

# General Characterization of Damage

# 3

Chapter 3 provides a general characterization of the damage that resulted from Hurricane Ivan. Section 3.1 discusses flood effects on one- and two-family housing and on multi-family housing. Section 3.2 discusses wind effects on one- and two-family housing, multi-family housing, commercial buildings, and critical and essential facilities. Finally, Section 3.3 presents several case studies demonstrating lessons learned and best practices.

## 3.1 Flood Effects

As discussed in Chapters 1 and 2, Hurricane Ivan brought high storm surge and waves causing severe damage to buildings along the Gulf Coast in Baldwin County, Alabama, and the western portions of the Florida Panhandle. Damages resulted from high flood elevations and impacts from waves and debris. The storm surge caused severe coastal erosion that caused failure of shallow foundations. The MAT observed that flood elevations in many areas exceeded the 100-year BFEs depicted on the FIRMs by 2 to 4 feet, which was also confirmed by FEMA's Flood Hazard Recovery Maps, which were produced in the aftermath of Hurricane Ivan and included surveyed high water marks, as discussed in Chapter 1. Wave damage, which was anticipated in V-Zone areas, was also observed in mapped A-Zone areas. In many areas, flood levels resulted in V-Zone type damages in mapped A Zones. Wave and waterborne debris impacts caused significant damage to buildings and to enclosures, slabs, decks, stairs, utilities, and other ancillary features. See Appendix E for a discussion of FEMA's Flood Hazard Recovery Maps.

Since many houses were constructed to the current minimal flood standards and in many cases were pre-FIRM construction, Hurricane Ivan's high storm surge and waves, which exceeded the BFEs, significantly destroyed buildings on the open coast of the barrier islands and throughout the back bays and sounds.

### 3.1.1 Flood Effects on One- and Two-Family Housing

Severe flood damages occurred to one- and two-family buildings throughout the study area, on the barrier islands, and, more significantly, throughout the back bays and sounds. Particularly hard hit areas were near the shorelines of Little Lagoon, Big Lagoon, Santa Rosa Sound, Pensacola Bay, and Escambia Bay.

Most one- and two-family buildings on the barrier islands were built using V-Zone construction methods with pile foundations. Newer buildings constructed on pile foundations with proper embedment depth generally performed well, although many buildings experienced damages to lower area enclosures, nonstructural slabs, access stairways, and utilities. Older buildings (as well as a few newer buildings) that were built on piles with insufficient cross-section or embedment suffered destruction or severe damage.

In areas along the bays and sounds, Ivan's flood elevations frequently exceeded the BFE by 2 to 4 feet or more, which led to significant inundation, and wave and floodborne debris damage to buildings, even those constructed in compliance with community floodplain management requirements.

Many of the hardest hit areas were mapped as A Zone, but buildings experienced V-Zone conditions, with severe damage occurring to buildings elevated to the BFE on slab, pier, and crawlspace foundations. Buildings constructed outside the SFHA in areas mapped as Zones B, C, or X were often subject to A-Zone flood conditions during Ivan. As a general rule, wherever wave crest elevations and floodborne debris strikes occurred above the lowest floor elevation, the buildings, regardless of foundation type, were destroyed or severely damaged. The severity of wave and debris damage near bay and sound shorelines is one of the most noteworthy characteristics of Hurricane Ivan.

