

CHAPTER

5 Pile Foundations - General

5-1 Introduction

Pile foundations are used when the underlying soils are incapable of resisting the loads from the structure. The piling is placed in the ground through poor quality materials to bear on competent soils. The piles are either driven into the ground or holes are drilled and filled with reinforced concrete. The piles transfer the load by bearing on competent material or through the friction between the soil and the pile (skin friction.)

Pile foundations can be categorized into two general types: displacement piles and replacement piles. A displacement pile is a pile that is driven or vibrated into the ground and displaces the surrounding soil during installation. A replacement pile is a pile that is placed or constructed within a previously drilled borehole and replaces the excavated soil. Chapter 7, *Driven Piles*, contains information on displacement piles. Chapters 6, *Cast-In-Drilled-Hole Piles*; Chapter 9, *Slurry Displacement Piles*; and Chapter 10, *Pier Columns*, contain information on replacement, or cast-in-place piles. Chapter 13, *Micropiles*, contains information on alternative piles and micropiles, which can be a combination of displacement and replacement piles.

Driven piles are braced structural columns that are driven, pushed, or otherwise forced into the soil. Two types of pile foundations were developed through the ages to support structures on poor quality soil: piles and piers. Piles are more commonly used and are essentially small diameter piers that work in groups. Pier foundations are large in diameter and tend to work independently. They have gained favor over the last several years as they behave very well seismically. Piles/Piers can be classified as friction piles, end bearing piles, or a combination of the two. They can also provide lateral stability in foundations. Friction piles can transfer both tensile and compressive forces to the surrounding soil.

5-2 Specifications

The specifications for piling are contained in the *Standard Specifications*¹. Project specific requirements and revisions to the *Standard Specifications* are included in the

¹ 2010 SS Section 49, *Piling*.

Special Provisions. The contract plans and *Standard Plans* are additional contract documents needed for pile work and describe what piling goes where for each structure. In general, the contract plans describe the intended pile type, specified tip elevation(s) and a minimum nominal resistance. The contract specifications provide project-specific requirements on how to perform the work. These documents also include specific requirements for activities such as embankment pre-drilling, load testing, and other items specific to a project. For example, if difficult driving is anticipated, the Designer may provide the option of using either steel “H” piling or precast concrete piles. When this option is written into the contract, the Contractor is allowed to choose the most economical option. If specifications allowing options are not included in the contract, then changes from one pile type to another cannot be made without a contract change order and concurrence from the Designer.

Details for the different classes of typical piles are found in the *Standard Plans* while details for atypical or nonstandard piles are shown on the contract plans. The *Standard Plans* also provide options and alternative details for the different classes of piles. Note that different pile classes are not interchangeable. For example, when Class 140 piles are specified, the Contractor can select either of the alternatives shown in the *Standard Plans* for Class 140 piles but cannot select an option from a different class of piles such as Class 90 or 200. Occasionally, the Designer may decide to exclude some of the alternatives for a given class of pile. In this situation, the excluded alternatives will be noted in the special provisions or contract plans.

The *Standard Specifications* contain the general information for pile work. This includes specifics for submittals, type of materials, quality assurance, construction procedures, measurement, and payment. Remember that the *Special Provisions* and the contract plans have precedence over the *Standard Plans* and *Standard Specifications*. For this reason, it is imperative that all contract documents be thoroughly reviewed well in advance of the work and inconsistencies resolved prior to start of work.

5-3 Cast-in-Place Piles

The 2010 version of the *Standard Specifications* identifies 3 different types of cast-in-place (CIP) piles. They are as follows:

1. Cast-in-Drilled-Hole (CIDH) concrete piles.
2. CIDH concrete pile rock sockets.
3. Driven steel shells filled with concrete and reinforcement.

The first type is typically known as a Cast-in-Drilled-Hole (CIDH) Pile. The second type is essentially a CIDH pile drilled in rock. Sometimes combinations of two or more types of cast-in-place piles are used to construct a single pile. This can happen when soft materials such as clays overlay rock formations. Permanent or temporary steel casings may be utilized for the first two types. The third type involves the installation of a steel

shell, removal of the soil inside the steel shell and subsequently filling with reinforced concrete. Steel shells add to structural capacity to the pile while steel casings generally have no structural value and are only used to facilitate construction.

The 2006 version of the *Standard Specifications* identifies four (4) different types of cast-in-place piles. They are as follows:

1. Steel shells driven permanently to the required nominal resistance and penetration and filled with concrete.
2. Steel casings installed permanently to the required penetration and filled with concrete.
3. Drilled holes filled with concrete.
4. Rock sockets filled with concrete.

The first two types involve the installation of a permanent steel casing or shell, removal of the soil inside the casing and subsequently filling with reinforced concrete. Steel shells add to structural capacity to the pile while casings are assumed to have no structural value and are only used to facilitate construction. The third type is typically known as a CIDH Pile. The last type is essentially a CIDH pile drilled in rock. Sometimes combinations of two or more types of cast-in-place piles are used to construct a single pile. This can happen when soft materials such as clays overlay rock formations. Permanent or temporary steel casings may be utilized for these two types.

