Pile Design and Installation

Purpose: *To provide basic information about pile design and installation.*

Key Factors

- Use a pile type that is appropriate for local conditions.
- Piles should resist coastal hazards such as high winds and flood loads in addition to withstanding erosion and scour. Erosion being the widespread loss of soil and scour being a localized loss of soil around a building or foundation element due to turbulent water movement.
- Have a registered engineer design piles for adequate layout, size, and length.
- Use installation methods that are appropriate for the conditions.
- Brace piles properly during construction.
- Make accurate field cuts, and treat all cuts and drilled holes to prevent decay.
- Have all pile-to-beam connections engineered, and use corrosion-resistant hardware (see Fact Sheet No. 1.7, C*oastal Building Materials*).

Pile Types

The most common pile types used are preservative treated wood, concrete, and steel. Contractors doing construction in coastal areas typically select preservative treated wood piles for pile foundations. They can be square or round in cross section. Wood piles are easily cut and adjusted in the field. Concrete and steel can also be used but are less common in residential construction. Concrete piles—may be an appropriate choice depending upon the pile capacity requirements and elevation needed by the design—are available in longer lengths and are usually installed by pile driving. Concrete piles tend to have higher strengths and are durable to many factors that are in the coastal environment when properly designed and detailed. Steel piles are rarely used because of potential corrosion problems.

Pile Size and Length

The foundation engineer is the one who determines pile size and length. Specified bearing and penetration requirements must be met. Round piles should have no less than an 8-inch tip diameter; square piles should have a minimum timber size of 8 by 8 inches. The total length of the pile is based on building code requirements [see the 2009 International Building Code (IBC) Section 1810 on deep foundations], calculated penetration requirements, erosion and scour potential, Design Flood Elevation (DFE), and allowance for cut-off and beam width (see Figure 1 and Table 1, which is an example of foundation design results). Substantial improvement in foundation performance can be achieved by increasing the minimum timber size for square piles to 12 by 12 inches or minimum tip diameter for round piles of 12 inches.

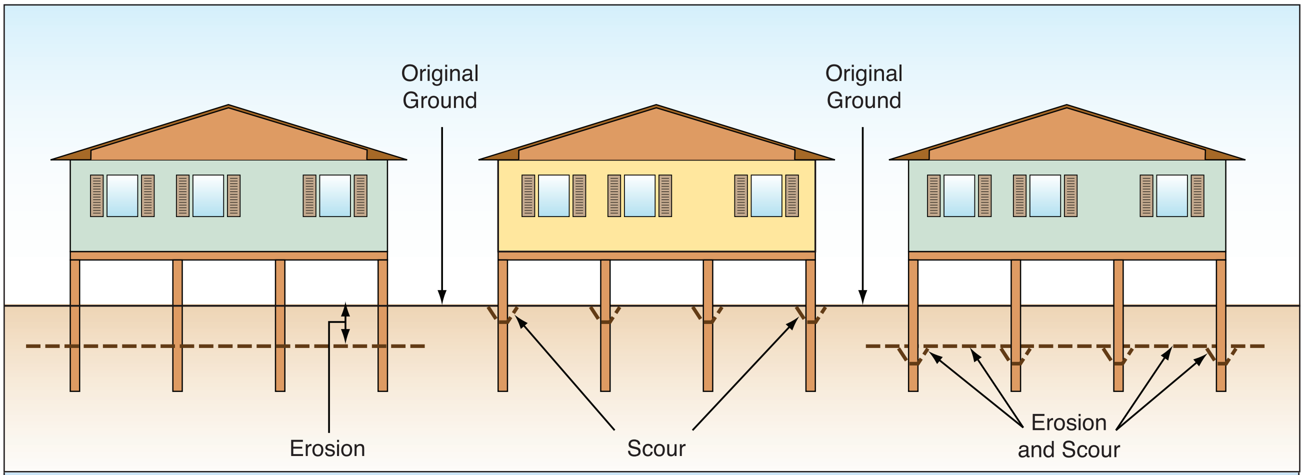

Figure 1. Distinguishing between coastal erosion and scour. A building may be subject to either or both, depending on the building location, soil characteristics, and flood conditions.

Table 1. Example foundation adequacy calculations for a two-story house supported on square timber piles and situated away from the shoreline, storm surge, and broken waves passing under the building, 130-mph basic wind speed per ASCE 7-05 (167-mph equivalent ASCE 7-10 basic wind speed for Risk Category II buildings), soil = medium dense sand. Shaded cells indicate the foundation fails to meet bending (P) and/or embedment (E) requirements.

