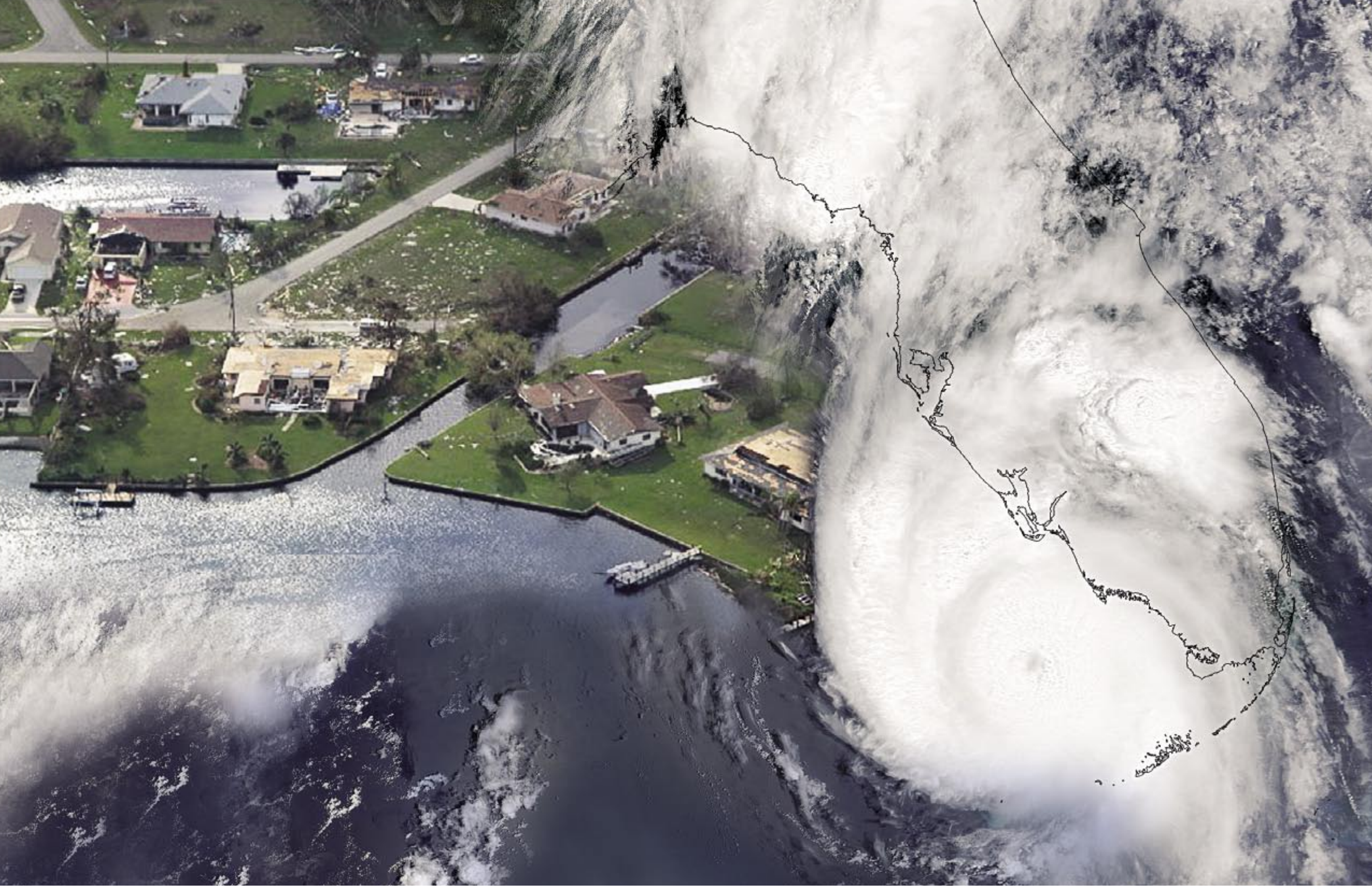

Mitigation Assessment Team Report

Hurricane Charley in Florida

Observations, Recommendations, and Technical Guidance

FEMA 488 / April 2005

U.S. DEPARTMENT OF HOMELAND SECURITY

FEMA

FLORIDA DEPARTMENT OF
Community Affairs

In response to Hurricane Charley, the Federal Emergency Management Agency (FEMA) deployed a Mitigation Assessment Team (MAT) to evaluate and assess damage from the hurricane and provide observations, conclusions, and recommendations on the performance of buildings and other structures impacted by wind and flood forces. The MAT included members of FEMA Headquarters and Regional engineering staff, and code enforcement officials, as well as experts from the design and construction industry. The conclusions and recommendations of this Report are intended to provide decision-makers information and technical guidance that can be used to reduce future hurricane damage.

About the Cover

The photograph on the cover shows damage in Charlotte County, Florida, caused by Hurricane Charley on August 13, 2004. (Photograph courtesy of the Florida Division of Emergency Management and the State Emergency Response Team.) Superimposed on this photograph is an image of Hurricane Charley captured on August 13, 2004, at 12:35 p.m. Eastern Daylight Time by the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor aboard the National Aeronautics and Space Administration's (NASA's) Terra satellite. At the time the image was taken, Charley was rapidly gaining strength and would reach Category 4 status just 90 minutes later. Maximum sustained winds at 2:00 p.m. were at 145 miles per hour (mph), and Charley was moving toward the north-northeast at 20 mph.

(IMAGE COURTESY OF NASA AND THE SPACE SCIENCE AND ENGINEERING CENTER, UNIVERSITY OF WISCONSIN-MADISON.)

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Florida Department of Community Affairs

Institute for Business & Home Safety

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Executive Summary

Hurricane Charley made landfall on Friday, August 13, 2004, at Mangrove Point, just southwest of Punta Gorda, Florida, The hurricane crossed the barrier islands of Cayo Costa and Gasparilla with wind speed estimates from the National Hurricane Center (NHC) of 150 miles per hour (mph) measured as 1-minute sustained wind speeds (over open water). In its *Tropical Cyclone Report, Hurricane Charley, 9-14 August 2004* (NHC, October 2004), the NHC categorized the storm at landfall as a Category 4 hurricane as measured by the Saffir-Simpson Hurricane Scale. The storm traveled the width of the state from west coast to east coast in approximately 7½ hours. It struck the Orlando International Airport with wind speeds of nearly 105 miles per hour (mph), and went back out over open water near Daytona Beach.

On August 19, 2004, the Federal Emergency Management Agency's (FEMA's) Mitigation Division deployed a Mitigation Assessment Team (MAT) to Florida to assess damages caused by Hurricane Charley. This report presents the MAT's observations, conclusions, and recommendations in response to those field investigations.

