



# *Hurricane Opal in Florida*

A BUILDING PERFORMANCE ASSESSMENT



FEDERAL EMERGENCY MANAGEMENT AGENCY  
MITIGATION DIRECTORATE

# *The Building Performance Assessment Team Process*

In response to hurricanes, floods, earthquakes, and other disasters, the Federal Emergency Management Agency (FEMA) often deploys Building Performance Assessment Teams (BPATs) to conduct field investigations at disaster sites. The members of a BPAT include representatives of public sector and private sector entities who are experts in specific technical fields such as structural and civil engineering, building design and construction, and building code development and enforcement. BPATs inspect disaster-induced damages incurred by residential and commercial buildings and other manmade structures; evaluate local design practices, construction methods and materials, building codes, and building inspection and code enforcement processes; and make recommendations regarding design, construction, and code issues. With the goal of reducing the damage caused by future disasters, the BPAT process is an important part of FEMA's hazard mitigation activities.

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## *About the Cover*

THIS PHOTOGRAPH WAS TAKEN ALONG THE GULF COAST IN THE CITY OF PENSACOLA BEACH, FLORIDA, AFTER THE PASSAGE OF HURRICANE OPAL. IN THE FOREGROUND ARE THE REMAINS OF A STRUCTURE BUILT BEFORE THE CITY ADOPTED THE FLOODPLAIN MANAGEMENT ORDINANCE REQUIRED FOR PARTICIPATION IN THE NATIONAL FLOOD INSURANCE PROGRAM (NFIP). THE STRUCTURE IN THE BACKGROUND WAS BUILT AFTER THE ADOPTION OF THE REQUIRED ORDINANCE AND WAS THEREFORE REQUIRED TO MEET NFIP STANDARDS FOR CONSTRUCTION IN THE COASTAL HIGH HAZARD AREA. THE DRAMATIC DIFFERENCE BETWEEN THE POST-STORM CONDITIONS OF THESE TWO STRUCTURES UNDERSCORES THE IMPORTANCE OF PROPER CONSTRUCTION IN COASTAL AREAS SUBJECT TO HURRICANES.

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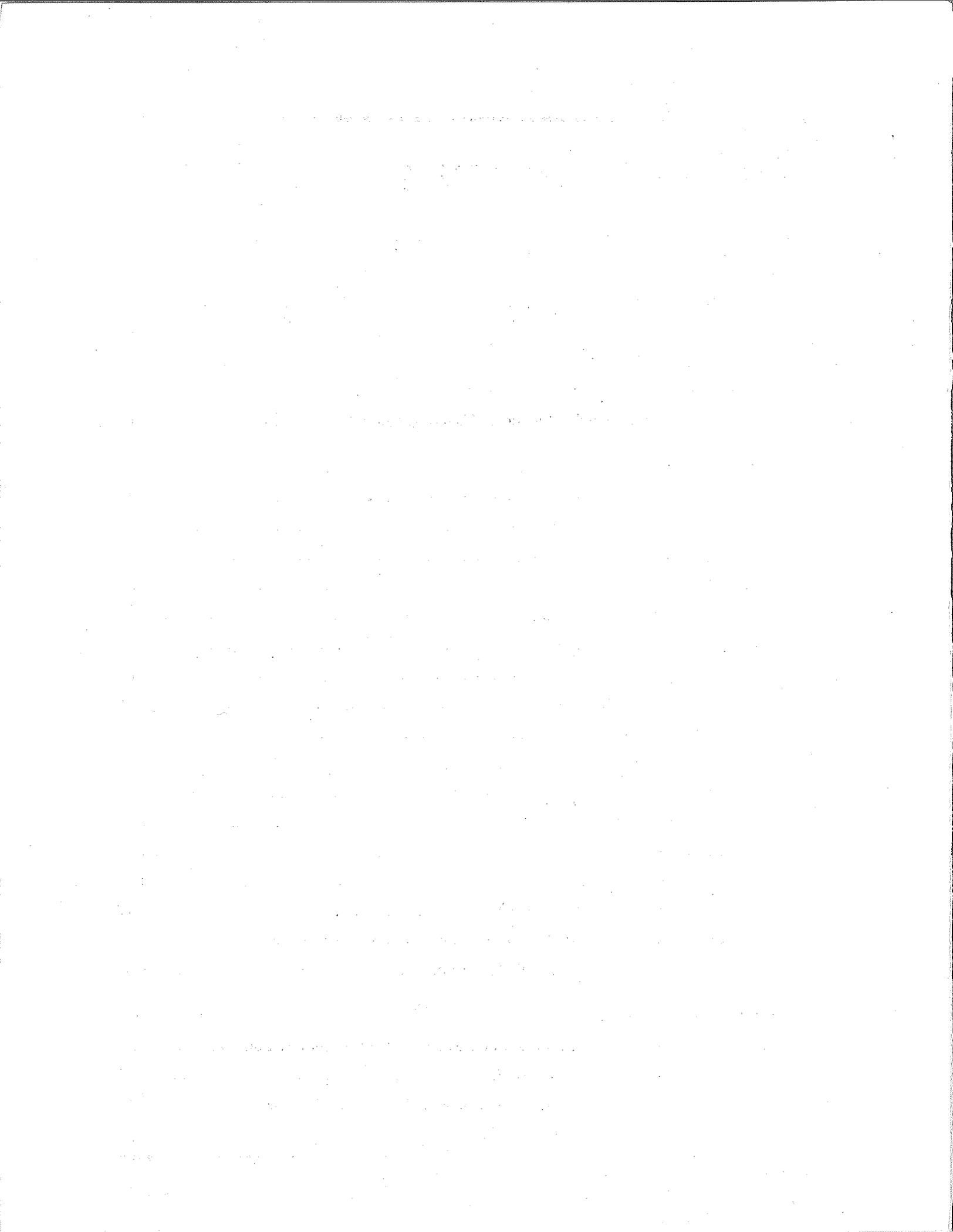
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*August 30, 1996*



