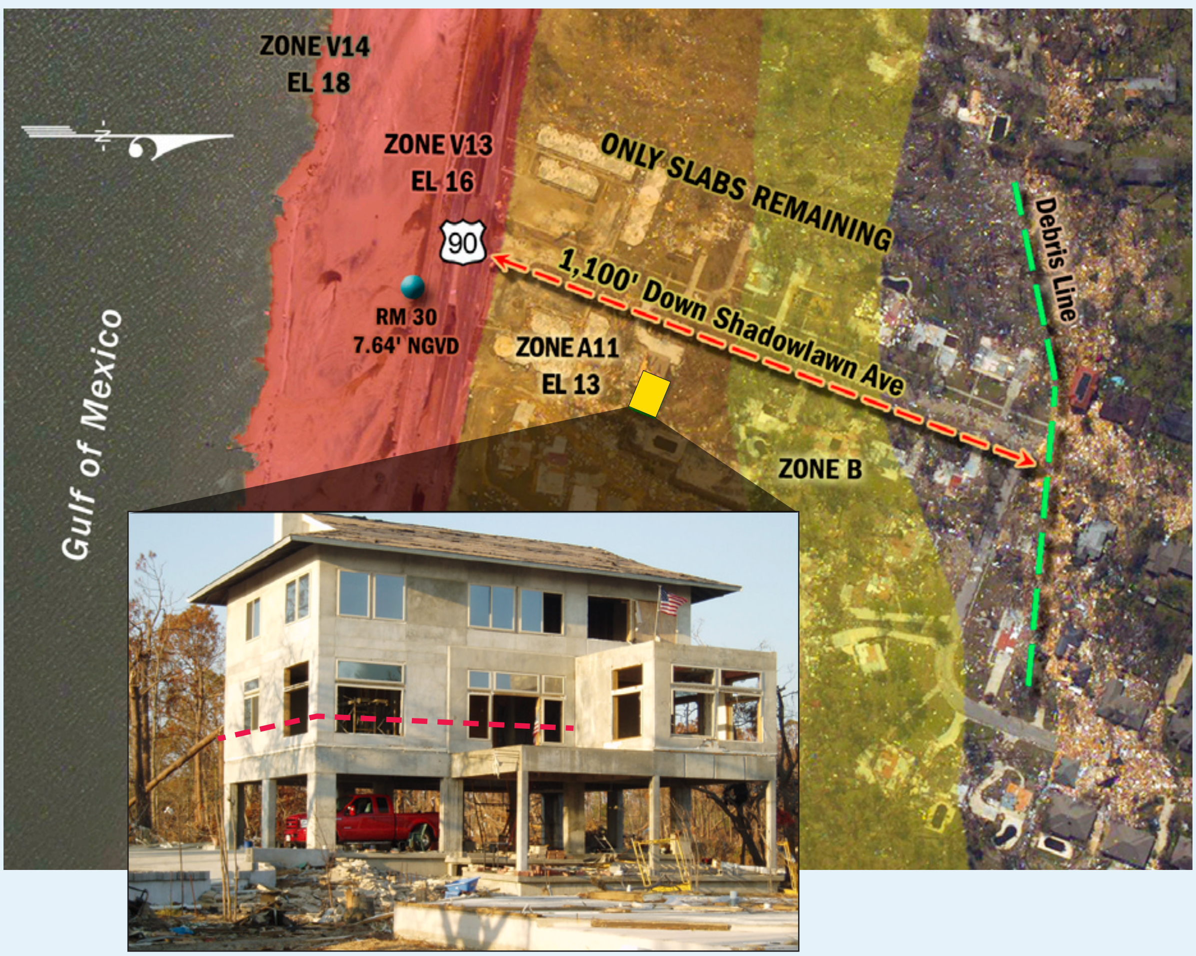

Figure 2-4.
The surviving building on Shadowlawn Avenue (yellow highlight and inset) in relation to aerial observations of post-Katrina damage and approximate flood zone delineations. The red line in the inset illustrates the depth of flooding at the building.

EXAMPLE: SLAB-ON-GRADE HOUSE
OCEAN SPRINGS, MISSISSIPPI

Several buildings in Ocean Springs, Mississippi, which were visited by the MAT, exhibited varying conditions with regard to observed damage from Hurricane Katrina and the effective FIRMs. One such building, located on Arbor Circle, was a single-family residential property on the Back Bay with the regulatory lowest floor elevation 1 foot above the BFE.

