Building on Strong and Safe Foundations

5. Foundation Selection

This chapter presents foundation designs, along with the use of the drawings in Appendix A, to assist the homebuilder, contractor, and local engineering professional in developing a safe and strong foundation. Foundation design types, foundation design considerations, cost estimating, and how to use this manual are discussed.

5.1 Foundation Design Types

The homebuilder, contractor, and local engineering professional can utilize the designs in this chapter and Appendix A to construct residential foundations in the Gulf Coast. The selection of appropriate foundation designs for the construction of residences is dependent upon the

coastal zone, wind speed, and elevation requirements, all of which have been discussed in the previous chapters. The following types of foundation designs are presented in this manual:

Open Foundations

- Timber pile
- Steel pipe pile with concrete column and grade beam
- Timber pile with concrete column and grade beam
- Concrete column and grade beam
- Concrete column and grade beam with slab

Closed Foundations

- Reinforced masonry – crawlspace
- Reinforced masonry – stem wall

Each of these foundation types designed for the Gulf Coast region have advantages and disadvantages that must be taken into account. Modifications to the details and drawings might be needed to incorporate specific house footprints, elevation heights, and wind speeds to a given foundation type. Consultation with a licensed professional engineer is encouraged prior to beginning construction.

The foundation designs and materials specified in this document are based on principles and practices used by structural engineering professionals with years of coastal construction experience. This manual has been prepared to make the information easy to understand.

Guidance on the use of the foundation designs recommended in this manual is provided in Appendix B. Examples of how the foundation designs in this manual can be used with some of the houses in the publication *A Pattern Book for Gulf Coast Neighborhoods* are presented in Appendix B. Design drawings for each of the foundation types are presented in Appendix A, and any assumptions used in these designs are in Appendix C.

5.2 Foundation Design Considerations

The foundation designs proposed are suitable for homes whose dimensions, weights, and roof pitches are within certain ranges of values. A licensed professional engineer should confirm the appropriateness of the foundation design of homes whose dimensions, weights, or roof pitches fall outside of those defined ranges.

Most of the foundation designs are based on a 14-foot wide (maximum) by 24-foot deep (minimum) "module" (see Figure 5-1). From this basic building block, foundations for specific homes can be developed. For example, if a 30-foot deep by 42-foot wide home is to be constructed, the foundation can be designed around three 14-foot wide by 30-foot deep sections. If a 24-foot

deep by 50-foot wide home is desired, four 12.5-foot wide by 24-foot deep sections can be used. If a 22-foot deep home is desired, the foundation designs presented here should only be used after a licensed professional engineer determines that they are appropriate since the shallow depth of the building falls outside the range of assumptions used in the design.