Several maps in Chapter 1 illustrate the path of the storm, the wind field estimates, the impact on people and infrastructure, and the depth of storm surge along the path. The width of the high-wind field was very narrow even though hurricane force winds affected some portion of the Florida peninsula from Punta Gorda to Daytona Beach. There was little storm surge or coastal flooding because of the narrow size of the storm and the translational speed with which it came ashore and crossed the state.

The hurricane is believed to have been a design wind event (the wind speeds equaled or exceeded those delineated in the current version of the Florida Building Code [FBC]) for a narrow area from the point of landfall on the west coast inland for 120 miles. The design wind speed for Charlotte County (Punta Gorda) per the FBC is 114 to 130 mph (measured as a 3-second peak gust). The actual measured wind speed near Punta Gorda was 112 mph (3-second peak gust) and measured speeds in other parts of the state suggest that Charley was a design wind event. The storm created a very small area affected by storm surge and most damage was not caused by flooding from storm surge, waves, or erosion.

Florida Building Code Changes

The State of Florida adopted a new building code that went into effect in March 2002, the 2001 Edition of the FBC. The 2001 FBC is modeled after the 1999 edition of the Standard Building Code (SBC) and the South Florida Building Code and retained many of the county-specific wind speed and debris designations used in these codes. The FBC uses the wind design methods specified in the American Society of Civil Engineers (ASCE) 7-98, improves the requirements for wind resistance of components and cladding (C&C), and requires impact resistance glazing or shutters in windborne debris regions. The 2001 FBC, in combination with legislative statutes, will continue to regulate construction in Florida until the 2004 Edition of the FBC becomes effective in the summer of 2005.

Prior to the adoption of the FBC in 2002, the state administered the 1997 Edition of the SBC, with Florida-specific amendments and the South Florida Building Code. Although the codes addressed wind design issues, the wind pressure determined by formula in the SBC is less than the wind design pressure determined by the FBC in many applications, thus understating what the design level wind pressure should be.

Recent changes to regulations and statutes governing the manufacture and installation of manufactured housing include closer spacing of tie-downs and requirements that additions are to be free-standing and self-supporting, with only the flashing attached to the main unit (unless the added unit has been designed to be structurally attached to the existing unit). Further, the regulations state that all additions must be constructed in compliance with state and locally adopted building codes. This portion of the manufactured housing regulations is important in the context of understanding the damage that was caused by this event.

Damage Assessment Observations

Because Hurricane Charley was a design level wind event, the resultant storm damage provides valuable evidence about the effectiveness of building codes and design practices as they address design guidelines for high winds. For buildings built prior to the adoption of the current codes, judgments were made about how the observed damage was reflective of the code to which the building was constructed, and the quality of construction or the inspection process that followed construction. Consideration also was given to the type and use of buildings. Many buildings that were expected to function for critical/essential services were severely damaged by the hurricane and lost function for significant periods of time after the event.

Generally speaking, the structural systems of buildings designed and constructed to the 2001 FBC performed as expected and thus there was little to no damage to the structural systems of these buildings. For older buildings, a number of damage observations were pervasive:

- Design wind loads used were often too low, resulting in a design that was not sufficient for the winds encountered, thus creating some roof and framing damage
- Fasteners for roof sheathing were often too small or spaced too far apart and led to loss of roof panels
- Small or missing strapping used to anchor the roof structure to the walls was often observed
- Unreinforced masonry walls often lacked a continuous load path and led to wall damage and failure
- Lack of a continuous load path at the connection between the walls to the foundations was often observed
- Structural design often did not account for unprotected glazing, leading to structural failures due to increased internal pressures
- Unprotected glazing, leading to interior damage from wind and wind-driven rain was often observed
- Corrosion of ties or fasteners used to attach siding to the wall structure was often observed
- Corrosion of anchors or connectors that attach the building to the foundations or tie structural elements together was often observed
- Improper elevation of habitable space and utilities relative to flood risks was often observed

- Degradation of building elements and connections due to material deterioration, termite infestation, or lack of proper preventive maintenance was often observed

The MAT noted substantial damage to building envelopes and accessory structures on many different types and ages of buildings. The most common damage included:

- Roof coverings blown off
- Soffits blown away, allowing water to enter buildings
- Unprotected glazing, leading to interior damage from wind and wind-driven rain
- Siding blown off buildings, including exterior insulation and finish systems (EIFSs)
- Garage doors blown in or out, allowing wind inside garages and often causing significant structural damage to the garages
- Metal roof and wall panels blown off pre-engineered metal buildings
- Rooftop mounted equipment blown off roofs or severely damaged
- Carports and accessory structures attached to manufactured homes blown off, creating additional debris

The damage to building envelopes allowed wind to enter buildings in many cases, causing property loss, and/or the loss of some component, which then allowed rain water to enter the buildings, causing additional non-structural damage.

This damage indicates that insufficient attention has been given to selecting materials or components of the building envelope that will meet the building code requirements for wind and water resistance. Further, many products do not have test protocols that provide verification that they can meet design loads. Materials are often selected based on criteria other than "disaster resistance." In spite of new codes and education related to the enforcement of and construction to meet the new codes, not enough attention is paid to building envelopes.

A significant number of critical and essential facilities (including fire stations, police stations, hospitals, and schools and other buildings used as shelters) were damaged. The damage was primarily to building envelopes (e.g., large rolling and sectional doors on fire stations or roof coverings on hospitals or schools). Some of the damage to these elements caused subsequent damage to the buildings. There were a few catastrophic failures (i.e., fire stations that lost their entire roof structure, rendering the facilities unusable for their intended functions, and collapse of a wall and portion of the roof of a building where 1,400 people were gathered to seek shelter from the hurricane).

Recommendations

The recommendations in this report are based solely on the observations and conclusions of the MAT, and are intended to assist the State of Florida, local communities, businesses, and individuals in the reconstruction process and to help reduce damage and impact from future natural events similar to Hurricane Charley. The general recommendations presented in Section 8.1 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.

Buildings constructed in accordance with the 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 performance was not without exception. Proposed changes to codes and statutes are presented in Section 8.2.

Specific recommendations for improving the performance of the building structural system and envelope, and the protection of critical and essential facilities (to prevent loss of function) are provided in Chapter 8. Implementing these specific recommendations in combination with the general recommendations of Section 8.1 and the code recommendations of Section 8.2 would significantly improve the ability of buildings to resist damage from hurricanes. Recommendations specific to structural issues, building envelope issues, critical and essential facilities, and education and outreach have also been provided.

