PENNSYLVANIA HOUSING RESEARCH CENTER

SITE DESIGN CONSIDERATIONS FOR MANUFACTURED HOUSING

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PURPOSE

The manufactured housing industry provides installation manuals with every house it produces. Those manuals provide instructions for the onsite completion of the home, including acceptable foundation design and construction practices.

This document is intended to provide some supplementary guidance to the manufactured housing industry, including retailers and others responsible for the onsite completion of manufactured houses in Pennsylvania. It focuses on determining:

1. The soil bearing capacity of a site and
2. Appropriate site design and drainage.

This document seeks to expand upon or enhance the information presented in the various manufacturers' installation manuals. When installing a house, all concerned should follow the manufacturer's installation instructions unless permission for an alternative approach is obtained from the manufacturer. The information presented here will help installers to more closely tailor the installation to the particular site on which the house is being built and improve long-term performance of the house. By using this information, the installer may reduce construction costs and avoid costly performance problems.

SOIL BEARING CAPACITY

The determination of soil bearing capacity is critical to designing a foundation that will perform satisfactorily over the life of the house. If the bearing capacity of the soil is over estimated the soil may not be able to support the weight of the house and its contents. This would cause the foundation to settle, which usually results in windows and doors that do not operate and can lead to structural failure of the home.

Pier Foundations

Pier foundations are a common foundation system for both single and multiple unit homes in Pennsylvania.

The spacing and number of piers required depend on the soil bearing capacity and the pier footing size. The stronger the soil and/or the bigger the footing, the fewer the number of piers needed; thus reducing the cost of the foundation.

For pier foundations, the installation manuals provide tables somewhat similar to the example shown on the next page in Table 1. For a single unit house, Table 1 shows an example of how the pier spacing varies with the diameter of the piers and the bearing capacity of the soil. For example, if the holes for the piers are increased from 18 inches to 28 inches in diameter the piers spacing is increased from 3.7 feet to 10.0 feet. Note that the pier spacing requirements for a particular home may differ from those shown in the example in Table 1; the manufacturer's pier spacing requirements should always be followed.

DETERMINING SOIL CAPACITY

Retailers and others responsible for the onsite completion of houses are faced with determining the actual bearing capacity of the soil at a particular site. The following are two approaches to determining the soil bearing capacity.

Default Approach

A default value for soil bearing capacity of 1,500 psf may be assumed provided that the foundation depth is at least 12 inches. **Note: Foundation depth must extend to frost depth.** This approach will result in adequate performance for houses built on most of the soils in Pennsylvania, but the default approach should not be used for wet or low-lying areas. This value may be conservative for a particular site, but it is consistent with most model building codes. For a site on which only a single house will be located, the default approach is usually the most cost effective approach.

Table 1: Example Pier Spacing

Bearing Capacity of Soil (PSF)	18 inch Diameter Pier (1.77 ft²)		24 inch Diameter Pier (3.14 ft²)		28 inch Diameter Pier (4.27 ft²)	
	Pier Spacing	Max Pier Load (lbs)	Pier Spacing	Max Pier Load (lbs)	Pier Spacing	Max Pier Load (lbs)
1,000	2'-6"	1,770	4'-5"	3,140	7'-10"	4,270
1,500	3'-8"	2,655	6'-6"	4,710	10'-0"	6,405
2,000	4'-10"	3,540	8'-8"	6,280	10'-0"	8,540
3,000	7'-5"	5,310	10'-0"	9,420	10'-0"	12,810
4,000	9'-10"	7,080	10'-0"	12,560	10'-0"	17,080

Notes: Example for a 16'x60' single-unit house:

- Roof live load (snow) = 20 PSF
- Floor live load = 40 PSF
- Unit weight = 30 PSF
- 10 foot maximum allowable pier spacing
- PSF = Pounds per square foot
- Default bearing capacity = 1,500 PSF

Site Investigation Approach

Determining the exact soil bearing capacity for a particular site is complicated and calls for the services of an experienced geotechnician or soil engineer. Soil conditions usually vary with depth. For a particular site, it is usually necessary to investigate the subsurface to a depth of around 10 feet, well below the depth of the foundation. Typically one or more holes are drilled or a trench is excavated specifically for this purpose. Soil samples are collected at various depths and are analyzed, and information is gathered on the location of the water table.

