3. General Overview of Storm-Related Damage

One of the goals of a MAT is to observe buildings that effectively withstood design flood and/or wind conditions with little or no damage and document successes.

This chapter presents a general overview of typical types of damage that resulted from Hurricane Katrina, as well as the effects caused by flood and wind damage. Section 3.1 characterizes flood damages observed by the MAT, with additional discussion and examples provided by different types of building occupancy (e.g., one- and two-family residential buildings, multi-family residential buildings, commercial buildings, critical and essential facilities, and historic buildings). Section 3.2 includes a similar treatment and breakdown for wind effects. More detailed discussions of the observations are presented in Chapters 4, 5, 6, and 7.

Katrina's wind speeds were generally below the design winds in most areas, and yet wind damage was still observed. Flood conditions, however, were far in excess of design conditions over a large area. Flood damage was so widespread that there were relatively few successful (flood-resistant) buildings in the coastal SFHAs of Alabama, Louisiana, and Mississippi. The MAT documented the successes it observed, but also expanded its scope to document *survivors* (buildings that were damaged, sometimes heavily, but stood out from the destruction around them). Many of these survivors provide useful information about the benefits of designing and constructing for flood conditions in excess of the base flood conditions shown on the FIRMs. The terms "successes" and "survivors" will be used throughout this report, and are more fully described and compared in Table 3-1.

Table 3-1. Building Classifications Used by the MAT: Successes and Survivors

Building Element Characteristic	Success	Survivor
Overall	No structural damage, with minimal non-structural damage during design event.	Building is recognizable - structural system (foundation and frame) intact, with no more than minor damage. Damage to envelope and non-structural elements may be severe.
Foundation	Building foundation is intact and functional.	Foundation may have sustained minor damage; any damage or displacement is repairable.
Structural Frame	Structural frame is intact and functional.	Frame may have sustained minor damage; any damage or displacement is repairable.
Envelope (walls, openings, roof, and lowest floor)	Envelope is structurally sound and capable of minimizing penetration by wind, rain, and debris.	Envelope may be breached, damaged, or destroyed by flooding or waves allowing interior damage by wind, rain, and debris. Interior may have been damaged or destroyed by wind, rain, and debris.
Lowest Floor Elevation	Lowest floor elevation was sufficient to prevent floodwaters from entering the elevated building envelope during the design event.	Lowest floor elevation may have been insufficient to prevent floodwaters from entering the building.
Utilities	Utility connections (e.g., electricity, water, sewer, natural gas) are intact or restored easily.	Utility connections (e.g., electricity, water, sewer, natural gas) are severed, but restorable.
Access and Usability	Building is accessible and usable following a design-level event.	Restoration of building access and use is possible.
Below DFE Enclosures	Damage to enclosures below the design flood elevation (DFE) did not result in damage to the foundation, the utility connections, or the elevated portion of the building.	Below-DFE enclosures are destroyed.

3.1 Flood Effects

As discussed in Chapters 1 and 2, high storm surge and waves from Hurricane Katrina caused severe (often catastrophic) damage to buildings on the Alabama, Louisiana, and Mississippi Gulf Coast. Damage in coastal areas primarily resulted from wave effects, velocity flooding, floodborne debris impacts, and, to a lesser extent, erosion and scour. Further inland, flood damage was associated principally with storm surge inundation.

Storm Surge and Wave Damage

The MAT observed that flood elevations in many areas exceeded the 100-year BFEs shown on the FIRMs by as much as 15 feet or more.[1] The team observed that storm surge and wave damage typically associated with V Zones also occurred in Coastal A Zones and in areas outside the SFHA (refer to Section 2.1.1 for definitions of zones). Pre-FIRM buildings and buildings constructed to comply with pre-Katrina flood standards were subjected to unanticipated levels of flooding. The resulting destruction of buildings and infrastructure in the coastal areas along the Gulf was unprecedented, as was the damage resulting from long-duration flooding behind the failed levees in New Orleans and surrounding areas.

Figure 3-1 illustrates the general relationship observed by the MAT between flood depth (relative to the lowest floor) and damage resulting from waves and storm surge striking typical light frame construction where erosion and scour were not sufficient to undermine or destroy the building foundation. Note the increase in damage when the wave crest elevation rose above the bottom of the lowest horizontal member.

