Recommendations 8

The recommendations in this report are based solely on the observations and conclusions of the MAT, and are intended to assist FEMA, the States of Alabama, and Florida, local communities, businesses, and individuals in the reconstruction process and to help reduce damage and impact from future natural events similar to Hurricane Ivan. The general recommendations presented in Sections 8.1 (for flood) and 8.2 (for wind) relate to policies and education/outreach that are needed to ensure that designers, contractors, and building officials understand the requirements for disaster resistance construction in hurricane-prone regions.

8.1 Flood Related Recommendations

The most severe flood-related damages experienced during the 2004 hurricane season were associated with Hurricane Ivan. Recommendations and tables summarizing key recommendations are provided below:

8.1.1 General Hazard Identification Recommendations

- **Re-evaluate the hazard identification/mapping approaches in coastal AE/VE Zones –** Re-evaluate the methodology to determine flood zones and flood elevations in coastal areas, to address the inconsistencies between observed flood elevations (and damages) and BFEs (and anticipated damages). Re-evaluate the criteria for determining the AE/VE Zone boundary, which currently is based on a 3-foot wave. Areas subject to waves of 3 feet or higher

are considered V Zones. Flood hazard mapping procedures and methodologies in coastal areas (especially on barrier islands, and on mainland, open coast shorelines) may need revisions to capture anticipated future coastal conditions (for instance, the possible effects of multiple storm events and long-term erosion).

- **Re-evaluate the storm surge modeling –** Review the storm surge data and modeling procedures that served as the basis for the effective FIRMs. Updates after Hurricane Opal (1995) were limited and did not affect areas north of Highway 98 in Escambia County. Conduct a revised tide frequency analysis, update storm climatology for the area, and utilize modern storm surge models to estimate the BFEs throughout the Ivan impact area.
- **Reconstruction Guidance –** Use Hurricane Ivan tide levels, inundation limits, and areas subject to wave effects as proxies for reconstruction guidance until such time as new, up-to-date regulatory studies and maps can be prepared and adopted.

8.1.2 Design Guidance

- Although not mandated by the IRC or the FBC, utilize ASCE 24-05 for flood-resistant design of one- and two-family structures (the IBC references ASCE 24, but the IRC does not). Design and construction practices specified in ASCE 24-05 will result in flood- and erosion-resistant foundations throughout coastal areas (not just V Zones) and the addition of freeboard to the lowest floor elevation, utility equipment that is protected from the flood damage, and the use of flood-resistant materials below the BFE.
- Use ASCE 7-05, Section 5.3 and the associated Commentary, for the calculation of flood loads during the base flood. The Commentary provides guidance for characterizing and calculating floodborne debris loads.
- Use the *Home Builder's Guide to Coastal Construction Technical Fact Sheets* (FEMA 499) and the Coastal Construction Manual (FEMA 55) for additional guidance related to flood- (and wind-) resistant design and construction.

8.1.3 Foundation Recommendations

- **Elevate the bottom of the lowest structural member above the BFE for coastal A Zones –** Elevate all new construction (including substantially improved structures and replacement of substantially damaged structures) in coastal A Zones with the bottom of the

lowest horizontal supporting member above the BFE. This is a higher standard than the NFIP minimum requirement, which calls for only the top of the lowest floor (walking surface) to be at or above the BFE.

- **Freeboard –** Require freeboard for all structures in all flood hazard zones with the amount varying with building importance (see ASCE 7-05 and ASCE 24-05 for building importance classification and freeboard requirements) and anticipated exposure to wave effects (see Figure 8-1). When using pile foundations, elevate the lowest floor a minimum of one story above grade to allow for parking and storage, which is the current practice by some builders.

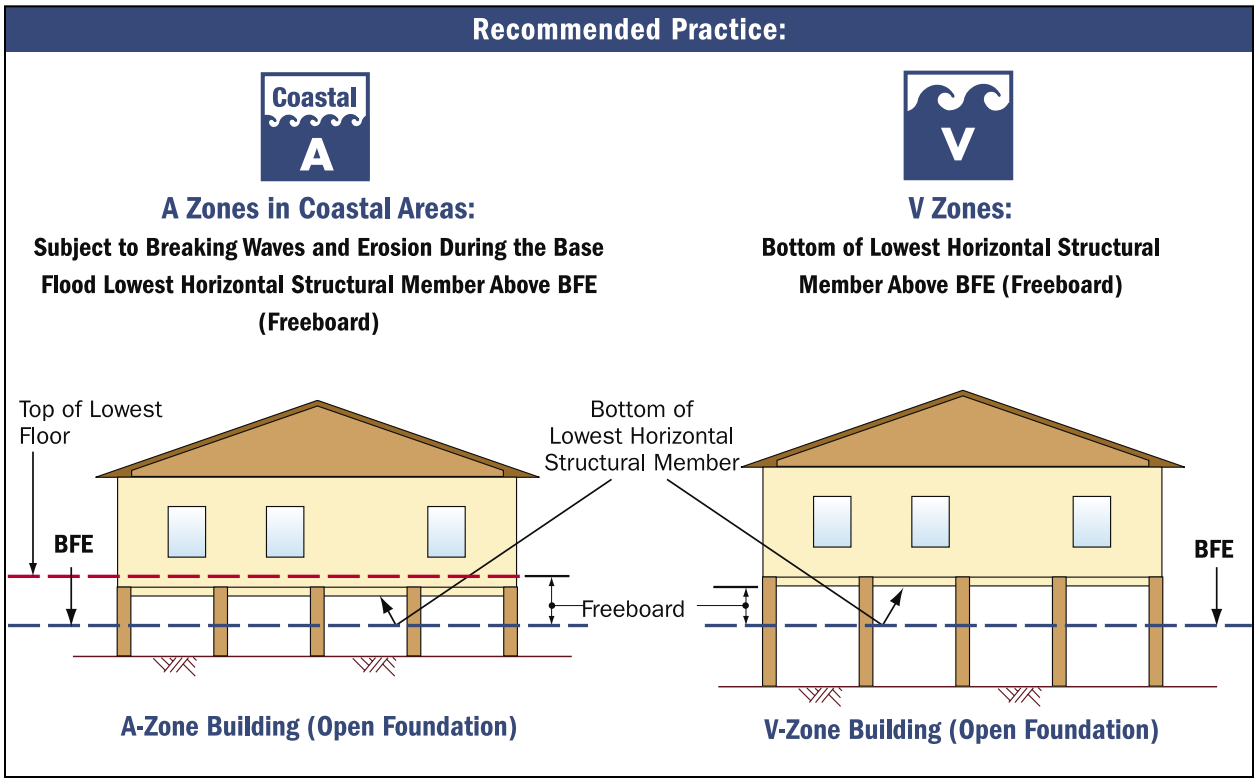

Figure 8-1. Freeboard and open foundations are recommended for V Zones and coastal A Zones.