The site investigation approach offers two important potential benefits. First, the soils may be found to have a higher allowable bearing capacity than the default value. In such cases, the foundation can be optimized for the site, which may reduce the number of piers, simplify the foundation, and reduce foundation costs. Second, the likelihood of performance problems is reduced. The cost of the soil survey is money well spent when compared to the cost of repairing structural damage caused by an inadequate foundation.

This approach would be most appropriate for communities, subdivisions or areas where several houses will be located since the cost of conducting a site investigation can be spread over several units.

Site Design and Drainage

While the bearing capacity of the soil is important, there is no more important issue for the longevity of a structure than the planning for water control at the site. Site design and grading that does not permit rain water or melting snow to be quickly drained from the site can cause significant problems for the structure as well as its inhabitants.

- Allowing the water to accumulate around the foundation can decrease the bearing capacity of the soil. Generally, as the water content of soil increases, its load bearing capacity decreases. This is especially true of the clayey soils found in many parts of Pennsylvania. If the soil around the foundation is allowed to become saturated, the risk of excessive settlement is significantly increased.

- The increased moisture content can also lead to increased frost heaving of the soil around the home, causing damage to attached structures such as porches and sidewalks. In the case of houses with pier foundations, the skirting around the house may be damaged or deformed by the movement of the soil.

- The trapping of water near the foundation can lead to damp or wet basements or crawlspaces. The presence of high levels of moisture frequently contributes to mold and mildew growth. The spores from many molds cause problems for people with asthma or allergies. Very wet or damp soil can also lead to an increase in the presence of insects (termites, mosquitoes, etc.) that can certainly have a detrimental effect on the structure and its occupants.

The site design should control water by providing drainage from the site. The two main components are site grading and gutters.

Grading

Proper grading of the site allows surface water to drain away from the foundation. Generally the site should be graded for at least 10 feet away from the home (see Figure 1) to remove water quickly from the site. A rule of thumb is to slope the grade 1 inch per foot for the first 6 feet then ¼ inch per foot after that. The water must be able to drain away, not only from the home, but also from the site. Any pooling or standing water can be problematic.

Sloped Sites

Sloped sites must be protected from surface runoff from the surrounding area. Where the site is sloped toward the foundation, it is important to provide a drainage swale on the uphill side of the house. Figure 2 shows a primary swale above the primary cut area with a secondary swale to remove runoff from around the house.