Pile Embedment Before Erosion and Scour	Erosion and Scour Conditions	Pile Diameter, Ø		
		8 inch	10 inch	12 inch
10 feet	Erosion = 0, Scour = 0	P, E	E	OK
	Erosion = 0, Scour = 2.0Ø	P, E	E	E
	Erosion = 1, Scour = 2.5Ø	P, E	E	E
	Erosion = 1, Scour = 3.0Ø	P, E	E	E
	Erosion = 1, Scour = 4.0Ø	P, E	P, E	E
15 feet	Erosion = 0, Scour = 0	P	OK	OK
	Erosion = 0, Scour = 2.0Ø	P	OK	OK
	Erosion = 1, Scour = 2.5Ø	P	OK	OK
	Erosion = 1, Scour = 3.0Ø	P	OK	OK
	Erosion = 1, Scour = 4.0Ø	P, E	P, E	E
20 feet	Erosion = 0, Scour = 0	P	OK	OK
	Erosion = 0, Scour = 2.0Ø	P	OK	OK
	Erosion = 1, Scour = 2.5Ø	P	OK	OK
	Erosion = 1, Scour = 3.0Ø	P	OK	OK
	Erosion = 1, Scour = 4.0Ø	P	P	OK

Pile Layout

The foundation engineer and designer determine the pile layout together. Accurate placement and correction of misaligned piles is important. The use of a drive template for guiding the pile driving operation greatly increases the accuracy of the pile location and need for difficult remediation. A drive template is a temporary guide structure that is installed in a manner to restrict the lateral movement of the piles during driving. The pile template is reused for each row of piles to assure consistent spacing and alignment. Pile placement should not result in more than 50 percent of the pile cross section being cut for girder or other connections. Verify proper pile locations on drawings before construction and clarify any discrepancies. Layout can be done by a licensed design professional or surveyor, a construction surveyor, the foundation contractor, or the builder. The layout process must always include establishing an elevation for the finished first floor. Construction of the first-floor platform should not begin until this elevation is established (see Fact Sheet No. 1.4, *Lowest Floor Elevation*).

Installation Methods

Piles can be driven, augered, or jetted into place. The installation method will vary with soil conditions, bearing requirements, equipment available, and local practice. One common method is to initially jet the pile to a few feet short of required penetration, then complete the installation by driving with a drop hammer. Driving the pile even a few feet helps assure the pile is achieving some end-bearing capacity and some skin friction. Full depth driving where achievable provides for a pile foundation that has several advantages that merit consideration.

Pile Bracing

The engineer determines pile bracing layout. Common bracing methods include knee and diagonal bracing. Knee bracing is an effective method of improving the performance of a pile system without creating an obstruction to the flow of water and debris from a design event. Because slender bracing is susceptible to buckling, slender bracing should be considered as tension only. Bracing can become an obstruction, however, and increase a foundations exposure to wave and debris impact. Bracing is often oriented perpendicular to the shoreline so that it is not struck broadside by waves, debris, and velocity flow (see Figure 2). Temporary bracing or jacking to align piles and hold true during construction is the responsibility of the contractor.

It is recommended that pile bracing be used only for reducing the structure's sway and vibration for comfort. In other words, bracing should be used to address serviceability issues and not strength issues. The foundation design should consider the piles as being un-braced as the condition that may occur when floating debris removes or damages the bracing. If the pile foundation is not able to provide