- **V-Zone standards –** Require V-Zone design and construction for new construction in coastal A Zones subject to erosion, scour, velocity flow, and/or wave heights greater than 1.5 feet.
- **Foundations on barrier islands –** Use a deep pile and/or column foundation anywhere on a barrier island – including B, C, and X Zones – if erosion/or scour are possible. Use of other foundation types should be limited to those areas far outside the SFHA, not

subject to future flooding if dunes or other natural protective features are lost and not subject to erosion or scour. Other foundation types should be the exception, not the rule.

- **Foundations near bay/sound shorelines –** For sites near bay or sound shorelines, foundation selection should be based on several factors: erodibility of the soil; exposure to "damaging" waves (≥1.5 feet high); potential for velocity flow; potential for floodborne debris; and required resistance to lateral flood and wind forces. Aside from the lateral resistance issue, which will probably be a function of wind loads, Table 8.1 should be used to help select the appropriate foundation near bay/sound shorelines.

Table 8-1. Recommended Foundations for Coastal Areas near Bay/Sound Shorelines and Not Mapped as V Zone

Foundation Type	Base Flood Condition Present			
	Erodible Soils, Base Flood Inundation Possible	Wave Heights between 1.5 and 3.0 Feet*	Velocity Flow	Large Debris
Fill	no	no	no	no
Slab on grade	no	no	no	no
Crawlspace, shallow footing	no	no	no	no
Foundation walls, shallow footing	no	no	no	no
Stemwall, shallow footing	no	yes	no	yes
Stemwall, deep footing**	yes	yes	yes	yes
Pier, shallow footing	no	yes	no	no
Pier, deep footing**	yes	yes	yes	no
Post, shallow embedment	no	no	no	no
Pile/Column, deep embedment**	yes	yes	yes	yes

* wave heights greater than 3.0 ft mapped as V Zone: fill, slab, crawlspace, wall foundations not permitted

** deep means sufficiently deep to withstand erosion and scour, including that induced by the presence of the foundation itself

Absent a detailed study for a site, exposure to damaging waves ≥ 1.5 feet can be estimated based on three factors:

- Fetch (during the base flood) from the bay/sound shoreline across the water body. If the fetch is less than 1 mile, the potential for generation of damaging waves is low; if the fetch is 1 mile or greater, assume damaging waves can be generated.
- Stillwater depth at the site, after accounting for erosion. If the stillwater depth is 2 feet or greater, sufficient depth exists to allow passage of 1.5-foot waves; if the stillwater depth is less than 2 feet, waves may be present but should be less than 1.5 feet high.
- Obstructions between the site and the shoreline. If dense stands of trees or buildings/structures capable of withstanding the base flood occur between the site and the shoreline, it is reasonably safe to assume the height of any damaging waves will be reduced; if these obstructions do not exist (or if they exist but their future existence is questionable), assume the wave heights will not be reduced appreciably.

Pier foundations should be used only where soil characteristics and flood conditions permit, and where their design and construction are consistent with the details shown in Figure 8-2. Although this is a common foundation type, its performance in coastal areas has been poor where erosion, waves, and/or debris are present.

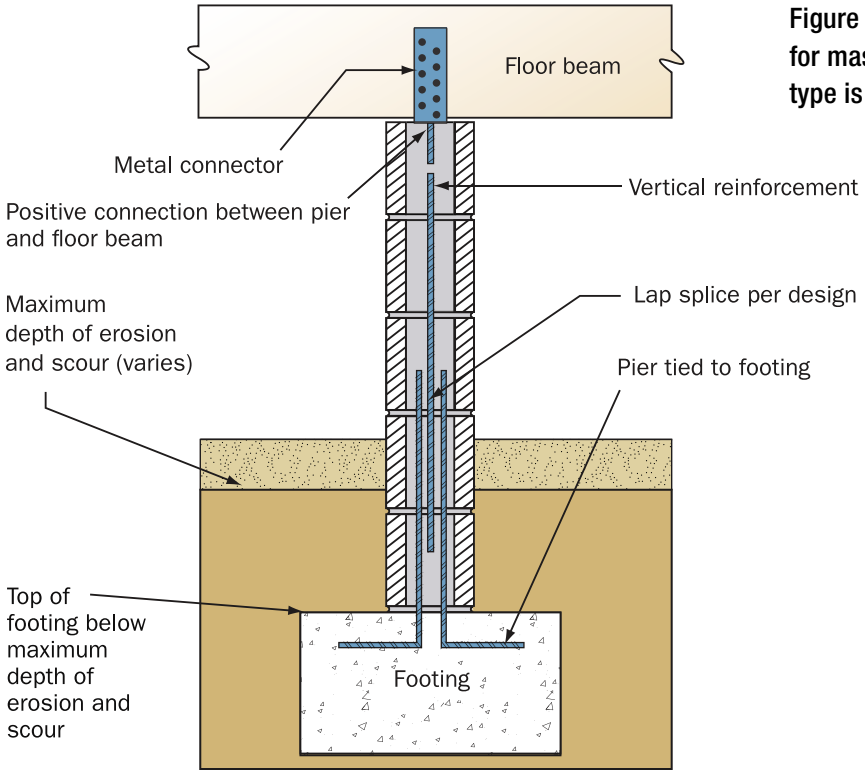

Figure 8-2. Recommended design details for masonry piers where this foundation type is appropriate

Although stemwall foundations (backfilled with a concrete slab on top) performed better than many other A-Zone type foundations near bay/sound shorelines, their use should be contingent on having footings deep enough to withstand erosion and scour, including that due to the presence of the foundation itself.

If there are any doubts as to the appropriate foundation to use near bay and sound shorelines, elevate the building at least one story above grade on piles or another deeply embedded open foundation, and leave the area below free of obstructions or enclose it with breakaway walls.

- **Debris Impacts –** Design foundations and structures to withstand loads from floodborne debris during a base flood event (100-year).
- **Multi-story Construction –** For barrier island sites outside the V Zone, the ground level floor of a multi-story building (typically used for vehicle parking and building access) should either: 1) use a lowest floor slab or floor system that will not collapse and can support all design loads, if undermined, or 2) use a slab or floor system that will collapse and break into small pieces if undermined. For V-Zone sites (on barrier islands and bay/sound shorelines), the ground floor system must collapse and break into small pieces if undermined.

8.1.4 Building Utilities

Electrical wiring and equipment and plumbing should be securely fastened to the landward side of an interior piling and should not be attached to breakaway walls or in areas exposed to wave and debris impacts.