As the people of Florida rebuild their lives, homes, and businesses, there are a number of ways they can minimize the effects of future natural hazards, including:

- Continue to design and construct facilities to at least the minimum design requirements in the 2001 FBC and the 2004 FBC (after it becomes effective in the summer of 2005)
- Involve a structural engineer/design professional/licensed contractor in the design and planning if buildings (both residential and commercial) are being renovated and remodeled for structural and building envelope improvements

- Assure code compliance through increased enforcement of construction inspection requirements such as the Florida Threshold Inspection Law, the International Building Code (IBC) Special Inspections Provisions, or the National Fire Protection Association (NFPA) 5000 Quality Assurance Requirements
- Perform follow-up inspections after a hurricane to look for moisture that may affect the structure or building envelope

Furthermore, improvements can be made to forecasting, tracking, and responding to hurricanes. Specifically, the following recommendations are provided for State and Federal government agencies:

- The government should place a high priority on and allocate resources to hardening, providing backup power and data storage to the National Oceanic and Atmospheric Administration's (NOAA's)/National Weather Service's (NWS's) surface weather monitoring systems, including Automated Surface Observing Systems (ASOSs) located in hurricane-prone regions.
- 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.

Additional recommendations and mitigation measures for design professionals, building officials, contractors, homeowners, and business owners are presented in Chapter 8, including:

- Improving the performance of building structural and envelope systems through proper design of the continuous load path
- Proper design of structural attachments and additions to manufactured homes
- Improving quality control and inspections
- Retrofitting existing residential and commercial buildings from the roof decks to the foundations
- Improving the performance of critical and essential facilities (including shelters)
- Improving design and construction guidance
- Improving public education and outreach

Table of Contents

Executive Summary i

1 Introduction 1-1

1.1 Hurricane Charley – The Event 1-3
    1.1.1 Summary of Winds 1-3
    1.1.2 Summary of Storm Surge 1-5
    1.1.3 Summary of Storm Damage 1-7

1.2 Comparisons of Predictions and Post-Landfall Estimates: Wind 1-10
    1.2.1 Predictions 1-10
    1.2.2 Post-Landfall Observations 1-10
    1.2.3 Reported Data 1-13
    1.2.4 Wind Field Estimates – Model-Based Results 1-13

1.3 Comparisons of Predictions and Post-Landfall Observations: Storm Surge 1-16
    1.3.1 Predictions 1-17
    1.3.2 Post-Landfall Observations 1-18

1.4 Economic and Social Impacts of Hurricane Charley 1-19
    1.4.1 Loss Estimates 1-19
    1.4.2 Economic Impacts 1-20
    1.4.3 Social and Psychological Impacts 1-21

1.5 FEMA Mitigation Assessment Teams (MATs) 1-22
  1.5.1 Methodology 1-23
  1.5.2 Team Composition 1-23
  1.5.3 The Significance of Hurricane Charley 1-23

2 Codes, Standards, and Regulations 2-1

2.1 The Building Codes 2-2
  2.1.1 Comparing Design Wind Speeds 2-3
  2.1.2 Comparing Calculated Wind Pressures (Old vs. New Code Methods) 2-5
  2.1.3 Comparing Debris Impact Criteria 2-8
  2.1.4 High-Wind Elements of the Code 2-9
2.2 Florida Statutes Affecting Building Design 2-10
2.3 HUD Manufactured Housing Design Standards 2-11
2.4 Florida Manufactured Housing Installation Standards 2-13
2.5 Floodplain Regulations 2-15

3 Basic Assessment and Characterization of Damage 3-1

3.1 Wind Effects 3-2
  3.1.1 Variability in Hurricane Winds 3-4
  3.1.2 Building Structural Damage Due to Wind Effects 3-5
    3.1.2.1 Residential Buildings (One- and Two-Family Dwellings, Wood-Frame Multi-Family Buildings, and Manufactured Housing) 3-6
    3.1.2.2 Commercial and Mixed-Use Buildings 3-11
  3.1.3 Building Components and Cladding (C&C) Damage Due to Wind Effects 3-15
    3.1.3.1 Residential Buildings (One- and Two-Family Dwellings) 3-15
    3.1.3.2 Commercial and Mixed-Use Buildings (Including Multi-Family) 3-21
  3.1.4 Building Damage Due to Windborne Debris 3-26
  3.1.5 Attached and Accessory Structures 3-36

3.2 Flood Effects 3-38
    3.2.1 Flood Damage Observations 3-38
    3.2.2 Coastal Surge Damage 3-38

3.3 Critical and Essential Facilities 3-42
    3.3.1 Fire and Police Stations and Hospitals 3-43
    3.3.2 Emergency Operations Centers, Storm Shelters, and Schools 3-44

4 Structural Systems Performance 4-1
4.1 Wood-Frame Buildings 4-2

4.2 Manufactured Housing 4-9

4.3 Concrete and Masonry Buildings 4-10

4.4 Structural Steel-Frame Buildings 4-14

4.5 Pre-Engineered Metal Buildings 4-15

4.6 Accessory Structures/Attachments 4-17

5 Building Envelope Performance 5-1
5.1 Doors 5-2
    5.1.1 Personnel Door Damage 5-2
    5.1.2 Garage Door Damage 5-5
    5.1.3 Rolling and Sectional Door Damage 5-6

5.2 Windows, Shutters, and Skylights 5-10
    5.2.1 Residential Buildings 5-11
    5.2.2 Commercial and Critical/Essential Facilities 5-15

5.3 Roof Systems 5-18
    5.3.1 Asphalt Shingles 5-21
    5.3.2 Tiles 5-26
        5.3.2.1 Mortar-Set Tile Roofs 5-27
        5.3.2.2 Mechanically Attached Tile Roofs 5-29
        5.3.2.3 Foam-Set Tile Roofs 5-32

5.3.2.4 Hip and Ridge Tiles 5-38
5.3.2.5 Sprayed Polyurethane Foam....5-38
5.3.2.6 Tile Missiles 5-40
5.3.3 Metal Panel Roofs 5-41
5.3.4 Low-Slope Membrane Systems 5-48
5.3.4.1 Built-up Roof (BUR) and Modified Bitumen....5-48
5.3.4.2 Single-Ply....5-52
5.3.5 Gutters and Downspouts 5-54

5.4 Wall Coverings, Non-Load Bearing Walls, and Soffits 5-54
5.4.1 Wall Coverings....5-54
5.4.2 Non-Load Bearing Walls....5-57
5.4.3 Soffits 5-57

5.5 Exterior Mechanical and Electrical Equipment Damage....5-60
5.5.1 Damage to Exterior Equipment Attached to Residential Buildings....5-60
5.5.2 Damage to Exterior Equipment Attached to Commercial and Critical/Essential Facilities....5-62
5.5.2.1 Condensers....5-62
5.5.2.2 Fan Units and HVAC Units....5-63
5.5.2.3 Electrical and Communications Equipment....5-65

