

1 Introduction

This revised edition of FEMA 85 provides new recommendations for manufactured home foundation design and installation. The initial 1985 edition of FEMA 85 provided guidance on installation methods designed to make manufactured homes less susceptible to damage caused by flood and wind events. Significant advances in design and construction technologies, mitigation strategies, and regulatory requirements since 1985 have all contributed to the need for updated guidance.

1.1 Purpose and Scope of the Guide

Like the original guide, this updated version of FEMA 85 focuses primarily on the installation and foundation requirements for manufactured homes in floodplains for communities participating in the National Flood Insurance Program (NFIP). However, it also addresses other natural hazards such as high winds and earthquakes.

The purpose of the second edition of FEMA 85 is to provide guidance for the design and construction of alternative foundation systems as described in the HUD *Model Manufactured Home Installation Standards* (24 CFR 3285). It is important to recognize that both the U.S. Department of Housing and Urban Development (HUD) and the NFIP require that foundation systems for manufactured homes located in Special Flood Hazard Areas (SFHAs) prevent flotation, collapse, or lateral movement of the structure (24 CFR 3285.302 and 44 CFR 60.39(a)(3), respectively).

The manufactured housing industry has adopted the term “community” for manufactured home developments. However, the term “park” is used in the NFIP and is also used in this publication.

With its broad and comprehensive scope, this document provides guidance on siting and installing manufactured homes in areas exposed to natural hazards. The guide is organized into 10 chapters, each covering a different aspect of manufactured homes in the United States, and 8 appendices.

Chapter 1 provides a historical overview of Federal, State, and local regulations that affect the design, construction, and installation of manufactured homes, including guidance on the NFIP and HUD installation requirements.

Chapter 2 presents and defines the characteristics of a manufactured home, the types of foundations used, typical installation techniques, and additional design considerations of attachments to manufactured homes (e.g., carports, decks, porches, and awnings).

Chapter 3 provides the regulatory requirements pertaining to the installation of manufactured homes in flood-prone areas. NFIP, HUD and model building code requirements are discussed as well as methods for mitigating manufactured homes (e.g., elevation and relocation).

Chapter 4 presents issues to consider in the siting of manufactured homes.

Chapter 5 provides a review of natural hazards that must be considered in site selection, foundation design, and installation of manufactured homes. The discussion covers flooding, including the special hazards associated with coastal flooding (e.g., storm surge, velocity flow, and wave impact), high winds, and seismic events. The combined effects of multiple hazards are also covered.

Chapter 6 contains a review of the geology and hydrology of soils and their effects on manufactured home foundation systems. Soil characteristics and the behavior of saturated soils are discussed. Recommendations are provided for soil testing criteria applicable for manufactured home installation.

Chapter 7 presents a review of the use of ground anchors with manufactured home foundations, including the results of laboratory and field tests of anchor performance in saturated soils.

Chapter 8 presents different types of manufactured home foundation systems, including their performance, installation procedures, maintenance requirements, and possible modifications. Systems discussed include pier systems that incorporate ground anchors, braced piers and piles, slabs, elevated floors or crawlspaces, and proprietary systems.

Chapter 9 discusses recommended design processes and criteria for manufactured home foundations in SFHAs. Recommended design criteria, performance requirements, and best practice recommendations are presented. Sites that fall outside of the criteria specified for recommended foundations in Chapter 10 can use the design process detailed in this chapter.

Chapter 10 provides design criteria for recommended foundations appropriate for typical installation of manufactured homes in flood zones designated A, AE, A1-A30, A0, or AH on a FEMA Flood Insurance Rate Map (FIRM). Criteria are presented regarding maximum flood depth, flow velocity, wind speed, and seismic force. The designs are shown in Appendix H.

The appendices include:

A: References

B: Sources for Flood Information

C: Flood Velocity Determination

D: Definitions

E: Acronyms and Abbreviations

F: Example Calculations

G: Wind Zone Comparisons

H: Pre-Engineered and Prescriptive Foundation Designs

The foundation designs discussed in Chapter 10 and shown in Appendix H are but one of a group of acceptable foundation solutions. They should not be considered mandatory or all

inclusive. Any modifications to the foundation drawings must be designed and approved by a licensed professional engineer. Alternative foundation systems designed to resist equivalent loads and to provide equivalent performance should be considered equally acceptable.