Figure 2-5.
The slab of this house is at 14 feet NGVD. According to the FIRM for this area, the building is located in Zone AE with a BFE of 13 feet. The building sustained severe flood damage and wave impacts, with water rising 4 feet above the slab.

within the protected area, which generated runoff and produced localized flooding.

The following two examples (Figures 2-6 and 2-7) show residential buildings in two Louisiana communities that relate observed flood damage to the FIRMs.

PRE-FIRM AND POST-FIRM

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.

EXAMPLE: WOOD-FRAMED HOUSE
NEW ORLEANS, LOUISIANA

One representative residential building in New Orleans/Orleans Parish visited by the MAT, located on Memphis Street, was a wood-framed building constructed in 2003. The structure experienced flood depths from the 17th Street Canal levee breach that were 6 feet above the first floor, which was at a BFE of –2.5 feet NGVD.

Figure 2-6.
Note the actual flood depth from Hurricane Katrina (dashed line) vs. the BFE (solid line).

2.1.5 Alabama – Relating Observed Flood Damage to the FIRMs

Severe flooding occurred in many areas within Mobile County, including areas in the cities of Mobile, Bayou La Batre, Fairhope, and Daphne as well as the town of Dauphin Island. Many buildings, except those on Dauphin Island, were pre-FIRM and were constructed to much lower elevations compared to the current BFE. In Bayou La Batre, the FIRMs along two roads (Shell Belt and Coden Belt) indicate that the BFEs vary between 14- to 16-feet NGVD, VE Zone, depending on location along the beach from east to west, respectively. At no point does the regulatory BFE fall below 14 feet NGVD. Many of the lower elevated buildings (pre-FIRM) along

EXAMPLE: HOUSE ELEVATED ON FILL
MYRTLE GROVE, LOUISIANA

The house shown in is located between the levee and Highway 23 in Myrtle Grove in Plaquemines Parish (the body of water in the top left corner of the photo is the Mississippi River). The area was inaccessible at the time of the MAT ground investigation, so it is unknown whether the structure received flood damage. It is easy to presume, however, especially given that this photo was taken more than a month after the event, that the house would definitely have been flooded had it not been elevated on fill.

Figure 2-7.
Parts of Highway 23 remain under water as does much of the surrounding area more than a month after the event. Note the location of the levee behind the surviving structure (red line).

these roads were destroyed; the higher elevated buildings, built to the current floodplain regulations, performed well. In Fairhope and Daphne, damages were limited to water-dependent structures (e.g., piers and boat houses) and older pre-FIRM residences.

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 IRC, and the 2003 and 2006 editions of the NFPA's *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 design and construction of buildings (see Section 2.2.1).

> The MAT report references the 2000 and 2003 editions of the IBC and the IRC published by the ICC. In 2006, the ICC issued their latest editions of the IBC and IRC. These editions became available after much of the MAT report had been completed, so detailed discussions of those codes have not been included.

Once a community has joined the NFIP and adopts its NFIP regulations, that community has adopted minimum floodplain standards for buildings constructed in the SFHA. These standards provide the minimum elevation for the regulatory lowest floor of a building. Building codes and standards, on the other hand, cover a wide range of areas, including electrical, mechanical, and fire, and provide specific provisions for wind. The newer model codes now also include flood provisions.

The IBC is a performance 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 and ASCE 24) that include provisions pertaining to flood hazards are briefly described in Sections 2.2.2 and 2.2.3.

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

With respect to managing flood hazard areas as required by the NFIP, communities traditionally haven't relied solely on the building codes because they lacked requirements on basic development issues (other than buildings and structures). However, with the arrival of the I-Codes floodplain requirements for development issues, which include some aspects of site development, floodways, coastal setback lines, erosion-prone areas, and other environmental constraints, can also be found in NFPA 5000 and the appendices and annexes of these codes.

At the time of Hurricane Katrina, each of the three states visited by the MAT had adopted building codes on a statewide basis only for state-owned buildings; local jurisdictions have the authority to adopt building codes for non state-owned buildings.

2.2.1 Flood Requirements in the IBC and the IRC

The IBC is applied 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 IBC addresses flood loads and flood-resistant construction primarily in Section 1612 (*Flood Loads*), which refers to the consensus standards ASCE 7 and ASCE 24. Flood loads and load combinations are specified in Section 1605. The designer must identify the pertinent, site-specific characteristics and then use ASCE 7 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 (in/out of the mapped flood hazard area, BFE/depth of water) and then specifies certain conditions that must be met during design and construction. The body of the IBC, together with Appendix G, addresses all of the key building and development requirements of the NFIP. If communities participate in the NFIP, they should coordinate their floodplain ordinances with the I-Codes to ensure that all requirements are addressed.