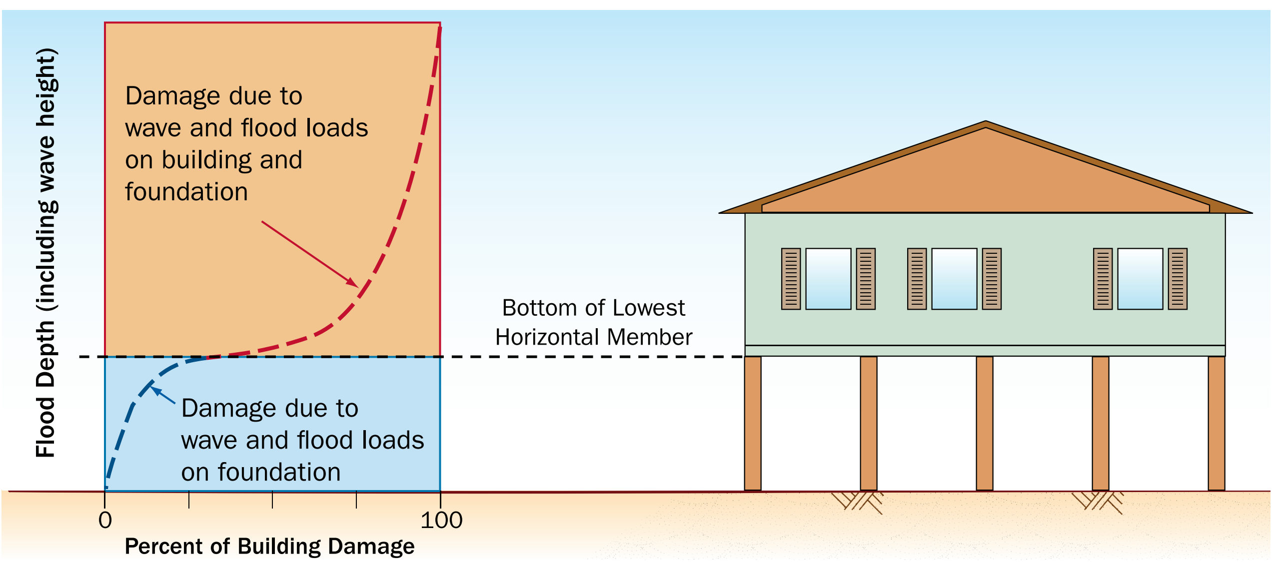

Figure 3-1. Idealized building damage vs. flood depth relative to lowest horizontal member

[1] Recognizing the potential impact of increased flood elevations on long-term recovery efforts and risk reduction, FEMA issued Flood Recovery Maps in 2006 to provide guidance during the rebuilding process. The Flood Recovery Maps provide ABFEs that were based on a statistical analysis of the high water marks and the wind-water damage boundary surveyed in Katrina's aftermath, plus an additional 25 years of historical flood data not available when the earlier FIRMs were published in the 1980s.

Floodborne Debris

Besides waves and storm surge flooding, floodborne debris was a significant and widespread contributor to building damage in coastal Mississippi (and to a lesser extent in Alabama and Louisiana). Floodborne debris included small pieces of destroyed buildings, intact buildings washed off their foundations, vehicles and shipping containers, and casino barges. Although it is difficult to separate the specific effects of floodborne debris from those of waves and velocity flow, it is likely that the presence of the debris increased flood damage in some areas; in other areas, large piles of debris could have sheltered landward buildings from damaging waves. Examples of floodborne debris and debris damage are shown in Figures 3-2 through 3-4.

Figure 3-2.
Displaced casino barge floated inland, struck and came to rest near a hotel along U.S. 90 (Biloxi, Mississippi)

Figure 3-3.
A major element of debris in this debris field was shipping containers from the port (arrows indicate examples) (Gulfport, Mississippi).

Figure 3-4. Floodborne debris, including shipping containers and sections of destroyed buildings (Gulfport, Mississippi)

3.1.1 Flood Effects on One- and Two-Family Residential Buildings

Severe flood damage occurred to one- and two-family residential buildings throughout the study area. In areas close to the shoreline, the damage was principally a result of waves, velocity flow, and floodborne debris, while in areas distant from the shoreline damage was primarily a result of inundation by storm surge. Since Katrina's flood elevations greatly exceeded mapped BFEs, flood damage was more extensive and severe than would be expected from a design level flood event. Typical flood damages are shown in Figures 3-5 through 3-11.