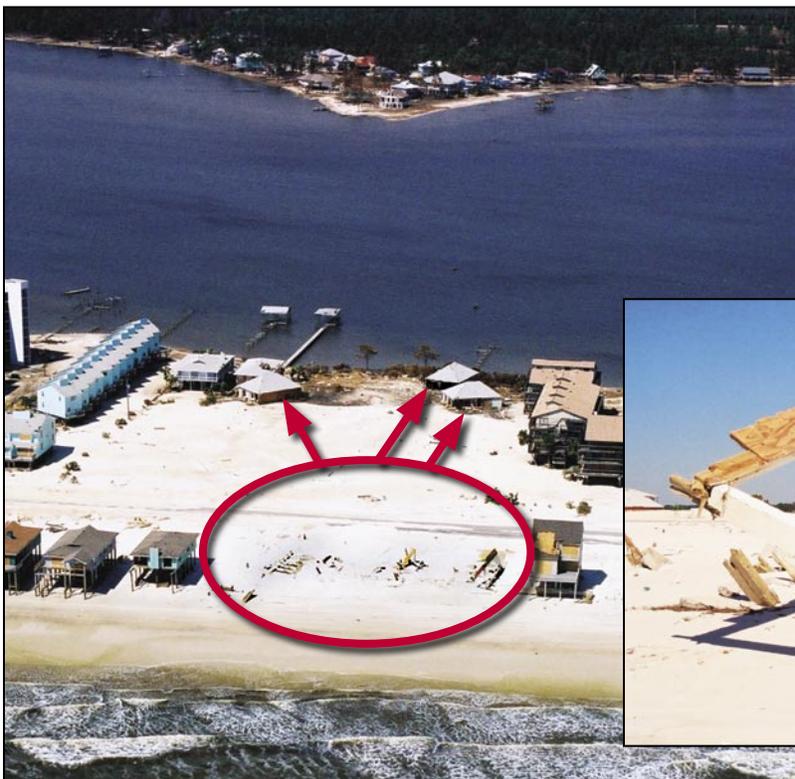
The buildings that resisted Ivan's flood forces most successfully were elevated several feet above the BFE on pile foundations. Buildings elevated on stem wall foundations in Zones A, B, C, and X also performed reasonably well, where the top of the foundation was above the limits

of wave action and floating debris, and where the footing depth was sufficient to resist scour.

Figures 3-1 through 3-5 illustrate typical flood damages to one- and two-family buildings.



**Figure 3-1.** Buildings constructed on deep pile foundations performed well; however, significant damage occurred to lower-level enclosed areas and to stairways, utilities, and non-structural parking slabs below the elevated portion of the building.



**Figure 3-2.** Insufficient pile embedment caused displacement of houses (Gulf Shores, West Beach)



In many back bay and sound areas, the flood elevations exceeded the 100-year BFEs and this led to significant damage to buildings, especially those that were constructed to lower elevations. Severe damage was caused by wave and debris impacts. Most of the buildings on the bays and sounds were pre-FIRM buildings built below the current BFE or post-FIRM buildings built at BFE. When floodwaters exceeded their lowest floor elevations, these buildings were damaged by waves and debris impacts. The severity of the damage varied depending on the elevation of the lowest floor.

Many houses that were several rows back from the shoreline (in Zones A, B, C, and X) were somewhat protected, but they sustained considerable flood damage due to inundation levels above the lowest floor. In many cases, debris from docks and seaward of the rows of houses was carried inland by surge and waves, battering other houses and causing significant damage.

**Figure 3-3.** This building, which was less than 2 years old, was constructed on piers at the current BFE of 9 feet. It was severely damaged by high storm surge, and wave and debris impacts. (Big Lagoon)



Even in areas where buildings were designed and elevated for high wave impacts, buildings suffered severe waterborne debris, surge, and wave damage when flood levels exceeded FIRM elevations by several feet, as shown in Figure 3-4.



Figure 3-4. Damage to NFIP-compliant elevated structure in a V Zone (north end of Escambia Bay-Floridatown)



Figure 3-5. Buildings constructed on piles and elevated several feet above the BFE sustained less flood damage than adjacent buildings at lower elevations. (Big Lagoon)

Pre- and post-FIRM residential buildings on slab-on-grade, crawlspace, or stem wall foundations in Zone AE near the back-bay or sound shore-lines experienced substantial damage and/or complete destruction when flood elevations significantly exceeded mapped levels. Representative damages are shown in Figures 3-6, 3-7, and 3-8 where houses exposed to flood conditions from Little Lagoon and Big Lagoon (the water bodies behind Gulf Shores and eastern Perdido Key) experienced

severe surge, wave, and debris damage when flood levels exceeded the BFE by 2-4 feet. Note that Figure 3-5 shows a pile-elevated building near the building shown in Figure 3-8.



Figure 3-6. Surge, wave, and debris damage (Little Lagoon)

Figure 3-7.  
Older buildings below the  
current BFE sustained  
severe flood damage  
throughout the back  
bays. (Little Lagoon)





**Figure 3-8.** This new building was constructed to the BFE, but was wiped off its foundation (slab atop stem walls) by Ivan. The destruction was likely due to storm surge, wave action, and floodborne debris, although wind could have contributed to the breakup of the building (note pine tree leaning over slab). (Big Lagoon)

Severe damage was caused by flood and wave impact to decks, stairs, utilities, and enclosed areas beneath elevated buildings, as shown in Figure 3-9. Floodborne debris impacts caused severe damage to buildings that were elevated to the BFEs, as shown in Figures 3-10 and 3-11.