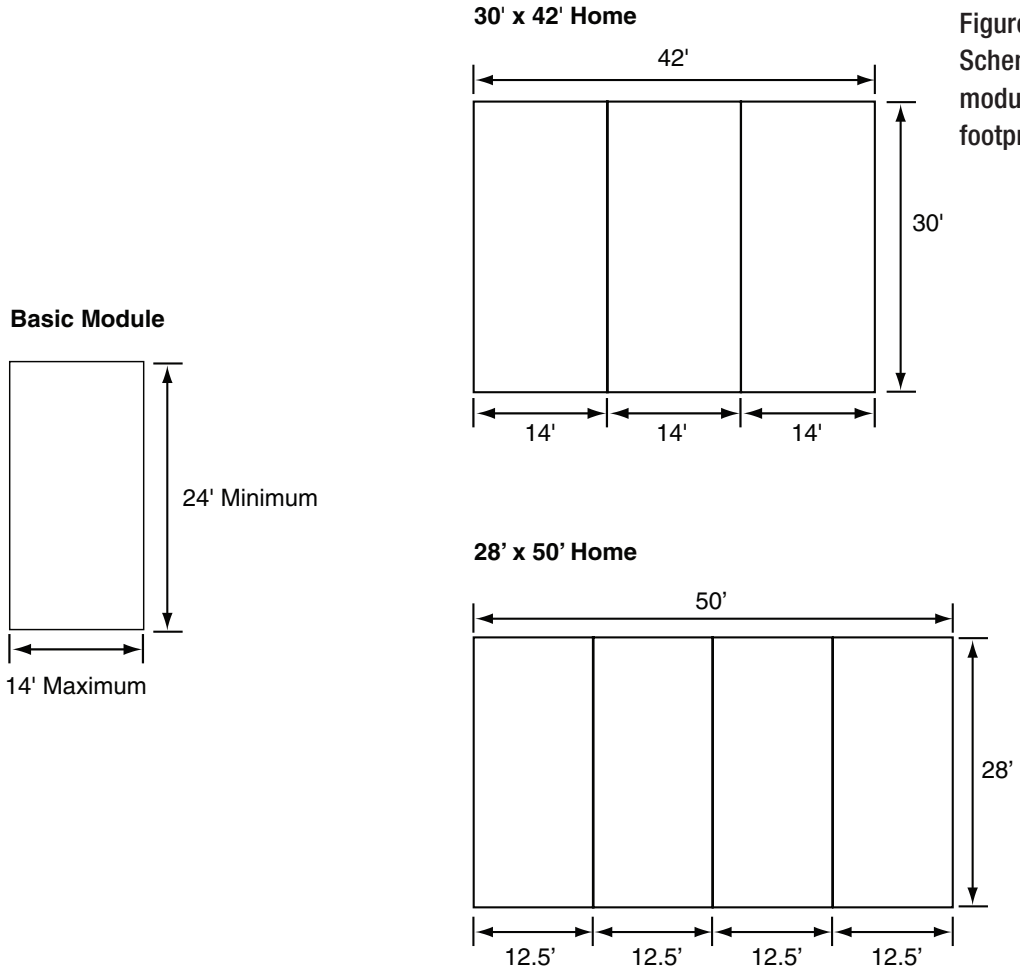


Figure 5-1. Schematic of a basic module and two footprints

The licensed professional engineer should also consider the following:

- **Local soil conditions.** The piling foundations have been developed for relatively soft subsurface soils. Presumptive gravity loading values of 8 tons per pile, uplift loads of 4 tons per pile, and lateral loads of 1 ton per pile were used in these designs. Soil testing on the site may determine that fewer piles are needed to support the home, and the reduced cost of driving fewer piles could justify the cost of soils testing and redesign. Soils test should also be considered to validate the assumptions made.
- **Building weight.** The foundations have been designed to resist uplift forces resulting from a relatively light structure. If the actual home is heavier (e.g., from the use of concrete composite siding or steel framing), it may be cost-effective to reanalyze and redesign the footings. This is particularly true for a home that doesn't need to be elevated more than several feet or has short foundation walls that can help resist uplift.

- **Footprint complexity.** By necessity, the foundations have been designed for relatively simple rectangular footprints. If the actual footprint of the home is relatively complex, the engineer may need to consider torsional wind loading, differential movement among the "modules" that make up the house, concentrated loading in the home's floor and roof diaphragms, and shear wall placement.

5.3 Cost Estimating

Cost information that the homebuilders can use to estimate the cost of installing the foundation systems proposed in this manual are presented in Appendix E. These cost estimates are from information provided by local contractors and are based on May 2006 prices.

5.4 How to Use This Manual

The rest of this chapter is designed to provide the user with step by step procedures for the information provided in this document.

1. Determine location of the dwelling on a general map. Identify the location relative to key features such as highways and bodies of water. An accurate location is essential for using flood and wind speed maps in subsequent steps of the design process.

2. Determine location of dwelling on the appropriate FIRM

- Determine the flood insurance risk zone from the FIRM (Select V Zone, Coastal A Zone, non-Coastal A Zone, or other). Refer to FEMA 255, *Guide to Flood Maps, How to Use Flood Maps to Determine Flood Risk for a Property*, for instructions. For the Gulf Coast, the FEMA Hurricane Katrina Flood Recovery Advisories should be used until the Gulf Coast is restudied and remapped. New flood maps are scheduled to be completed in 2006.
- Determine the BFE or the interim Advisory Base Flood Elevations (ABFEs) for the location from the FIRM. If the dwelling is outside of floodprone areas, it only needs to be designed for gravity and appropriate wind loads. Seismic events are considered too rare for the Gulf Coast to control the design and analysis.

FIRM Panel No.	_____
Flood Insurance Risk Zone	_____
Base Flood Elevation (BFE) or Advisory Base Flood Elevation (ABFE)	_____

3. Identify the local building code. Several Gulf States are adopting new building codes to govern residential construction. Several parishes, counties, and towns in Louisiana and Mississippi have adopted the IBC and the IRC to govern construction. This document assumes that the IRC governs the design and construction requirements.

County/Parish/City	_____
Building Code	_____
Building Code Date	_____

4. Identify the local freeboard requirements and DFE. Using either the local building codes, local floodplain ordinances, data obtained from local building officials, or personal preferences (only if greater than minimum requirements), determine the minimum freeboard above the BFE or ABFE. The DFE is the sum of the BFE or ABFE and freeboard values.