In the New Orleans area, severe building damage near levee breaches as well as some areas in Plaquemines Parish (with many buildings washed off their foundations) resulted from rapidly rising, fast-moving water flowing through breaches. Within the levee-protected areas, but away from the breaches, flood damage to buildings was typically a result of slowly rising water, which inundated houses for long periods (most of these buildings were heavily damaged, but remained structurally intact). Refer to Chapter 8 for a more detailed discussion of the effects of long-term flooding.

Most one- and two-family residential buildings in the Katrina-affected area were built on shallow foundations such as slabs, stem walls, crawlspaces, or piers. In some cases, more deeply embedded pile or column foundations were used. Masonry pier foundations were the most common foundations in V Zones and in A Zones near the shoreline, followed by timber pile foundations. When properly designed and constructed, all of these foundations were effective for those buildings where waves and surge remained below the floor system and erosion and scour did not undermine the foundations. However, in areas where Katrina's surge and waves exceeded the floor elevation, many buildings were destroyed, often leaving only foundations behind. In areas subject to erosion and scour, shallow foundations usually failed. Detailed discussions about the performance of the various foundation types are provided in Chapter 4.

Figure 3-5.
House on verge of collapse due to shallow embedment of timber pile foundation (Dauphin Island, Alabama)

Figure 3-6.
Elevated house atop masonry pier foundation was lost, probably due to waves and storm surge reaching above the top of the foundation (Long Beach, Mississippi)

Figure 3-7.
Building floated off of foundation (Happy Jack, Louisiana)

Figure 3-8.
Wave and surge damage to load-bearing walls atop stem wall foundation. The house was located in flood hazard zone C, approximately 1/4 mile from the shoreline (Pointe Aux Chens area, Jackson County, Mississippi).

Figure 3-9.
Interior damage and mold from prolonged flooding (New Orleans, Louisiana)

Figure 3-10.
This new public housing neighborhood (not yet occupied) was flooded by storm surge to the first floor ceilings. Houses closest to the bay also sustained damage to walls by waves and floodborne debris. The arrows indicate the locations of the inset photos (Biloxi, Mississippi).

Figure 3-11.
Wave, floodborne debris, and surge damage to some Gulf-front neighborhoods was extreme. Arrows indicate locations of buildings in both photos (Waveland, Mississippi).

SOURCE: UNITED STATES GEOLOGICAL SURVEY [USGS]

Like site-built homes, manufactured homes sited in Katrina's path were damaged and often destroyed. Damage resulted from the hydrodynamic effects of rapidly moving floodwaters (storm surge) and also from submergence (inundation). Many manufactured homes floated or washed off of their supports or had supports collapse due to velocity flow and scour (see Figure 3-12).

Figure 3-12. Manufactured home washed off its supports by moving floodwaters (Ocean Springs, Mississippi)

3.1.2 Flood Effects on Multi-Family Residential Buildings

Structural damage to multi-family residential buildings varied with the severity of flooding and construction type. Multi-family buildings sustained flood damage consistent with that observed for one- and two-family buildings, which is further discussed in Chapter 4. As observed with multi-family buildings, such as apartments, reinforced concrete and steel-framed buildings generally sustained less structural damage than light-framed wood or masonry construction, but were still subject to wall collapse in instances where wave action was present. Examples of multi-family building flood performance are shown in Figures 3-13 through 3-18.

Figure 3-13. Apartments damaged by storm surge, floating automobiles, and wave action (Biloxi, Mississippi)

Figure 3-14. Apartments on slab foundations destroyed by waves, storm surge, and wind (Long Beach, Mississippi)

Figure 3-15. Aerial photo of apartment complex shown in Figure 3-14 and the surrounding area (Long Beach, Mississippi)

Figure 3-16.
Wood-framed and masonry multi-family residential buildings damaged by storm surge (limited wave action). The building in foreground sustained flooding to a level approximately 30 inches above the elevated floor. The building in the background was flooded to the ceiling of the lower floor units (Ocean Springs, Mississippi).

Figure 3-17.
Wave and surge damage to Gulf-front apartments. Note the poured concrete foundation columns and slab performed well, but the waves rose above the slab and attacked the wood-framed buildings, destroying the building closest to the Gulf, and severely damaging the landward building. The severity of damage to the remaining building resulted in demolition (Biloxi, Mississippi).