**Figure 3-9.** Utilities, parking slabs, and enclosed areas under an elevated building were severely damaged by the high flood elevations and wave action. (Gulf Shores)

**Figure 3-10.**  
Large timbers washed  
from developments on  
Santa Rosa Island, across  
Santa Rosa Sound, and  
into several homes.  
(Santa Rosa Sound  
– Oriole Beach)



**Figure 3-11.**  
Significant floodborne  
debris contributed to  
the severe damage of  
at-grade enclosed area  
beneath an elevated  
building. (Big Lagoon)





Figure 3-12. Significant floodborne debris contributed to the severe damage of buildings throughout the back bays and sounds in areas mapped as Zone AE. (Oriole Beach – Santa Rosa Sound)

### 3.1.2 Flood Effects on Multi-Family Housing

The nature and extent of flood damage to multi-family buildings varied considerably, depending on: 1) the location, foundation, and lowest floor elevation of the building, 2) the local flood conditions during Ivan, and 3) the degree of engineering attention received during design. Note that in some areas, building age was a poor predictor of building performance; the MAT observed some older multi-family buildings that performed well, and some newer multi-family buildings that were destroyed by Ivan's flood and erosion effects.

Obviously, building success or failure during Ivan was also dependent on how well the flood hazard maps in effect at the time of construction represented site conditions at the time of Ivan. Beach and dune erosion over time undoubtedly contributed to the damage or destruction suffered by barrier island multi-family buildings on shallow foundations in Zones B, C, or X. In addition, the accuracy of BFEs, flood hazard zones, and SFHA boundaries contributed to the damage suffered by multi-family buildings (on both barrier islands and back bays) that were constructed to minimum standards only.

Multi-family buildings that received a high degree of engineering attention (fully engineered structures) and had deep foundations appeared to withstand Ivan's flood and erosion effects, with the exception of lowest floor living units that were below Ivan's wave crest elevation. Fully engineered, multi-family buildings with parking areas at ground level and elevated floors built using VE-Zone construction

methods above the BFE generally sustained the least amount of flood and erosion damage.

Many multi-story buildings (e.g., multi-family and commercial) along the Gulf shoreline suffered extensive surge, debris, and erosion damage to their lowest floor levels, pool decks, and bulkheads. The most extreme cases were complete building collapse due to undermining of shallow foundations (see Figure 3-13).



Figure 3-13. Collapse of 5-story, multi-family buildings on shallow foundations (Orange Beach)

Less extreme – but still severe – damage was observed at many multi-story condominium buildings along the Gulf shoreline of Orange Beach and Perdido Key. The lowest floors containing living units, lobbies, and common areas were often destroyed by storm surge and waves, as a result of floor collapse or destruction of exterior walls, or a combination of the two (see Figures 3-14 to 3-15).



Figure 3-14. Pile foundations performed well, but non-structural floor slabs collapsed and low-elevation living units were destroyed. (Orange Beach)



Figure 3-15. Building supported on pile foundation (foreground) survived while building on shallow foundation (background) collapsed. (Orange Beach)

A separate rapid-response study of Orange Beach multi-story structures was undertaken to determine the extent and characteristics of lowest floor living unit damages (see Appendix F). The study examined 41 multi-story buildings, not including the collapsed buildings, such as those shown in Figure 3-13. Thirty-nine of the 41 buildings had a total of 233 living units at the lowest floor level.

Dates of construction and flood regulations in effect at the times of construction (i.e., flood hazard zones and BFEs) were not available at the time of the study; thus, compliance with those regulations could not be verified. However, although it appears the majority of the buildings were constructed in Zones B, C, or A, they were constructed on pile foundations. Lowest floor elevations (top of floor and bottom of lowest horizontal supporting members) were measured as part of the study, and this information was compared against the FIRMs in effect between 1983 and 2004, during which the majority of the construction was thought to have taken place.

The study found that approximately 80 percent of the lowest floor living units were destroyed by flood and/or erosion effects, despite the fact that most of the buildings were constructed on pile foundations with the top of the lowest floor at or above the BFEs that have been in effect over the past two decades. The buildings that sustained the least structural damage due to waves and erosion were constructed to VE-Zone standards with their lowest horizontal structural member several feet above the BFE.