HVAC equipment should be elevated above the BFE and preferably to the same elevation as the lowest floor of the building. The equipment should be supported to prevent damage from flooding and fastened to resist blow-off from high winds. The preferred approach is a cantilevered platform (see Figure 8-3). Other acceptable support systems include knee-braced platform supports (with the bottom of knee braces above wave and debris impacts), and pile supports (with piles substantial enough to resist all flood loads and anticipated erosion and scour). Shallow and/or small diameter post or pile supports should not be used under any circumstances in coastal flood hazard areas.

Figure 8-3.
A cantilevered platform.

8.1.5 Building Access Structures and Enclosures beneath Elevated Buildings

Although newer buildings elevated on piles that were built to V-Zone standards performed well structurally, there were considerable residual damages to the lower portions of the buildings to enclosed areas and elaborate staircases. These damages could have been avoided or at least reduced. Although many of these damages are uninsured and the costs of repair borne by the owner, there are some added costs to the NFIP, particularly for staircases. In addition, as these enclosures and stairways become larger, they are less likely to break away and, thus, more likely to become obstructions to flood flows increasing risk to the rest of the building. The following guidance is provided:

- Ensure that breakaway walls are designed and built to break away cleanly and do not cause additional damage to the building. Do not overlap piles or floor beams with breakaway walls. Provide a clean joint between the breakaway wall and the siding on the elevated portion of the building.
- Minimize the size of any enclosed areas to the amount necessary for parking and building access. Fully enclosing large areas below elevated buildings only increases repair costs and contributes to increased risk of debris impacts to the building and other nearby homes.

- Design staircases to provide a reasonable means of safe and convenient access to the building. Many of the more elaborate staircases on newer buildings were obstructions to flood flows under the building and may have contributed to increased damages and at a minimum, the repairs are costly.
- Flood insurance claims for stairs and building access structures should be limited to a reasonable fraction of the policy limit. The amount should be based on the costs to provide access to the building that is safe and convenient, but no more.
- Flood insurance rating and claims procedures should be modified to ensure that ratings and claims payments are accurate and reflect the risks, particularly in regard to enclosures and obstructions.

8.1.6 Pools and Bulkheads

Post-storm inspections consistently show pool and bulkhead failures and building owners need to understand that these will likely be destroyed during a major hurricane. The following guidance is provided:

- **Pools –** either elevate the pool above the BFE on a pile foundation (and design the pool without side support from soil), or install a frangible (breakaway) pool at grade level and consider it expendable. Do not rely on a bulkhead to protect the pool during a severe storm.
- **Bulkheads –** subject to local and state regulations for coastal armoring, assume that only heavy walls will provide protection during a severe storm, and note that even those may be overtopped by surge and waves. Consider lightweight bulkheads as temporary structures that may provide protection during minor storms, but which will likely fail during a major storm. Do not rely on bulkheads to protect soil supporting buildings; hence, construct buildings on pile foundations even if a bulkhead exists.

8.1.7 Public Outreach and Education

Tailor informational pamphlets to homeowners and building owners to:

- Educate about the risks of natural hazards and best practices for mitigating damages.
- Educate about the risk of constructing enclosures and accessory structures beneath the first floor and emphasize the significant damage that will result during a severe coastal flood event.

For architects, engineers, consultants, building officials, and contractors, prepare monographs for trade-wide distribution, and web-based tutorials and seminars. Encourage colleges, universities, and trade schools to augment existing curriculum with hurricane-resistant design and construction instruction. The following topics can be covered:

- Share post-disaster building performance information to maximize the value of lessons learned.
- Emphasize best practices such as those in the Coastal Construction Manual (FEMA 55) and the Home Builder's Guide to Coastal Construction Fact Sheets (FEMA 499).
- Emphasize importance of freeboard and strong structure-to-beam connections to prevent structure detachment from the foundations.
- Emphasize the importance of flood- and erosion-resistant foundations in coastal areas, even if not required by code and floodplain management regulations.

For elected officials, develop outreach efforts that clearly demonstrate the value of exceeding minimum floodplain and code requirements:

- Illustrate the fact that freeboard and V-Zone foundations are critical to building survival across entire barrier islands, not just sites near the shoreline.
- Show examples of other communities that have adopted higher standards and their experience with those higher standards.
- Assist elected officials in the revision of floodplain management ordinances, development regulations, and building codes to reduce future storm damage.

Tables 8-2 through 8-5 present the flood-related recommendations developed by the MAT and first presented in FEMA 490, *Summary Report on Building Performance 2004 Hurricane Season*, March 2005. Table 8-2 presents the recommendations for design and construction of buildings and accessory structures.

Table 8-2. Design and Construction Recommendations

Flood Hazard		
Building Component	**Recommendation**	**Action Required By[1]**
Design, Foundations and Structures		
Design guidance	Use ASCE 7-05, section 5.3 for the calculation of flood loads during the base flood.	D, C, G
Design guidance	Use ASCE 24-05 for the flood-resistant design of all structures in flood hazard areas, including one- and two-family structures.	D, C, G
Design guidance	Use the *Home Builder Guide to Coastal Construction Technical Fact Sheets* (FEMA 499) and the *Coastal Construction Manual* (FEMA 55) for additional guidance related to flood- (and wind-) resistant design and construction.	D, C, G
Floodborne debris	Design foundations and structures to withstand loads from floodborne debris during a base flood event (100-year).	D, C, G
Lowest floor elevation	Elevate all new construction (including substantially improved structures and replacement of substantially damaged structures) in A Zones with the bottom of the lowest horizontal supporting member above the base flood level. Freeboard for all structures in all flood hazard zones is desirable; the amount will vary with building importance (see ASCE 7-05 and ASCE 24-05) and anticipated exposure to wave effects.	D, C, G
Foundations on barrier islands	Require V-Zone standards for new construction in coastal A Zones subject to erosion, scour, velocity flow, and/or subject to wave heights greater than 1.5 feet.	G
High rise foundations on barrier islands	For areas outside the V Zone, the ground level floor of a multi-story building (typically used for parking or building access) should either: 1) use a lowest floor slab or floor system that will not collapse and can support all loads or 2) use a slab or floor system that will collapse into small pieces. For areas within the V Zone, the ground floor system must collapse and break into small pieces if undermined.	D, C, G
Foundations near bay and sound shorelines	For sites near bay or sound shorelines, foundation selection should be based on several factors as described in section 8.1.3 and an appropriate foundation should be selected as outlined in Table 8-1.	D, C, G
Utilities	Design and construct to ASCE 24-05. HVAC equipment should be elevated above the BFE and should be supported to prevent damage from flooding, wave, and debris impacts, and high winds. The support system should be a cantilevered platform or knee-braced platform with the bottom of the knee braces above the wave and debris impacts.	D, C, G
Dock and piers	Implement design requirements for docks and piers that minimize damage to other structures.	D, C, G

Table 8-2. Design and Construction Recommendations (continued)

Flood Hazard		
Building Component	**Recommendation**	**Action Required By[1]**
Accessory Structures		
Pools	Either elevate the pool above the BFE on a pile foundation (and design the pool without side support from soil), or install a frangible (breakaway) pool at grade level and consider it expendable.	D, C, G
Bulkheads	Do not rely on bulkheads to do any more than retain soil under normal and minor storm conditions; do not design building foundations or other structures that rely on bulkheads to retain soil during a base flood event.	D, C, O

1 Action required by: Designer (D), Contractor (C), Manufacturer (M), Government Official (G), Building Owner (O)

Table 8-3 presents flood hazard identification and regulations recommendations.

