

CHAPTER 2.0

FOUNDATION DESIGN PROCEDURE

2.1 DESIGN OF FOUNDATIONS

Foundations are often classified as shallow or deep foundations, depending on the depth of the load-transfer member below the superstructure. Thus a deep, as compared with a shallow, foundation becomes a somewhat relative term. A shallow foundation, as defined in this manual, is one in which the depth to the bottom of the footing is less than or equal to four times the smallest dimension of the footing.

The foundation engineer must have a thorough understanding of the foundation loads, subsurface conditions, including soil/rock properties and behavior, foundation performance criteria, and current practices in foundation design and construction in the area where the work is to be done to arrive at the optimum foundation solution. When designing foundations, it is essential to systematically consider the various foundation types and to select the optimum alternative based on the superstructure requirements and subsurface conditions.

2.2 FOUNDATION DESIGN PROCESS

The timber pile foundation design-construction process is outlined in the flow chart in Figure 2-1. This flow chart will be discussed block by block, using the numbers in the blocks as a reference, and will serve to guide the designer through all of the tasks that should be considered (after FHWA, 1998).

Block 1: Assemble Information Regarding Proposed Structure

The first step in the process is to determine the general structure requirements. The following questions should be asked and answered during this phase of the design process: Is the project a new commercial office building, a residential building, a new bridge, a replacement bridge, a retaining wall, a noise wall, a sign, etc.? Will the project be constructed in phases or all at once? What is the general structure layout? Is the structure subjected to any special design events such as seismic, scour, debris, etc.? If there are special design events, the design requirements for the event should be reviewed at this stage so that these considerations can be factored into the site investigation. What are the approximate foundation loads? Are there deformation or deflection limitations beyond the usual requirements?

Block 2: Obtain General Site Geology

A great deal may be learned about the foundation requirements with even a very general understanding of the site geology. For small structures, this may involve only a very superficial investigation such as a visit to the site. The foundation design for very large structures may require extensive geologic studies.

Block 3: Collect Foundation Experience from the Area

Frequently there is information available on foundations that have been constructed in the area. This information can be of assistance in avoiding problems. Both subsurface exploration information and foundation construction experience should be sought prior to selecting the foundation type.

Block 4: Develop and Execute Subsurface Exploration Program

Based on the information obtained in Blocks 1-3, it is possible to make decisions regarding the necessary information that must be obtained at the site. The program must meet the needs of the design problem that is to be solved at a cost consistent with the size of the structure. The subsurface exploration program, as well as the appropriate soil laboratory-testing program, must be selected. The results of the exploration and testing programs are used to prepare a subsurface profile and identify critical cross-sections.

Block 5: Evaluate Information and Select Foundation System

The information in Blocks 1-4 must be evaluated and a foundation system selected. The first question to be decided is whether a shallow or a deep foundation is required. This question will be answered based primarily on the strength and compressibility of the site soils, the proposed loading conditions and the project performance criteria. If settlement is not a problem for the structure, then a shallow foundation will typically be the most economical solution. Ground improvement techniques in conjunction with shallow foundations should be evaluated when a shallow foundation does not meet the project requirements. If the structure performance criteria can not be met by a shallow foundation, a deep foundation should be used.

Refined foundation loading information and performance criteria should be established at this time. In Block 1, this issue was considered. At this stage of the design effort, a better definition of the design foundation loads and performance criteria are typically available. They should be included in the design process. The geotechnical engineer should obtain a completely defined and unambiguous set of foundation loads and performance requirements in order to proceed through the foundation design.

Block 6: Deep Foundation

At this stage the designer must decide between a deep foundation system and either a shallow foundation of soil improvement or a shallow foundation. The decision on foundation type should be based on performance and economics.

Block 7: Driven Piles

Once a deep foundation has been selected, the designer must decide to use either driven piles or other deep foundation systems (i.e., drilled shafts, auger cast piles etc.). The question that should be answered in deciding between driven piles and other deep foundation systems is which system will perform as desired for the least cost. In addition to performance and cost, constructability should be considered.

Block 8: Select Driven Pile Type

The pile type should be selected consistent with the applied load per pile. The general magnitude of the applied load is known from the information obtained in blocks 1-5. A large number of combinations of pile capacities and pile types can satisfy the design requirements. The selection of pile type should consider both the structural capacity of a pile and the realistic geotechnical capacity of the pile type for the soil conditions at the site, the cost of alternative piles, and the capability of available construction contractors to drive the selected pile. Timber piles are economical piles that should be considered when anticipated pile loads are between 50 and 150 kips and when anticipated pile lengths are between 20 – 125 feet. Table 2-1 presents various types of driven piles their advantages and disadvantages, and what conditions are most favorable for their use.

Block 9: Calculate Pile Length and Capacity

For timber piles, perform a static analysis to estimate the length necessary to provide the required capacity (i.e., compression, uplift and lateral load). It may be necessary to increase the number of piles to satisfy the structural requirements.

Block 10: Calculate Driveability

The static design completed in block 9 addresses the structural capacity of the pile. It is also important to assess the driveability of the selected pile to assure that the required capacity and penetration depth may be achieved at a reasonable driving resistance. The driveability analysis cannot be completed until the pile hammer has been selected (this will depend on the contractor selected for the project). Pile driveability will be covered in some detail in Chapter 9.

Block 11: Satisfactory Design

At this point the computations for the design are complete.

Block 12: Prepare Plans and Specifications

The design is, in fact, not complete until the plans and specifications are prepared. It is important that all of the quality control procedures are clearly defined to avoid claims after construction is underway.