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 R323 (*Flood-Resistant Construction*; renumbered to R324 in the 2006 edition), although provisions for the mechanical and plumbing installations are included in pertinent sections of the code.

It is important that communities coordinate their ordinances with the I-Codes to ensure that all requirements are addressed. A crosswalk of the NFIP regulations and the IRC provisions is found in *Reducing Flood Losses Through the International Codes*.

There are some commonalities between the IBC and the IRC:

- They specify information related to special flood hazard areas that are to be included in permit applications and shown on plans.
- They 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.

2.2.2 Flood Requirements in ASCE 7

The ASCE develops and maintains the consensus standard for *Minimum Design Loads for Buildings and Other Structures* (ASCE 7). Since the 1995 edition, ASCE 7 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 refers to ASCE/SEI 7-05.

Design loads used by the IBC (2003) are taken from ASCE 7 (2002). The following sections of ASCE 7 deal with flood:

- Section 2.3 (*Load Combinations*, including different load combinations for V Zones and Coastal A Zones).
- Section 5.3 (*Flood Loads*, which covers hydrostatic, hydrodynamic, and wave and impact loads.) Load criteria for breakaway walls are also included in this section.

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 feet (the cutoff used to delineate FEMA's V Zone) cause considerable damage, ASCE 7 incorporates the concept of the Coastal A Zone and specifies that designers determine loads on structures in these areas. For the most part, Coastal A Zones are treated as V Zones.

The IRC does not refer to ASCE 7 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 V Zones, individual designs for buildings must be prepared and sealed by a registered design professional.

2.2.3 Flood Requirements in ASCE 24

The ASCE develops and maintains the consensus standard for *Flood Resistant Design and Construction* (ASCE 24). It is referenced by Section 1612 of the IBC (2003). The first edition of ASCE 24 was published in 1998 and it is referenced in the 2000 and 2003 editions of the IBC. The 2005 edition is a major revision and expansion of the standard, which is referenced in the 2006 IBC. The 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."

ASCE 24 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 (V Zones) and Coastal A Zones, ASCE 24 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 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).

The IRC does not refer to ASCE 24 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 V Zone buildings (which do require design) was listed above. Communities must, therefore, reference ASCE 24 directly for its provisions to apply to small residential buildings. However, Section R323 of the IRC states that buildings in floodways shall be designed in accordance with the IRC, thereby mandating use of ASCE 24 for buildings in floodways as shown on the FIRMs.

2.2.4 Wind Requirements in Building Codes and Standards – Mississippi

The wind speeds recorded in Hurricane Katrina, though high in some areas, were for the most part less than the design wind speed given in IBC/ASCE 7-02. Much of Mississippi sustained wind damage to building envelopes; however, the strongest effects were felt along the coast in Hancock, Harrison, and Jackson Counties. Exceptions occurred where severe damage was caused by either uprooted trees or by tornadic activity spawned by the hurricane. Impacted cities in the coastal counties include those listed in Table 2-2.

Table 2-2. SBC and I-Codes in Effect at the Time of Hurricane Katrina for Impacted Counties and Cities in Mississippi

County/City	Standard Building Code (SBC)	International Codes (IBC/IRC)
Hancock County	No Code Adopted	No Code Adopted
Bay St. Louis		2003 IBC and IRC
Waveland		2003 IBC and IRC
Harrison County	1997 SBC	
Biloxi	1997 SBC	
D'Iberville		2000 IBC and IRC
Gulfport	1997 SBC	
Long Beach		2000 IBC and IRC
Pass Christian		2000 IBC and IRC
Jackson County		2003 IBC and IRC
Gautier		2003 IBC and IRC
Moss Point		2003 IBC and IRC
Ocean Springs		2003 IBC
Pascagoula		2003 IBC and IRC

Mississippi adopts building codes on a statewide basis only for state-owned buildings. Most of these buildings are concentrated in the state capital of Jackson, while others are spread throughout the state (for example, in regional mental health centers and on university campuses). Only fire-related code provisions were required by statute prior to Katrina making landfall.