SOURCE: USGS

Figure 3-18.
Waves and storm surge washed through the lowest floor of this condominium building, but the building reportedly sustained no structural damage (Gulfport, Mississippi).

3.1.3 Flood Effects on Commercial Buildings

Damage to commercial buildings, like other building types, varied with location and flood conditions. Low-rise buildings close to the Gulf, including strip malls, individual food service/retail, and larger retail stores, were often destroyed or severely damaged by storm surge, waves, and floating debris. Several buildings along the shoreline lost load-bearing walls, leaving no evidence of the building other than the floor slab. Larger steel-framed commercial buildings performed better, as the structural frame and roof remained intact, but curtain walls and contents were destroyed. Flood impacts on high-rise buildings were less extreme, with most damage impacting parking decks located on the lower floors.

Figures 3-19 through 3-21 illustrate typical flood damage to commercial buildings observed by the MAT.

Figure 3-19.
Strip mall with walls destroyed by waves and storm surge (Biloxi, Mississippi)

Figure 3-20.
Marine Education Center, which lost most of its walls due to wave action, storm surge, and floating debris (Biloxi, Mississippi)

Figure 3-21.
A reinforced concrete and pre-engineered metal building (PEMB) housing a seafood processing building sustained severe damage due to storm surge, waves, and floating debris. Nearby marina buildings were also destroyed (Lakeshore area, Hancock County, Mississippi).

SOURCE: NOAA

3.1.4 Flood Effects on Critical and Essential Facilities

Critical and essential facilities did not perform any better than the commercial buildings, despite the importance attached to these facilities. More information on damage to these facilities is presented in Chapter 7. Figures 3-22 through 3-25 illustrate flood damage sustained by these facilities.

Figure 3-22. Newly constructed Gulfport Fire Station #7 destroyed by waves and storm surge (Gulfport, Mississippi)

Figure 3-23. Pass Christian Police Department destroyed by storm surge (Pass Christian, Mississippi)

Figure 3-24.
Storm surge damage to the St. Bernard Parish Coastal Government Complex (Delacroix, Louisiana)

Figure 3-25.
Floodwater isolated Charity Hospital and incapacitated its emergency generator (New Orleans, Louisiana)

3.1.5 Flood Effects on Historic Buildings

Throughout the impacted area, the MAT reviewed damage to an extensive number of historic buildings, which had fared well in past major hurricanes. Damage to historic buildings varied based on their elevation, structural system, foundation type, and, in some cases, the amount of retrofitting integrated while maintaining the facility. Most historic buildings survived inundation by floodwaters, but, like other buildings, those that were near the open coast were often damaged by waves and floodborne debris. More information on the damages and observations to historic buildings is contained in Chapter 6. Figures 3-26 through 3-28 illustrate flood damage sustained by several historic structures.

