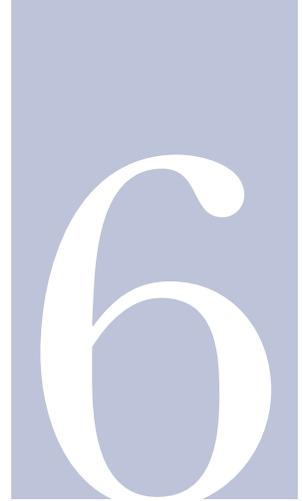


Performance of Critical and Essential Facilities



Critical and essential facilities are needed to lead and manage response and recovery operations during and/or after an event. Hurricane Ivan had a significant impact on critical and essential facilities. Though all of the buildings were subjected to winds that were below design conditions, the overall performance of the buildings the MAT observed was poor. The poor building performance placed additional burden on response and recovery personnel as they endeavored to provide assistance to their communities after the event. According to the 2003 IBC (Section 1604, Table 1604.5) and the 2001 FBC (Section 1606, Table 1606), critical and essential facilities include, but are not limited to, hospitals (and other medical facilities), fire and police stations, primary communication facilities, disaster (emergency) operations centers, and power stations and other utilities required in an emergency. Schools are also listed in the IBC, but not the FBC. Because of the poor performance and reported damage to these facilities, the MAT assessed numerous facilities to document the damage and loss of function.

Critical and essential facilities that were damaged include an EOC/police station, jails, hospitals, schools, and shelters. Most damage was to envelope systems, though a few structural failures did occur (see Chapter 5 for photographs and discussion of envelope damage). Most of the damage was to older facilities; however, some newer facilities also experienced failure. Except for occasional shattering of glazed openings, the investigated buildings did not appear to have been designed and constructed with wind-resistance enhancements to the building envelope and rooftop equipment.

The MAT observed minimal damages at several jail and fire station facilities. This consisted of minor damage to coping, edge flashing, and canopies, and loss of fan cowlings – none of which caused any significant functional disruption. Maintaining operation of the jails avoided transporting and housing inmates in other facilities and avoided placing additional burdens on law enforcement personnel. Maintaining operation of the fire stations avoided disruption of emergency response capability. However, all three of the fire stations that were observed by the MAT were older pre-engineered metal buildings. Had wind speeds been closer to a current design event, all three of these buildings would have likely suffered major damage to the sectional doors and/or the metal roof panels (see *Mitigation Assessment Team Report, Hurricane Charley in Florida*, FEMA 488 for a discussion of fire station performance in Hurricane Charley).

The MAT did not observe any critical or essential facilities located in areas affected by flooding. By being located outside of floodprone areas, these critical and essential facilities were able to provide community services without interruption due to flooding.

6.1 Emergency Operation Centers

EOCs are key buildings in preparing for and responding to an event from both local and state levels. The MAT observed only one EOC, which was located in the basement of the Escambia County Sheriff's Office (in Pensacola). This facility experienced several building envelope problems. However, although rainwater entered the building, it did not disrupt the EOC operations.

6.1.1 General Damage

The original building had two floors above grade. A new two-story addition was joined to the original building. Construction of the addition was essentially complete when Hurricane Ivan struck. A large roof membrane blow-off was experienced in one area (Figure 6-1). The damaged membrane was a BUR with a field-applied mineral surfacing over light weight insulating concrete (LWIC). The LWIC was likely installed over a structural concrete deck. Although the rooftop equipment was inadequately attached on both the original and new portions of the building, the equipment was likely damaged by windborne roof debris rather than wind pressure. The modified bitumen roof membrane on the new addition was also damaged. The membrane lifted and tore at a roof drain and the base flashing at the

parapet was displaced. A portion of the coping was also displaced. Some of the windows on the original building were shuttered, but some were not – at least one window was broken (likely by windborne debris). A portion of the LPS on the new addition was dislodged.



Figure 6-1. General view of the roof membrane and rooftop equipment damage at the Escambia County Sheriff's Office/EOC. The roof at the upper right is on the new addition. The mineral surfaced BUR landed on an aggregate surfaced BUR. (Pensacola)

6.1.2 Functional Loss

Some rainwater was able to enter the building at damaged rooftop equipment, but it was apparent that the roof deck was preventing major roof leakage in areas where the roof membrane blew off. Although the cost to repair the envelope and rainwater damage on the original and new portions of the building is significant, the EOC was able to continue functioning during and after the hurricane.