Local jurisdictions determine the adoption of building codes for all other buildings. Some jurisdictions in Mississippi had not adopted a building code, usually because inhabitants were not willing to pay the added expense of permitting and inspection or viewed any code as an invasion of privacy. Most jurisdictions in Mississippi have traditionally adopted the 1997 editions of the Standard Building Code (SBC) published by the Southern Building Code Congress International (SBCCI); however, a number of jurisdictions have adopted the 2003 editions of the IBC and IRC. The IBC requires the use of wind provisions given in ASCE 7 – *Minimum Design Loads for Buildings and Other Structures.*

As shown in Table 2-2, the 1997 SBC, 2000 and 2003 IBC, and 2000 and 2003 IRC codes were in effect prior to Hurricane Katrina for most impacted counties, except for Hancock County, which had not adopted any building codes. Clearly, the potential existed for variability in design and construction practice, as well as inspection and enforcement.

Katrina's landfall and impact on the coastal communities created a favorable climate for promoting the more recent codes. A short list of actions taken is given below to represent some positive steps in this regard:

- A workshop was held in Hattiesburg on December 19, 2005, to promote adoption of a state-wide building code. It was organized and sponsored by The Mississippi Construction Coalition, composed of material suppliers, general contractors, engineers, and architects, which formed in response to the Governor's Commission for Recovery, Rebuilding, and Renewal. At the workshop, a regional ICC representative outlined the history of building code adoption in the United States, including recent steps taken in Alabama and Louisiana; summarized some of the benefits; and recommended appropriate steps and mechanisms for adoption and management of building codes at the state level.
- The Governor's Commission issued its final report on December 31, 2005. Recommendation 4 was to adopt and enforce building codes as a primary hazard mitigation strategy.
- Building officials maintain communications with one another and FEMA regarding developments in the lessons learned from Katrina. On January 25, 2006, a meeting of building officials in communities having adopted the IBC and IRC was held in Moss Point.
- Senator Chaney of Vicksburg and others introduced Senate Bill SB2807 on behalf of the Coalition to adopt the IBC and IRC throughout the state in response to the Governor's Commission. The bill passed the Senate on February 15, 2006, and was then sent to the House Ways and Means Committee.
- Representative Compretta of Bay St. Louis and others introduced House Bill HB1406 as an emergency measure for the three coastal counties plus Pearl River County. The bill passed the House on February 4, 2006, and was sent to the Senate Committee on Insurance.
- House Bill 1406 was passed on April 9, 2006, and subsequently signed by the Governor. The new law requires that Jackson, Harrison, Hancock, Stone, and Pearl River Counties and municipalities therein enforce, on an emergency basis, all wind and flood mitigation requirements prescribed by the 2003 IRC and 2003 IBC as supplemented. A county board of supervisors may within 60 days formally resolve not to be subject to these codes. A Mississippi Building Codes Council was created to establish which codes counties may adopt.

The City of D'Iberville recently adopted the 2006 IBC, and Harrison and Hancock Counties, and the cities of Biloxi, Long Beach, and Pass Christian adopted the 2003 IBC. Unfortunately, the City of Gulfport did not adopt a new building code, and will continue to enforce the 1997 SBC.

2.2.4.1 Comparing Basic Design Wind Speeds

Current codes and standards (IBC and ASCE 7) standardize wind speed measurements 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. Table 2-3 provides a comparison of wind speeds for 3-second gust, fastest mile and 1-minute sustained.

Table 2-3. 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 ESDU gust factor curve.

The IBC specifies higher wind speeds for coastal Mississippi than any of the previous editions of the SBC. Hancock, Harrison, and Jackson Counties in Mississippi extend inland approximately 30 miles from the Gulf of Mexico coastline. Therefore, variation exists in the design wind speeds for areas throughout these counties. At the time of Hurricane Frederic in 1979, the SBC design wind speeds were 100-year recurrence of fastest-mile speeds, varying from 110 mph at the coast to 90 mph inland; if these are converted to equivalent 3-second gust speeds, they would be 130 mph at the coast to 110 mph inland.

The 1985 SBC modified the required speeds to match those in American National Standards Institute (ANSI) A58.1 -1982, the predecessor to the ASCE 7. For Hancock, Harrison, and Jackson Counties, that range of speeds was 90 to 95 mph based on 50-year recurrence fastest-mile values, or 110 to 115 mph measured as a 3-second gust. The wind speed map remained unchanged for all the 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 for Hancock, Harrison, and most of Jackson Counties increased significantly to approximately 120 mph (north end) to 150 mph (at the coast), as shown in Figure 2-8. For portions of Jackson County seaward of the 150-mph wind speed contour, ASCE 7-02 recommends that the 150-mph value be used.