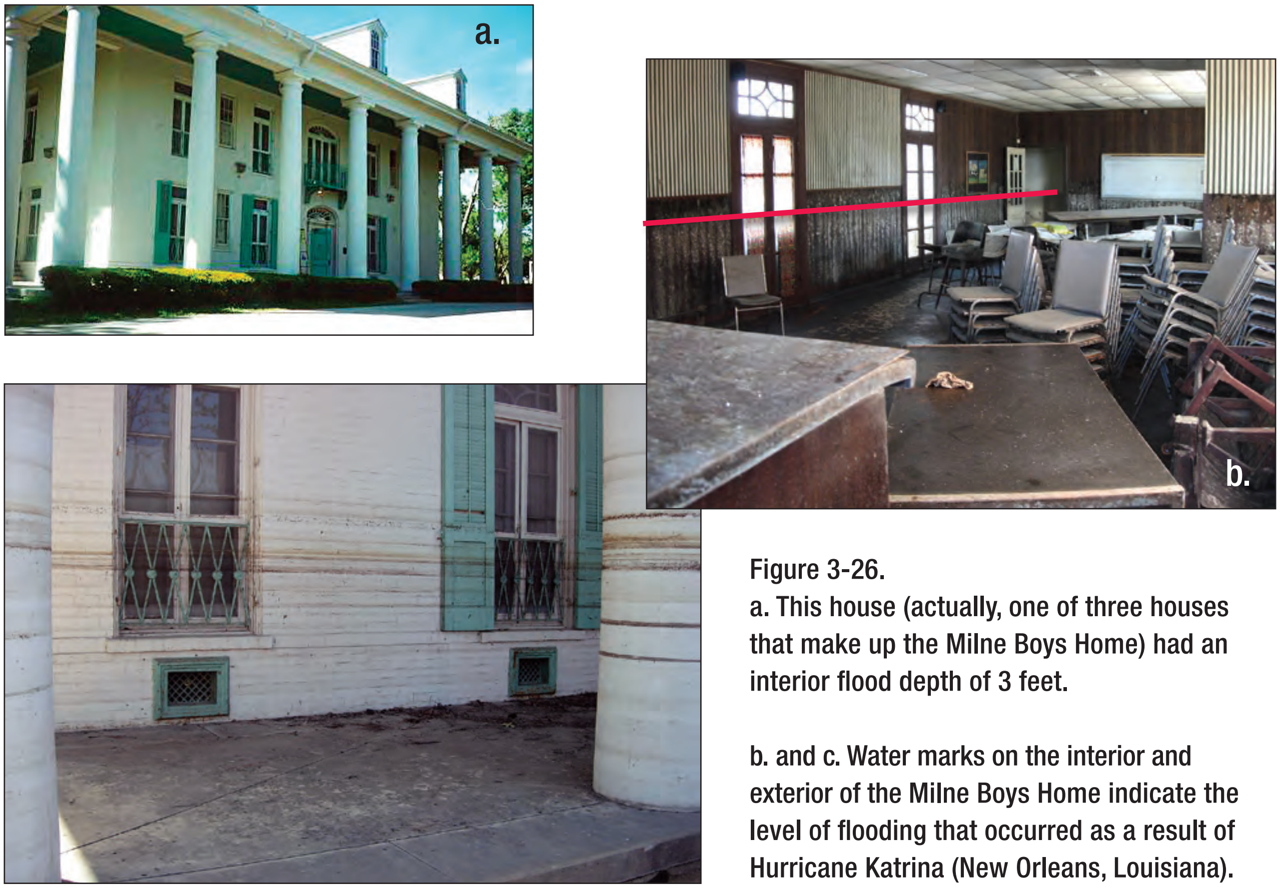

Figure 3-26.
a. This house (actually, one of three houses that make up the Milne Boys Home) had an interior flood depth of 3 feet.

b. and c. Water marks on the interior and exterior of the Milne Boys Home indicate the level of flooding that occurred as a result of Hurricane Katrina (New Orleans, Louisiana).

Figure 3-27.
Before (a.) and after (b.) photos of Beauvoir (Jefferson Davis' home), built in 1848. The building sustained severe surge damage from Hurricane Katrina's waves and storm surge (Biloxi, Mississippi).

Figure 3-28.
This hotel, built in 1927, suffered wave damage and was struck by a casino barge (Biloxi, Mississippi).

3.2 Wind Effects

As documented in Chapter 1, Hurricane Katrina's flood levels were significantly higher than the design level; however, Hurricane Katrina's wind speeds were below current design wind speeds in most areas, but the wind pressures exceeded some of the older code-level wind pressures. The MAT did observe damage to structural elements but, most noticeably, observed widespread wind damage to building envelopes along the entire coasts of Alabama, Louisiana, and Mississippi, and extending several miles inland. The MAT also observed numerous examples of building damage due to tree-fall and windborne debris (most windborne debris damage was a result of aggregate blowing off roofs and blown-off vinyl siding and asphalt shingles). Many buildings that experienced envelope breaches also suffered from internal pressurization, which resulted in additional building damage and damage to non-structural elements and contents from rainfall penetration.

Wind Damage

As expected, wind damage generally was greater in areas where wind speeds were higher and in areas where the housing inventory included many older homes or homes that lacked sufficient quality of construction. High-wind areas like the towns of Buras and Boothville in Plaquemines Parish, Louisiana, and Bay St. Louis, Waveland, and Pass Christian, Mississippi, were particularly hard hit. In areas like Biloxi and Pascagoula, Mississippi, and Slidell, Louisiana, where wind speeds were lower, wind damage was common, but typically not as extensive or severe as in areas exposed to higher wind speeds. However, wind damage was also common in some areas many miles from areas exposed to the highest winds. For example, some homes on Dauphin Island, Alabama, over 100 miles east of the storm's track, were damaged severely by Katrina's winds.