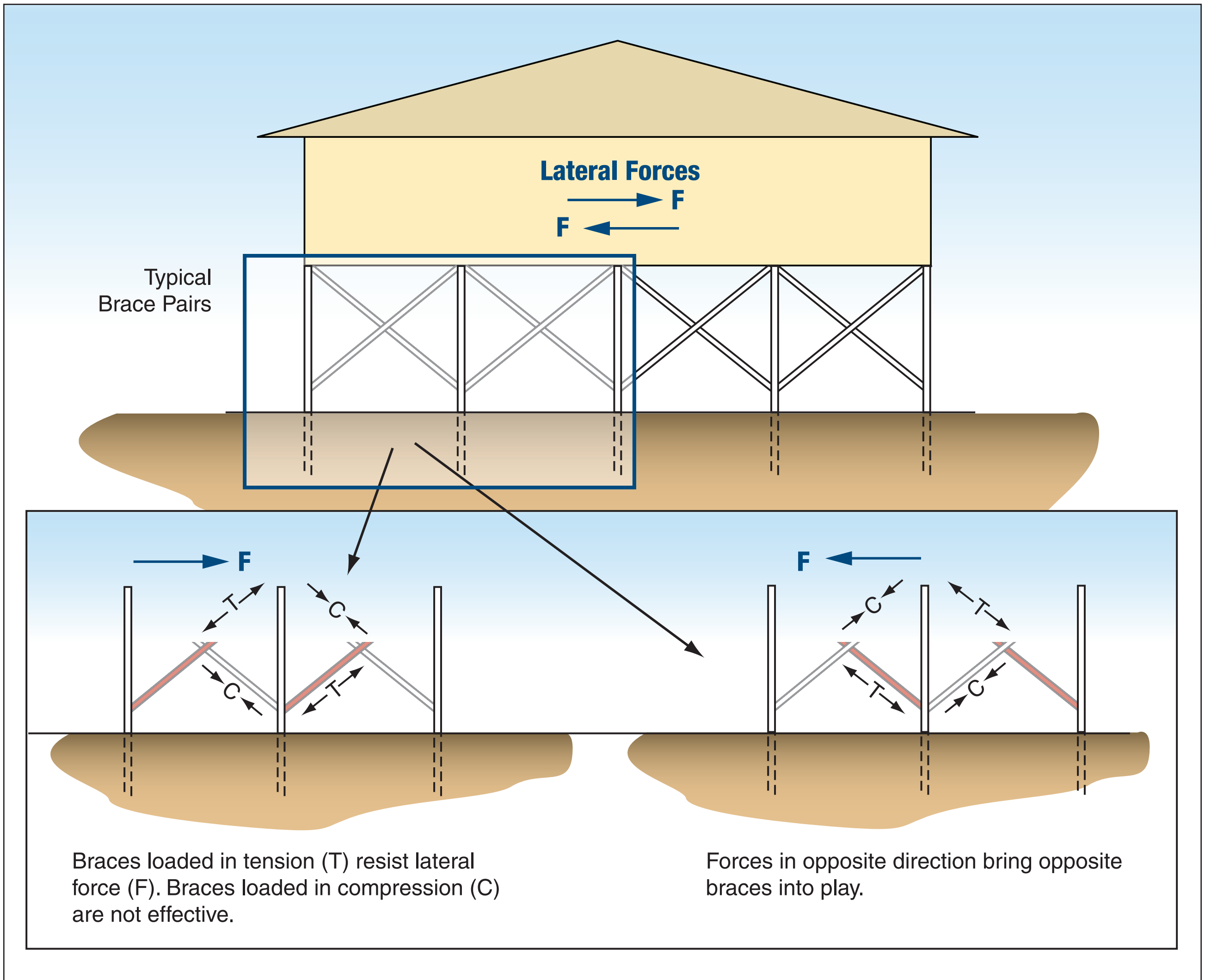

Figure 2. Diagonal bracing schematic.

the desired strength performance without bracing then the designer should consider increasing the pile size. Pile bracing should only be for comfort of the occupants, but not for stability of the home.

Field Cutting and Drilling

A chain saw is the common tool for making cuts and notches in wood piles. After making cuts, exposed areas should be field-treated with the proper wood preservative to prevent decay. This involves applying the preservative with a brush to the cut or drilled holes in the pile until no more fluid is drawn into the wood.

Connections

The connection of the pile to the structural members is one of the most critical connections in the structure. Always follow design specifications and use corrosion-resistant hardware. Strict attention to detail and good construction practices are critical for successful performance of the foundation (see Fact Sheet Nos. 1.7, *Coastal Building Materials*, and 3.3, *Wood-Pile-to-Beam Connections*).

Verification of Pile Capacity

Generally, pile capacity for residential construction is not verified in the field. If a specified minimum pile penetration is provided, bearing is assumed to be acceptable for the local soil conditions. Subsurface soil conditions can vary from the typical assumed conditions, so verification of pile capacity is prudent, particularly for expensive coastal homes. Various methods are available for predicting pile capacity. Consult a local foundation engineer for the most appropriate method for the site.

Additional Resources

American Concrete Institute (ACI), 543R-00: *Design, Manufacture, and Installation of Concrete Piles* (Reapproved 2005), (http://www.concrete.org)

American Forest and Paper Association (AF&PA). *National Design Specification for Wood Construction*. (http://www.afandpa.org)

American Society for Testing and Materials (ASTM). *Standard Specification for Round Timber Piles*, ASTM D25. (http://www.astm.org)

American Wood-Preservers Association (AWPA). *All Timber Products – Preservative Treatment by Pressure Processes, AWPA C1-00; Lumber, Timber, Bridge Ties and Mine Ties – Preservative Treatment by Pressure Processes, AWPA C2-01; Piles – Preservative Treatment by Pressure Process*, AWPA C3-99; and others. (http://www.awpa.com)

Pile Buck, Inc. *Coastal Construction*. (http://www.pilebuck.com)

Southern Pine Council (SPC) (http://www.southernpine.com/about.shtml)

Timber Pile Council, American Wood Preservers Institute, *Timber Pile Design and Construction Manual*, (http://www.wwpinstitute.org/pdffiles/TimberPileManual.pdf)

Developed in association with the National Association of Home Builders Research Center