Table 8-3. Hazard Identification and Regulations Recommendations

Flood Hazard	
Parameter	**Recommendation**
Hazard Identification and Regulation	
Storm surge	Re-evaluate storm climatology, water-level data, and storm-surge modeling; run modern storm-surge models as the basis for determining new BFEs.
A Zones in coastal areas	Re-evaluate the hazard identification/mapping approaches in coastal A Zones.
Zones B, C, and X on barrier islands	Re-evaluate flood and erosion hazards associated with areas outside the SFHA on barrier islands.
Open coast future conditions mapping	Flood hazard mapping of open coast areas should account for multiple storm events and future conditions (e.g., long-term erosion and sea level rise).

Table 8-4 presents recommendations to alert the public to the flood hazard.

Table 8-4. Public Outreach Recommendations

Flood Hazard	
Education Topic	**Outreach**
Building Owners and Homeowners	
Educate building and homeowners in the risks of natural hazards and best practices for mitigating damages.	Use FEMA *Home Builder's Guide to Coastal Construction Fact Sheets* (FEMA 499). Interview homeowners who have been through recent storms (both those whose buildings were not damaged and those whose buildings were). Use this information to prepare other informational pamphlets/video/web sites aimed at homeowners and building owners.
Educate homeowners on the risk of constructing enclosures and accessory structures beneath the lowest finished floor and emphasize the significant damage that will result during a severe coastal flood event.	Prepare pamphlet.
Architects, Engineers, Consultants, and Building Officials	
Architects, Engineers, Consultants	Distribute information in the areas of post-disaster building performance to maximize value of lessons learned. Emphasize best practices in *Coastal Construction Manual* (FEMA 55). Emphasize the importance of flood- and erosion-resistant foundations in coastal areas, even if not required by code and floodplain management regulations. Emphasize importance of freeboard and strong structure-to-beam connections to prevent structure detachment from the foundations.
Building Officials	Same as Architects/Engineers/Consultants, plus: Develop educational programs for annual seminars, specially designed to share "lessons learned" and receive training to address potential permitting/enforcement problems. Encourage building officials to obtain the new certification (coastal building inspector) being offered by ICC after July 2005.

Table 8-4. Public Outreach Recommendations (continued)

Flood Hazard	
Education Topic	**Outreach**
Elected Officials	
Educate elected officials on how to best design buildings for barrier islands.	Pamphlets, videos showing side-by-side photos and discussion of freeboard vs. elevating to BFE, V-Zone foundations vs. A-Zone foundations in coastal A Zones
Show elected officials examples of other communities that have adopted higher standards and their experience with those higher standards.	Interview community officials from communities that have adopted higher standards – what are the advantages and disadvantages of doing so? How much damage has been avoided in recent storms? Develop relationships with organizations of elected officials (county commissioners associations, league of cities, etc.), and get on the agenda for their national/state meetings – promote higher standards.
Assist elected officials in the revision of floodplain management ordinances, development regulations, and building codes to reduce future storm damage.	Obtain/prepare model ordinances, development regulations, and code revisions that mandate higher standards.
Contractors	
Share post-disaster building performance information to maximize the value of lessons learned. Emphasize best practices such as *Coastal Construction Manual* (FEMA 55) and *Home Builder's Guide to Coastal Construction* (FEMA 499). Emphasize importance of strong structure-to-beam connections to prevent structure detachment from the foundations while piles and beams are still intact.	Prepare monographs for trade-wide distribution. Prepare web-based tutorials and seminars. Encourage colleges, universities, and trade schools to augment existing curriculum with hurricane-resistant design and construction instruction.

The flood hazard recommendations in Table 8-5 are specific to critical and essential facilities.

Table 8-5. Recommendations Specific to Critical and Essential Facilities

Flood Hazard		
Parameter	**Recommendation**	**Action Required By[1]**
Critical/Essential Facilities		
Public shelters	Do not open shelters located in potential storm-surge inundation zones until after the hurricane makes landfall.	G, CFO
New structures	Elevate new structures in floodprone areas to the 500-year (0.2% annual exceedance) flood level or higher based on ASCE 24.	D, G, CFO
Existing structures	Evaluate vulnerability of existing structures in light of recent damage to similar facilities; strengthen and floodproof structures where feasible.	G, CFO, D

[1] Action required by: Designer (D), Government Official (G), Critical Facility Manager/Owner (CFO)

8.2 Wind Recommendations

As the people of southern Alabama and northwestern Florida rebuild their lives, homes, and businesses, there are a number of steps they can take to lessen the impact of wind damage from future natural hazards, including:

- Design and construct facilities to at least the minimum design requirements in the 2003 IBC in Alabama and the 2001 FBC and the 2004 FBC (after it becomes effective in the summer of 2005) in Florida.
- When renovating or remodeling for structural or building envelope improvements (both residential and commercial), involve a structural engineer/design professional/licensed contractor in the design and planning.
- Assure code compliance through increased enforcement of construction inspection requirements such as the Florida Threshold Inspection Law or the IBC Special Inspections Provisions.
- Perform follow-up inspections after a hurricane to look for moisture that may affect the structure or building envelope.
- Use the necessity of roof repairs to damaged buildings as an opportunity to significantly increase the future wind resistance of the structure.

The following recommendations are specifically provided for state and Federal government agencies:

- The government should place a high priority on and allocate resources to hardening, and providing backup power and data storage to NOAA/NWS's surface weather monitoring systems, including the ASOS located in hurricane-prone regions. Continued support is also needed for maintenance, expansion and deployment of stand alone unmanned surface observation systems that can be safely and reliably placed in advance of a land falling hurricane. Support should be provided for the real-time communication of data from all these platforms to forecasters and wind field modeling efforts.
- The government should place a high priority on continuing to fund the development of several different tools for estimating and mapping wind fields associated with hurricanes and for making these products available to the public as quickly as possible after a hurricane strikes.