Table 2-4 summarizes the progression over time of the basic design wind speeds for the counties in Mississippi visited by the MAT. Table 2-5 presents a summary of the design wind pressures on wall and roof areas for a typical residence in Pass Christian. The IBC calculations are based on Exposure B. 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

DEFINITION OF WIND EXPOSURE ZONES

Exposure B. Urban, suburban, wooded areas.

Exposure C. Open terrain, flat open country, grasslands, all water surfaces in hurricane-prone regions.

cladding or C&C). In instances where Exposure C is applicable, the tabulated pressures would be approximately 30 percent higher than the values shown in the table. SBC loads were based on Exposure B (the SBC did not provide different criteria for Exposure C conditions).

Table 2-4. 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 1979 Edition*	SBC 1997 Edition*	2003 IBC and ASCE 7-98 and Later
Hancock	110-130 mph	110-115 mph	120-130 mph
Harrison	110-130 mph	110-115 mph	120-135 mph
Jackson	110-130 mph	110-115 mph	125-150 mph

* Code wind speeds reported as fastest-mile wind speeds in the 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 2000/2003 (ASCE-7-98, ASCE-02) Basic Wind Speeds

Ratio of Peak Gusts to ASCE 7 Design Wind Speeds

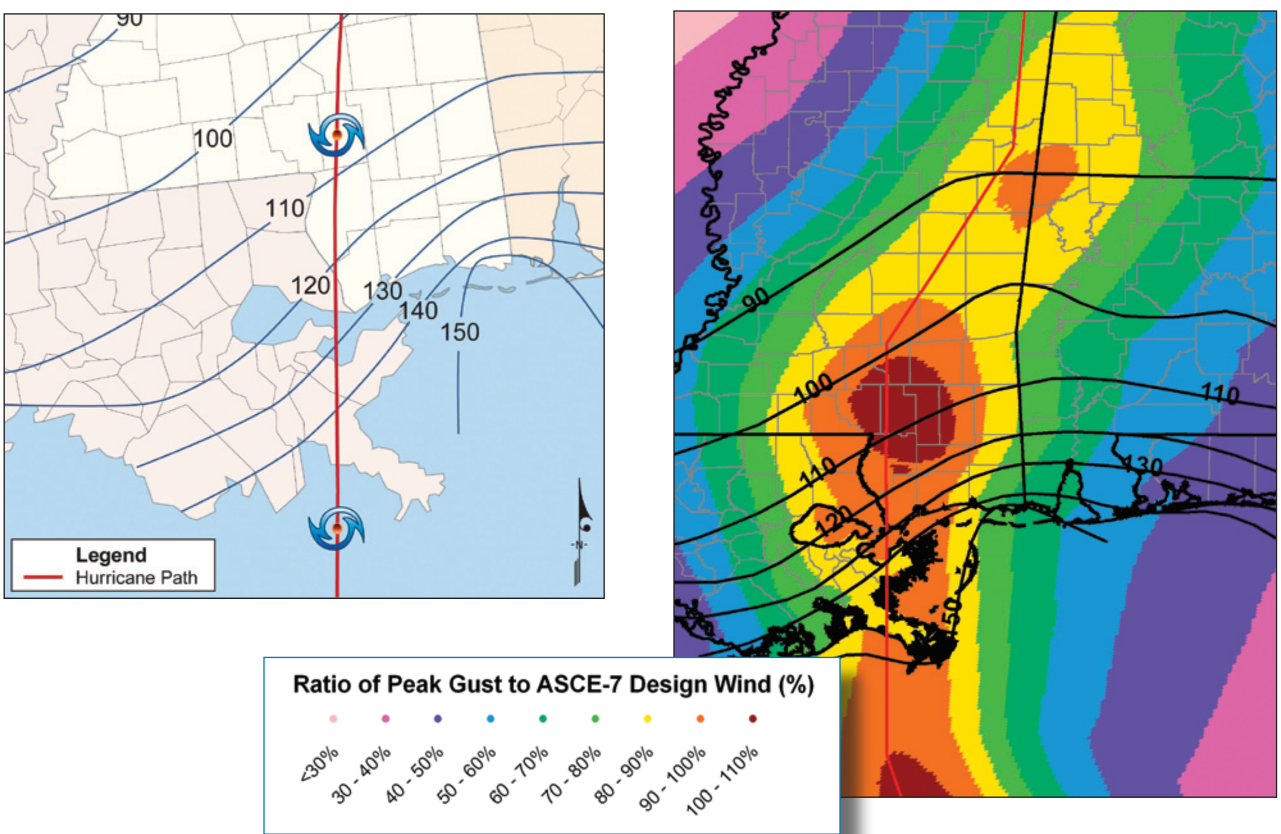

Figure 2-8.
Comparison of code and Katrina peak gust wind speeds

Table 2-5. Design Loads for a Typical Single-Family Residence in Pass Christian, Harrison County, Mississippi

Description	SBC 1979 Edition	SBC 1997 Edition	2002/2003 IBC and ASCE 7-98 and Later Editions
Basic Design Wind Speed	110 mph	95 mph	130 mph*
Equivalent Wind Speed (3-Second Gust)	130 mph	115 mph	130 mph*
Wind Design Pressures on Exterior Walls (psf)			
As MWFRS			
Edge	20/-18	21/-18	26/-23
Middle	20/-18	15/-13	19/-16
Net Edge	33	32	37
Net Middle	33	21	25
As C & C			
Middle	27/-27	25/-25	31/-34
Corner	27/-27	25/-29	31/-42
Wind Design Pressures on Roof (4 in 12 slope) (psf)			
As MWFRS			
Windward Edge	-25	-26	-33
Leeward Edge	-19	-19	-23
Windward Middle	-25	-19	-23
Leeward Middle	-19	-14	-18
As C & C			
Middle	-23	15/-23	18/-29
Corner	-23	15/-52	18/-59

Notes:

1. The pressure calculations under each code for both MWFRS and C&C were calculated using building design coefficients in wind zones that provide the maximum wind pressure for any area on that building surface.

2. Positive value pressures indicate pressures acting inward toward building surfaces. Negative value pressures indicate pressures acting outward from building surfaces.

