# CHAPTER 4 - DESIGN LOADS FOR PERMANENT FOUNDATIONS

**400. GENERAL.** Design and construction must insure that the load bearing portion of the home's foundation will remain stable and maintain its capacity to transmit all imposed loads to the ground.

**400-1. FOUNDATION DESIGNER.** The foundation designer must be aware of the structural limitations of the home to accommodate differential foundation movement. This is especially important with differential soil settlement or movement of problem soils.

**400-2. REFERENCED STANDARDS.** All structural design shall be based on generally accepted engineering practice. All loads shall be in accordance with ASCE 7-93, except as shown otherwise in this manual. Local codes must be reviewed for requirements that may be more stringent than ASCE 7-93.

**400-3. DESIGN STANDARDS.** Foundation design criteria is based on foundation criteria for conventional housing as defined in the *Minimum Property Standards*, and is not based on the *Manufactured Home Construction and Safety Standards* (Part 3280). Foundation Design Load Tables, Appendix B, were developed based on average ASCE *Minimum Design Dead Loads*. See Table 4-1 below. (See Derivation of Foundation Design Load Tables, Appendix D.)

**401. BUILDING STRUCTURE AND SIZE.** Information must be provided by the manufacturer to assist in determining the suitability of a manufactured home for a particular site and foundation system. The inspector shall do a preliminary check to verify that all information has been prepared by the manufacturer. (The Manufacturer's Worksheet can be found in Appendix E, page E-3.)

## 402. DESIGN LOADS

### 402-1. DEAD LOADS

**A. Computation of Forces.** Two design dead load values are used in this guide. The values are based on typical materials used in construction of homes.

1. The lightest combination of loads is used for computation of horizontal

| **Range of Dead Loads Covered by This Guide**<br>(Average pounds per lineal foot (plf) of home length ± 5%) | | | | | | |
|---|---|---|---|---|---|---|
| Nominal unit width: | **12 feet** | | **14 feet** | | **16 feet** | |
| Dead load: | light | heavy | light | heavy | light | heavy |
| **Single-Section**<br>Type C, E, I | 260 | 380 | 290 | 425 | 320 | 470 |
| **Multi-Section**<br>Note: Refer to the "Manufacturer's Worksheet" Appendix E for unit type. | 500 | 715 | 560 | 805 | 615 | 895 |

*Table 4 - 1*

and vertical anchorage forces for wind related overturning and sliding stability.

2. The heaviest combination of loads is used for computation of: (1) footing bearing area and (2) equivalent lateral inertia forces applied at roof and floor levels for seismic related overturning and sliding stability.

**B. Dead Load Values.** The design light and heavy dead load values are shown in Table 4-1 for manufactured home type and nominal unit width.

**C. Distributed Weight Calculation.** The manufacturer shall provide the total weight (W) and the length (L) of the manufactured housing unit, including mechanical equipment. These values are used to convert the weight (W) into the distributed value of pounds per lineal foot (w). Use the following formula to make this conversion:

$$w = \frac{W}{L}$$

Where: L = length of home (Mfr. Wksht. #3)
W = total weight (Mfr. Wksht. #8)

**D. Distributed Weight Comparison.** The distributed home weight (w) shall be compared with the average calculated values in Table 4-1.

1. If the manufacturer's distributed value (w) is less than the light load or greater than the heavy load, the structural engineer will be required to design the foundation system and anchoring system. Proceed no further until an approved system, certified by a licensed structural engineer, has been provided. DO NOT USE THE TABLES. The tables are based on estimated conditions. Once outside those limits, the results will not be valid.

2. If the manufacturer's value falls within the light and heavy load limits (± 5%), USE THE TABLES IN THIS MANUAL and proceed with the verification process.

**E. Other Dead Loads.** Manufactured home partitions and other known loads caused by special installations such as stationary equipment, i.e. water heater, furnace, etc., shall be included to arrive at applicable dead loads.

**402-2. SNOW LOAD**

**A. General.** Ground snow loads are based on values from ASCE 7-93. The Ground Snow Load map on pages H-11, H-12, H-13, shall be used to determine a ground snow load value (Pg) for the manufactured home location. For areas where ground snow load values are not shown, consult local weather data or governing code authority. Ground snow loads (Pg) are converted to roof design snow loads (Ps) by multiplication on 0.7 × Pg. See Appendix D for derivation. The tables in Appendix B use Pg values from the map. Roof snow loads are assumed to be horizontally projected over the roof area.

**B. Heavy Snow Loads.** If the ground snow load value (Pg) exceeds 100 psf, consult a licensed structural engineer for footing design.

**C. Minimum Roof Live Load.** Roofs shall be designed for a minimum horizontally projected live load in accordance with *MPS* HUD Document 4910.1, Appendix K, art.200.926e. The load magnitude is related to roof slope as follows: greater than 3 in 12: 15 psf; less than or equal to 3 in 12: 20 psf. The larger magnitude, between the design roof snow load and the minimum roof live load, shall be used for design. Note that a 20 psf ground snow load (Pg) corresponds closely to a 15 psf minimum roof live load (i.e. $0.7 \times 20 = 14$ psf rounded to 15 psf) and a 30 psf ground snow load corresponds closely to a 20 psf minimum roof live load (i.e. $0.7 \times 30 = 21$ psf rounded to 20 psf in the Foundation Design Load Tables).