The study also found that the most common damage state was with the lowest floor intact and the non-structural walls destroyed (see Figures 3-16 and 3-17; this occurred in 21 of the 39 buildings, in 101 of the 233 lowest floor living units). The next most common damage state was lowest floor and walls destroyed (this occurred in 15 of the 39 buildings, in 58 of the 233 lowest floor living units). Fully intact conditions (no damage to the lowest floor or lowest floor living units) occurred at only 6 of the 39 buildings, and 28 of the 233 lowest floor living units.

**Figure 3-16.**  
Foundation and structural floor slab survived but lowest floor non-structural exterior walls were destroyed by surge and waves (Orange Beach)



**Figure 3-17.**  
Destruction of low-elevation living units by surge and waves, while second floor units survived intact (Orange Beach)



## 3.2 Wind Effects

**A**s documented in Chapter 1, the maximum recorded 3-second peak gust wind speed in Hurricane Ivan was 117 mph in the Perdido Key area. The maximum wind speeds in Gulf Shores and Pensacola Beach were recorded to be 109 mph. The wind speeds recorded were well below the design wind speeds for this area under current building codes, but were just below the design wind speeds used for many years under the SBC. Both the IBC and FBC use the wind speed map from ASCE 7, as shown in Figure 2-16. This map prescribes a design wind speed of between 140 and 150 mph for the affected coastal areas. This means that the estimated actual wind speeds were almost 20 percent below the design wind speeds required by the current codes.

An analysis of the wind pressures resulting from the actual speeds indicates a disparity between the current code-prescribed design pressures and the pressures predicted from the estimated actual wind speeds. As seen in Chapter 2, the resulting pressures are 25 percent to 40 percent below the current code-prescribed pressures. However, it was notable that the magnitude of the calculated wind pressures based on the estimated wind speed is very similar to the wind pressures and loads calculated using the SBC codes that were in effect from 1985 until the present for the main structural systems. Comparing the pressures calculated for a code event under the SBC codes with the pressures calculated based on the estimated wind speed suggests that structural systems such as wall and roof framing received design level pressures while components and cladding systems such as roof decking, windows, doors, and wall cladding appeared to have been exposed to higher than design level pressures. With the code in effect for 20 years, it is reasonable to expect that a large percentage of buildings in the impacted area had been constructed under that code, and, thus, the damage discussed is consistent with the lower (older) design pressures that were exceeded.

### 3.2.1 Summary of Damage Types

Since the wind loads in Hurricane Ivan were significantly below the current design level and approximately equal to design levels of the past twenty years, one might expect that the buildings in the affected area would have minimal wind damage, but that was not the case. The damage observed appeared to be disproportionate to the wind speeds. The MAT observed the following:

- Wind damage to wall cladding was widespread throughout all building types and sizes. Damage to exterior insulation finish systems (EIFS) and vinyl siding was common.

- Roof coverings of all types were frequently heavily damaged.
- Rooftop equipment was frequently damaged or completely detached as a result of the wind.
- Soffit damage was also observed throughout the entire wind field of the storm.
- Building envelope damage to older buildings was more common than to newer buildings; however, there were still many incidences of substantial damage even to new buildings.

Wind-related structural damage was less widespread than the building envelope damage, but was not uncommon. The MAT observed the following:

- The most common structural damage was loss of light-framed roof structures, primarily in the form of roof sheathing attachment failure, and subsequent damage to framing such as trusses or rafters.
- Another common failure mode was wood framed gable end walls.
- Many pre-engineered metal buildings experienced heavy damage to both the building envelope and to the secondary framing members.
- Cantilevered gas station canopies failed frequently throughout the damage zone.

Older buildings typically experienced more damage than buildings constructed since the adoption of 2001 FBC and 2003 IBC for the following reasons:

- Older building codes' methods did not always result in resistance to high design wind pressures on critical building areas such as corner and wall areas (notable points of failure initiation).
- Even if an older building code was in place, the enforcement of the code may have been ineffective.
- Older buildings may have suffered from degradation of strength due to corrosion, termites, dry rot, poor maintenance, or a variety of other factors.
- Construction methods and materials commonly used at the time the older buildings were built may now be considered inappropriate for a high-wind area.