6 Performance of Critical and Essential Facilities....6-1
6.1 Emergency Operations Centers....6-2
6.1.1 General Damage 6-3
6.1.2 Functional Loss 6-5

6.2 Fire and Police Stations....6-6
6.2.1 General Damage 6-6
6.2.2 Functional Loss 6-7

6.3 Hospitals....6-11
6.3.1 General Damage 6-11
6.3.2 Functional Loss 6-13

6.4 Schools 6-13
6.4.1 General Damage 6-13
6.4.2 Functional Loss 6-17

6.5 Shelters 6-18
6.5.1 Damage and Performance of Shelters...6-19
6.5.1.1 Turner Agri-Civic Center, Arcadia...6-19
6.5.1.2 Port Charlotte Middle School, Port Charlotte 6-22
6.5.1.3 Liberty Elementary School, Port Charlotte 6-24
6.5.2 Functional Loss 6-26
6.5.3 Buildings Selected for Shelter Use 6-27
6.5.4 The Florida SESP 6-29

7 Conclusions

7 Conclusions... 7-1
7.1 General Conclusions...7-1

7.2 Building Performance and Compliance with the Building Codes, Statutes, and Regulatory Requirements of the State of Florida 7-3

7.3 Performance of Structural Systems (Residential and Commercial Construction).....7-5
7.3.1 Internal Pressures 7-5
7.3.2 Wind Mitigation for Existing Buildings 7-6

7.4 Performance of Accessory Structures/Attachments 7-7

7.5 Performance of Building Envelope, Mechanical and Electrical Equipment...7-9
7.5.1 Building Envelope 7-10
7.5.1.1 Roof Coverings, Wall Coverings, and Soffits 7-10
7.5.1.2 Windows, Doors, and Shutters 7-11
7.5.1.3 Attached Equipment (Rooftop and Ground Level) 7-12
7.5.2 The Need for High-Wind Design and Construction Guidance 7-12

7.6 Performance of Critical and Essential Facilities (Including Shelters) 7-13

7.7 Observed Mitigation Successes 7-16
7.7.1 Mitigation Success in Residential Construction..7-16

7.7.2 Mitigation Success in Commercial Construction 7-18
7.7.3 Mitigation Success in Critical and Essential Facility Construction 7-20

8 Recommendations

8 Recommendations 8-1
8.1 General Recommendations 8-2
8.2 Proposed Changes to Codes and Statutes 8-3
8.2.1 Statutory Building Code Provisions 8-4
8.2.2 General Code Changes Proposed for FBC Consideration 8-5
8.2.3 Code Changes Proposed for Critical/Essential Facilities and Shelters 8-6
8.3 Structural (Residential and Commercial Construction) 8-7
8.3.1 New Residential and Commercial Structures 8-7
8.3.2 Wind Mitigation for Existing Residential Buildings 8-8
8.3.3 Wind Mitigation for Existing Commercial Buildings 8-11
8.4 Accessory Structures/Attachments 8-14
8.5 Architectural, Mechanical, and Electrical 8-15
8.6 Critical and Essential Facilities (Including Shelters) 8-19
8.7 Design Guidance and Public Education 8-21
8.7.1 Design and Construction Guidance 8-21
8.7.2 Public Education and Outreach 8-24

Appendices

Appendix A References
Appendix B Acknowledgments
Appendix C Acronyms and Abbreviations
Appendix D FEMA Hurricane Recovery Advisories
Appendix E The History of Hurricanes in Southwest Florida
Appendix F Guidance and Statute Requirements for Design and Construction of EHPAs

Tables

Chapter 1

Table 1-1. Wind Speeds of the Saffir-Simpson Hurricane Scale 1-2

Table 1-2. Additional Storm Surge Depths Observed After Landfall 1-7

Table 1-3. Summary of Initial ISO Insured Loss Estimates 1-20

Chapter 2

Table 2-1. Basic Design 3-Second Peak Gust Wind Speeds (Ranges for Each County) 2-4

Table 2-2. Typical Single-Family Residence in Port Charlotte 2-6

Table 2-3. Typical Critical/Essential Facility in Port Charlotte 2-7

Chapter 6

Table 6-1. Summary of Fire/Police Station Damage and Functional Loss from Hurricane Charley 6-8

Appendix F

Table F-1. Summary of EHPA Wind Design Criteria F-4

Figures

Chapter 1

Figure 1-1. Infrared satellite image of Hurricane Charley making landfall on the southwest Florida coast on August 13, 2004 (NOAA) 1-4

Figure 1-2. Extent of the hurricane and tropical storm force winds for Hurricane Charley as estimated by the NOAA H-wind model 1-6

Figure 1-3. Map of Hurricane Charley's path of destruction 1-8

Figure 1-4. Results of the preliminary H-wind swath analysis for Hurricane Charley (NOAA/HRD) 1-12

Figure 1-5. Results of the preliminary wind field analysis for Hurricane Charley based on HAZUS-MH wind methodology. The insets provide a close-up of the areas that experienced the highest winds with the design wind speed contour lines from the 2001 FBC overlaid across the wind field. (ARA) 1-14

Figure 1-6. Storm surges computed using the NWS SLOSH model for Hurricane Charley, using R_{max}= 40 miles (NOAA/NHC) 1-17

Figure 1-7. Storm surges computed using the NWS SLOSH model for Hurricane Charley, using R_{max}= 6 miles. The track and intensity remain the same as those in Figure 1-6. (NOAA/NHC) 1-18

Chapter 2

Figure 2-1. Wind speed and windborne debris region map (2001 FBC) 2-4

Figure 2-2. Basic wind zone map for the design of manufactured homes 2-12

Chapter 3

Figure 3-1. Overlay of estimated Hurricane Charley wind field from H-wind (adjusted to 3-second peak gust) on wind contours from the 2001 FBC wind speed map 3-3

Figure 3-2. Failure of roof structure from pressurization of a pre-2001 FBC house when window failed on windward face (Punta Gorda) 3-7

Figure 3-3. Loss of roof structure in a wood-frame building likely due to internal pressurization resulting from unprotected windows and doors (Captiva Island) 3-8

Figure 3-4. Nearby undamaged wood-frame building similar to that shown in Figure 3-3 protected with shutters (Captiva Island) 3-8

Figure 3-5. Wall failure on older multi-family wood-frame building due to lack of continuous load path. Internal pressurization may have also contributed to this failure (Fort Myers Beach). 3-9

Figure 3-6. Damage to older multi-family building roof deck with inadequately supported and braced overhang (Captiva Island) 3-10

Figure 3-7. Pre-1976 manufactured home unit displaced from its foundation, damaging the structure itself (Pine Island) 3-10