Flowcharts, checklists, maps, formulas, and drawings are provided throughout the guide to help in understanding the issues to consider when installing a manufactured home in a floodplain. Examples are presented to demonstrate decisions and calculations designers must make to reduce the potential damage to manufactured homes from natural hazard events.

1.2 Background

1.2.1 Manufactured Homes in the United States

Manufactured homes help fill a demand for affordable housing in many parts of the United States. In 2007, the U.S. Census reported that the industry shipped 95,700 homes with an average price of \$64,500. Single-section homes had an average price of \$35,200, and double-section homes had an average price of \$73,100. U.S. Census Bureau figures from Census 2007 show that 74 percent of new manufactured homes were located on private properties and 26 percent were located in manufactured home parks. The average floor area of a manufactured home placed in 2007 was approximately 1,600 square feet. Approximately 31 percent of the manufactured homes placed in 2007 were located in four States (Florida, California, Louisiana, and Texas).

Since 1976, the NFIP has regulated the installation of manufactured homes in floodplains. Over the years, the NFIP has strengthened the regulations by defining existing and new manufactured home parks and applying differing standards for each. The standards governing manufactured homes continue to improve; Federal, State, and local governments and the manufactured home industry strive to institute construction practices and regulations to increase the safety of manufactured homes in natural hazard environments. The following list summarizes regulations, programs, and actions that have been developed to improve the resistance of manufactured homes to natural hazards:

- On July 13, 1994, HUD adopted new structural resistance guidelines for the construction of manufactured homes to be placed in HUD Wind Zones II and III (Figure 1-1).
- Section 605 of the National Manufactured Housing Construction and Safety Standards Act of 1974 (42 U.S.C. 5401), as amended by the Manufactured Housing Improvement Act of 2000, authorized the Secretary of HUD to establish and implement a national manufactured housing installation program to include (1) installation standards, (2) the training and licensing of manufactured home installers, and (3) the inspection of manufactured home installations.

States may choose to operate an installation program for manufactured homes in lieu of the Federal program. The State must implement standards that provide protection to its residents that equals or exceeds the *Model Manufactured Home Installation Standards* (24 CFR 3285.1(a)(1). See <http://www.hud.gov/offices/adm/hud-clips> for more information.