3. Pressures calculated from the 1979 and 1997 SBC were calculated using their appropriate fastest-mile wind speed and design methods in the code that were in effect at the time. The 3-second gust wind speed is shown for comparative purposes only and was not used in the calculation of the design wind pressures.

4. The 1979 and 1997 SBC and ASCE 7-98 simplified design procedures used in this comparison account for effects of internal pressure implicitly through the selection of pressure coefficients that vary depending on the degree of enclosure provided by the building envelope. The ASCE 7-02 and ASCE 7-05 (Method 2) detailed design procedures consider the effect of internal pressure explicitly by requiring that multiplicative external pressure coefficients be adjusted by 0 (open) to +/-0.18 (full enclosure) to +/-0.55 (partial enclosure).

psf = pounds per square foot

Net edge = the net pressure contributing to the shear force for the wall edge strips; equal to the sum of the external pressures from edge wall Zones 1E and 4E (see ASCE 7-98 Figure 6-4; internal pressures cancel).

Net middle = the net pressure contributing to the shear force for the interior wall zone; equal to the sum of the external pressures from wall Zones 1 and 4 (see ASCE-98 Figure 6-4; internal pressures cancel).

* = maximum estimated HAZUS modeled wind speed (see Table 1-4)

2.2.4.2 Comparing Design Wind Pressures

The methodology required for calculating wind loads in the 2003 IBC is that prescribed in Chapter 6 of ASCE 7-02. Using ASCE 7 for determining wind loads ensures that designers are using state-of-the-art methodology to calculate wind loads. The ASCE 7-02 provisions provide the same loads as ASCE 7-98 for the cases discussed previously. In addition to the improved load computations, ASCE 7-02 also provides performance and testing requirements for windborne debris protection of glazing. For the purpose of the loads listed in Table 2-5, the 1998 and 2000 editions of the ASCE 7 are indicated.

2.2.5 Wind Requirements in Building Codes and Standards – Louisiana

Similar to Mississippi, Hurricane Katrina's wind speeds (see Section 1.1.3) in Louisiana were less than design wind speeds given in IBC/ASCE 7-02. Wind damage was the most severe near where the storm made landfall in Plaquemines Parish. The rest of the populated areas in Louisiana were to the left of the storm track (i.e., on the weak side of the storm). Wind damage in Jefferson, Orleans, and St. Tammany Parishes was clearly more intense in the eastern portions of those communities, which were closer to the west side of the eyewall. Modest levels of wind damage extended as far east as Baton Rouge, where minor wind damage to roof coverings and damage due to falling trees was not uncommon.