Windborne Debris

Structural and building envelope failure resulted from windborne debris, which included roof aggregate (see Figure 3-29); roofing panels, tiles, shingles, and rooftop equipment; vinyl siding; tree limbs; and falling trees. Fallen tree damage was widespread and even affected areas where wind speeds were relatively low. Buildings surrounded by tall dense forests had reduced wind loads compared with buildings that were not protected by trees. However, as wind speed increases, trees fall (see Figure 3-30) and/or are stripped of leaves and branches, which then reduces some of the protection they may initially provide.

Figure 3-29. Roof aggregate was the primary windborne debris source for the window damage (New Orleans, Louisiana).

Figure 3-30. Tree-damaged home (Diamondhead, Mississippi)

3.2.1 Wind Effects on One- and Two-Family Residential Buildings

Many one- and two-family residential buildings observed by the MAT experienced no wind damage, while others sustained varying degrees of non-structural or structural damage due to wind. The most common type of wind damage was to the building envelope, including loss of asphalt shingles and vinyl siding, soffit blow-out, and broken glazing. When loss of glazing or other damage created breaches in building envelopes, building interiors were pressurized and the damage was greater. When a building lost soffit materials or roof sheathing, the loss of the roof or other structural damage typically followed. Usually, structural damage typically was limited to loss of a few sheets of roof sheathing (see Figure 3-31) but, in some cases, there was extensive loss of sheathing (see Figure 3-32), which resulted in loss of trusses or joists. Typical examples of wind damage to one- and two-family residential buildings are shown in Figures 3-32 through 3-37.

While most of the damage to manufactured housing was from flooding, wind damage was noted in both older and newer manufactured housing. Wind damage to manufactured homes included loss of asphalt shingle roofing, loss of vinyl siding, loss of large overhangs, and damage to window and door glazing (see Figure 3-38).

Figure 3-31.
Roof sheathing was a source of windborne debris (Waveland, Mississippi).

Figure 3-32.
Relatively new home damaged from internal pressurization and lack of adequate connections (Pass Christian, Mississippi)

Figure 3-33.
Loss of shingles and chimney failure caused by inadequate attachment (Slidell, Louisiana)

Figure 3-34.
Row house with failed gable end wall and roof (gable end wall was being replaced when this photo was taken) (Biloxi, Mississippi).

Figure 3-35.
House constructed in 2001 on Gulf side of Dauphin Island, Alabama, was destroyed by wind (Dauphin Island, Alabama)

Figure 3-36.
Roof sheathing damage to an older home (Gulfport, Mississippi)

Figure 3-37. A home under construction racked severely when exposed to Katrina's winds. Its attached garage also collapsed (Slidell, Louisiana).

Figure 3-38. Manufactured home lost a gable roof over its entrance, asphalt shingles, and metal fascia along its eaves (Plaquemines Parish, Louisiana)

3.2.2 Wind Effects on Multi-Family Residential Buildings

As was the case with one- and two-family residential buildings, wind damage to multi-family residential buildings varied with wind speed, building shape, structural design, and construction quality. Examples of wind damage to multi-family residential buildings are shown in Figures 3-39 through 3-42, and a more detailed discussion of wind damage can be found in Chapters 4 and 5.

Damage was greatest when building envelopes were breached at "soft" portions of the building exteriors, like soffits and lightly constructed ceilings over covered corridors or breezeways, which resulted in pressurization and structural failures.

Figure 3-39.
Apartment complex severely damaged by wind. Although wind speeds were less than current code-specified values, widespread and severe damage occurred at this development, a result of poor construction quality (Ocean Springs, Mississippi).

Figure 3-40.
Multi-family, wood-framed residential building damaged by high winds (Waveland, Mississippi)

Figure 3-41.
Wind damage to wood-framed, multi-family residential building (Long Beach, Mississippi)

Figure 3-42.
Gable end wall and roof sheathing loss to apartments near the City of Toca (St. Bernard Parish, Louisiana)

Multi-family residential buildings constructed with reinforced concrete or steel frames performed well structurally (see Figure 3-43). Unfortunately, many of those buildings had weak envelopes covered with materials like exterior insulation finishing systems (EIFS) (see Figure 5-8 for typical EIFS assemblies). Although the structural systems performed well, many sustained extensive damage due to water entry through failed building envelopes (see Figures 3-44 and 3-45).