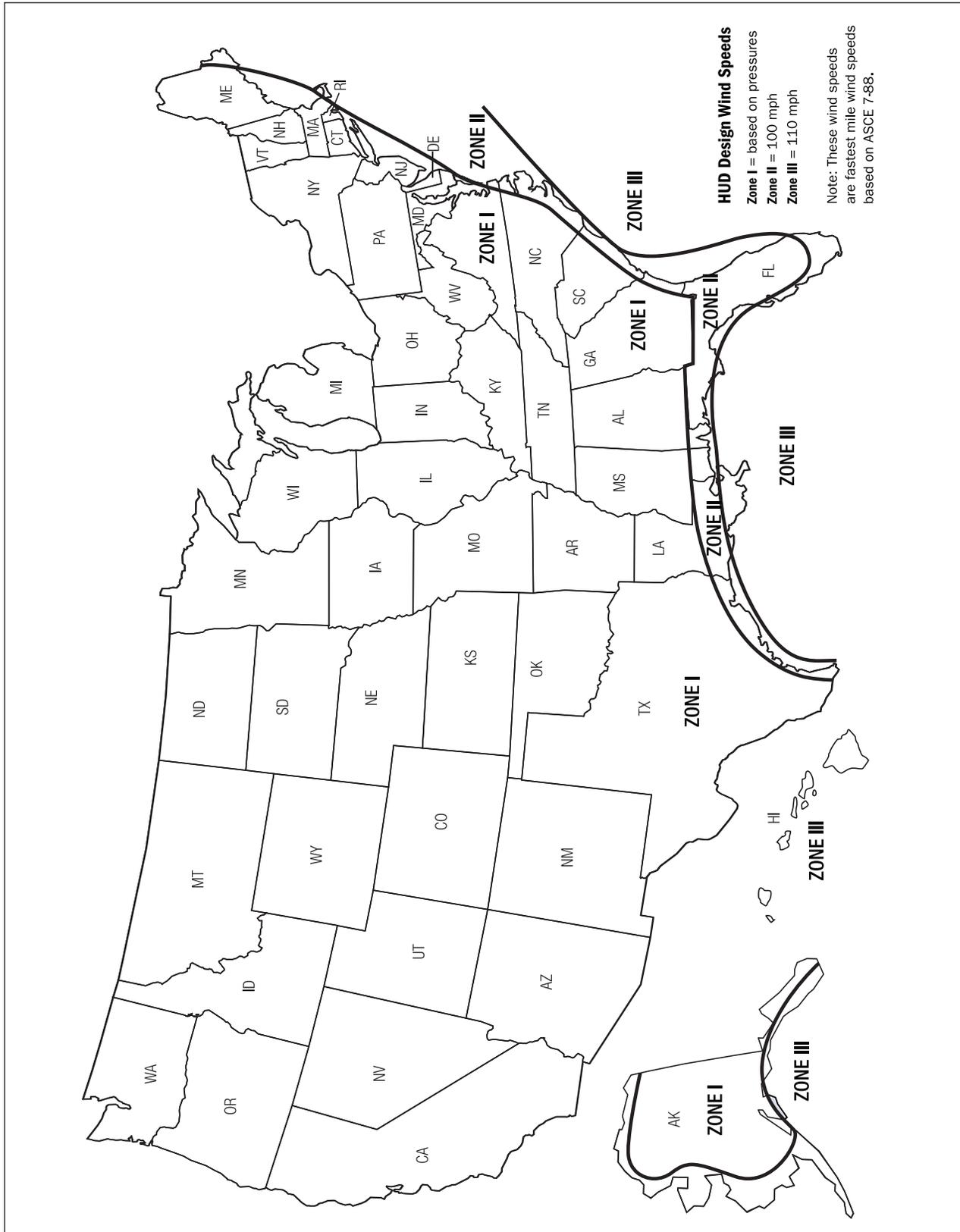


Figure 1-1. Basic wind zone map for manufactured housing.

- Installation program requirements have been established under 24 CFR 3286, *Federal Manufactured Home Installation Program* effective October 20, 2008. Compliant training and licensing programs for installation and inspections are being implemented in all States.
- The National Fire Protection Association (NFPA) has published three documents on the subject of manufactured housing:
 - NFPA 501, *Standard on Manufactured Housing*
 - NFPA 501A, *Standard for Fire Safety Criteria for Manufactured Home Installations, Sites and Communities*
 - NFPA 225, *Model Manufactured Home Installation Standard*, which will, in adopted areas, govern installation of manufactured homes.
- The National Technology Transfer Act of 1995 included a goal that Federal agencies use technical standards developed or adopted by voluntary consensus standard bodies. Although HUD has recognized NFPA as a consensus standard developing body, HUD is not obligated to use standards developed by that body.
- Several States and localities, including Florida and North Carolina, have strong installation standards, which include requiring manufactured homes to meet State and local building code requirements; a manufactured home installer education, testing, and certification program for HUD homes; and aggressive inspection programs to ensure proper installation.

1.2.2 National Flood Insurance Program

The U.S. Congress established the NFIP with the passage of the National Flood Insurance Act of 1968, as amended. The NFIP is a Federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses in exchange for State and community floodplain management regulations that reduce future flood damages. Participation by communities in the NFIP is based on an agreement between communities and the Federal Government. If a community adopts and enforces floodplain management regulations to reduce future flood risks to new construction in floodplains, the Federal Government will make flood insurance available within the community as a financial protection against flood losses. Participation in the NFIP by communities is voluntary.

Federal flood insurance is designed to provide an alternative to disaster assistance and disaster loans for home and business owners. Disaster assistance rarely comes close to covering all of the costs to repair and cleanup. While available to qualified victims, disaster loans do not significantly ease the financial burden due to repayment terms. It is important to remember that disaster assistance is available only after floods have been declared major disasters by the President of the United States. In contrast, insurance claims will be paid any time damage from a qualifying flood event occurs.