8.2.1 Proposed Changes to Codes and Statutes

Buildings constructed in accordance with 2001 FBC (and those that had been mitigated to resist high-wind loads) were observed to perform substantially better than typical buildings constructed to earlier codes, but their positive performance was not without exception. The study of buildings and their interaction with high winds associated with hurricanes is a continuous process and much has been learned since the current codes and statutes were developed and adopted. Incorporating the recommendations in this report into the next available code cycle is key to setting the new standard in hurricane-resistant construction in Alabama, Florida, and all hurricane-prone regions.

Subsections 8.2.1.1, 8.2.1.2, and 8.2.1.3 provide recommendations specific to the codes and statutes currently adopted and being enforced in the States of Alabama and Florida. If these recommendations are not codified by the states in response to the hurricanes of 2004, the design changes recommended herein should be considered "best practices" in hurricane-resistant construction and incorporated in all new construction and mitigation projects as a discretionary matter.

8.2.1.1 Statutory Building Code Provisions – Alabama

- Adopt the 2003 IBC and IRC for all high-wind jurisdictions in the state.

- Do not modify the wind provisions of the IBC/IRC and ASCE 7-02 with local amendments that suspend some of the provisions, such as windborne debris protection.
- Require the use of high wind provisions for residential construction in wind zones of 100 mph and greater. The current 2003 IRC requirement is 110 mph; however, the IRC Code Development Committee has approved a code change proposal for the 2006 version lowering the threshold to 100 mph.
- Review the exemption in windborne debris regions that allows for residences to be designed as "partially enclosed" structures with unprotected openings. The MAT observed instances where the breach of unprotected glazing led to significant damage to building contents that would have been prevented if the damaged buildings had been equipped with protected glazing to resist windborne debris. The next version of the IRC does not allow for the design of partially enclosed structures without protecting glazing. The IBC Structural Code Development Committee has approved a code change proposal for the 2006 version eliminating the partially enclosed option. Based on observed damages in Hurricane Ivan, this exemption should not be allowed for any use (residential or commercial) in windborne debris regions.

8.2.1.2 Statutory Building Code Provisions - Florida

The following design criterion is recommended for inclusion into statewide design requirements for all construction. The criteria are addressed in Ch. 553.71 and Ch. 2000-141 of the *Laws of Florida* (and presented in Section 2.2 of this report).

- Review the exemption in windborne debris regions that allows for residences to be designed as "partially-enclosed" structures with unprotected openings. The MAT observed instances where the breach of unprotected glazing led to significant damage to building contents that would have been prevented if the damaged buildings had been equipped with protected glazing to resist windborne debris. The next version of the IRC does not allow for the design of partially enclosed structures without protecting glazing. The IBC Structural Code Development Committee has approved a code change proposal for the 2006 version eliminating the partially enclosed option. Based on observed damages in Hurricane Ivan, this exemption should not be allowed for any use (residential or commercial) in windborne debris regions.

8.2.1.3 Reference Standards – ASCE 7

All of the various building codes that govern the areas within the Ivan damage zone in one way or another reference ASCE 7 for wind loads. Within that standard is Table 1-1, which classifies buildings based on occupancy. This classification is used to determine the importance factors for wind, snow, and earthquake loads. The Ivan MAT discovered a loophole in this system of classification that needs to be examined by the ASCE 7 committee. The loophole was evident in the classification of various buildings on hospital campuses. Using Table 1-1, an MOB would be classified as a Category II building because it has no patients. Further, the table requires a patient bed count of 50 beds or more to move the building up to a Category III building, thus invoking the 1.15 safety factor. However, the MAT observed instances where clinical functions essential to the treatment of the community were housed in MOBs attached to the hospital. One example of this was a large dialysis clinic housed in an MOB. Although the building sustained major building envelope damage, it was able to quickly make temporary repairs and restore services. This could have easily not been the case, and many patients would have been denied treatment. Immediately after a hurricane, movement and access are problematic at best; hence, requiring patients to travel to more distant locations to receive life sustaining treatments is more than a mere inconvenience. Consideration should be given to changing Table 1-1 to include in Category III those buildings that house essential clinical treatment functions that are not easily available elsewhere in the community.

Designers should take care when classifying some facilities that provide care, such as nursing homes. For example, skilled nursing homes and Alzheimer's facilities should be Category III, but an assisted living facility might suitably be classified as Category II. Also, the occupancy trigger should be reexamined. A skilled nursing home or Alzheimer facility should be Category III regardless of the number of patients. It is, therefore, also recommended that the ASCE committee examine Table 1-1 with respect to nursing homes.

8.2.2 Architectural, Mechanical, and Electrical

To improve the performance of the building envelope and rooftop equipment, the following action items are recommended in addition to the code revisions identified previously.

- **Sheathing on the Underside of Elevated Buildings.** Preservative-treated plywood is recommended in lieu of gypsum board and vinyl siding. It is recommended that the plywood be attached with stainless steel nails or screws. As discussed in Section 5.1, because

of lack of guidance on determining wind loads, it is recommended that designers use professional judgment in specifying the fastener type, size and spacing.

- **EIFS.** Many of the failures of EIFS systems observed by the MAT were related to the design and installation of fasteners of the EIFS systems. In many other cases, failure modes could not be determined but could result from one or more of the following: material defects, inadequate test standards and methods, specification of inappropriate system by designers, or poor installation. Nevertheless, the failures were so common, and the consequences of the failures were so severe, that continued use of EIFS is not recommended in high wind coastal areas. When these systems are used, fastening of the systems could be improved if the following methods and approaches are considered:
  - As discussed in Section 5.3.1, it is recommended that two revisions be made to test method ASTM E 330. In lieu of a 10-second load duration, a 60-second duration is recommended. It is also recommended that deflection criteria specified in test method ASTM E 1592 be incorporated into ASTM E 330.
  - It is also recommended that the EIFS Industry Members Association (EIMA) consider all elements of the EIFS assembly. Although EIMA members may not manufacture or supply assembly components such as metal framing, sheathing, or sheathing fasteners, these other elements are also critical in achieving suitable wind performance.
  - It is recommended that manufacturers re-evaluate their training programs because it was evident that many EIFS assemblies were installed improperly, most likely by inadequately trained workers.
  - For EIFS installed over sheathing, it is recommended that designers specify attachment requirements for all elements of the assembly, including framing and sheathing attachment. It is also recommended that designers specify special inspections to ensure proper application of all elements of the assembly.
- **Vinyl Siding.** As discussed in Section 5.3.2, it is recommended that two revisions be made to test method ASTM D 5206. In lieu of a 30-second load duration, a 60-second duration is recommended. It is also recommended that deflection criteria specified in test method ASTM E 1592 be incorporated into ASTM D 5206. It is also recommended that the ASTM task group responsible for ASTM D 5206

give consideration to dynamic testing of vinyl siding in lieu of the static testing now prescribed in ASTM D 5206.