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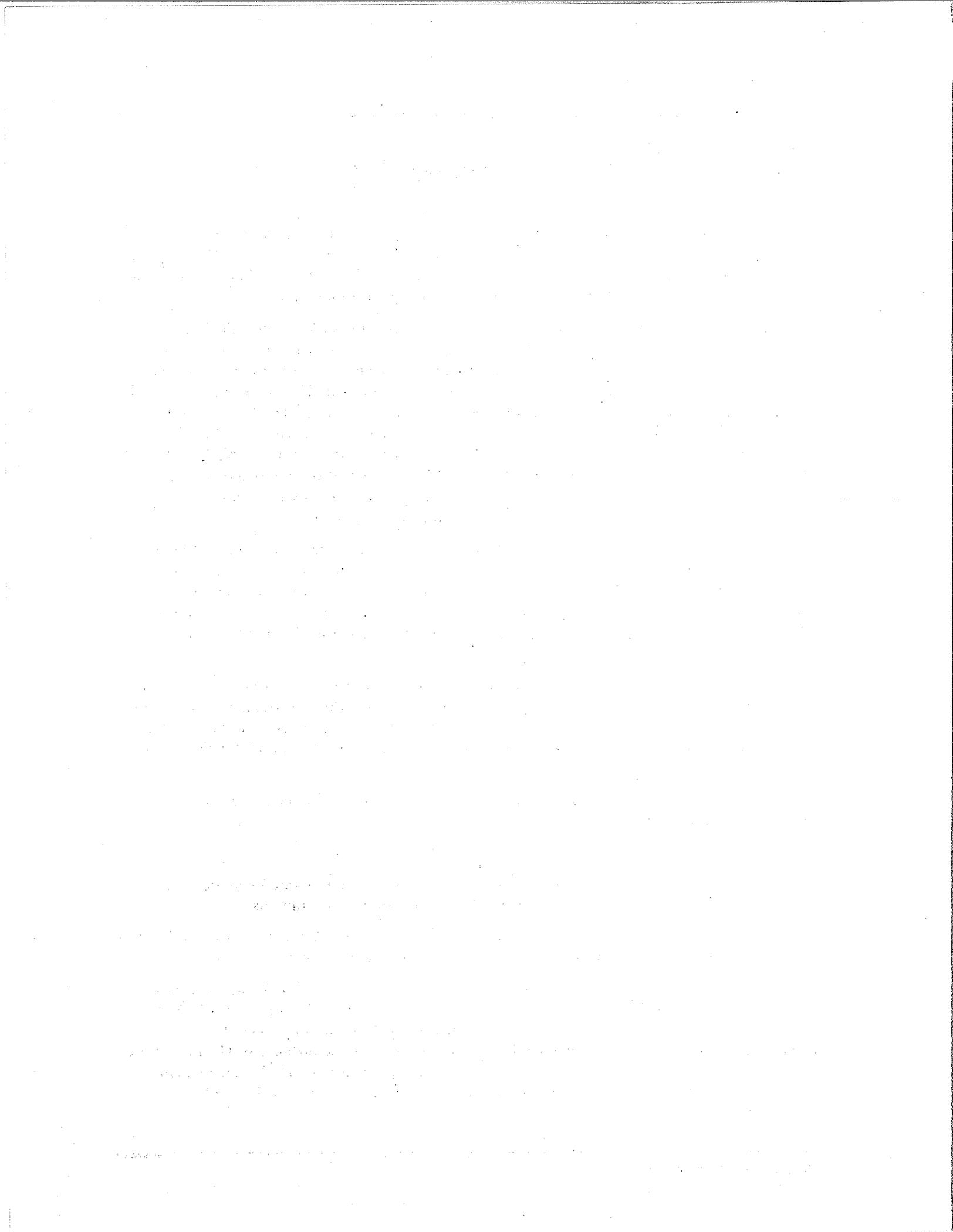
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# *Executive Summary*