Six days after the hurricane struck, emergency repairs had not been made to the roof and open ductwork on this important facility. Demands for repair crews are enormous in the aftermath of a hurricane like Ivan. To ensure priority service, it is prudent for owners of critical and essential facilities to have pre-established agreements with contractors to perform emergency inspection and repair if needed.

6.2 Hospitals

A hospital in Gulf Breeze and all four hospitals and a psychiatric-care hospital in Pensacola were observed. All experienced building envelope problems. Though none of the hospitals were taken out of service, the envelope damage placed significant burdens on several of the facilities.

6.2.1 General Damage

Buildings at four of the five hospital complexes experienced roof membrane damage – damage was significant at three of the facilities. Windows were broken at four of the complexes, with significant damage at one of them. EIFS blew off the walls at two complexes. At both complexes, the EIFS failures resulted in disruption of elevator service (see Figures 5-15 and 5-16). At one of the complexes, the EIFS failure resulted in significant glazing damage (see Figures 5-16 and 6-2). Rooftop equipment and LPSs were damaged at four of the complexes. Communications towers and antennas were damaged at two complexes. A loading dock canopy was blown away and several tall parking lot light fixtures collapsed at one complex. Sewage backed up in a cancer treatment facility because of power loss to a lift station. Tree-fall caused roof damage to a materials management building (an ancillary building at one complex).

Figure 6-2.
View of EIFS damage
at hospital building
(Pensacola)



6.2.2 Functional Loss

The damage described above placed burdens on hospital staffs and took portions of some of the facilities out of service. However, all six hospitals were able to continue to provide care. The following is a synopsis of the major disruptions:

- At the Pensacola Naval Hospital complex, two patient floors were taken out of service because of minor rainwater leakage due to roof membrane blow-off from a large portion of the roof (Figures 6-3 and 6-4). The concrete roof deck was effective in minimizing leakage. The modified bitumen membrane had been installed over polyisocyanurate insulation mopped to the concrete deck. The blow-off was initiated by lifting and peeling of the metal edge flashing, or lifting of the wood nailers that the edge flashing was attached to, or by debonding of an insulation board from the deck. Debris from the roof broke several of the second and third floor windows (including some glazed with tempered glass) (Figure 6-4). Roof debris also damaged several antennas (Figure 5-80).



Figure 6-3. General view of upper roof of the Pensacola Naval Hospital. Note the missing insulation boards near the corner of the roof. (Pensacola)

Figure 6-4.
View of a portion of the lowest floor roof showing broken 2nd and 3rd floor windows and debris from the roof above shown in Figure 6-3



- At one hospital complex, a portion of the surgical suite and the intensive care unit was taken out of service during the hurricane due to rainwater infiltration. Sewage disposal was interrupted due to lack of power at a lift station – waste was bagged. This interruption was of short duration.
- At one hospital, elevator service at the MOB was interrupted due to rainwater infiltration at the elevator penthouse due to EIFS blow off (see Figure 5-15). The MOB was connected to the hospital. Sewage disposal was interrupted due to lack of power at a lift station. This interruption was of short duration.
- At one hospital complex there were numerous disruptions. Communications were lost about an hour after arrival of high winds. EIFS failure caused extensive glazing damage and disruption of elevator service. Glass shards fell and punctured the roof membrane over a regional dialysis unit and urgent care facility. However, the roof deck (concrete topping over steel decking) minimized rainwater infiltration. Emergency repairs were made, and the unit was opened after being out of operation for only one day. Rainwater from a punctured roof membrane entered a portion of the surgical suite. Sewage back-up disrupted the cancer treatment facility for one day. Loss of the canopy at the loading dock hampered materials handling. Quick and aggressive emergency repairs were responsible for minimizing the impacts of the service interruptions at this facility.

- At one hospital complex, a very large piece of HVAC equipment blew off the MOB roof (see Figure 5-73). Extensive rainwater damage occurred on the floor below. An emergency generator was brought in to run fans to dry out the facility.