It is recommended that ASTM D 3679 be revised to require a minimum safety factor of 2 versus the 1.5 factor currently specified. It is recommended that ASTM D 4756 be revised to require installation of a water-shedding underlayment (e.g., asphalt-saturated felt or housewrap).

The method used to determine the pressure equalization factor currently specified in ASTM D 3679 appears to be questionable. It is therefore recommended that the ASTM task group responsible for the Standard reevaluate the magnitude of the pressure equalization factor (0.36).

Tables 8-6 through 8-9 present the wind-related recommendations developed by the MAT and first presented in FEMA 490, *Summary Report on Building Performance 2004 Hurricane Season*, March 2005. A full discussion of these recommendations can be found in the Hurricane Charley MAT report (FEMA 488). Hurricane Charley was a code level wind event, and readers are encouraged to obtain a copy of this report.

Table 8-6 presents design and construction recommendations to avoid or lessen potential wind hazard damage to accessory structures, the building envelope and exterior equipment.

Table 8-6. Design and Construction Recommendations

Building Component	Recommendation	Action Required By[1]
Wind Hazard		
Accessory Structures		
Attached and detached	Add additional anchors at corner post connections to concrete.	D, C
Attached and detached	Use AAF *Guide to Alluminum Construction in High Wind Areas* until FBC 2004 is adopted.	D
Attached and detached	Increase wind resistance of accessory structure walls parallel to primary building (e.g., tension cable, solid "K" bracing).	D
Attached and detached	Provide lateral bracing in roof planes using rigid diagonal structural members.	D, C
Attached	Ensure attached building and primary building can withstand equal wind pressures.	D, C
Attached	Determine implications to primary building if attached structure collapses.	D, C

Table 8-6. Design and Construction Recommendations (continued)

Building Component	Recommendation	Action Required By[1]
Wind Hazard		
Building Envelope		
Detached	Determine ability to withstand windstorm events to reduce windborne debris.	D, C
Doors		
Exterior doors	Specify wind-driven rain resistant weather-stripping at exterior doors (see FEMA 424).	D
Entrance vestibules	Design entrance vestibules in areas where basic wind speed is greater than 120 mph.	D
Rolling and sectional doors	Consider type, size, and spacing of door, frame, and frame fasteners to loads. If frame is attached to wood blocking, attention should also be given to the blocking attachment.	D, C
Rolling and sectional doors	Maintain adequate edge distances for frame fasteners placed in concrete or masonry.	C
Soffit		
Soffits	Design Guidance: Develop design guidance for attaching soffits, including design of baffles or filter media to prevent wind-driven rain from entering attics.	
Roof Assembly		
Roof systems	Testing: Roof assemblies susceptible to dynamic loading should be dynamically tested to obtain realistic measure of their wind resistance. Higher safety factors should be used for those assemblies requiring dynamic testing, but for which dynamic test methods are not available.	D, C, G
Reroofing	Tear off old roof (do not re-cover) in areas where basic wind speed is 110 mph or greater.	D, C
Reroofing	Install additional sheathing fasteners if existing sheathing attachment is not in compliance with current building code.	D, C
Asphalt shingles	Ensure manufacturers' installation instructions are followed (i.e., starter strips and nail locations) and use Recovery Advisory Nos. 1 and 2.	D, C
Asphalt shingles	Re-evaluate attachment of factory-laminated tabs.	M
Metal panel roof system	Chalk-line clip locations for panels with concealed clips and ensure clip locations are not excessively spaced.	C
Metal panel roof system	Base uplift resistance on ASTM E 1592.	M, D
Metal panel roof system	Specify close spacing of fasteners at eaves, and hip and ridge flashings.	D
Tile roof system	Use Recovery Advisory No. 3.	D, C

Table 8-6. Design and Construction Recommendations (continued)

Building Component	Recommendation	Action Required By[1]
Wind Hazard		
Roof Assembly (continued)		
Tile roof system	Develop tiles with improved ductility via internal or backside reinforcement or bonding film in hurricane-prone regions (e.g., develop tile similar to laminated glass).	M
Tile roof (foam-set) system	For foam set tile, simplify number of installation options and clarify requirements.	M
Tile roof (foam-set) system	Modify training and certification programs to ensure that foam-set roof installers are adequately trained.	M, C
Tile roof (foam-set) system	Use a higher safety factor (e.g., 4) to account for application and testing issues.	M, D
Mechanically attached roof systems	FRSA/TRI re-evaluate use of safety factor of 2. Either develop dynamic test method or use existing test method with higher safety factor (e.g., 3).	M, D
Built-up roofs	Develop and codify technically based criteria for aggregate surfacing on built-up and sprayed polyurethane foam roofs.	M, G
Edge flashings and copings	Comply with ANSI/SPRI ES-1 (2003). Use safety factor of 3 for critical and essential facilites and a factor of 2 for other buildings.	D
Edge flashings and copings	Install edge flashings on top of membrane to clamp it down.	D, C
Edge flashings and copings	Place a bar over roof membrane near edge of flashing and coping to provide secondary protection (see FEMA 424).	D, C
Gutters and downspouts	Use professional judgment to specify and detail gutter uplift resistance.	D
Gutters and downspouts	Design Guidance: Develop design guide, test method, and code criteria for gutters, including attachment of downspouts.	M, C
Rooftop walkway pads	Research wind resistance of roof walkway pads.	M, G
Windows		
General	Develop window assemblies that are more wind-driven rainwater-resistant.	M
General	The window industry should re-evaluate current test procedures to better represent wind-driven rain produced by hurricane and tropical storm winds.	D, C, M, G
Exterior Equipment		
General	For all exterior equipment, recommend safety factor of 3 due to uncertainties pertaining to wind load.	D
General	Design Guidance: Develop guidance and code criteria for attaching condensers and rooftop mechanical equipment (including ductwork).	D, G

Table 8-6. Design and Construction Recommendations (continued)

Building Component	Recommendation	Action Required By[1]
Wind Hazard		
Exterior Equipment (continued)		
General	Evaluate the need to better secure exterior devices, such as pool equipment and roof-mounted solar heaters.	D, C, O, CF
Cowlings	Anchor cowlings on exhaust fans to curbs using cables (see FEMA 424).	M, D, C
Access panels	Modify access panels attached by manufacturer to ensure secure attachment (see FEMA 424).	M, D, C
Lightning protection systems	Develop guidance and code criteria for attachment of lightning protection systems (see FEMA 424), communications towers, and satellite dishes.	M, D, C

[1] Action required by: Designer (D), Contractor (C), Manufacturer (M), Government Official (G), Building Owner (O)

Table 8-7 presents building code recommendations to avoid or lessen damage from potential wind hazards to the building envelope, windows and shutters, exterior equipment, and critical and essential facilities.