Prior to 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 must use the 2000 IBC (Louisiana Act 387 of the 2003 Legislative Session, which supplanted the 1997 SBC as the State Uniform Construction Code). There were no state-level provisions relating to residential building codes. Most of the larger cities and parishes in the state had adopted the IBC in compliance with the state requirements (e.g., New Orleans, Baton Rouge, Lafayette, Lake Charles, Shreveport, and others), but many other communities had not adopted the IBC, and were still enforcing various editions of the SBC.

Even more variation was present in adoption of residential codes that provide specific residential design and construction guidance typically not provided in a commercial building code. 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. The lack of a residential code, or use of older versions of the residential codes, is often a clear indicator that the residential buildings in these areas were designed and constructed without the guidance and criteria of the newer hazard-resistant codes. It should be noted that, if a residential code has not been explicitly stated as adopted, it is likely that no residential code has been adopted. Table 2-6 shows the building codes in place in the most severely impacted parishes in Louisiana at the time when Katrina made landfall. In some cases, municipalities within a parish enforced different codes than the rest of the parish.

Table 2-6. SBC and I-Codes in Effect for Impacted Parishes and Cities in Louisiana

Parish/City	SBC	International Codes (IBC/IRC)
Plaquemines Parish	1997 SBC	
Jefferson Parish	1997 SBC and 1995 CABO	
Gretna	1997 SBC	2000 IBC and IRC
Harrahan	1997 SBC and 1995 CABO	
Kenner	1997 SBC and 1995 CABO	
Westwego	1997 SBC and 1995 CABO	
St. Bernard Parish	1994 SBC	
Orleans Parish	1997 SBC	2000 IBC
St. Tammany Parish	1997 SBC and 1995 CABO	
Covington	1997 SBC	
Mandeville	1997 SBC	2000 IRC
Slidell	1997 SBC	2000 IBC and IRC

Prior to Hurricane Katrina, in response to the lessons learned in Florida from the 2004 hurricane season, the state had taken steps toward improving building codes. Louisiana House Concurrent Resolution 135 called for creation of a Uniform Building Code Task Force, under the Commissioner of Insurance. The charge for this task force was "…to study current laws and regulations related to the construction of buildings and structures and make recommendations regarding legislation that would best insure maintenance of buildings and structures throughout the state and to adequately protect the health, safety, and welfare of the people." The task force was to have reported its findings, recommendations, and drafts of proposed legislative changes to the governor and legislature not later than March 1, 2007. Ironically, the first meeting of this task force was scheduled to take place on August 31, 2005, 2 days after Katrina made landfall.

Because of the devastation caused by Hurricane Katrina, the focus of a state building code has been a major priority; therefore, the State has taken the following actions:

1. The first (and only) meeting of the Uniform Building Code Task Force was held at the Louisiana Department of Insurance on October 4, 2005. This meeting provided a forum to open the building code reform discussion in the wake of Hurricane Katrina. A second meeting was scheduled for mid-November, but this meeting was later cancelled, as the legislature was subsequently called into special session and was considering building code reform (see item 2).

2. Governor Blanco called the legislature into a special session (November 6-22, 2005) focused on hurricane recovery, where one of the items in the call for the special session was building code reform. The House and Senate Commerce Committees considered code reform bills and amendments through many days of hearings. The legislature ultimately passed SB44, 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 requests for amendments to the code, except the La. State Plumbing Code." On November 29, 2005, Governor Blanco signed SB44 into law as Act 12 of the 1st Extraordinary Session of the 2005 Legislature.

The provisions of the newly revised State Uniform Construction Code are to be implemented in several phases. The new law contains emergency provisions requiring Calcasieu, Cameron, Iberia, Jefferson, Lafouche, Orleans, Plaquemines, St. Bernard, St. Tammany, Terrebone, and Vermilion Parishes to enforce all wind and flood mitigation requirements prescribed by the 2003 IBC and the 2003 IRC, as modified and amended by Section 301.2.1.1(2) to replace "Southern Building Code Congress International Standard for Hurricane-Resistant Construction (SSTD 10)" with the *Guidelines for Hurricane Resistant Residential Construction* as published by the Institute for Business and Home Safety, 2005.