Base Flood Elevation (BFE) or Advisory Base Flood Elevation (ABFE)		_____
Freeboard	+	_____
Design Flood Elevation		_____

5. Determine the required Design Wind Velocity. The IRC references ASCE 7-02 as the source of the wind speed information. The IRC will be used as the source of all individual and combined loads.

Design Wind Velocity	_____
Wind Exposure Category	_____

6. Establish the topographic elevation of the building site and the dwelling. Elevations can be obtained from official topographic maps published by the National Geodetic Survey and/or as established or confirmed by a surveyor.

- If the dwelling and its surrounding site are above the DFE, no flood forces need to be considered.
- If the desired topographic elevation is below the DFE, the dwelling must be elevated above the BFE or ABFE.

Source of Topo Elevation	_____
Topo Elevation (Site)	_____

7. Determine the height of the base of the dwelling above grade. Subtract the lowest ground elevation at the building from the lowest elevation of the structure (i.e., bottom of lowest horizontal structural member).

Design Flood Elevation	_____
Topo Elevation	_____
Elevation Dimension	_____

8. Determine the general soil classification for the site. To determine the load capacity of the soil, the soil must first be classified according to its strength groupings. For purposes of using this manual, the classification system has been greatly simplified into two groups commonly found in coastal areas along the Gulf of Mexico States: (1) loose granular, cohesionless (having little or no clay content) soils and (2) soft, cohesive (principally clayey content) soils.

Soil Classification	_____

9. Determine the type of foundation to be used to support the structure. Depending on the location of the dwelling, design wind speed, and local soil conditions documented above, select the desired or required type of foundation. Note that more than one solution may be possible. Refer to Chapter 4 for the potential foundation designs that can be used within the flood zones determined from the FIRM maps. Drawings in Appendix A illustrate the construction details for each of the foundations. Refer to the drawings for further direction and information about the needs for each type of unit.

10. Evaluate alternate foundation type selections. The choice of foundation type may be on the basis of least cost or to provide a personal choice, functional, or aesthetic need at the site. Refer to Appendix E for guidance on preparing cost estimates. Functional needs such as provisions for parking, storage, or other non-habitable uses for the area beneath the living space should be considered in the selection of the foundation design. Aesthetic or architectural issues (i.e., appearance) also must be included in the evaluation process. Guidance for the architectural design considerations can be obtained from *A Pattern Book for Gulf Coast Neighborhoods* by the Mississippi Governor's Commission on Recovery, Rebuilding and Renewal (see Appendix B) and from many other sources.

As part of the final analysis, it is strongly recommended that the selection and evaluation process be coordinated with or reviewed by knowledgeable contractors or design professionals to arrive at the best solution to fulfill all of the regulatory and functional needs for the construction.

11. Select the foundation design. If the home's dimensions, height, roof pitch, and weight are within the ranges used to develop these designs, the foundation designs can be used "as is." However, if the proposed structure has dimensions, height, roof pitch, or weights that fall

outside of the range of values used, a licensed professional engineer should be consulted. The materials presented in the appendices should help reduce the engineering effort needed to develop a custom design. Figure 5-2 is a foundation selection decision tree for determining which foundation design to use based on the requirements of the home. Table 5-1 shows which foundation design cases can be used for the home based on height of elevation and wind velocity.

Because the designs are good for a range of buildings, they will be conservative for some applications. A licensed professional engineer will be able to provide value engineering and may produce a more efficient design that reduces construction costs.

5.5 Design Examples

The foundation designs were developed to allow a "modular approach" for developing foundation plans. In this approach, individual rectangular foundation components can be assembled into non-rectangular building footprints (see Figures 5-3 through 5-5). Appendix D provides detailed calculations and analysis for open and closed foundation designs. There are, however, a few rules that must be followed when assembling the modules:

1. **The eave-to-ridge dimension of the roof is limited to 23 feet.** The upper limit on roof height is to limit the lateral forces to those used in developing the designs.