Table 8-7. Building Code Recommendations

Wind Hazard	
Building Component	**Recommendation**
Building Envelope	
Soffit	
Soffit	Develop and adopt wind resistance and wind-load criteria regarding wind resistance for soffits. Wind-driven rain resistance of ventilated soffit panels should also be added. Testing Application Standard (TAS) 110 may be a suitable test method, although it may require modification.
Roof Assembly	
Edge flashing and coping	**FBC Section 1503** (Weather Protection): Compliance with American National Standards Institute (ANSI) SPRI ES-1.
Gutters	**FBC Section 1503** (Weather Protection) **and IBC/IRC**: Develop and add criteria regarding uplift resistance of gutters.
Ridge vents	**FBC Section 1503** (Weather Protection) **and IBC/IRC**: Add criteria regarding wind and wind-driven rain resistance of ridge vents. Attachment criteria require development, but TAS 110 could be referenced for rain resistance.
Metal panel roof system	**FBC Section 1504** (Performance Requirements): Require compliance with ASTM E 1592 for testing the uplift resistance of metal panel roof systems.

Table 8-7. Building Code Recommendations (continued)

Wind Hazard	
Building Component	**Recommendation**
Roof Assembly (continued)	
Roof system	**FBC Section 1510.3** (Recovering vs. Replacement) and IBC/IRC: Require removal of existing roof covering down to the deck and replacement of deteriorated sheathing in areas where basic wind speed is 110 mph or greater. If existing sheathing attachment does not comply with loads derived from Chapter 16, require installation of additional fasteners to meet loads.
Asphalt shingles	**FBC Section 1507.2** (Roof Covering Application) **and IBC/IRC**: Require compliance with UL 2390. Also require six nails per shingle and require use of asphalt roof cement at eaves, rakes, hips, and ridges where basic wind speed is 110 mph or greater (refer to Recovery Advisory No. 2).
Mortar-set tile roof system	**FBC Section 1507.4** (Clay and Concrete Tile) **and IBC/IRC**: Provide an alternative to the use of mortar to attach field tiles and hip/ridge tiles.
Built-up roof	**FBC Section 1508** (Roof Coverings with Slopes Less Than 2:12): Add technically based criteria regarding blow-off resistance of aggregate on built-up and sprayed polyurethane foam roofs.
Windows and Shutters	
Shutters	**IBC and FBC Section 1606.1.4** (Protection of Openings): Add requirement to label shutters (other than wood) because without labels, building owner does not know if shutters are suitable.
Windborne debris region	**FBC:** Revise the Florida Panhandle criteria to match ASCE 7.
Manufactured Housing	Revise Chapter 15C of the Rules and Regulations of Florida to provide window protection systems (and a strengthened structure around openings) on Zone II and Zone III units being installed in the windborne regions defined by Chapter 16 of the FBC.
Exterior Equipment	
General	**FBC Section 1522.2** (Rooftop Mounted Equipment): Make applicable throughout the State of Florida for all wind speeds. Develop and add criteria that pertain to attaching lightning protection systems. Provisions also included in electrical codes.
Critical and Essential Facilities	
General	Critical and essential facilities, at a minimum, should be designed with wind loads using an importance factor of 1.15 in accordance with ASCE 7.

Table 8-7. Building Code Recommendations (continued)

Wind Hazard	
Building Component	**Recommendation**
Critical and Essential Facilities (continued)	
General	For hurricane shelters and Enhanced Hurricane Protection Areas (EHPAs), adopt wind speed recommended by FL DCA in the SESP and the ASCE 7-02/2001 FBC wind speed map design wind speed plus 40 mph. This is also the recommended best practice in the FL DCA shelter design guidance and in FBC Section 423, Part 24; change to *a requirement*. This criterion should be required by the SESP and should be used until the International Code Council's High Wind Shelter Standard is completed in 2006/2007 and available for adoption.
General	Minimum debris impact protection should be per ASTM E 1996 Category E for a 9-pound 2x4 (nominal) missile traveling at 50 mph. This criterion should be required by the SESP and should be used until the ICC's High Wind Shelter Standard is completed in 2006/2007 and available for adoption.
General	As an alternative to designing shelters to the SESP or ASCE criteria, design or retrofit buildings to be used as shelters to the design guidance provided in FEMA 361, *Design and Construction Guidance for Community Shelters*.

Table 8-8 presents recommendations to alert building owners and homeowners; architects, engineers, and consultants; building officials; contractors; manufacturers; and associations, institutions, and societies of steps they can take to avoid or lessen potential damages from wind hazards.

Table 8-8. Public Outreach Recommendations

Wind Hazard	
Education Topic	**Outreach Method**
Building Owners And Homeowners	
Plan and budget construction projects that incorporate natural hazard mitigation measures. Select design and construction teams knowledgeable in effective construction methods in hurricane-prone areas. Prepare and protect building prior to hurricane landfall. What to do after hurricane passes (building inspection for damage, emergency repairs, and drying out building interiors). Rebuild damaged structure in manner that protects against future damage. Inspect exterior connections and fasteners for wear, corrosion, and other deterioration. Educate building owners on how wind-driven rainwater enters buildings, the resulting implications (loss of electricity, mold), and prevention methods.	✓ Tailor informational pamphlets to homeowners and building owners. ✓ Develop strategy to distribute information (e.g., standardized information sheets during sale of building). ✓ Enlist assistance of real-estate companies and organizations such as the Building Owners and Managers Association. ✓ Provide public service notices at start of each hurricane season. ✓ Develop informational materials on how wind-driven rainwater enters buildings, the resulting damage, and prevention methods.
Architects, Engineers, Consultants	
Improve the technical proficiency of building envelope design. Provide adequate level of design details for connecting rooftop equipment, including mechanical, electrical and lightning protection. Share post-disaster building performance information to maximize the value of lessons learned.	✓ Prepare monographs for trade-wide distribution. ✓ Prepare web-based tutorials and seminars. ✓ Encourage colleges and universities to augment existing curriculum with hurricane-resistant design instruction.