Figure 3-8. Post-1994 manufactured home with major roof and wall failure (east of Port Charlotte) 3-11

Figure 3-9. Example of wood truss roof failure due to sheathing loss and lack of bracing at gable end on a pre-2001 FBC unreinforced masonry building (north of Arcadia) 3-12

Figure 3-10. Roof sheathing and partial failure of wood roof structure on a masonry building. Note damage to inadequately reinforced masonry parapet at gable end wall (Wauchula). 3-13

Figure 3-11. Damage to a pre-2001 FBC masonry building with steel joist roof framing and metal deck (Port Charlotte) 3-13

Figure 3-12. Pre-engineered metal building with progressive failure and severe panel loss (Arcadia) 3-14

Figure 3-13. Roof framing failure and gable end wall collapse due to insufficient supports of pre-engineered metal building. Note base plate with failed bolts for gable end wall column (Wauchula). 3-14

Figure 3-14. Asphalt shingle roof covering damage on a new one-story house. In some areas, the underlayment was also blown away (Deep Creek). 3-16

Figure 3-15. Typical asphalt shingle roof covering loss on elevated, two-story house (Captiva Island) 3-16

Figure 3-16. Foam set tile roof covering failure (Punta Gorda) 3-17

Figure 3-17. Typical pile-elevated residence with undamaged metal panel roof (coastal flood zone on Pine Island) 3-17

Figure 3-18. Example of roof decking loss on one-story house (Punta Gorda) 3-18

Figure 3-19. Partial gable end wall failure with loss of roof shingles (Deep Creek) 3-18

Figure 3-20. Double-entry door that failed under wind pressure. Upper inset shows close-up of crack in door frame at top latch. Lower inset shows crack in door emanating from bottom latch (Punta Gorda). 3-19

Figure 3-21. Typical elevated wood-frame house with extensive soffit damage (North Captiva Island) 3-20

Figure 3-22. The drywall ceiling in the home shown in Figure 3-21 collapsed after becoming waterlogged and weakened by wind-driven rain that entered through the exterior soffit space (North Captiva Island) 3-21

Figure 3-23. Roof covering loss. Note dark areas on roof are exposed underlayment (Captiva Island). 3-22

Figure 3-24. Vinyl siding wall covering on multi-family building with damage to gable end wall sheathing (Port Charlotte) 3-22

Figure 3-25. Example of unreinforced masonry wall and parapet collapse due to breaching of roof (on opposite side of building) (Wauchula) 3-23

Figure 3-26. Example of damage to EIFS wall panels (Punta Gorda) 3-24

Figure 3-27. Structural steel frame building showing loss of roof decking and damage to EIFS wall coverings (Punta Gorda) 3-24

Figure 3-28. Damage to large rolling and sectional doors at Fire Station No. 1 (Punta Gorda) 3-25

Figure 3-29. Dislocation of rooftop equipment (Pine Island) 3-26

Figure 3-30. Newer house with storm shutters (Sanibel Island) 3-27

Figure 3-31. Extensive damage to mortar-set tile roof on this pre-2001 FBC home. Note broken windows to the right of the front door (Punta Gorda). 3-28

Figure 3-32. A roof tile punctured this Miami-Dade County-approved shutter (Punta Gorda) 3-29

Figure 3-33. Damage to glass atrium of high-rise hotel. Note the loss of EIFS, which was the cause of the glass breakage (Orlando) 3-30

Figure 3-34. Edge impact of an asphalt shingle on decorative column (Punta Gorda)....3-30

Figure 3-35. Impact of tree branch through the stucco and metal lath wall system of a fire station. The branch was about 5 inches in diameter and protruded about 3½ feet out of the wall (Aqui Esta, east of Punta Gorda Isles). 3-31

Figure 3-36. Tile damage to a metal-panel garage door (Punta Gorda) 3-31

Figure 3-37. Impact of structural wood members in the gable end from a neighboring house (Pine Island) 3-32

Figure 3-38. Large section of roof structure transported over 200 yards from its source (Captiva Island) 3-32

Figure 3-39. Typical metal roof panel and siding debris from failed accessory structures and manufactured homes that were stripped of siding resulting from accessory structures failure (Arcadia) 3-33

Figure 3-40. Typical metal roof panel and siding debris caused glazing damage to units (Port Charlotte) 3-33

Figure 3-41. Aggregate from the built-up roofs broke windows at the intensive care unit of a hospital where 3-second peak gust wind speeds were estimated between 110 and 120 mph (Arcadia) 3-34

Figure 3-42. Damage to three-story home from tree impact (Wauchula) 3-35

Figure 3-43. Damage to manufactured home from tree impact (Pine Island) 3-35

Figure 3-44. Fallen communications tower (Aqui Esta, east of Punta Gorda Isles) 3-36

Figure 3-45. Example of typical damage to roof covering, roof sheathing, and exterior siding of a manufactured home as a result of the failure of an attached carport structure (Port Charlotte) 3-37

Figure 3-46. Example of damage to manufactured home roof covering, roof deck, and siding due to failure of screen enclosure attached to home (Port Charlotte) 3-37

Figure 3-47. Example of damage to pool screen enclosure. Note broken window in center of photo from debris (Punta Gorda Isles) 3-38

Figure 3-48. Minor scour of parking lot from overwash of storm surge (Fort Myers Beach) 3-39

Figure 3-49. Minor scour around pile (Fort Myers Beach) 3-39

Figure 3-50. Oceanfront house constructed on piles sustained only minor damage as a result of storm surge (Fort Myers Beach) 3-40

Figure 3-51. Storm surge damage of 2 to 3 feet limited to lower floor of two-story house (Fort Myers Beach) 3-40

Figure 3-52. Typical house with first-floor living space at grade sustained 2 to 3 feet of storm surge damage (lack of wall damage suggests low velocity flows) (Fort Myers Beach) 3-40

Figure 3-53. Newly constructed house elevated on piles sustained no storm surge damage (Fort Myers Beach) 3-41

Figure 3-54. Fire station elevated on fill prevented any storm surge damage (Fort Myers Beach) 3-41

Figure 3-55. Storm surge caused scouring of the road and damage to the infrastructure (i.e., water main) (Fort Myers Beach) 3-42

Figure 3-56. Cementitious wood-fiber roof deck panels at this older fire station were not adequately secured to resist uplift (Port Charlotte) 3-43

Figure 3-57. Gable end wall collapse and rolling and sectional door failure at fire station (Aqui Esta, east of Punta Gorda Isles). A close-up of the missile in the circle is shown in Figure 3-35. 3-44

Figure 3-58. End wall damage to long span, pre-engineered metal building designed for use as a storm shelter (Arcadia) 3-45