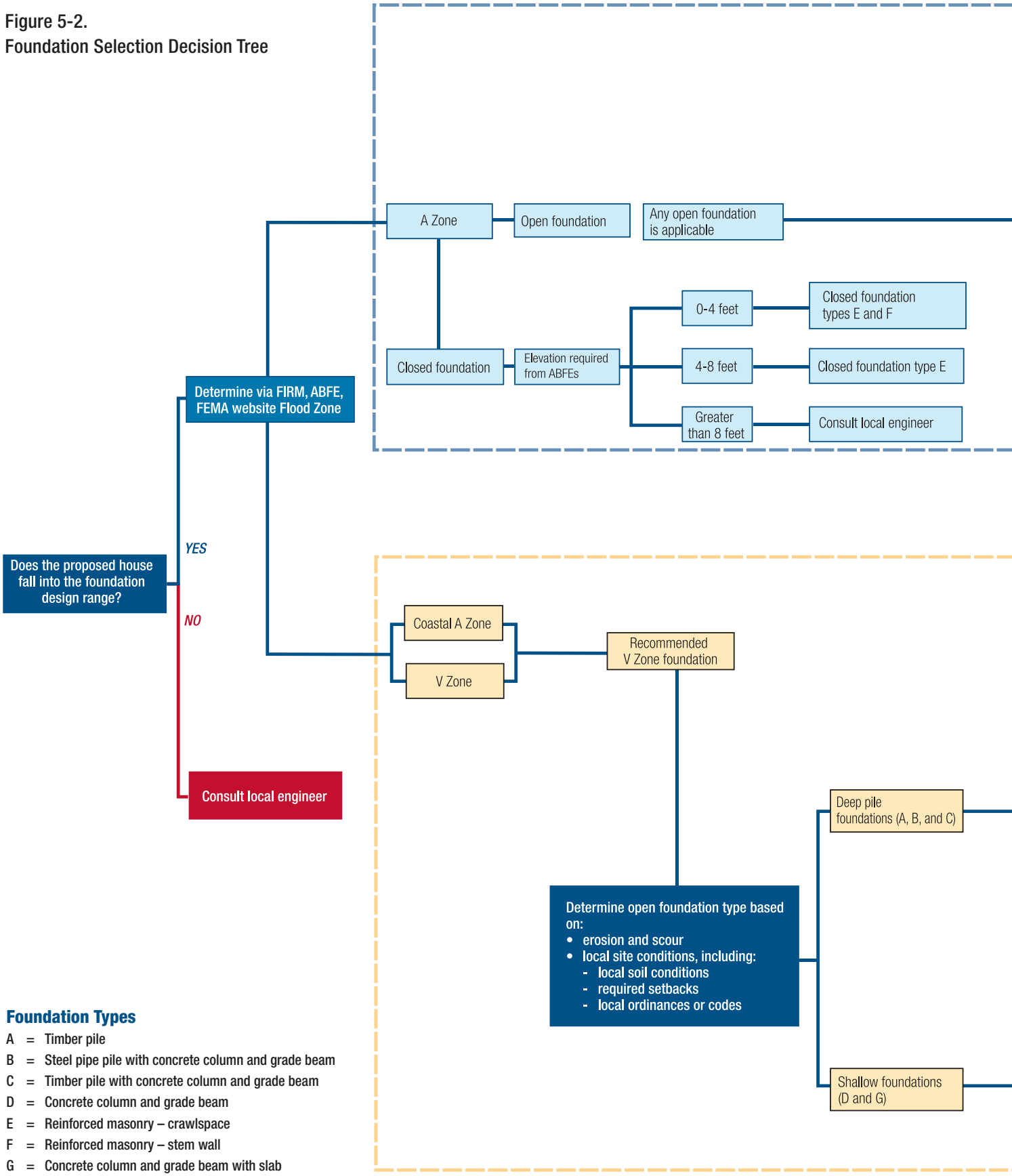
2. **Roof slopes shall not be shallower than 3:12 or steeper than 12:12.** For a 12:12 roof pitch, this corresponds to a 42-foot deep home with a 2-foot eave overhang.

3. **The "tributary load depth" of the roof framing shall not exceed 23 feet, including the 2-foot maximum roof overhang.** This limit is placed to restrict uplift forces on the windward foundation elements to those forces used in developing the design. As a practical matter, clear span roof trusses are rarely used on roofs over 42 feet deep; therefore, this limit should not be unduly restrictive. The roof framing that consists of multiple spans will require vertical load path continuity down through the interior bearing walls to resist uplift forces on the roof. Load path continuity can be achieved in interior bearing walls using many of the same techniques used on exterior bearing walls.

4. **On the perimeter foundation wall designs (Cases E and F), foundation shear walls must run the full depth of the building module, and shear walls can not be spaced more than 42 feet apart.**