Foundation Design Process

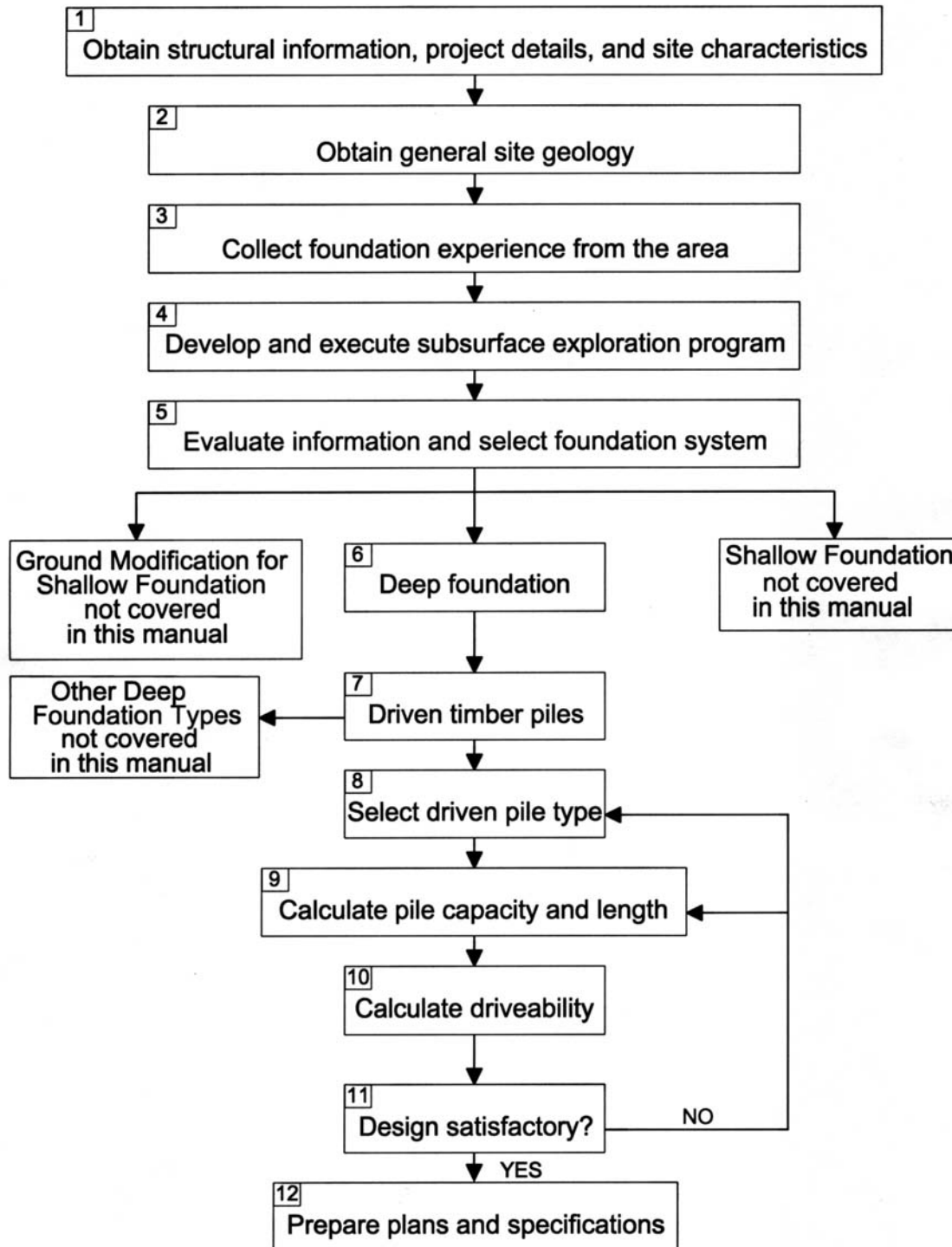


Figure 2-1: Flow chart timber pile design process

Table 2-1

Pile Type	Timber	Steel H-Piles	Steel Pipe Piles	Pre-Cast/ Prestressed Concrete	Cast-in-Place Concrete Mandrel Driven Shell	Cast-in-Place Concrete Shells Driven Without Mandrel
Typical Length (ft)	20-75 (Douglas Fir to 125)	20-100	30-120	30-45 (precast) 45-120 (pre-stressed)	10-120	15-80
Typical Axial Design Loads (kips)	35-150	100-400	200-500	100-250	100-300	100-300
Advantages	<ul style="list-style-type: none"> • Low cost • Renewable resource • Easy to handle • Easy to drive • Pile length variations easily accounted for • Tapered section provides higher resistance in granular soils than uniform piles • Used as friction or end bearing pile 	<ul style="list-style-type: none"> • Easy to splice • High capacity • Small displacement 	<ul style="list-style-type: none"> • Open ended good against obstructions • High load capacity 	<ul style="list-style-type: none"> • High load capacity • Corrosion resistance obtainable 	<ul style="list-style-type: none"> • Initial economy • Tapered sections provide higher resistance in granular soils than uniform piles • Can be inspected after driving 	<ul style="list-style-type: none"> • Can be redriven • Shell not easily damaged
Disadvantages	<ul style="list-style-type: none"> • Difficult to splice • Low axial capacity 	<ul style="list-style-type: none"> • Vulnerable to corrosion • Not recommended for friction pile 	<ul style="list-style-type: none"> • Displacement for closed end pipe • Open ended not recommended as friction pile 	<ul style="list-style-type: none"> • Vulnerable to handling damage • High breakage rate • High initial cost 	<ul style="list-style-type: none"> • Difficult to splice after concreting • Thin shell vulnerable during driving • Considerable displacement 	<ul style="list-style-type: none"> • Difficult to splice after concreting