Cast-In-Drilled-Hole piles are made of reinforced concrete cast into holes drilled in the ground to a specified tip elevation. Diameters generally range from 12 to 168 inches and lengths range from 10 feet to well over 200 feet. They are satisfactory in suitable material and are generally more economical than most other types of piling. They are especially advantageous where vibration from pile driving operations might damage adjacent infrastructure, such as pipelines or buildings. The geological ground formations into which the holes are drilled must be capable of retaining their shape during drilling and concrete placement operations and no groundwater should be present.

If there are concerns about the presence of groundwater, the slurry displacement method specifications may need to be utilized. Cast-In-Drilled-Hole piles are discussed in more detail in Chapters 6, *Cast-In-Drilled-Hole Piles*, and Chapter 9, *Slurry Displacement Piles*. Special consideration piles, such as those for changeable message signs (CMS), are discussed in Chapter 13, *Micropiles*.

5-4 Driven Piles

Driven piles typically consist of three different types: (1) concrete, (2) steel, and (3) timber. A general description of each type is given below. Driven piles are discussed in more detail in Chapter 7, *Driven Piles*.

Table 5-1. Driven Pile Types

TYPE OF PILE	DESCRIPTION
Driven Piles – Concrete	<p>Driven concrete piles come in a variety of sizes, shapes, and methods of construction. In cross section, they can be square, octagonal, round, solid or hollow. These piles generally vary in sizes from 10 to 60 inches in diameter and consist of precast prestressed concrete.</p> <p>Caltrans has standard details for splicing precast concrete piles but it is a difficult, time consuming, and expensive procedure. Hence, this almost precludes the use of precast piles where excessively long piles are required to obtain necessary bearing.</p> <p>The unit cost to furnish concrete piles is usually lower than the steel equivalent. But this cost is often offset by the requirement for a larger crane and hammer to handle the heavier pile. This is particularly true when there are a small number of piles to drive.</p>
Driven Piles – Steel	<p>Steel piling includes structural shape piles and pipe piles. Structural shape piles are generally used for lower capacity piles shown in the Standard Plans. Pipe piles are generally used for high capacity piles. The pipe section is a standard alternate for structural shape Class 90 and 140 piling, but is seldom used.</p> <p>Although steel piling is relatively expensive on a “per foot” furnish basis, it has a number of advantages. Structural shape steel piles come in sizes varying from HP 8 x 36 to HP 14 x 117 rolled shapes or may consist of structural steel plates welded together. They are available in high strength and corrosion-resistant steels. They can penetrate to bedrock where other piles would be destroyed by driving. However, even with “H” piles, care must be taken when long duration hard driving is encountered as the pile tips can be damaged or the intended penetration path of the pile can be drastically deflected. Using a reinforced point on the pile can sometimes prevent this type of damage. Due to the light weight and relative ease of splicing, they are useful where great depths of unstable material must be penetrated before reaching the desired load carrying stratum and in locations where reduced clearances require use of short sections. They are useful where piles must be closely spaced to carry a heavy load because they displace a minimal amount of material when driven.</p> <p>Steel pipe piling comes in sizes varying from 10 to 120 inches in diameter, for heavy walled pipe that are driven directly with the hammer to thin walled or step-taper pipes which are driven with a mandrel. The steel shell may have a flat bottom or be pointed, and may be step-tapered or a uniform section. Steel pipe piling may or may not be filled with reinforced concrete.</p> <p>Splice details are shown on the Standard Plans and contract plans for contracts that permit the use of steel piling. Pile welding work requires the submittal and authorization of a Welding Quality Control Plan. The requirements for the Welding Quality Control Plan are addressed in the contract specifications².</p> <p>Sometimes “H” piles must be driven below the specified tip elevation before the nominal driving resistance is attained. This can present an administrative problem (cost) if the length driven below the specified tip elevation is significant. Steel lugs</p>

² 2010 SS, Section 11-3.02, *Welding Quality Control*, or Special Provisions for contracts using 2006 SS.



TYPE OF PILE	DESCRIPTION
	welded to the piles are commonly used to solve this problem. This subject is covered in detail in Bridge Construction Memo 130-5.0, <i>Steel H-Pile Lugs</i> .
Driven Piles – Wood	Untreated timber piles may be used for temporary construction, revetments, fenders and similar work; and in permanent construction where allowed by the contract specifications. They are also sometimes used for trestle construction, although treated piles are preferred. Timber piles are difficult to extend, hard to anchor into the footing to resist uplift, and subject to damage if not driven carefully. Timber piles also have a maximum allowable bearing capacity of 90 kips, whereas most structure piles are designed for at least 140 kips.

5-5 Micropiles and Alternative Piles

Micropiles are currently used when the contract specifications allow their use. The State standard micropile design or proprietary micropile systems may be used. At the time of publication, the Alternative Piling specifications were being rewritten, and there are no currently approved alternative piling systems. Refer to Chapter 13, *Micropiles*, and Appendix D, *Pier Column & Type I Pile Shaft*, for additional information.