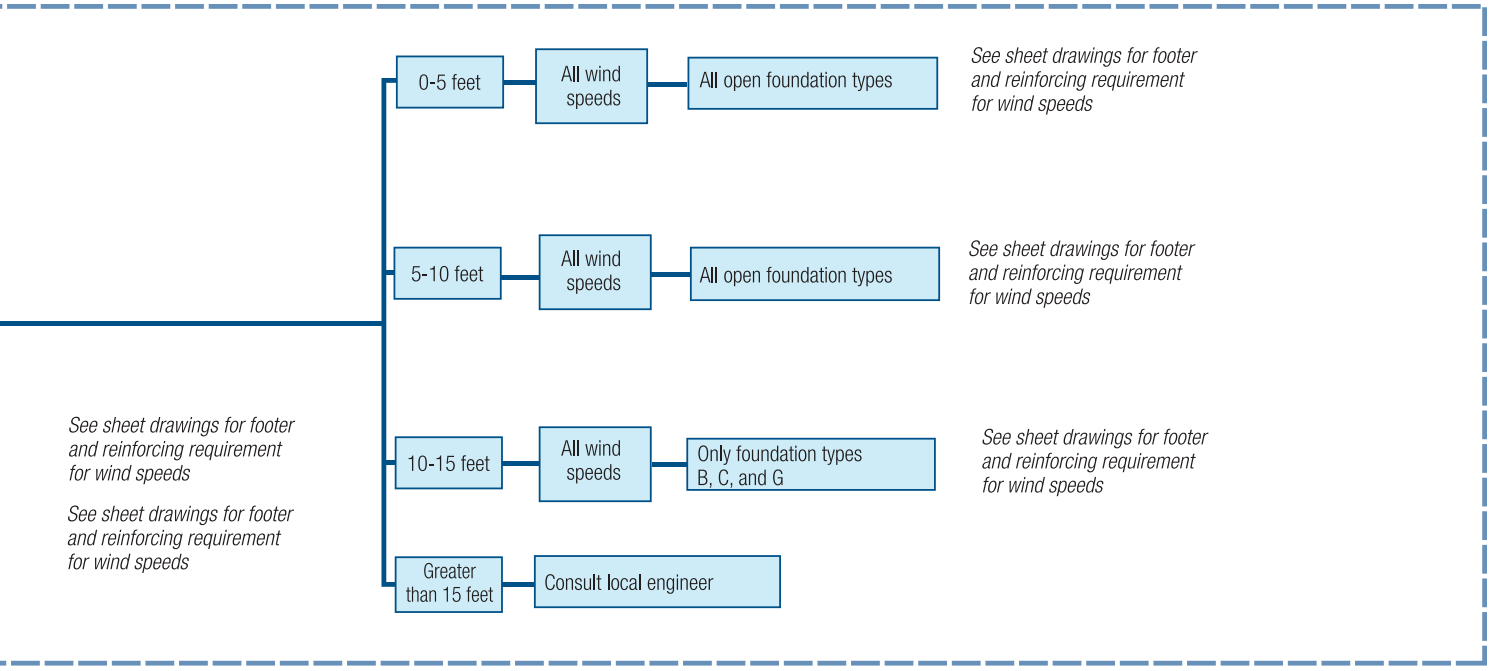
5. **All foundation modules shall be at least 24 feet deep and at least 24 feet long.** Although the basic module is limited to 42 feet long, longer home dimensions can be developed, provided that the roof does not extend beyond the building envelope as depicted in Figure 2 of the Introduction.

Figure 5-2.
Foundation Selection Decision Tree



Foundation Types

A = Timber pile
B = Steel pipe pile with concrete column and grade beam
C = Timber pile with concrete column and grade beam
D = Concrete column and grade beam
E = Reinforced masonry – crawlspace
F = Reinforced masonry – stem wall
G = Concrete column and grade beam with slab


0-5 feet
All wind speeds
All open foundation types
See sheet drawings for footer and reinforcing requirement for wind speeds
5-10 feet
All wind speeds
All open foundation types
See sheet drawings for footer and reinforcing requirement for wind speeds
10-15 feet
All wind speeds
Only foundation types B, C, and G
See sheet drawings for footer and reinforcing requirement for wind speeds
Greater than 15 feet
Consult local engineer
See sheet drawings for footer and reinforcing requirement for wind speeds
See sheet drawings for footer and reinforcing requirement for wind speeds