Some effects of these observations include the following:

- Design wind loads that are too low (due to older methods that have been revised by current codes), which result in members and

connections that are too weak for the winds likely to be encountered at the site

- Fasteners for roof sheathing that are too small or are spaced too far apart
- Undersized or missing strapping to anchor the roof structure to the walls
- Lack of a continuous load at the connection between the walls and the foundations
- Structural design that did not account for unprotected windows and doors, which, when broken or damaged, lead to structural failures due to rapid increases in internal pressure
- Unprotected openings and glazing, which, when broken or damaged, lead to interior damage from wind-driven rain
- Collapse of large doors, leading to damage resulting from increased internal pressure and damage from wind-driven rain
- Corrosion of ties or fasteners used to attach cladding to the structure
- Corrosion of anchors or connectors that attach the building to the foundations or tie structural elements together

The MAT repeatedly observed cases where buildings constructed within the past few years survived the storm relatively unscathed, while older buildings next door or directly across the street sustained significant damage due to rainwater intrusion through damaged roof coverings, damaged soffits, and/or broken windows and doors.

### 3.2.2 Wind Effects on One- and Two-Family Housing

Hurricane Ivan affected a large stock of one- and two-family housing. In Gulf Shores alone there were over 1,400 homes in the barrier island damage zone. The other communities from Gulf Shores to Navarre Beach suffered varying degrees of wind-related damage to houses. The most widespread type of wind damage to homes was building envelope damage. Roof covering damage was the most common type of building envelope damage. All types of roof coverings were affected. Structural wind damage was mainly in the form of light-framed roof framing failures as shown in Figure 3-18. Insufficient attachment of roof sheathing panels to the framing beneath was the most common problem. Gable end wall failures were frequently observed, as were failed connections between the roof and wall members.

**Figure 3-18.**  
Typical wind damage  
showing loss of roof  
sheathing and damage  
to structural roof framing  
(Ono Island)



### 3.2.3 Wind Effects on Multi-Family Housing

Wind damage to multi-family housing varied considerably with construction type. Low-rise, wood-framed condominium buildings suffered the same types of damage as their one- and two-family counterparts, as shown in Figures 3-19 and 3-20. Higher story buildings, typically built of cast-in-place concrete, suffered no wind damage to the primary structural frame. The observed damage was to the building envelope and, in some cases, to structural framing members, such as roof trusses. The common types of high-rise cladding damage were to stucco and EIFS, a popular wall material in the region as shown in Figure 3-21, and to all types of roof coverings.

**Figure 3-19.**  
Typical roof sheathing  
and covering loss  
(Pensacola Beach)





Figure 3-20.  
Typical gable end wall  
failure and loss of roof  
sheathing and wall  
(Perdido Key)



Figure 3-21.  
Typical high rise cladding failure (Perdido Key)

### 3.2.4 Wind Effects on Commercial Buildings

Although the MAT did not focus on commercial buildings, the Team observed several while in the area. The wind damage was consistent with the damage observed in multi-family buildings in that it varied with construction type. Cladding damage was widespread, particularly to EIFS and all types of roof coverings, as seen in Figures 3-21, 3-22, and 3-23. Many pre-engineered metal buildings suffered significant damage to the building envelope and to secondary structural members such as girts and purlins, as seen in Figure 3-24. Steel joist and metal deck roof structures generally fared well. Wood-framed roof structures performed much as they did on residential buildings.

Figure 3-22.  
Commercial building  
roof covering failure  
(Pensacola Beach)



Figure 3-23.  
Commercial building wall  
cladding and secondary  
structure failure  
(Gulf Shores)





Figure 3-24.  
Pre-engineered metal  
building damage  
(Orange Beach)

### 3.2.5 Wind Effects on Critical/Essential Facilities

The MAT focused on the damage and loss of function observed at many critical and essential facilities such as hospitals, schools, and shelters. Damage and resulting loss of function was most often the result of building envelope damage, as seen in Figures 3-25 and 3-26. Rooftop equipment damage was widespread. Little structural wind damage was observed.



Figure 3-25.  
Metal wall panel damage  
to middle school  
(Gulf Breeze)

Figure 3-26.  
Roof covering and roof  
deck damage to middle  
school (Pensacola)



### 3.3 Lessons Learned and Best Practices

Given the hurricane history of the area, several buildings previously visited before Ivan were visited again after Ivan. The MAT team also observed many other situations where prudent siting and construction improved the building performance during Hurricane Ivan. Several of these buildings are described below.