6.2.3 Best Practices – Hospitals

Though all of the hospitals had to cope with building performance problems, there were observed successes and best practices that contributed to minimal damage, particularly in terms of operational actions:

- Shutters. Some of the buildings had shutters over lower-level windows. No shutter breaches were observed.
- Relocation of patients. At one hospital, patients were moved into the corridors in case patient room windows were broken. This practice may have been employed at other hospitals, although at one of the hospitals, a patient was in a room when a window broke. If patient room windows are not impact resistant or protected by shutters, moving patients out of the rooms during a hurricane appears to be a prudent practice.
- Satellite dish. At one hospital, satellite dishes were removed from their support stands and placed inside a penthouse prior to the hurricane. Had this action not been taken, the dishes would likely have been blown away and perhaps caused damage to the facility. An antenna that was not needed during the hurricane was also taken down.
- Damage response. One hospital experienced significant building problems; however, the hospital quickly mobilized contractors and cleaning crews. Quick action brought the cancer therapy facility and regional dialysis back online within a day, so those vital services were only minimally impacted. The rapid damage response also likely minimized rainwater damage costs. Rapid response was also observed at some of the other hospitals.

6.3 Schools

The MAT observed 13 schools, including elementary, middle, and high schools. In addition to their traditional role as educational facilities, schools often play an important role in providing space for sheltering, emergency response, and recovery after a hurricane. Thus, their loss of use can greatly impact a community's ability to rapidly respond to the needs of disaster victims. See Section 6.4 for additional discussion on schools used as shelters.

6.3.1 General Damage

A limited amount of structural damage was observed. It consisted of collapsed walkway canopies at a few schools (Figures 4-98 and 6-5), loss of a portion of wood joists and roof decking at one school, loss of roof decking at one school (Figure 6-6), loss of an auto shop roof structure and portion of a CMU load-bearing wall (Figure 6-7), and loss of roof joists and collapse of CMU walls at an HVAC chiller enclosure. At three of the schools that experienced structural damage, portions of the schools were used as shelters. However, the structural damage did not occur where people were sheltered.

All of the observed schools experienced building envelope damage, with damage to roof coverings and rooftop equipment being the most common problem. Other observed damage included soffit damage, metal wall panel damage, and the collapse of a non-load bearing brick wall.

Figure 6-5.
Walkway canopy
collapse at Bellview
Middle School. Stronger
winds could have turned
the debris into lethal
missiles. (Pensacola)



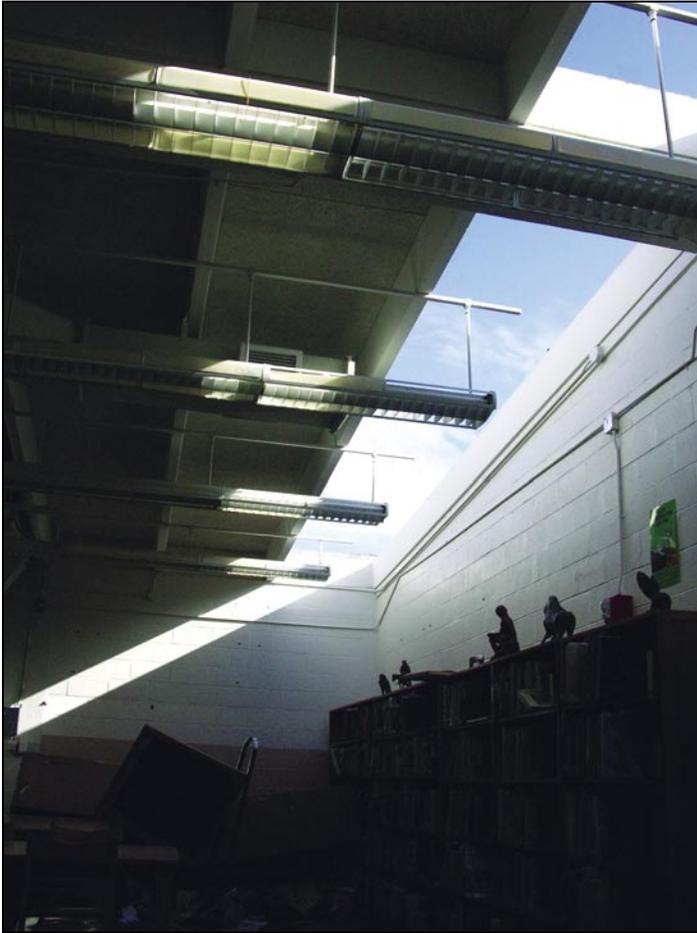


Figure 6-6.
Loss of cementitious wood-fiber roof deck panels at Workman Middle School (Pensacola)



Figure 6-7.
Loss of the roof structure and rear portion of the CMU load-bearing wall at the George Stone Career Center auto shop (Pensacola)

6.3.2 Functional Loss

Many of the observed schools experienced widespread rainwater damage due to breached building envelopes, which resulted in disruption or loss of school operations. In some cases, such as that shown in Figure 5-71, the envelope damage was minor, but lack of quick emergency repairs allowed significant rainwater to subsequently enter the building.