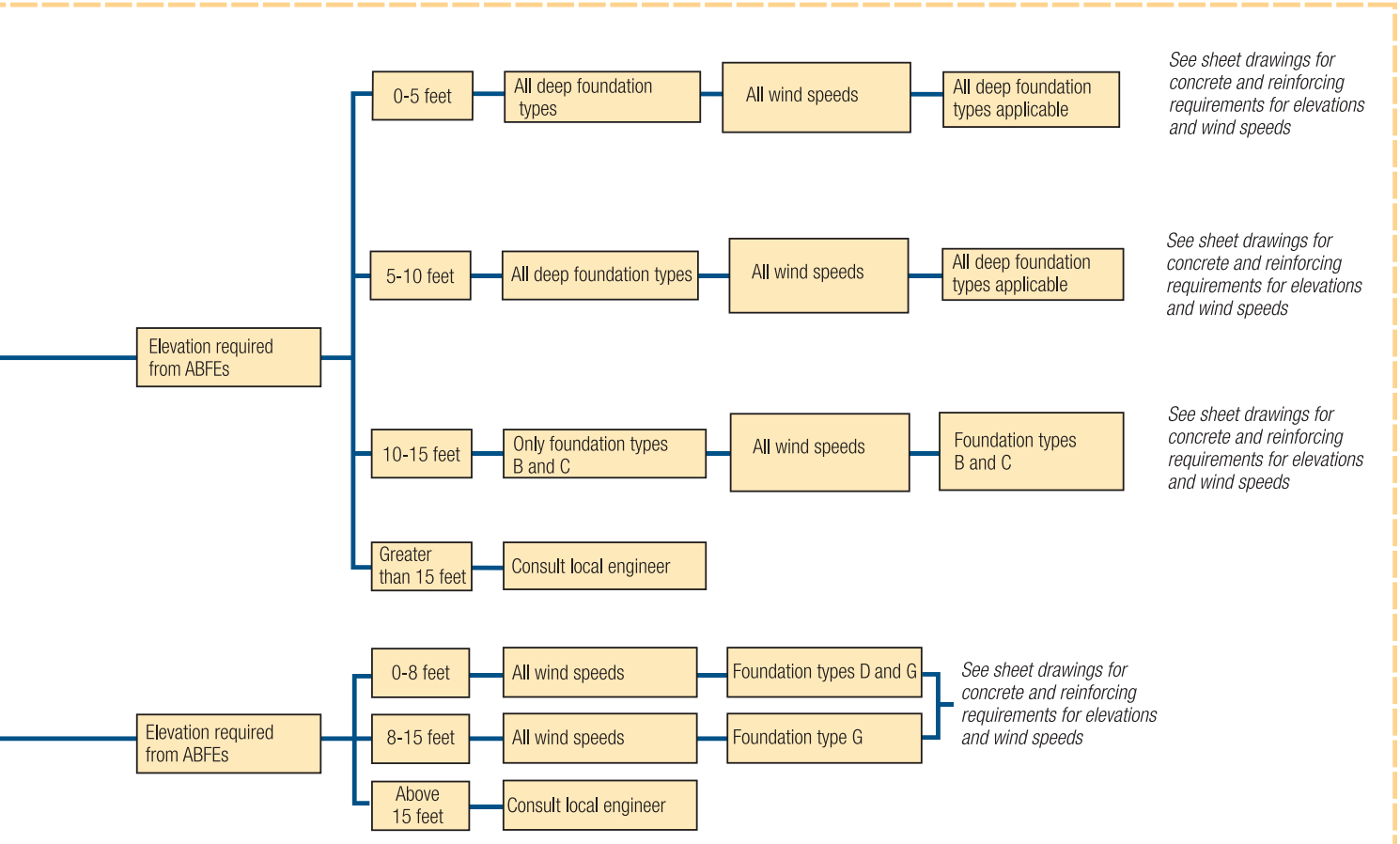

Elevation required from ABFEs
0-5 feet
All deep foundation types
All wind speeds
All deep foundation types applicable
See sheet drawings for concrete and reinforcing requirements for elevations and wind speeds
5-10 feet
All deep foundation types
All wind speeds
All deep foundation types applicable
See sheet drawings for concrete and reinforcing requirements for elevations and wind speeds
10-15 feet
Only foundation types B and C
All wind speeds
Foundation types B and C
See sheet drawings for concrete and reinforcing requirements for elevations and wind speeds
Greater than 15 feet
Consult local engineer
Elevation required from ABFEs
0-8 feet
All wind speeds
Foundation types D and G
8-15 feet
All wind speeds
Foundation type G
See sheet drawings for concrete and reinforcing requirements for elevations and wind speeds
Above 15 feet
Consult local engineer

Table 5-1. Foundation Design Cases Based on Height of Elevation and Wind Velocity