Figure 3-59. Example of roof covering damage at a school. This was a mechanically attached single-ply membrane over a previous aggregate surfaced built-up roof (Port Charlotte). 3-46

Figure 3-60. Example of URM parapet wall collapse and broken windows at an older school (Punta Gorda) 3-46

Chapter 4

Figure 4-1. No structural damage was observed to new buildings built to the 2001 FBC standards (North Captiva Island) 4-2

Figure 4-2. Newer single-family wood-frame residences that demonstrated good structural performance (North Captiva Island) 4-3

Figure 4-3. An older building that was renovated for architectural improvements a few years ago collapsed due to limited load path connections (North Captiva Island) 4-4

Figure 4-4. Load path of a two-story building with a primary wood-framing system: walls, roof diaphragm, and floor diaphragm 4-4

Figure 4-5. Failure of the roof over a cathedral ceiling from pressurization of the house when the window failed on the windward face (Pine Island) 4-6

Figure 4-6. Roof decking failed due to uplift (Deep Creek) 4-7

Figure 4-7. Multi-family residential building that performed well structurally, although it had severe roof covering and some sheathing failure at the overhangs, allowing water intrusion (Pine Island) 4-8

Figure 4-8. Wall failure on older (1980s vintage) multi-family wood-frame building due to lack of load path. Internal pressurization may have also contributed to this failure (Captiva Island). 4-8

Figure 4-9. Pre-1976 HUD manufactured home sustained substantial damage (Bowling Green) 4-9

Figure 4-10. Post-1994 HUD manufactured home with significant roof damage (peeling of roof panels) resulting from collapse of attached accessory structure (Zolfo Springs) 4-10

Figure 4-11. New concrete masonry residential structure built to 2001 FBC standards performed well structurally, although it did experience some asphalt shingle damage (Port Charlotte). 4-10

Figure 4-12. Adequately designed reinforced masonry wall system 4-11

Figure 4-13. Unreinforced brick wall failure of a building built over 50 years ago (photo taken from the inside of a classroom, looking out) (Punta Gorda) 4-12

Figure 4-14. Partial failure of an unreinforced concrete masonry commercial structure (Port Charlotte) 4-12

Figure 4-15. Roof truss hurricane anchor straps failed at the tie-beam at Fire Station No. 12 (Port Charlotte) 4-13

Figure 4-16. Older steel-frame structure performed well in spite of major damage to the roof decking and the exterior walls (Wauchula) 4-14

Figure 4-17. Completely destroyed pre-engineered metal building (Arcadia). 4-15

Figure 4-18. Collapsed older pre-engineered metal structure (Wauchula) 4-16

Figure 4-19. Main column at Fire Station No. 8 collapsed due to corrosion and metal siding failed (Port Charlotte) 4-16

Figure 4-20. Significant amount of corrosion at Fire Station No. 8, which contributed to failure shown in Figure 4-19 (Port Charlotte) 4-17

Figure 4-21. Damaged carport (Zolfo Springs) 4-18

Figure 4-22. Damaged garage (Zolfo Springs)...4-19

Figure 4-23. Damaged screened porch (Punta Gorda) 4-19

Figure 4-24. Stairway blown into a post of an aluminum carport accessory structure (Zolfo Springs)..4-21

Figure 4-25. Typical consequence of corner post failure (Punta Gorda Isles) 4-22

Figure 4-26. Consequence of corner post not directly tied down to the slab (Punta Gorda Isles)..4-22

Figure 4-27. Breakfast nook window viewed through the pool cage (Punta Gorda Isles)..4-23

Chapter 5

Figure 5-1. Sliding glass doors blown out of their tracks (Punta Gorda Isles)...................5-3

Figure 5-2. Tempered glass in office building entry door and side windows broken by missiles (Punta Gorda) 5-4

Figure 5-3. Improper attachment of doors 5-4

Figure 5-4. Door lacked sufficient strength to resist the suction load (Deep Creek) 5-5

Figure 5-5. Garage door at the home in the center buckled and the rollers pulled out from their tracks; garage door at the home on the right also failed (Deep Creek). 5-6

Figure 5-6. Garage door failed because the removable stiffener bar was not in place at the time of the hurricane (Punta Gorda Isles). 5-7

Figure 5-7. New door that failed. Non-load bearing CMU wall at the left tilted (see Figure 5-8) (Punta Gorda)..5-7

Figure 5-8. After the door shown in Figure 5-7 failed, buildup of internal pressure tilted the wall (Punta Gorda)....5-8

Figure 5-9. Windward side of a fire station; two doors blew inward, but the newer center door remained intact (Cape Coral)....5-9

Figure 5-10. At two of the windward doors, the doors were pushed out of the tracks; at the third door, one of the tracks was pushed from the wall (Deep Creek). 5-10

Figure 5-11. Most of windows on this side of a manufactured home were broken by windborne debris (east of Port Charlotte). 5-11

Figure 5-12. Three of four panes broken by windborne debris; other windows in this house also broke (Deep Creek)....5-12

Figure 5-13. This house, which appeared undamaged from windborne debris, had roll-up shutters at the windows and metal panel shutters at the garage (Deep Creek). 5-12

Figure 5-14. Metal awning shutter penetrated by a missile (Zolfo Springs) 5-13

Figure 5-15. All of the windows on this house were covered by plastic shutters, many of which were blown off during the hurricane, resulting in several broken windows (North Captiva Island)....5-14

Figure 5-16. Window most likely broken by missing plastic lens covers on hotel sign (see top of building) (Orlando airport area....5-15

Figure 5-17. Broken glass in windows and doors in this building. Buildings across the street also had several broken windows caused by windborne debris (Wauchula). 5-16

Figure 5-18. All of the glazing, including glass spandrel panels, was broken on the long side of the building (Punta Gorda)....5-16

Figure 5-19. Windows broken by aggregate from a nearby BUR. Besides impact at the crack intersection, aggregate chipped the glass in three other locations (Punta Gorda). 5-17

Figure 5-20. Plywood panels installed where aluminum spandrel panels were blown out of the curtain wall (Punta Gorda) 5-17

Figure 5-21. After the attic vent failed, water entered this residence. Wet carpeting and a substantial amount of wet gypsum board had to be removed (Punta Gorda Isles). 5-19

Figure 5-22. The attic vent to the right (temporarily covered with felt) on this foam-set tile roof lifted during the hurricane and allowed water to enter the residence shown in Figure 5-21. The failed vent is like the one on the left (Punta Gorda Isles) 5-19

Figure 5-23. Installation of self-adhering modified bitumen tape at sheathing joints, as part of an enhanced underlayment system on a Fortified…for safer living™ house under construction (IBHS) 5-20