Figure 3-43.
Multi-family residential building constructed with reinforced concrete frame showed no visible structural damage (Ocean Springs, Mississippi)

Figure 3-44.
Reinforced concrete frame building that performed well structurally, but sustained extensive damage due to water intrusion from EIFS failure (Biloxi, Mississippi)

Figure 3-45.
Damage to EIFS on hotel and casino (Biloxi, Mississippi)

3.2.3 Wind Effects on Commercial Buildings

Wind damage to commercial buildings' structural systems depended much more on building construction than on building location. Relatively weak (i.e., non-engineered or not structurally reinforced) commercial buildings were destroyed in areas where wind speeds were relatively low, while stronger (i.e., engineered or structurally reinforced) buildings experienced little or no structural damage in areas exposed to the highest winds.

In general, high- and medium-rise buildings performed much better than low-rise structures. MAT team members investigated few buildings over three stories that experienced significant structural wind damage, but did observe envelope damage (see Figures 3-46 and 3-47). No wind-induced collapses of high- and medium-rise buildings were noted, but deck failure was observed on a 400-foot tall building (see Figure 3-48).[2] In comparison, several one- and two-story commercial structures sustained severe structural damage due to wind.

Figure 3-46.
Closeup of high-rise building whose structure performed well, but experienced widespread damage to its EIFS envelope and some glazing damage (Biloxi, Mississippi)

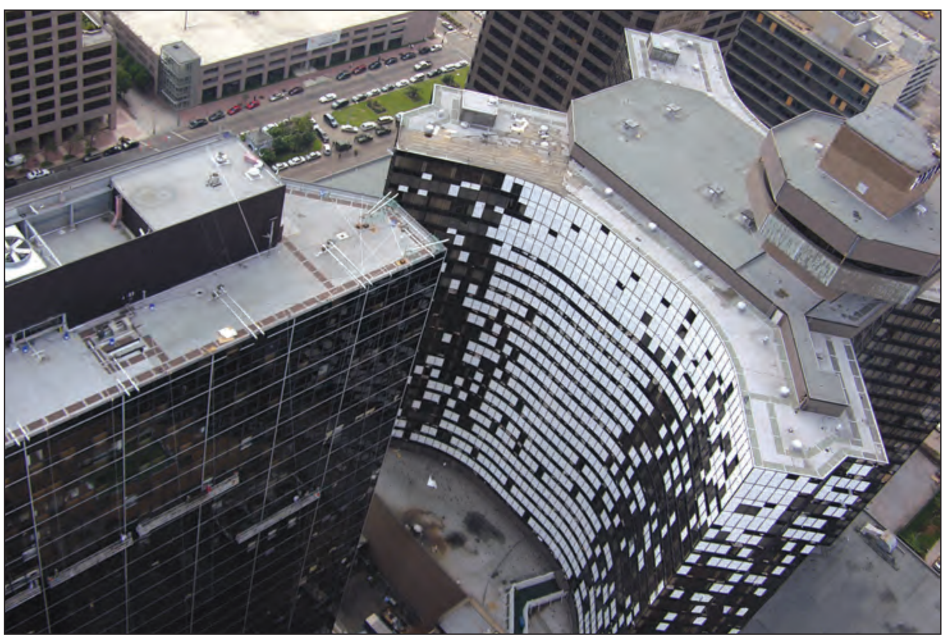

Figure 3-47.
Roof aggregate was the primary windborne debris source for the glazing damage to the hotel and office building (New Orleans, Louisiana).

[2] In discussing wind damage to buildings, it is important to differentiate between structural components and envelope components. Many commercial buildings experienced little or no structural damage, but may be total losses due to failure of the building envelope and the resulting water entry. In this report, structural components are limited to those required to resist lateral and vertical loads and those that provide structural stability to the building. Generally, structural components in commercial buildings are limited to foundations and footings, beams, columns, load-bearing and shear walls, structural frames, and roof decks. Roof coverings, wall coverings, and non-load-bearing walls are not considered structural components.

Figure 3-48.
The deck on this 400-foot tall building was lightweight insulating concrete over steel form deck. The form deck was blown from the deck supports (New Orleans, Louisiana).