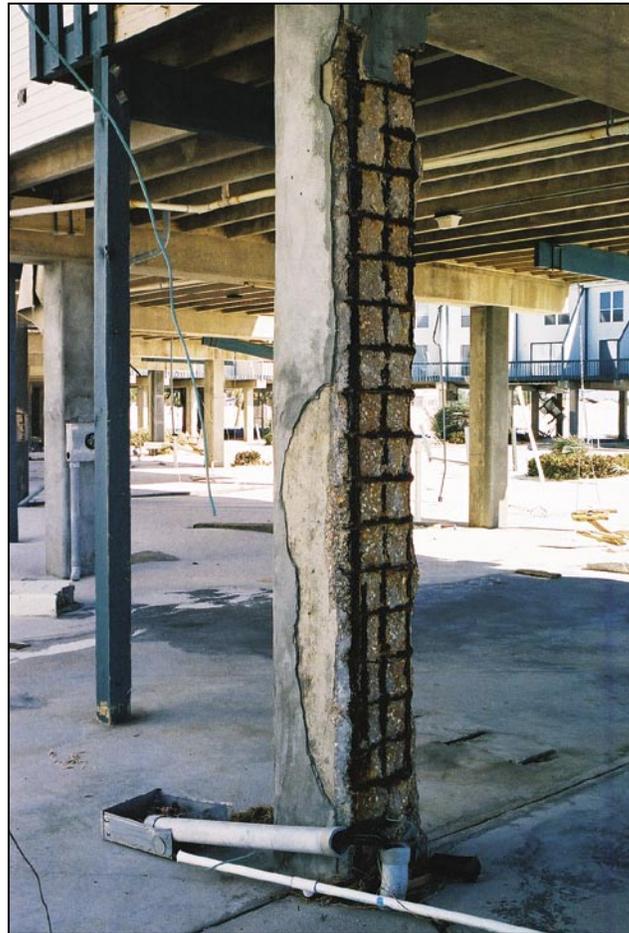
#### Condominium – Gulf Shores, Alabama

One of the best known examples is a U-shaped condominium in Gulf Shores. The original building was elevated on solid walls and was destroyed by surge and wave effects during Hurricane Frederic in 1979 (see Figure 3-27, upper photo). The building was reconstructed after Frederic on an open foundation (concrete columns atop pile caps and deep pilings). Even though the foundation survived Hurricane Ivan (Figure 3-27, lower photo), the MAT team observed significant wind damage and corrosion. Closer inspection (Figure 3-28) revealed the concrete columns elevating the building had been deteriorating for some time (i.e., chloride penetration into the concrete, corrosion of the reinforcing steel, and spalling of the concrete cover), and prior efforts to patch the columns were evident. This points out the need for constructing near the coast with sound, durable materials and high-quality workmanship.



Figure 3-27. After this building was destroyed by Hurricane Frederic in 1979 (upper photo), it was re-constructed on concrete columns, pile caps, and deep piles. The foundation survived Hurricane Ivan; however, the building experienced significant wind damage (lower photo). (Gulf Shores)

**Figure 3-28.** Severe corrosion of reinforcing steel and spalling of the concrete columns supporting the post-Frederic building shown in Figure 3-27. Note evidence of prior attempts to repair the columns.



### Condominium Complex – Pensacola Beach, Florida

Another example of reconstruction using flood-resistant techniques is shown in Figures 3-29 through 3-33. In 1995, Hurricane Opal destroyed one of four low-elevation, masonry and wood-frame buildings comprising a condominium complex at Pensacola Beach (Figure 3-29). The destroyed building was replaced by an elevated building supported on concrete pilings above the BFE, in accordance with the local government's (Santa Rosa Island Authority) freeboard requirements (Figure 3-30). Waves, surge, and wind during Hurricane Ivan severely damaged the remaining three original buildings (Figure 3-31 and 3-32). The newer pile-supported building performed well from a flood perspective (but sustained some wind damage to the roof covering). Ground level breakaway walls, decks, and parking slabs were damaged under the new building, but the foundation and main structure successfully resisted flood and wave effects (Figure 3-33). The ability of the new building to successfully avoid structural damage due to flood forces demonstrates the importance of elevation on a deep pile foundation with breakaway construction below the elevated building.