On October 4, 1995, Hurricane Opal made landfall on Santa Rosa Island, Florida, near Navarre Beach, at approximately 6:00 p.m. c.d.t. (central daylight time.) As a result of the damage caused by Hurricane Opal, President Clinton declared 15 counties in the Florida Panhandle and Lee County, on the southwest Florida coast, Federal disaster areas (see Figure 1-1).

The Federal Emergency Management Agency (FEMA) deployed a Building Performance Assessment Team (BPAT) whose mission was to evaluate structural damage and recommend mitigation measures that will enhance the performance of buildings in future storms. The team was composed of engineers and building construction specialists from FEMA, the State of Florida, and the private sector (see the Appendix for a list of the team members). The BPAT conducted its evaluation in the area where most of the severe damage was concentrated: along a 200-mile stretch of Florida's Gulf of Mexico shoreline, between Pensacola Beach, in Escambia County, and St. Joseph Spit, in Gulf County (see Figure 1-1). The BPAT's observations focused on the performance of buildings during the hurricane, including both successes and failures. These observations and the BPAT's recommendations are documented in this report.

Preliminary estimates by the insurance industry indicate that Opal may be one of the most costly natural disasters to affect the United States (ranking only behind Hurricane Andrew; the Northridge, California, earthquake; and Hurricane Hugo). According to State of Florida estimates, more structures were damaged or destroyed by the effects of flooding and erosion during Hurricane Opal than in all other coastal storms affecting Florida in the past 20 years combined.

Most of the structural damage associated with the storm appeared to have been caused by coastal flood forces — storm surge, wind-generated waves, flood-induced erosion, and floodborne debris. Wind damage along the coast was confined primarily to roof damage, sign damage, tree damage, and similar impacts and was judged by the BPAT to be less severe and less extensive than flood damage.

Construction along and near the shoreline in the study area was generally governed by one or more of the following:

- The Standard Building Code, enforced by local or county governments
- National Flood Insurance Program (NFIP) construction requirements — in identified Special Flood Hazard Areas — enforced by local or county governments
- State construction requirements for structures seaward of the Coastal Construction Control Line, enforced by the Florida Department of Environmental Protection

To participate in the NFIP, a community must adopt and enforce a floodplain management ordinance based on the Flood Insurance Rate Map (FIRM) issued for the community by FEMA. The communities in the study area include structures built before the adoption of the floodplain management ordinance and structures built after the adoption of the ordinance. The former are referred to as "pre-FIRM" structures, the later as "post-FIRM." Typical pre-FIRM structures in the study area are one-story concrete block or wood-frame structures built on slab-on-grade

foundations, one- to three-story concrete block structures, and one- to three-story wood-frame structures founded on timber piles. Many of these structures were behind concrete sheetpile seawalls. Typical post-FIRM structures in the study area are one-, two-, and three-story wood-frame structures elevated on timber or concrete pile foundations. Post-FIRM structures, although sustaining damage, performed much better than the pre-FIRM structures.