The low-rise commercial buildings observed by the MAT to have sustained significant wind damage were older, pre-engineered metal buildings. While many older PEMBs were heavily damaged, newer ones performed much better. At St. Ansyslem's School in Bay St. Louis, a PEMB constructed in 2001 was not visibly damaged by wind (however, it did experience severe flood damage). Figures 3-49 through 3-52 show examples of damage to PEMBs.

Newer, low-rise commercial buildings generally performed well, but like their high-rise counterparts, several sustained damage to their envelopes (see Figures 3-52 and 3-53).

Figure 3-49.
Low-rise PEMB that was severely damaged by wind. The building was constructed with steel moment frames and purlins, metal roof and wall panels, and unreinforced masonry infill walls (Gulfport, Mississippi).

Figure 3-50.
Low-rise PEMB at the Gulfport-Biloxi Airport severely damaged by winds. The building was constructed with steel moment frames and purlins, and metal roof and wall panels (Gulfport, Mississippi).

Figure 3-51.
Wind, wave, and surge damage to St. Thomas Catholic Church. Destruction of the PEMB envelope likely reduced wind damage to the structure itself (Long Beach, Mississippi).

Figure 3-52.
Newer low-rise PEMB that performed well structurally, but experienced some envelope damage. Metal coping along the top of the left wall (circle) was lifted by high winds (Bay St. Louis, Mississippi).

Figure 3-53.
This bank building performed well structurally, but its envelope, specifically the metal roofing and brick, failed (Gulfport, Mississippi).

3.2.4 Wind Effects on Critical and Essential Facilities

The poor performance of critical and essential facilities was widespread throughout the Gulf Coast. Almost without exception, critical and essential facilities such as hurricane evacuation shelters, police and fire stations, hospitals, nursing homes, schools, and EOCs were damaged, and many were completely destroyed. While much of the damage to critical and essential facilities was caused by surge or stillwater flooding, high winds caused damage to many facilities, impacting the use and operations of the facility (see Figures 3-54 through 3-61).

Figure 3-54.
The Long Beach Police Station was severely damaged by high winds (Long Beach, Mississippi).

Figure 3-55.
Wind damage to the New Orleans Fire Department 3rd District Headquarters (New Orleans, Louisiana)

Figure 3-56.
The Harrison Central Elementary School was used as an evacuation shelter during Katrina. Portions of its roof covering were blown off by high winds and many of its windows were broken by windborne aggregate from its own roof (Gulfport, Mississippi).

Figure 3-57.
Ceiling damaged by wind and rain entry due to soffit failure (Gulfport, Mississippi)

Figure 3-58.
Window failed due to wind pressures, resulting in water entry into the building and damage to ceiling boards. After the failure, metal panels were installed for temporary protection (circled) (Gulfport, Mississippi).

Though not completely destroyed, most of the hospitals were damaged and other types of critical and essential facilities performed poorly. Most of the fourteen hospitals observed by the MAT experienced building envelope damage and a few were flooded. Often their ability to operate during and after the storm was due to the heroic efforts of their staff. Several of the hospitals had to contend with the loss of windows (see Figure 3-59), failed roofs and rooftop equipment (see Figures 3-60 and 3-61) and other exterior elements, loss of water, and, occasionally, loss of emergency power and communications.

Figure 3-59.
Temporary repairs for broken windows in Memorial Hospital. The black panels are painted plywood installed after the spandrel panels were damaged by windborne roof aggregate from the hospital's own roofs (Gulfport, Mississippi).

Figure 3-60.
Temporary repairs required after combustion air louvers for emergency generators were blown off of the roof at the Garden Park Medical Center (Gulfport, Mississippi)

Figure 3-61.
The equipment on this new Federal courthouse blew away because it was resting on vibration isolators that provided lateral resistance, but no uplift resistance. Two large openings through the roof were left after the duct work blew away (temporary covers had been placed over the openings) (Gulfport, Mississippi).

3.2.5 Wind Effects on Historic Buildings

Wind effects on historic buildings were primarily limited to the removal of roof covering, sheathing, and limited curtain wall damage. Figure 3-62 is an example of a wood window that blew in. Even though these structures pre-date the building codes, buildings that had sufficient connection details in their design and construction, or were retrofitted, performed well against Hurricane Katrina's winds. More detail may be found in Chapter 6.

Figure 3-62.
Wind damage to a New Orleans church built in 1886 (New Orleans, Louisiana)