Table 8-8. Public Outreach Recommendations (continued)

Wind Hazard	
Education Topic	**Outreach Method**
Building Officials	
Share post-disaster building performance information to maximize the value of lessons learned. Train building officials to identify structural weaknesses that may cause structure or building component failure during a hurricane (e.g., unbraced gable ends, missing truss bracing, truss' anchorage, window/door anchorage). Implement effective enforcement techniques to maintain a high construction quality.	✓ Conduct annual seminars for building officials and plan reviewers in coastal areas to share lessons learned. ✓ Implement hurricane disaster building inspection training program and "train the trainer" program.
Contractors	
Educate contractors who construct building envelopes and install rooftop equipment on hurricane resistant fastening and anchoring systems. Educate contractors on how wind-driven water enters buildings, the resulting implications (loss of electricity, mold), and prevention methods.	✓ Develop and distribute visual tools such as instructional videos or DVDs. ✓ Conduct on-the-job training to highlight failures that occur when simple anchoring techniques are not applied. ✓ Encourage trade schools in hurricane-prone areas to augment their curriculum with courses on state-of-the- art hurricane-resistant construction.
Manufacturers	
Educate manufacturers of building envelope materials and rooftop equipment on the performance of their products during hurricanes. Encourage manufacturers to provide special guidance for use of their products in hurricane-prone areas. Develop improved products and systems for hurricane-prone areas. Manufacturers should educate designers and contractors on their products.	✓ Develop and distribute informational notices to manufacturers.
Associations, Institutes, and Societies	
Advocate hurricane-resistant design and construction to their membership.	Develop educational materials for distribution to their members and industry.

Table 8-9 presents wind-hazard recommendations specific to critical and essential facilities.

Table 8-9. Recommendations Specific to Critical and Essential Facilities

Wind Hazard		
Component	**Recommendation**	**Action Required By[1]**
General		
Detailing and notations on the building plans	Facility plans should delineate the facility area designed to function as a shelter or hardened area. Details of the shelter or hardened area and the envelope elements should be provided to ensure that the construction requirements are clearly understood by the builder and building official. Provide facility design criteria and maximum design pressures for the main wind force resisting system (MWFRS) and for components and cladding.	D, C, CFO
Material selection	Reinforced concrete roof deck and reinforced concrete and/or reinforced and fully grouted concrete masonry unit (CMU) exterior walls are recommended. FEMA 424, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds*, and FEMA 361, *Design and Construction Guidance for Community Shelters,* provide detailed guidance on material selection for structural and building envelope systems.	D, C, CFO
General	Develop additional criteria to help ensure continuity of function. See FEMA 424 and FEMA 361.	CFO
General	Emphasize best practices for schools and shelters described in FEMA 424 and FEMA 361 respectively, and in the latest codes and standards for wind resistance (ASCE 7).	CFO
Design guidance	Develop a comprehensive design guide to complement FEMA 424 for mitigating existing facilities.	D, G
Perform vulnerability assessment	Perform vulnerability assessment to ensure continuity of operations. The assessment should evaluate the building performance and utilities that service critical/essential facilities so that the building owner understands impacts to the facility during a storm and operational impacts due to limited utility services.	CFO

Table 8-9. Recommendations Specific to Critical and Essential Facilities (continued)

Wind Hazard		
Component	**Recommendation**	**Action Required By[1]**
General (continued)		
General	Implement mitigation measures or structurally retrofit critical/essential facilities to design levels other than minimum code requirements for general use buildings. Do not house critical facilities in lightly engineered buildings such as pre-engineered metal buildings.	CFO, D
General	Educate designers: buildings designed to minimum EHPA requirements does not guarantee that building used as shelter will be properly designed and constructed to resist extreme wind events. Emphasize best practices for shelters described in FEMA 361.	D, C
General	Educate designers: American Red Cross 4496 provides a baseline for a shelter's integrity and performance, but meeting this criterion does not guarantee that the building will resist wind and windborne debris associated with hurricanes. Emphasize best practices for shelters described in FEMA 361.	D, C
General	Conduct special inspections for key structural items and connections to ensure performance of critical facilities.	CFO, C
General	Design critical and essential facilities with wind loads using an importance factor of 1.15 in accordance with ASCE 7. For some facilities, design using the 40-mph increase with importance factor of 1 (recommended for shelter EHPA design in FBC Section 423, Part 24).	D
General	Incorporate hazard mitigation peer review into design approval process to ensure that critical and essential facilities are adequately designed to resist extreme winds.	D
Accessory Structures		
Detached	Strengthen the anchorage of structures and portable classroom buildings at schools.	D, C, G, CFO
Building Envelope		
General	Contract drawings and specifications for new construction and remedial work on existing building envelopes and rooftop equipment should undergo rigorous peer review, submittal review, field observation (inspection), and testing prior to construction.	D, C, G
General	Implement mitigation measures in buildings not built to current building codes to protect roof coverings, wall coverings, window and door systems, and rooftop equipment.	D, CFO

Table 8-9. Recommendations Specific to Critical and Essential Facilities (continued)

Wind Hazard		
Component	**Recommendation**	**Action Required By[1]**
Building Envelope (continued)		
General	Conduct special inspections for key building envelope components to ensure performance of critical/essential facilities. Inspect roof top equipment twice a year. Inspect doors, windows, and wall coverings at 5-year intervals. Conduct special inspections of the entire facility (both structural and building envelope systems) after storms with wind speeds in excess of 90 mph 3-second gust winds.	CFO
Doors		
Doors	Design or mitigate to the FBC or IBC design wind speed.	D
Rolling and sectional doors	Purchase and install high wind-rated, sectional/rolling doors to protect against high wind.	D, CFO
Rolling and sectional doors	Ensure sectional rolling doors are properly installed and reinforced to prevent catastrophic door failure and building pressurization. Replace or retrofit existing doors that lack adequate resistance.	D, CFO
Roof Assembly		
Roof structure	Install hurricane clips or straps on inadequately connected roof beams and joists in those buildings that will be occupied during a hurricane.	C, CFO
Roof decks	Strengthen inadequately attached roof decks.	CFO
Roofing	Replace aggregate-surfaced roof systems with non-aggregate systems.	D, C, CFO
Roof system	Design roof system that will prevent water infiltration if roof is hit by windborne debris.	D
Edge flashings and copings	Install exposed fasteners to weak metal edge flashings and copings.	D, C, CFO
Gutters and downspouts	Install tie-down straps on gutters to avoid membrane blow-off.	D, C, CFO
Rooftop equipment	Anchor all rooftop equipment.	D, C, CFO

Table 8-9. Recommendations Specific to Critical and Essential Facilities (continued)

Wind Hazard		
Component	**Recommendation**	**Action Required By[1]**
Building Envelope (continued)		
Windows		
Windows	Implement window protection systems to protect critical facilities from windborne debris.	CFO, D
Shutters	Install shuttering system on all exterior glazing that is not windborne debris resistant. Install power-operated shutters or laminated glass, or apply an engineered film system to the glazing and frame on upper-level floors.	D, C, CFO

[1] Action required by: Designer (D), Government Official (G), Critical Facility Manager/Owner (CFO)