The emergency wind and flood provisions were required to be effective within 30 days of the new law (i.e., December 29, 2005) for parishes and municipalities in the affected areas that are already enforcing building codes, and within 90 days for other communities. The emergency wind and flood mitigation requirements remain in effect until the Louisiana State Uniform Construction Code Council adopts the latest editions of both the IBC and the IRC. The initial codes adopted by the Council go into effect statewide on January 1, 2007.

2.2.6 Wind Requirements in Building Codes and Standards – Alabama

On a statewide basis, Alabama adopts building codes for state-owned buildings, including schools. Local jurisdictions determine the adoption of building codes for private buildings. All Alabama jurisdictions have traditionally adopted editions of the SBC. Mobile County adopted the IBC 2000 in 2000, and the City of Mobile adopted it on May 15, 2001. The city of Orange Beach adopted the IBC 2003 in the summer of 2004. The City of Gulf Shores adopted the IBC 2003 as an emergency measure after Hurricane Ivan in 2004 to improve the quality of the reconstruction. After Hurricane Katrina, Dauphin Island adopted the IBC and recently adopted provisions requiring deeper pile embedment. Most other affected Alabama communities, such as those in unincorporated Baldwin County, were still enforcing the 1997 or 1999 SBC at the time of Hurricane Katrina.

The IBC 2000 was the first model code to address windborne debris protection. Many communities in Mississippi enforced the SBC, which has no requirements for windborne debris. Some communities that had adopted the IBC had deleted the windborne debris requirements by local amendment. The IBC defines the windborne debris region as:

- Areas where the basic wind speed is 120 mph or greater.

- Areas within 1 mile of the coastal mean high water line where the basic wind speed is 110 or greater.

If windows and glazed doors are not protected, they may be damaged and allow wind and water into a building, which could lead to significant water damage and development of high internal air pressure, which could result in structural damage or damage to the building envelope, interior partitions, or ceilings.

2.3 HUD Manufactured Housing Design Standards

The design and construction of manufactured homes have been governed at the Federal level by 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, 24 Code of Federal Regulations (CFR) 3280, established the minimum requirements for the construction, design, and performance of a manufactured home. These standards are preemptive over any state or local standard for home construction, provided that the HUD standards cover that aspect of performance of the home. The HUD standards cover body and frame requirements; thermal protection; plumbing; electrical; heating, ventilation, and air conditioning (HVAC); fire safety; and other performance aspects of the home.

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 assure 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 homes were substantially damaged and almost all manufactured homes were destroyed. As a direct consequence, HUD developed improved wind-resistance requirements for the hurricane-prone coastal areas of the United States. Contained in Final Rule 59 FR 2456 (1994), these changes included defining 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 American National Standards Institute (ANSI)/ASCE 7-88, *Minimum Design Loads for Buildings and Other Structures,* for a 50-year recurrence interval; or a fastest-mile design wind speed of 100 mph, as specified for pressures in the Table of Design Wind Pressures (24 CFR 3280.305).

In addition, the new 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.

Federal, state, and local governments and the manufactured home industry strive to institute construction practices and regulations to increase the safety of manufactured homes in natural hazards environments. The following list summarizes some of the recent regulations that have been passed or are in the process of being developed to improve the resistance of manufactured homes to natural hazards:

- Section 605 of the National Manufactured Housing Construction and Safety Standards Act of 1974 (42 U.S.C. 5401) required the Secretary of HUD to establish and implement a national manufactured housing installation program by December 27, 2005. This installation program must include: (1) installation standards, (2) the training and licensing of manufactured home installers, and (3) the inspection of manufactured home installations. The HUD program will be implemented in any state that does not have its own program, which includes all three of the previous components, established by state law. Further, to be exempted, a state must have adopted standards that equal or exceed the protection provided by HUD's national manufactured housing installation program. More information on the development of this new program can be found at http://www.hudclips.org.

- The National Fire Protection Association 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 that provides a source for revisions to the Federal regulations (24 CFR 3280); (2) NFPA 501A, *Standard for Fire Safety Criteria for Manufactured Home Installations, Sites and Communities;* and (3) NFPA 225, *Model Manufactured Home Installation Standard*, a consensus document that governs the installation of manufactured homes. Both the 2005 editions of NFPA 501 and NFPA 225 have wind-related requirements based upon ASCE 7-02.

- The HUD program only requires that Zone III units be constructed to receive high-wind shutters to protect openings; there is no requirement to provide window protection in areas where other one-and two-family dwellings are constructed.

Additional information may be found in Section 4.1.2.