Figure 3-29.  
Hurricane Opal (1995)  
flood damage to one of  
the four original buildings



Figure 3-30.  
1998 photograph  
showing the post-  
Opal replacement (pile  
supported) building  
(background) and one of  
the three remaining older  
buildings (foreground)

Figure 3-31.  
Post-Ivan aerial  
photograph showing  
severe flood damage to  
two of the three older  
buildings, with newer,  
pile-supported building  
intact (left side)



Figure 3-32.  
Ivan flood and wind  
damage to older building  
(post-Opal building  
visible at far left)





Figure 3-33.  
Hurricane Ivan, non-  
structural enclosure and  
deck damage below  
newer building

### Condominiums – Perdido Key, Florida

The MAT observed 4 condominiums in close proximity to each other on Perdido Key. They are shown in their pre-Ivan condition in Figure 3-34, and after Ivan in Figure 3-35. The lower pairs of buildings in each figure were newer, having been rebuilt after their predecessors (built on shallow foundations) collapsed during Hurricane Georges (1998). The upper pair of buildings (also on shallow foundations) survived Georges but collapsed during Ivan.

The lessons learned in Hurricane Georges served the owners of the bottom pair of buildings well during Ivan. These buildings were re-constructed following Georges with deep-pile foundation systems, and the foundations performed well during Ivan. The building on the left lost the ground floor parking slab as seen in Figure 3-36, and suffered substantial roof covering loss due to wind. The building on the right had a structural parking slab, which was undermined by Ivan but undamaged. The building had only minor cladding damage due to the wind.

**Figure 3-34.**  
Four Orange Beach  
condominiums before  
Hurricane Ivan. The  
lower pair of buildings  
was newer, having  
been constructed after  
the predecessors were  
destroyed by Hurricane  
Georges (1998) (USGS)





Figure 3-35. The four condominiums in Figure 3-34 after Hurricane Ivan. The newer buildings on pile foundations survived, while the older buildings on shallow foundations collapsed. However, the newer building on the lower left experienced significant interior water damage due to roof loss. (USGS)



**Figure 3-36.**  
Deep foundation exposed by erosion, and collapse of undermined parking slab, as shown in the photo on the right.

### Residential Buildings

Figures 3-37 and 3-38 show two residences near Big Lagoon after Ivan: an elevated building constructed to a newer code and an adjacent non-elevated building constructed to an older code. The difference in the performance of each building is apparent. The newer building sustained only non-structural flood damage at grade level, with no apparent wind damage to the roof or building envelope (the building performed as expected). The older building was severely damaged by flood and wind forces. This comparison demonstrates the importance of building elevation and wind-resistant design.



Figure 3-37.  
Elevated building  
constructed to newer  
code that survived  
Hurricane Ivan (Big  
Lagoon)



Figure 3-38.  
Older, non-elevated  
building (near building  
in Figure 3-37) severely  
damaged in Hurricane  
Ivan (Big Lagoon)

As discussed throughout this report, elevating a house on piles to the minimum standards and preferably several feet higher can prevent significant damage. Figure 3-39 shows an older house with a slab-on-grade foundation that was not elevated to the current BFE and that sustained considerable damage from Hurricane Ivan's high storm surge and debris impacts. Figures 3-40 and 3-41 show two houses located in the same general area as the house shown in figure 3-39, but, because they were elevated on piles to higher standards, they sustained minimal flood damage.

**Figure 3-39.**  
House on La Paz Street  
that was not elevated to  
the current BFEs, and,  
therefore, was severely  
damaged by the high  
coastal flooding and  
wave impacts



**Figure 3-40.**  
House on La Paz Street  
that was elevated on  
piles, which prevented  
severe damage from  
coastal flooding





Figure 3-41.  
House on La Paz that  
was elevated on piles,  
which prevented major  
flood damage

Following Hurricane Ivan, Alabama homeowners with houses constructed to standards exceeding the adopted building code were rewarded with significantly less damage. The higher building standards, contained in the IRC and IBC, require far stronger framing, connections, walls and roofs that will withstand winds up to 140 mph. The homeowner of the surviving house shown in Figure 3-42 constructed the house on Orange Beach to the new code, before the town adopted the IRC and IBC in June 2004. As a result, the house had virtually no damage, although numerous houses nearby had significant damage or were destroyed. Figure 3-42 demonstrates the contrast between a house destroyed by wind and flood forces and a house that survived because it was built to the new code.



Figure 3-42.  
The surviving house  
was built to incorporate  
the provisions of the  
new building code (IRC,  
IBC) even before it was  
adopted. (Orange Beach)