## 402-3. WIND LOAD

**A. General.** Wind loads must be based on values from ASCE 7-93. The Basic wind speed map on page H-14 must be used to determine the basic wind speed (v) for the manufactured home location. Refer to Appendix D for factors influencing wind load. Map values below 80 mph shall conform to the minimum wind speed of 80 mph in accordance with *MPS* HUD Document 4910.1, Appendix K, art. 200.926e.

NOTE: Tornadoes have not been considered in the development of the basic wind speed map, and resistance to such conditions is not included in this manual.

**B. Coastal or Inland Sites.** Coastal regions include any locations within 100 miles of the Atlantic Ocean or Gulf of Mexico hurricane coastlines. All other locations are to be considered Inland regions. Exposure Category C has been assumed regardless of Coastal or Inland location in accordance with *MPS* HUD Document 4910.1, Appendix K, art. 200.926e.

**C. Severe Wind and Design Pressures.** In hurricane zones, or where severe wind pressures occur, foundations and anchoring for manufactured homes will require special treatment.

1. Foundations may be required to resist greater uplift and overturning than values shown in this manual.
2. Heavier, more deeply buried foundations may be required than values shown in the tables. It may be necessary to provide additional foundation shear walls and/or specially designed cantilever piers.
3. Home-to-foundation connections must be strengthened.
4. Refer to *Mobile Home Anchoring Systems and Related Construction and An Engineering Analysis: Mobile Homes in Windstorms*, Institute for Disaster Research in Lubbock, Texas.

**D. Design Verification.** The field office must verify the existence of engineered drawings showing connection and anchorage details. The connection details shall be engineered to resist wind speeds at the building site.

**E. High Wind Design.** For high wind areas, foundation designs must be those that are suited to both high wind and other site conditions, such as seismic or soil conditions.

## 402-4. SEISMIC LOADS

**A. General.** Seismic design loads and requirements are based on criteria and values from ASCE 7-93, which are taken from the NEHRP *Recommended Provisions for the Development of Seismic Regulations for New Buildings* (NEHRP 1991). The two seismic maps on pages H-15 and H-16 shall be used to determine the seismic values Aa and Av for the manufactured home location (county). Seismic values of Aa and Av that equal or exceed 0.3 shall conform to the special requirements of seismic performance category C and D (cited on page H-17) as they apply to foundation design and detailing. When Av values from the map on page H-16 are less than 0.15, the seismic provisions of ASCE 7-93 need not be considered, and anchorage design is then based on wind considerations alone. In seismic areas where Av and/or Aa $\geq$ 0.3, foundations must be designed by a professional engineer licensed in the applicable state.

**B. Design Verification.** The design concept proposed in question 10 of the "Manufacturer's Worksheet", found in Appendix E, should be compared with information in the Foundation Design Concept Tables (Appendix A) to determine whether the foundation is potentially suitable for location in a seismic zone.

**C. Characteristic Differences between Wind and Seismic Loading.**

1. Wind loads subject the exterior building envelope to pressures and suctions on each wall or roof surface. Thus, exposed surface area is important. Seismic loads are generated by the ground's acceleration being transferred to the foundation, according to the site soil characteristics (S) and then the building's structural system characteristics (R). This modified acceleration excites the building mass, which generates the inertia forces ($F = m \times a$) at each level (i.e. floor and roof). Thus, the entire building participates in the creation of seismic force, while only the exterior envelope participates in wind load generation.

2. Wind loading is usually long duration with short duration gusting that usually creates slow stress reversals, while seismic events are of short duration, creating accelerations that generate rapid oscillations in all directions with sudden stress reversals.

3. The slow structural response from wind loading permits frictional resistance from gravity loads to be considered for sliding resistance between superstructure and foundation. The simultaneous horizontal and vertical acceleration during a seismic event, generally negates the frictional resistance from gravity loads. Thus, friction is ignored as a potential resistance between superstructure and foundation for seismic loading. Even when wind loads exceed seismic loads, positive connections between superstructure and foundation are required for areas with Av equal to or greater than 0.15.

**D. Seismic / Wind Force Comparisons.** Overturning and sliding anchorage forces found in the Foundation Design Load Tables of Appendix B are based on the largest lateral forces from a consideration of wind and equivalent lateral seismic inertia forces. The results were as follows:

1. Wind controls for single or multi-section units subjected to (1) overturning from lateral forces in the transverse direction (perpendicular

to long dimension of unit) and (2) uplift forces in the vertical direction. Both conditions require vertical anchorage.

2. Wind or seismic may control for single or multi-section units subjected to sliding in the transverse and/or longitudinal direction. Values in the tables of Part 3 and 4 of Appendix B are grayed if seismic controls.