Figure 5-24. Asphalt shingle roof installed on a new residence about 2 months before the hurricane hit; shingles were blown off several areas (Deep Creek). 5-22

Figure 5-25. Residence with a significant number of asphalt shingles lost. The metal window shutters shown were not designed for windborne debris (Fort Meade). 5-22

Figure 5-26. Only the portion of the self-seal adhesive that is indicated in yellow had bonded (within the red circle). No bonding occurred on the right side of the hip line (Deep Creek). 5-23

Figure 5-27. Two laminated tabs blown off (Deep Creek) 5-23

Figure 5-28. Re-covered apartment building (the newer shingles are grey and the older shingles are brown) (Deep Creek). 5-24

Figure 5-29. Edge flashing that caused a progressive failure of the shingles (Deep Creek) 5-25

Figure 5-30. A large area of underlayment at this mortar-set flat tile roof blew away. The loss of tile underlayment was atypical (Punta Gorda). 5-27

Figure 5-31. Mixed failure modes occurred on this mortar-set tile roof Port Charlotte). 5-28

Figure 5-32. Most of the mortar-set hip and ridge tiles blew off this house (Port Charlotte). 5-28

Figure 5-33. Tile debris from the roof shown in Figure 5-32 (Port Charlotte) 5-29

Figure 5-34. Each tile on this building was attached to battens with a single 3$^1/_8$-inch long smooth shank nail (Arcadia) 5-30

Figure 5-35. Windborne debris (likely tiles from this roof) broke several of the field tiles. Note that much of the vinyl soffit was blown away (Deep Creek). 5-31

Figure 5-36. Loss of mortar-set hip tiles and several of the field tiles. Some of the screws remained in the deck, while others had been pulled out (Deep Creek). 5-31

Figure 5-37. Fire station with at least three battens blown off. Some tiles remained attached (Fort Meade). 5-32

Figure 5-38. In addition to the damage shown in this photo, this one-story roof lost virtually all of the hip and ridge tiles (see Figures 5-22, 5-39, and 5-40) (Punta Gorda Isles) 5-33

Figure 5-39. Note the very small contact area of foam at the tile heads (left side of the tiles) and very small contact area at the tails. The long narrow paddies were intended to be underneath the pan portion of the tile (Punta Gorda Isles). 5-34

Figure 5-40. View of the eave. The first row of tiles was attached with two screws per tile; foam was not used to adhere this row (Punta Gorda Isles) 5-34

Figure 5-41. In addition to field tile blow-off, most of the hip tiles and several ridge tiles were also blown off this house (Punta Gorda Isles). 5-35

Figure 5-42. The paddy on the tile at the lower left debonded from the asphalt bleed-out near a cap sheet lap. Only the center portion of the paddies made contact with the tiles, as shown in the inset (Punta Gorda Isles). 5-36

Figure 5-43. This photo clearly shows insufficient contact area of foam-set paddies on the bank's roof (Punta Gorda Isles). 5-37

Figure 5-44. In this photo, the portion of the paddy that made contact with the tile is clearly visible (Punta Gorda Isles). 5-37

Figure 5-45. Tile remained bonded to the paddy, but, except where bonded, the tile blew away. A large portion of the paddies shown in Figure 5-43 and this figure failed to make tile contact, which was a typical observation (Punta Gorda Isles) 5-38

Figure 5-46. This residence had a tile roof that had been covered with SPF. A missile gouged the foam, but no tile debris was blown off (Punta Gorda Isles) 5-39

Figure 5-47. The other side of the roof shown in Figure 5-46 with a portion of the underlayment and several tiles blown off (Punta Gorda Isles) 5-39

Figure 5-48. Tiles that flew through windows of an occupied residence (Deep Creek) 5-40

Figure 5-49. A view of the roof on the back side of the garage shown in Figure 5-41. Tiles (including a hip tile) from the front garage roof landed in this area and broke several field tiles (Deep Creek). 5-41

Figure 5-50. The number of fasteners was not increased at the corner, perimeter, hip, or ridge areas (close-up of the residence shown in Figure 5-5). Also note that several of the soffit panels were blown away (Deep Creek). 5-42

Figure 5-51. These panels blew off the upper roof and landed on the lower roof of this house (Bokeelia, north end of Pine Island). 5-43

Figure 5-52. Medical office building (Port Charlotte). 5-44

Figure 5-53. The wood and metal framed superstructure blew away and exposed the lightweight insulating concrete roof deck (Port Charlotte). 5-44

Figure 5-54. View of the canopy ridge at the building shown in Figure 5-52. The ridge flashing fasteners were placed too far apart and a significant amount of water leakage can occur when ridge flashings are blown away (Port Charlotte). 5-45

Figure 5-55. This standing seam metal roof had a 16-inch rib spacing. There was some rake flashing damage, and a few rake panels were also damaged (Arcadia). 5-46

Figure 5-56. Several of the architectural panels and hip flashings blew off this fire station (Deep Creek). 5-46

Figure 5-57. This photo provides a view of the eave of the building shown in Figure 5-56. The clip at the left was 13 inches from the edge of the deck. The other clip was 17 inches from the edge (Deep Creek). 5-46

Figure 5-58. The metal wall panels and metal edge flashing on this building blew away, but the exposed fastener R-panels with an SPF covering did not progressively fail (Wauchula). 5-47

Figure 5-59. Metal shingles (simulating tile) that performed well (Port Charlotte) 5-48

Figure 5-60. This view of the back side of the upper roof of a hospital (see Figure 6-8) shows that the missing gutter and asphalt plank walkway pad were blown away (Arcadia) 5-49

Figure 5-61. Although this roof had an 11-inch high parapet, aggregate was blown off (Port Charlotte)....5-50

Figure 5-62. The edge flashing at this mineral surface cap sheet roof lifted (Port Charlotte)......5-50

Figure 5-63. The edge flashing had a 2-inch vertical flange that extended into the gutter. The flashing was not cleated (Cape Coral). 5-51

Figure 5-64. View of a portion of the fourth floor roof of a hospital after installation of an emergency roof (the black area). The deck was concrete (Port Charlotte). 5-53

Figure 5-65. The vinyl siding panel with the red arrow is unlatched. The panel above and several others are also unlatched (Zolfo Springs). 5-55

Figure 5-66. The vinyl siding on this manufactured house was ruptured in several locations by windborne debris (most of which were likely building envelope components from other nearby manufactured houses). Note the missing skirt and loose foundation anchor straps (Zolfo Springs). 5-56

Figure 5-67. Standing seam metal panels with a 16-inch rib spacing were used at the fascia and secured with closely spaced exposed fasteners (Arcadia)....5-57

Figure 5-68. This hotel experienced significant EIFS failure on several sides (Orlando). EIFS debris broke several windows (Figure 3-33). 5-58