## **FLOOD DAMAGE AND VULNERABLE COMPONENTS**

Because most of the structural damage observed by the BPAT along the Gulf of Mexico shoreline appeared to have been caused by flood forces rather than wind forces, the team focused on flood-induced damage. The observations of the team presented in this report address following issues:

- storm-induced erosion and scour
- debris flow and impact
- slab foundations
- pile and pier foundations
- framing systems
- connections
- bracing
- breakaway construction and enclosures below elevated buildings
- stairs, decks, and porches
- utilities
- seawalls
- drainage and drainage structures

Other issues discussed in this report include (1) the incorporation of pre-FIRM construction into new construction during the improvement of existing structures and (2) structures that appear to have been built without the aid of detailed plans prepared by a design professional. The BPAT found that poor workmanship frequently accompanied the lack of professional design in such instances.

## **RECOMMENDATIONS**

The BPAT developed recommendations that address observed damages and vulnerabilities for both new construction and substantial improvements to existing structures in areas subject to coastal and hurricane storm forces. These recommendations include the following:

- Restudies and FIRM revisions now underway for the affected communities will use updated V-Zone mapping procedures and may result in more extensive areas being shown as V-Zones. Consequently, until such time as revised FIRMs are completed, the affected communities should consider studying local coastal flooding conditions that occurred during Hurricane Opal to determine whether areas shown as coastal A-Zones on the current FIRMs, as well as areas within several hundred feet of the Gulf of Mexico shoreline, are actually subject to V-Zone flood forces. If such areas are identified, the affected

communities should strongly encourage the owners of new construction and substantial improvements to existing structures within those areas to conform with V-Zone construction standards. In addition, if areas shown as A-Zones on the current FIRMs are determined to be subject to V-Zone forces, the BFEs shown for those areas are likely to increase. Therefore, communities should also strongly encourage the owners of new construction and substantial improvements to existing structures in such areas to construct the lowest floors of their structures several feet above the BFEs shown on the current FIRMs.

- For all areas known to be subject to high-velocity wave action, strong currents, erosion, or combinations thereof — regardless of flood zone designation — the embedment depths specified for pile foundations should be sufficient to ensure that the foundation will withstand anticipated erosion and storm forces. Foundations for masonry columns should be designed to withstand all anticipated flood, erosion, debris, and wind forces. Shallow footings should not be used to support masonry columns where the risk of undermining exists.
- In areas subject to storm-induced erosion, regardless of the flood zone designation, any slabs serving as floors for habitable spaces should be designed and constructed as structural slabs, to withstand all anticipated erosion, scour, and storm forces, and attached to sufficient foundation systems that do not rely on underlying soil for support.
- In areas subject to storm-induced erosion, regardless of the flood zone designation, slabs used solely for parking should not be attached to structural members and should be designed and constructed to break into small pieces in the event of undermining, thereby minimizing potential transfer of flood loads to the structure.
- All materials should meet or exceed the minimum requirements for building materials in the Standard Building Code and FEMA's Technical Bulletin 2-93, *Flood-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas* (FEMA 1993b).
- Repairs of damaged structures should be completed in accordance with applicable Federal, State, and local codes and regulations and should be inspected to ensure conformance with building codes and floodplain management requirements.
- Engineered plans signed and sealed by a registered design professional should be provided for both new construction and substantial improvements to existing structures in areas subject to coastal storm forces. Siting and construction in 100-year coastal flood hazard areas must meet (and, if possible, exceed) setback and elevation requirements.

This report includes photographs taken by the BPAT during the site visit. Also included are engineering design drawings that provide details which can be used to enhance building performance under hurricane and coastal flood conditions.