Bridge Design - Shallow Foundations

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DEEP FOUNDATIONS

1.1 INTRODUCTION

This course discusses the design practice of deep foundations, which comprises pile and shaft foundations. A pile is defined as a slender deep foundation unit, entirely or partially embedded in the ground and installed by driving, vibration, or other method. A drilled shaft is defined as a foundation unit, entirely or partially embedded in the ground, constructed by placing concrete in a drilled hole with or without steel reinforcement. Within Caltrans terminology, "pile" is often used as a general term referring to both driven piles and drilled shafts. However, the term "piles" is referred as "Driven Piles" in the AASHTO LRFD Bridge Design Specification (AASHTO, 2012). Both piles and drilled shafts develop their geotechnical capacities from the surrounding soil. Pile/shaft groups in competent soil are addressed in Sections 16.1.3 and 16.2, shaft groups in soft/liquefiable soil are addressed in Section 1.3, and column shafts (Type I and Type II) are addressed in Section 1.4.

Pile/shaft foundations can be an economical/necessary alternative to spread footings, particularly when:

(i) competent soil strata are far from original ground;

(ii) liquefaction and/or lateral-spreading potential exist;

(iii) scour depth is large;

(iv) removal of existing soil is undesirable, e.g., soil contaminated by hazardous material; or

(v) space limitations prohibit the use of spread footings.

The structural system of a pile/shaft group is an array of piles or shafts that are connected to a relatively thick reinforced concrete or composite cap and that work interactively together to support the bridge bents/piers. The forces and moments acting at the base of the bent/pier are directly transferred to the pile cap, and resulting displacements and rotations of the cap generate axial force, shear force, and bending moment in the piles/shafts. Design provisions for driven piles and drilled shafts are specified in AASHTO Articles 10.7 and 10.8, respectively, with corresponding CA Amendments (Caltrans, 2014a). Furthermore, Caltrans Memo to Designers 3-1 (Caltrans, 2014b) provides general guidance for selection and design of the piles or shafts and detailed communication procedures between the Structural Designer (SD) and the Geotechnical Designer (GD).

1.1.1 Types of Piles and Shafts

Application of different types of piles and shafts are discussed in Memo to Designers 3-1 (Caltrans, 2014b). Standard Plan Piles (Class Piles) are structurally predesigned piles or shafts mostly used in pile groups to support columns or at abutments and piers. Upper limits of structural resistance of Standard Plan (Class) Piles in compression and tension, as well as structural details, are given in the Standard Plans. The most common types of driven piles are steel H-Pile (HP) or pipe piles, precast pre-stressed concrete piles, and Cast-in-Steel Shell (CISS) piles. In selection of driven piles, environmental constraints such as acceptable limits of noise and vibration, construction constraints such as required overhead, and geotechnical condition of the soil are of importance.

Drilled shafts also known as Cast-in-Drilled Hole (CIDH) concrete piles are often recommended when:

(i) pile driving is not viable, e.g., when there is interference of pile driving with overhead power or telephone lines or nearby underground utilities;

(ii) large vertical or lateral resistance is required; and

(iii) noise and vibration mitigation plans are either not feasible or too expensive.

However, disposal of hazardous drill spoils may be costly. Drilled shafts may be used in a group similar to driven piles or as large diameter isolated shafts, that is, pile extensions and Types I/II shafts. Memo to Designers 3-1 (Caltrans, 2014b) includes provisions that improve constructability of the shaft, such as the use of temporary/permanent casing and also construction joint in Type-II shafts. For more information on isolated large diameter shafts (Type I and II shafts), refer to Section 1.4.

1.1.2 Constructability Issues

If ground water is anticipated during construction, drilled shafts must be at least 24 in. in diameter, and PVC inspection pipes should be installed to allow Gamma-Gamma Logging (GGL) or Cross-Hole Sonic Logging (CSL) test of the shafts for quality assurance mostly performed by the Foundation Testing Branch of Geotechnical Services. Memo to Designers (MTD) 3-1 (Caltrans, 2014b) illustrates requirements for proper placement of the inspection pipes. Inspection pipes are laid out by the (SD) and must be shown in the structure plans where applicable. Drilled shafts need to allow for additional concrete cover for placement of the rebar cage. Minimum cover requirements for various drilled shaft sizes are shown in Table 1.1-1. The minimum cover is not related to protection of the reinforcing steel (refer to CA Amendment (Caltrans, 2014a) Table 5.12.3-1) but rather as an aid for construction. The minimum cover allows for rebar cage deformations that occur during placement as well as for some tolerance for the final shaft and column location. For non-Standard Plan Piles, irrespective of the actual cover, only 3 in. of cover is assumed effective and used in the structural capacity calculations.

Purchase this course to see the remainder of the technical materials.