Figure 5-69. An exterior eave with soffit failure, which resulted in water intrusion (North Captiva Island). 5-58

Figure 5-70. Loss of soffit at a bank drive-through. Note the coping damage (Port Charlotte). 5-59

Figure 5-71. Essentially all of the perforated aluminum soffit on this fire station was blown away (Aqui Esta, east of Punta Gorda Isles). 5-59

Figure 5-72. This condenser was not anchored to the concrete pad. The electrical and copper tube connections kept it from blowing farther away (Deep Creek)....5-61

Figure 5-73. Condenser on the elevated platform attached with four angle brackets. The other condenser, located adjacent to it on the ground, should also have been on an elevated platform to account for storm surge (Pine Island)....5-61

Figure 5-74. Condenser unit displaced from the elevated platform (Port Charlotte) 5-62

Figure 5-75. Rooftop condenser anchored to a support rail, but with only one small screw (which was corroded) used to connect the strap (Port Charlotte). 5-63

Figure 5-76. Cowlings blown off two exhaust fans in the foreground. Note also the loose LPS conductors and missing walkway pad (Punta Gorda). 5-63

Figure 5-77. A large HVAC unit blew off this curb. Note the loose LPS conductors (this side of the curb). This school had significant damage to several pieces of rooftop equipment (Port Charlotte) 5-64

Figure 5-78. A thick angle bracket was used to anchor this unit. Although two screws attached the angle to the support beam, only one screw was used at the unit (Port Charlotte). 5-64

Figure 5-79. This satellite dish at a hospital was held down only with CMU. Note the loose LPS conductors and displaced air terminal at the corner (Arcadia) 5-65

Figure 5-80. A satellite dish previously sat in this location. It was held down only with CMU and blew off the five-story building (Punta Gorda) 5-66

Figure 5-81. The LPS conductor on this hospital blew away, but the air terminal was still attached. A lightning strike to this air terminal would not be safely dissipated (Port Charlotte) 5-66

Figure 5-82. The LPS conductor pulled away from the conductor connector at the top of the photo. The conductor was also attached to the membrane with poorly welded strips of PVC (Port Charlotte) 5-67

Figure 5-83. The conductor connectors detached from the cap sheet on a hospital's BUR. The air terminal was also displaced (Port Charlotte). 5-67

Figure 5-84. A failed prong-type splice connector with prongs permitted for roof heights up to 75 feet caused roof damage at this facility (Cape Coral). 5-68

Figure 5-85. When LPS conductors detach, the conductor ends can whip around and puncture and tear the roof membrane. The patch near this frayed conductor is likely a repair of damage caused by a whipped conductor (Punta Gorda). 5-68

Chapter 6

Figure 6-1. Exterior wall and roof damage at Charlotte County EOC 6-3

Figure 6-2. Failure of wood stud wall supporting wall panels above masonry wall (Charlotte County EOC) 6-4

Figure 6-3. Failure of roof and soffit panels at rear awning (Charlotte County EOC) 6-5

Figure 6-4. Overview of west side of Port Charlotte Fire Station No. 12 6-7

Figure 6-5. View of damaged garage door and interior of Port Charlotte Fire Station No. 1; note missing deck panels over apparatus bay. 6-10

Figure 6-6. Overview of Punta Gorda Fire Station No. 1. The tile roof had been removed and a new roof was being installed. Note the damaged doors. 6-10

Figure 6-7. Damaged soffit at Punta Gorda Public Safety Complex 6-11

Figure 6-8. Aggregate damaged the windows to ICU rooms at a hospital (Arcadia) 6-12

Figure 6-9. Roof covering damage resulting in water intrusion, which required evacuation of a skilled nursing facility (Arcadia) 6-12

Figure 6-10. Hollow clay tile wall/parapet damage to roof of a high school auditorium (Punta Gorda) 6-14

Figure 6-11. URM parapet damage to front façade of a high school (Punta Gorda) 6-14

Figure 6-12. Collapsed gable end roof at an elementary school (Deep Creek) 6-15

Figure 6-13. Loss of lightweight composite panel overhang at an elementary school (Charlotte Harbor) 6-15

Figure 6-14. Broken window damage at a high school (Punta Gorda) 6-16

Figure 6-15. Collapsed metal walkway canopy at a high school (Punta Gorda) 6-17

Figure 6-16. Damaged portable classroom unit at an elementary school (Charlotte Harbor) 6-17

Figure 6-17. Aerial view of Turner Agri-Civic Center damage caused by Hurricane Charley (Arcadia) (FL DCA) 6-20

Figure 6-18. End wall failure at Turner Agri-Civic Center (Arcadia)....6-21

Figure 6-19. Middle school with minimal roof covering damage (Arcadia)....6-22

Figure 6-20. Pre-engineered metal buildings with minimal damage located near the Turner Agri-Civic Center (Arcadia)....6-22

Figure 6-21. Exterior view of Port Charlotte Middle School showing both gymnasium area (tall section) and typical classroom (lower section, rear of photo)....6-23

Figure 6-22. Edge flashing failure at Port Charlotte Middle School....6-23

Figure 6-23. Exterior view of Liberty Elementary School (Port Charlotte)....6-24

Figure 6-24. Shutters installed at openings at Liberty Elementary School shelter area (Port Charlotte)....6-25

Chapter 7

Figure 7-1. Residence constructed to the design requirements of the 2001 FBC performed well and only experienced some light trim damage (shown in the center of the photo) (North Captiva Island)....7-17

Figure 7-2. Older residence atop pile foundation that allowed floodwaters to pass safely underneath, resulting in only minor damage to enclosures and access stairways (Fort Myers Beach)....7-18

Figure 7-3. Exterior view of the elevated Lighthouse Resort Inn and Suites, which remained dry and undamaged after Hurricane Charley (Fort Myers Beach)....7-19

Figure 7-4. Exterior view of the galvanized shutters that protected the Charlotte County South Annex (Punta Gorda)....7-20

Figure 7-5. Courtyard of the newly constructed Sanibel School that was operational immediately after Hurricane Charley passed....7-21

Chapter 8

Figure 8-1. Plan view of a typical garage door....8-9

Figure 8-2. Detail A – recommended reinforced horizontal latch system for a typical garage door....8-10

Figure 8-3. Detail B – typical garage door failure at the edge and recommended assembly improvements 8-13

Figure 8-4. Continuous bar near the edge of edge flashing or coping. If the edge flashing or coping is blown off, the bar may prevent a catastrophic progressive failure. 8-17

Appendix E

Figure E-1. Historical hurricane and tropical storm paths E-2

Figure E-2. Continental U.S. landfalling hurricanes, 1950-2004 .... E-4