Another important objective of the NFIP is to break the cycle of flood damage. Many buildings have been flooded, repaired, or rebuilt, and flooded again. In some parts of the country, this cycle occurs every couple of years; people rebuilt in the same flood-prone areas and used the

same construction techniques that did not adequately protect the structure. By encouraging communities to guide development to lower risk areas, and by requiring the elevation of new buildings and older nonconforming buildings that are subject to flood damage, one of the long-term objectives of the NFIP can be achieved: reducing flood damage and losses. Older buildings may be removed or replaced, or they may be upgraded or modified with techniques that lead to little or no future flood damage.

The NFIP is administered by the Federal Emergency Management Agency (FEMA), which is part of the Department of Homeland Security (DHS).

In order to participate in the NFIP, communities must adopt minimum floodplain management requirements that meet or exceed the minimum requirements of the NFIP. Communities can adopt NFIP floodplain management requirements through building codes, zoning ordinances, subdivision regulations, health and safety codes, and stand-alone floodplain ordinances.

NFIP regulations have specific floodplain management requirements for manufactured homes located in a SFHA. In general, manufactured homes must be elevated and anchored to resist flotation, collapse, or lateral movement. At sites having a base flood elevation (BFE) identified for Zones AI-30, AH, or AE on the community's FIRM, NFIP regulations generally require that manufactured homes be elevated on a permanent foundation such that the lowest floor is at or above the BFE, and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, or lateral movement. At sites having a BFE identified for Zone VE on the community's FIRM, NFIP regulations require that manufactured homes be elevated on pilings and columns so that the bottom of the lowest horizontal structural member of the lowest floor is elevated to or above the BFE. More detailed information pertaining to the NFIP requirements for manufactured homes installed in flood hazard areas is provided in Chapter 3.

1.2.3 Performance of Manufactured Homes in Wind and Flood Events

1.2.3.1 Performance of Pre-1994 Manufactured Homes

In 1992, Hurricane Andrew struck Dade County, Florida, destroying 97 percent of the manufactured homes in its path. In 1994, in response to the devastating damage, HUD adopted more stringent wind design criteria for manufactured homes installed in HUD Wind Zones II and III. Provisions for doors and windows more resistant to wind pressures were required. Although numerous hurricanes have made landfall in the U.S. since 1994, none have produced winds that approached those of Hurricane Andrew. In 1998, Hurricane Georges caused damage throughout Monroe County (the Florida Keys), Florida. FEMA dispatched a Building Performance Assessment Team (BPAT) to report on the performance of manufactured housing in impacted areas. Most of the damage observed occurred to homes installed before Monroe County had adopted the NFIP regulations that required new and substantially damaged manufactured homes located in SFHAs be elevated to the BFE and anchored to resist flotation, collapse, or lateral movement.

Most of the flood damage caused by Hurricane Georges to the manufactured homes constructed before 1994 was the result of a lack of adequate elevation, the use of unreinforced piers

(dry-stacked blocks) in areas exposed to moving floodwaters, inadequate anchoring, and failure of attached site-built additions (Figures 1-2 and 1-3). Anchoring failure problems included poorly attached anchors; lack of corrosion-resistant materials; homes not fastened to their support piers; and improperly attached tie-down straps.