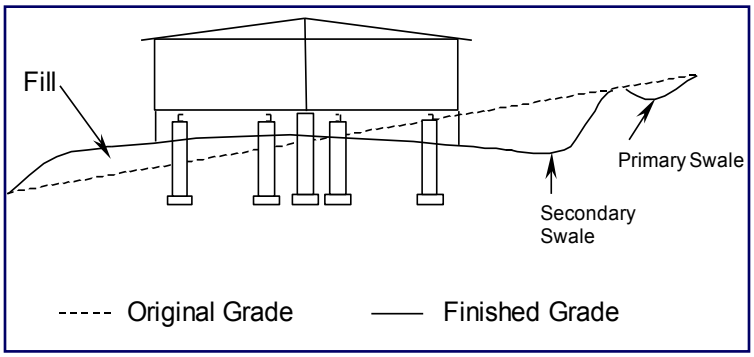

Figure 2: Sloped Site Considerations

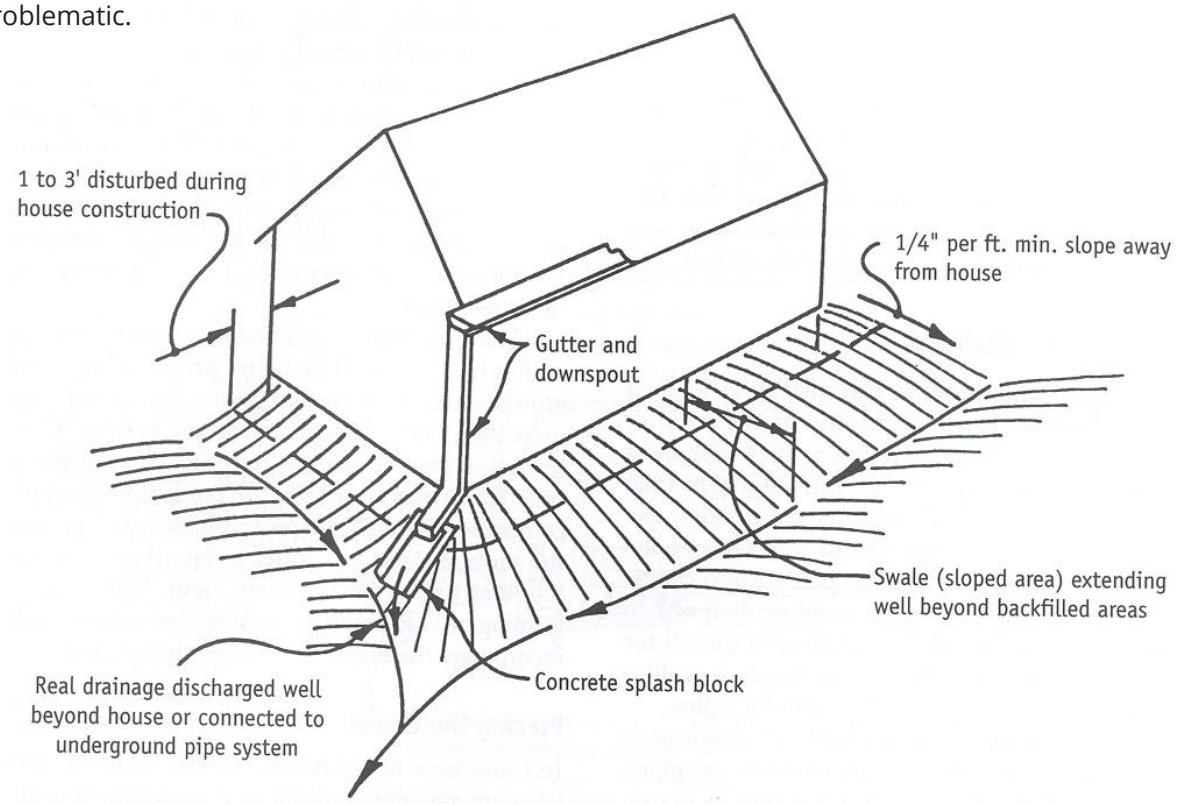

Figure 1: Site Grading and Drainage
Source: Residential Drainage, by S. Spano and D. Isokait, Washington Suburban Sanitary Commission, Hyattsville, MD; 1979

Gutters

Taken together, the gutters, down spouting, and splash blocks are an important part of any effective water management system. They help remove the water quickly from the site and minimize the amount of water that drains directly around the foundation. Gutters also limit the amount of water that must drain from a wall enclosure. A one-inch rainfall (not uncommon in Pennsylvania) equates to 1,135 gallons of water falling directly on an average two-section home. Allowing such a volume of water to reach the ground surrounding the foundation in an uncontrolled fashion can cause serious problems for the foundation, the house, and its occupants. Therefore, proper site grading which directs water away from the foundation in combination with gutters and down spouts will ensure that the building is capable of handling precipitation events. Check with the manufacturer for an approved method of attaching gutters and down spouting to the home.

OTHER CONSIDERATIONS

The following general points should be kept in mind when considering the soil bearing capacity of any site.

Municipal Requirements: Check with local building code officials to find out if they require soil testing or if they specify a minimum soil bearing capacity for the area where the house will be located. If so, the local requirements should be followed.

Pocket Penetrometer: Pocket penetrometers are often promoted by housing manufacturers and others as an appropriate tool for determining the bearing capacity of soil. Such use of this instrument is cause for concern. **The pocket penetrometer is neither designed nor intended to determine soil bearing capacity.** It is widely used in the field to determine the compaction of fill placed on a site or to help in classifying clayey soils. There is no direct correlation between compaction and soil bearing capacity. The pocket penetrometer is simply one of the tools that an experienced geotechnical engineer could use to determine the soil conditions at a site.

Wet Soils: Wet areas and areas with a high water table should be avoided. These areas may be identified through vegetation (such as cattails, marsh grass, or willow trees) or if water is found when excavating or boarding for the foundation. If the site must be built on, a design professional should be consulted regarding the site and foundation designs.

Fill: Where soil is added in order to level a site, it should be added in six-inch layers and compacted with heavy equipment between each layer. This method will help minimize settlement of the soil after the house is completed. **The bottom of the foundation should be located at least 12 inches below the undisturbed soil.** This is especially important for sloped sites that have been re-contoured as shown in Figure 2.

PHRC | 219 Sackett Building | University Park, PA 16802