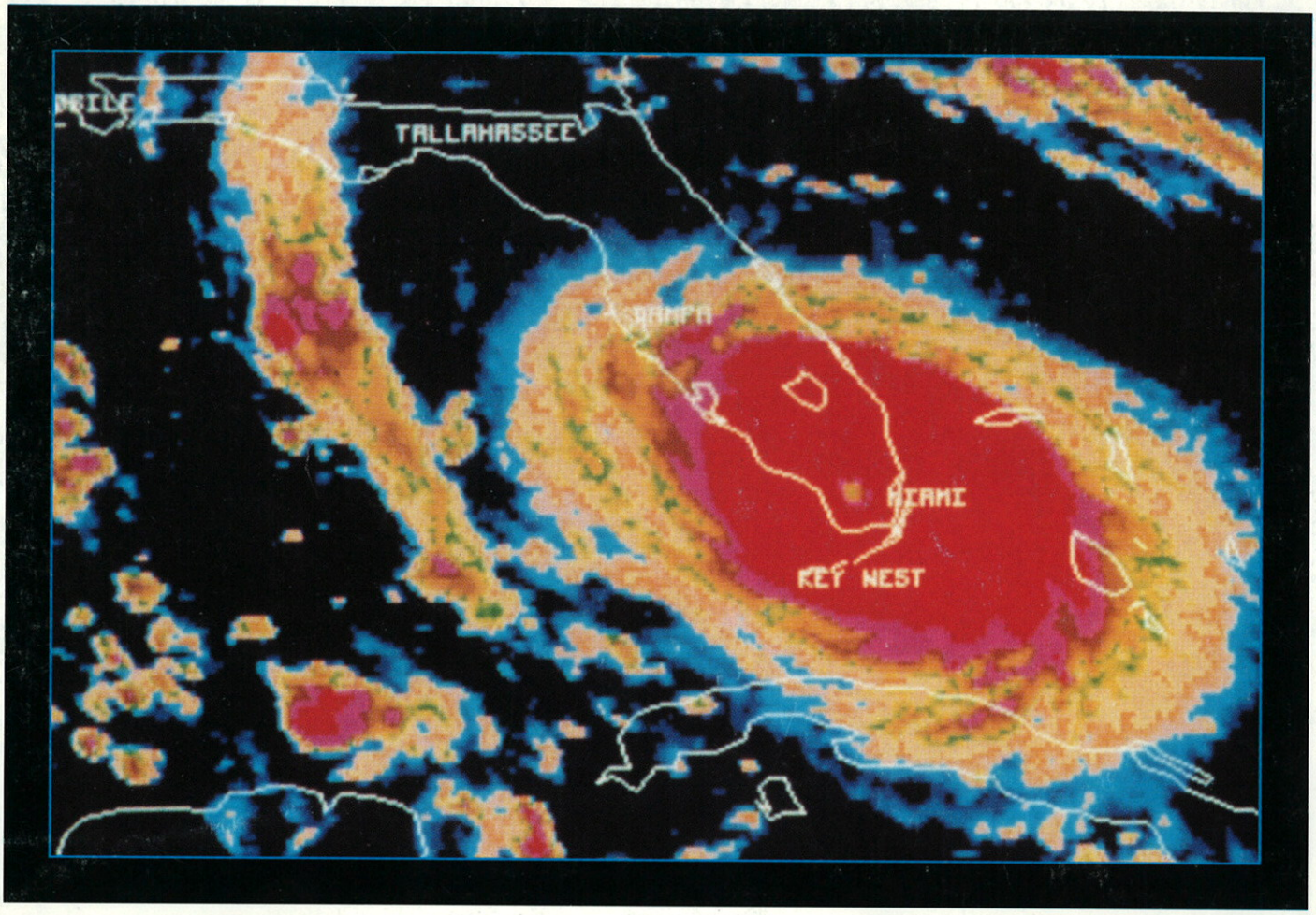

BUILDING PERFORMANCE: HURRICANE ANDREW IN FLORIDA

OBSERVATIONS, RECOMMENDATIONS, AND TECHNICAL GUIDANCE

FEDERAL EMERGENCY MANAGEMENT AGENCY
FEDERAL INSURANCE ADMINISTRATION

FIA–22
(2/93)