		Wind Velocity of 120 to 150 (mph)		
	Height (H) (ft)	V Zone	Coastal A Zone*	Non-Coastal A Zone
One-Story Dwelling	< 4	A,B,C	A,B,C,D,G	A,B,C,D,E,F,G
	5	A,B,C	A,B,C,D,G	A,B,C,D,E,G
	6	A,B,C	A,B,C,D,G	A,B,C,D,E,G
	7	A,B,C	A,B,C,D,G	A,B,C,D,E,G
	8	A,B,C	A,B,C,D,G	A,B,C,D,E,G
	9	A,B,C	A,B,C,G	A,B,C,G
	10	A,B,C	A,B,C,G	A,B,C,G
	11	B,C	B,C,G	B,C,G
	12	B,C	B,C,G	B,C,G
	13	B,C	B,C,G	B,C,G
	14	B,C	B,C,G	B,C,G
	15	B,C	B,C,G	B,C,G
Two-Story Dwelling	< 4	A,B,C	A,B,C,D,G	A,B,C,D,E,F,G
	5	A,B,C	A,B,C,D,G	A,B,C,D,E,G
	6	A,B,C	A,B,C,D,G	A,B,C,D,E,G
	7	A,B,C	A,B,C,D,G	A,B,C,D,E,G
	8	A,B,C	A,B,C,D,G	A,B,C,D,E,G
	9	A,B,C	A,B,C,G	A,B,C,G
	10	A,B,C	A,B,C,G	A,B,C,G
	11	B,C	B,C,G	B,C,G
	12	B,C	B,C,G	B,C,G
	13**	B,C	B,C	B,C
	14**	B,C	B,C	B,C
	15**	B,C	B,C	B,C

* In the Coastal A Zone, the tops of all footings and grade beams in Cases D and G foundations must be placed below the maximum estimated erosion and scour depth.

** Some foundation designs are not appropriate for two-story dwelling for a design wind speed of 150 mph. See individual design drawings for more details.

Foundation Types

A = Timber pile

B = Steel pipe pile with concrete column and grade beam

C = Timber pile with concrete column and grade beam

D = Concrete column and grade beam

E = Reinforced masonry – crawlspace

F = Reinforced masonry – stem wall

G = Concrete column and grade beam with slab

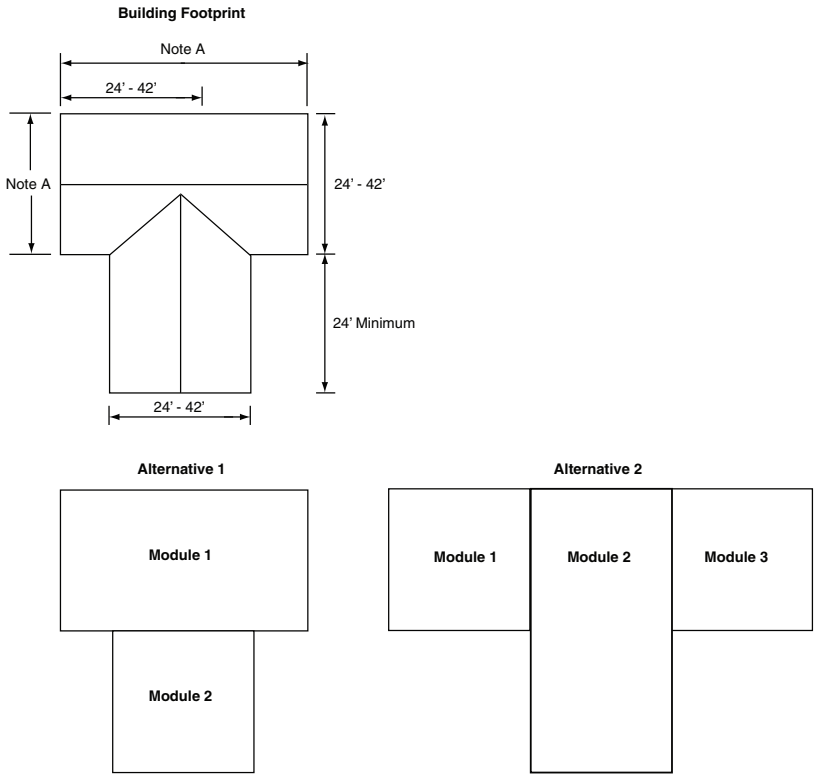


Figure 5-3.
"T" shaped modular design
Note A: Overall building dimensions can exceed 42 feet. The vertical dimensions from the eave to the ridge roof shall not exceed 23 feet.