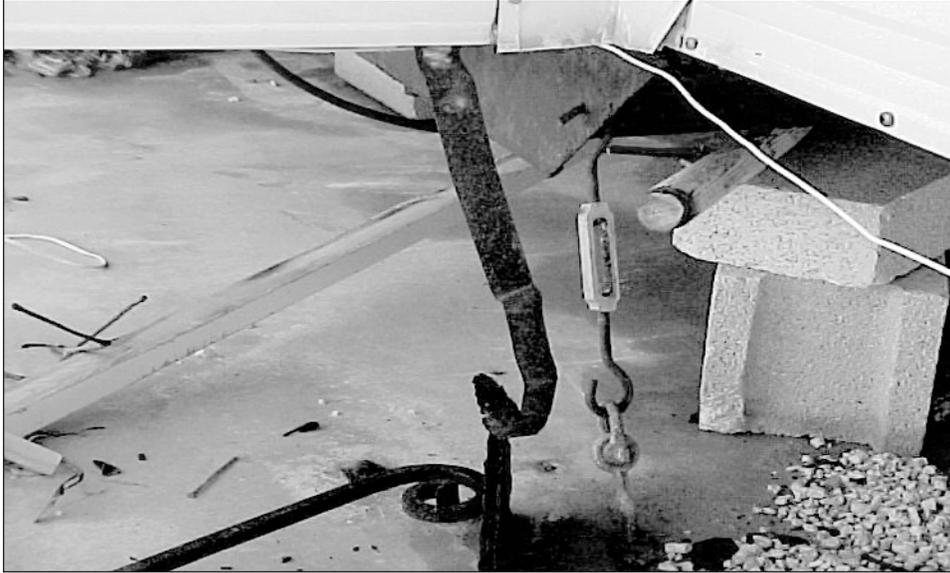


Figure 1-2. Inadequate turnbuckle anchor installed by the homeowner on this pre-1994 manufactured home, coupled with lack of elevation and an unreinforced foundation system, led to severe damage.



Figure 1-3. The addition to this manufactured home was destroyed, causing considerable damage to the rest of the home.

1.2.3.2 Performance of Post-1994 Manufactured Homes

The lessons learned from Hurricane Andrew in Florida have resulted in manufactured homes being built stronger and installed more solidly; thus these homes are able to better resist extreme loading (in particular, flood and wind loads).

Figure 1-4 shows the success of the reinforced masonry pier foundation of a manufactured home installed after 1994. Although the area experienced moving floodwaters fast enough to displace the air conditioning compressor shown under the home and create localized erosion and scour, the reinforced masonry piers survived without damage.

The manufactured home shown in Figure 1-5, on Cudjoe Key in Monroe County, was built to the 1994 standards. It survived Hurricane Georges with only minor damage caused by the loss of an awning. The older manufactured home on the lot next door was destroyed by high winds and coastal surge.

Figure 1-4. Reinforced masonry pier foundation system under a manufactured home installed after 1994 that performed well.



Figure 1-5. Manufactured home in Cudjoe Key, Florida, built and installed after 1994, survived Hurricane Georges with only minor damage caused by the loss of an awning. The older manufactured home on the lot next door was destroyed by high winds and coastal surge.



1.2.3.3 Performance of Manufactured Homes During Hurricane Charley (2004) in Florida

Based on field observations, the Hurricane Charley Mitigation Assessment Team (MAT) provided the following conclusions in their report as related to the performance of manufactured homes:

“Finally, performance of manufactured housing was also observed to be a function of age of the building and the regulations to which the units were designed, constructed, and installed. Widespread damage was observed to manufactured housing designed and constructed prior to the 1976 HUD regulations. The performance of units installed between 1976 when the first HUD regulations were enacted and the implementation of the 1994 HUD regulations was observed to be somewhat improved, but significant improvements in performance were observed in the units designed and installed to the HUD regulations implemented after 1994 in response to Hurricane Andrew. Although some instances of structural failure were observed, the newer manufactured housing units typically sustained minimal structural damage and remained secured to their foundations when installation followed State requirements (e.g., enforced by the Division of Motor Vehicles, Department of Highway Safety and Motor Vehicles, etc.) of unit tie-downs (anchors) at 5 feet, 4 inches on-center (if no ancillary structures were attached to the unit). Much of this improved performance was difficult to observe due to widespread damage caused by the failures of improperly designed and constructed attached structures (including screen enclosures, carports, and accessory structures). The failure of these attached structures, in many places occurring where wind speeds were below the design wind speed for the area, resulted in extensive damage to roof coverings, siding, windows, and doors of the manufactured units, and generated significant amounts of debris. Very few manufactured homes had glazing protection and, as a result, numerous unprotected windows on units along the path of the eye of the storm were damaged and broken. Had the [HUD design wind speed] Zone II and Zone III homes installed in areas where debris protection is required for site-built one- and two-family dwellings been shipped with appropriate glazing protection, these homes [within the path of Hurricane Charley] would have been protected from windborne debris.”