COVER PHOTO:

HURRICANE ANDREW, AUGUST 24,1992
Courtesy of the National Oceanic and Atmospheric Administration, National Weather Service

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DECEMBER 21, 1992

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EXECUTIVE SUMMARY

On August 24, 1992, Hurricane Andrew struck southern Dade County, Florida, generating high winds and rain over a vast area of the county. Although the storm produced high winds and high storm surge, the effects of storm surge and wave action were limited to a relatively small area of the coastal floodplain. It was evident from the extensive damage caused by wind, however, that wind speeds were significant.

In September 1992, the Federal Emergency Management Agency's (FEMA's) Federal Insurance Administration (FIA), at the request of the FEMA Disaster Field Office staff, assembled a Building Performance Assessment Team. The team consisted of FEMA Headquarters and Regional staff, professional consulting engineers, and a Metro Dade County building official. (See Exhibit I for a list of team members.) FIA was tasked because of its extensive experience in assessing building damage caused by hurricanes. The task of the team was to survey the performance of residential buildings in the storm's path and to provide findings and recommendations to both the Interagency Hazard Mitigation Team and the Dade County Building Code Task Force. The basis for performing the survey is that better performance of building systems can be expected when causes of observed failures are corrected using recognized standards of design and construction. Collectively, the team has invested over 1,500 man-hours of effort conducting the site survey, preparing documentation, and assessing damages. Documentation of findings made during ground level and aerial surveys included field notes, photographs, and videotaping.

In conducting its survey, the assessment team investigated primary structural systems of buildings, i.e, systems that support the building against all lateral and vertical loads experienced during a hurricane. The building types observed were one- and two-story light wood-frame, masonry wall, combination masonry first floor with light wood-frame second floor, wood-frame modular, and manufactured homes. In general, it was observed that masonry buildings and wood-frame modular buildings performed relatively well.

In addition, the performance of the exterior architectural systems, such as roofing, windows, and doors was analyzed. The analysis included the effects of debris and the quality of construction workmanship. The breaching of the building envelope by failure of openings (e.g., doors, windows) due to debris impact was a significant factor in the damage to many buildings. This allowed an uncontrolled buildup of internal air pressure that resulted in further deterioration of the building's integrity. Failure of manufactured homes and other metal-clad buildings generated significant debris. Numerous accessory structures, such as light metal porch and pool enclosures, carports, and sheds, were destroyed by the wind and further added to the debris.

The loss of roof material and roof sheathing and the failure of windows and doors exposed interiors of buildings to further damage from wind and rain. The result was significant damage to building interiors and contents that rendered many buildings uninhabitable.

Field observations concluded that the loss of roof cladding was the most pervasive type of damage to buildings in southern Dade County. To varying degrees, all of the different roof types observed suffered damage due to the failure of the method of attachment and/or material, inadequate design, inadequate workmanship, and missile (debris) impact.

Much of the damage to residential structures also resulted from inadequate design, substandard workmanship, and/or misapplication of various building materials. Inadequate design for load transfer was found to be a major cause of the observed structural failures of buildings. In adequately designed buildings, the load transfer path is clearly defined. Proper connections between critical components allow for the safe transfer of loads that is required for structural stability. Where high-quality workmanship was observed, the performance of buildings was significantly improved.

Inadequate county review of construction permit documents, county organizational deficiencies such as a shortage of inspectors and inspection supervisors,

and the inadequate training of the inspectors and supervisors are factors that may have contributed to the poor-quality construction observed.

The assessment team developed recommendations for reducing future hurricane damage such as that resulting from Hurricane Andrew. Recommendations included areas of concern such as building materials, construction techniques, code compliance, quality of construction, plan review, inspection, and reconstruction/retrofit efforts. The recommendations presented in this report may also have application in other communities in Florida.

This report presents the team's observations of the successes and failures of buildings in withstanding the effects of Hurricane Andrew, comments on building failure modes, and provides recommendations for improvements intended to enhance the performance of buildings in future hurricanes. Before this final report was printed, it was reviewed by other offices within FEMA. The substantive review comments received are presented in Appendix C.