6.4 Shelters

Shelters can be defined in many ways depending on their use. A shelter is a place where people go to take refuge during an event (often called storm shelters) or to recover when they cannot return to their homes immediately after an event due to widespread storm damage. For the purposes of this report, the term “shelters” refers to storm shelters or buildings where people went to take refuge from the winds and surge during Hurricane Ivan. The MAT assessed the performance of some of these storm shelters to document how these essential facilities performed.

Further, because portions of several school buildings evaluated by the MAT were designated as storm shelters, damages to schools in some communities led to loss of use of shelters that could protect residents from injury during subsequent hurricanes. The loss of use of schools that function as storm shelters is particularly difficult for smaller communities where they often serve as convenient places to provide recovery assistance to residents in the days and weeks immediately after a disaster event.

For a discussion of the Florida Statewide Emergency Shelter Plan (SESP), see Chapter 6 in *Mitigation Assessment Team Report, Hurricane Charley in Florida*, FEMA 488.

6.4.1 General Damage

The MAT observed six shelters, five of which were schools. The other shelter was the Pensacola Civic Center (a large arena). Structural damage consisted of collapse of canopies at three of the schools (Figure 6-5), blow off of roof deck panels at one school (Figure 6-6), and damage to a stand-alone auto shop at the backside of one school (Figure 6-7). All five of the schools had roof covering damage, with the damage being significant at three of the buildings. One of the schools had an

aggregate surfaced BUR. A substantial amount of aggregate was blown off and, subsequently, broke windows in one or more vehicles. Metal wall panels were blown off one of the schools and the Civic Center. Rooftop equipment was blown off of two schools and the Civic Center; a large fan from the Civic Center crushed an unoccupied car.

6.4.2 Functional Loss

Pensacola Civic Center had an occupant load of approximately 1,600 to 2,000 people at the time Hurricane Ivan struck. Five pieces of rooftop equipment over the arena floor were blown off. (For information on the roof membrane damage caused by the equipment blow off, see “Withstanding Hurricane Ivan” in the February 2005 issue of *Interface* (published by the Roof Consultants Institute).

However, the wind speeds quoted in the article are incorrect. As an added safety measure, people were moved out of the arena into peripheral areas of the facility before the high winds arrived. Thus, although rainwater entered the arena, people were not left exposed. Portable toilets were placed within the arena area prior to the hurricane. That proved to be prudent, for the center lost sewage service due to lift station power failure.

The Jim C. Bailey Middle School (built in 1995) was used as a shelter. Rainwater entered the building in several different areas where asphalt shingles, underlayment, rooftop equipment, and metal wall panels were blown off (Figure 6-8). The shingles were attached with only four nails instead of six, which the roofing industry recommends in high wind areas. The nails were incorrectly located (they were too high and at one of the shingles, an end nail was 2 ½ inches rather than 1 inch from the end). People were moved from one portion of the building to another to escape the rainwater leakage.

Figure 6-8.
Loss of asphalt shingles and underlayment at the Jim C. Bailey Middle School. Note the displaced wall panels at the upper left and the missing panel in the lower right.
(Pensacola)



The Workman Middle School sheltered approximately 25 people, including about 10 police officers who came in from patrol shortly before arrival of the high winds. Although a portion of the school complex experienced structural damage (Figure 6-6), no injuries were reported. Occupants took shelter in a newer building on campus that did not experience structural failure. As shown in Figure 3-26, a substantial amount of windborne debris (primarily roofing and canopy components from the school) was airborne in this area.

All of the shelters observed by the MAT experienced blow-off of building components. When building components are blown off there is a risk that people arriving at a shelter during the hurricane may be injured or killed. For this reason, buildings selected for shelters should be designed and constructed to avoid loss of components. Items particularly susceptible to blow-off include aggregate roof surfacing. Roof coverings and rooftop equipment were also susceptible if adequate attention was not given to wind-resistant design and construction.

At the time of the MAT observations (six days after the hurricane), none of the five schools were being used. Some of the schools had too much rainwater damage to be of service.