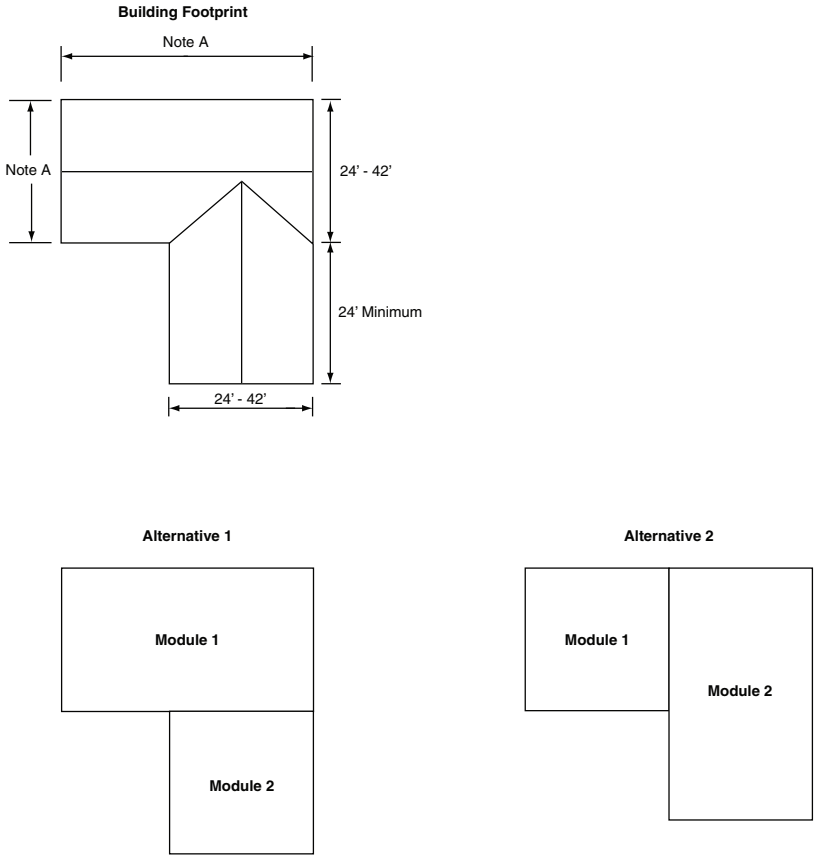


Figure 5-4.
"L" shaped modular design
Note A: Overall building dimensions can exceed 42 feet. The vertical dimensions from the eave to the ridge roof shall not exceed 23 feet.

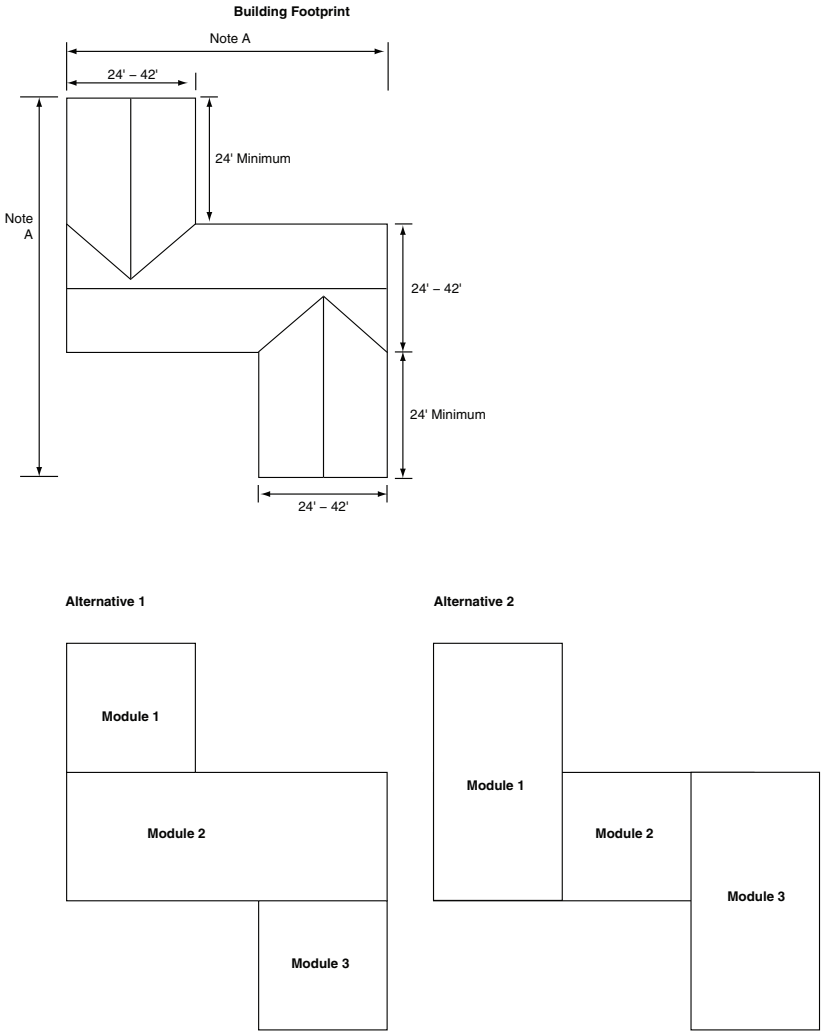


Figure 5-5.
"Z" shaped modular design
Note A: Overall building dimensions can exceed 42 feet. The vertical dimensions from the eave to the ridge roof shall not exceed 23 feet.