Step 11 – Static Load Testing

Test loading is the most definitive method of determining load capacity of a pile. Testing a pile to failure provides valuable information to the design engineer and is recommended for load tests performed prior to the foundation design. Such testing permits the selection of both the optimum helical screw foundation and the design load.

ASTM D-1143, Standard Test Method for Piles Under Static Axial Compressive Load, latest revision, should be used. This method is applicable to all types of deep foundations that function in a manner similar to piles regardless of their method of installation. It does not specify a particular method to be used, but rather provides several optional methods.

Load Testing during Design

Load test results are useful tools for the helical screw foundation designer. They confirm a theoretically designed foundation and allow for site-specific correlation between capacity and installing torque (For more details on Installation Torque/Load Capacity Relationship, see Step 9).

The test pile, installation equipment and installation procedure should be identical to that intended to be used for production piles to the extent practical.

The piles should be loaded to at least two times the design load, and preferably to failure. **Pile foundations, including helical screw foundations, that have been tested to their ultimate capacity should not be used as production piles.**

Battered Pile Test

Conducting a load test on battered helical screw foundations can be difficult. With approval of the responsible engineer, the results from a test on a vertical foundation installed to the same vertical depth, same helical configuration and similar installation torque as the battered foundation may be used to evaluate the axial capacity of the battered foundation.

Slow-Testing Methods

Quoting the Canadian Foundation Engineering Manual, 1985:

> “The slow-testing methods . . . (outlined by the ASTM D1143 Standard) . . . are very time-consuming. When the objective of the test is to determine the bearing capacity of the pile, these methods can actually make the data difficult to evaluate and disguise the pile true load movement behaviour, thereby counteracting the objective of the test. The benefit of the (slow) test methods lies in the additional soil-pile behaviour information, occasionally obtained, which the interpreting engineer can use, when required, in an overall evaluation of the piles.
>
> “. . . For routine testing and proof testing purposes, the quick methods . . . are sufficient. Where the objective is to determine the bearing capacity of the pile . . . the quick test is technically preferable to the slow methods.”

Quick Load Test Method for Individual Piles
(For complete description refer to ASTM D1143 – 81 subsection 5.6)

Apply the load in increments of 10 to 15% of the proposed design load with a constant time interval between increments of 2½ minutes or as otherwise specified. Add increasing load increments until continuous jacking is required to maintain the test load or until the capacity of the loading apparatus is reached, whichever occurs first. At this time, stop the jacking. After a 5 minute interval or as otherwise specified, remove the full load from the pile in four approximately equal decrements with 5 minutes between decrements so the shape of the rebound curve may be determined.

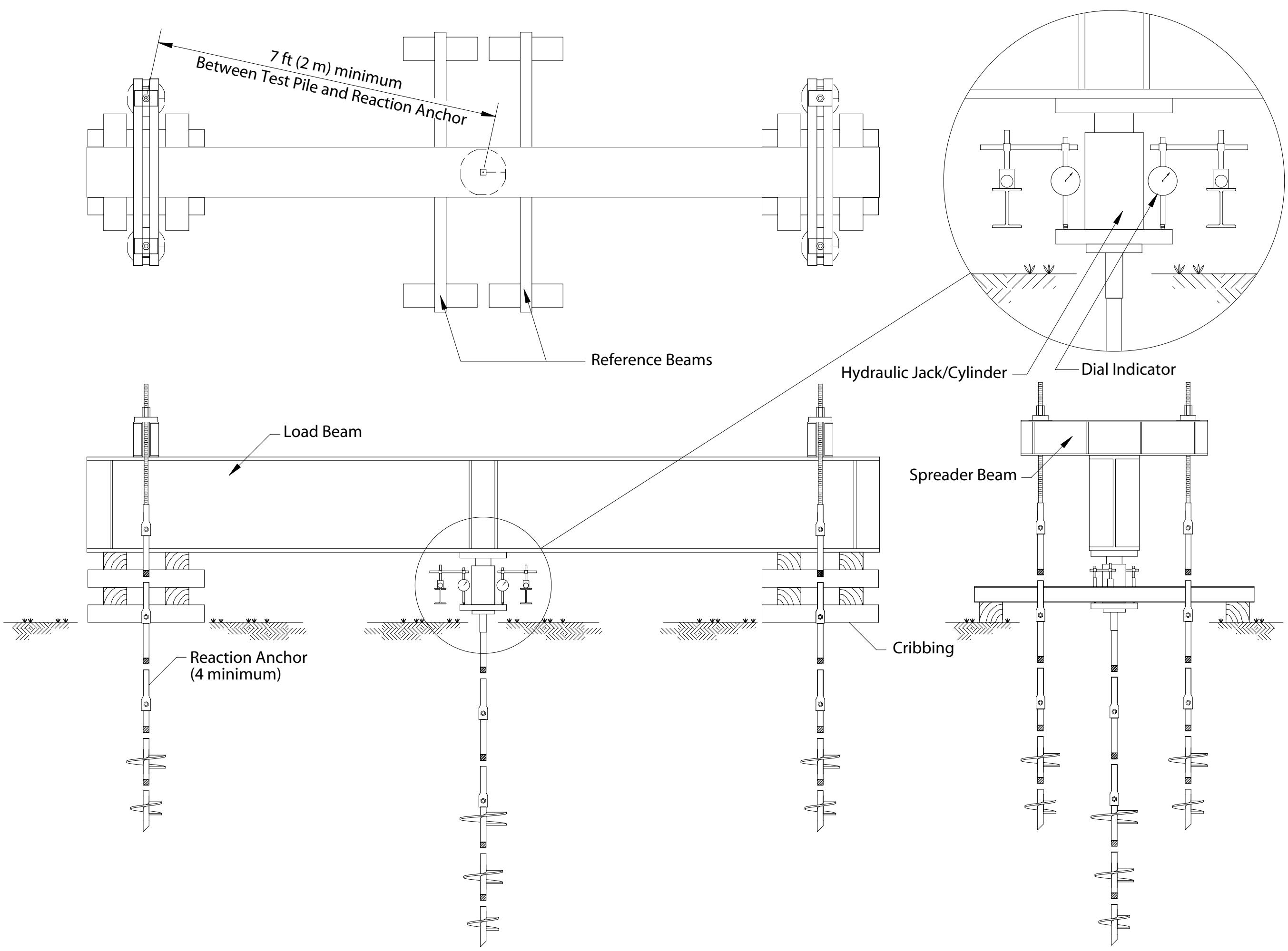
Loading Apparatus for Applying Compressive Load (see Figure 11.1)

The apparatus for applying compressive test load to a helical screw foundation should be constructed so that the load is applied concentrically to the axis of the foundation. Eccentric loading may cause foundation cap rotation and horizontal displacement; consequently, every effort should be made to minimize any eccentricity. A calibrated load cell or jacking system shall be used to measure the load. If the latter is used, the complete jacking system (including the hydraulic cylinder, hydraulic pump and pressure gauge) shall be calibrated as a unit.

It is suggested that a square bearing plate be centered on top of the helical screw foundation between the jack and the top of the foundation. The plate should be sized so that, with the ram placed at its center, sufficient area remains in the corners to allow proper placement and function of the dial indicators. A smooth bearing surface (such as glass) is required for the dial indicator stems. A second steel bearing plate of sufficient size and thickness is centered on top of the hydraulic cylinder/ram that will bear agains the centered test frame.

When a load cell is used, it is centered on top of the bearing plate. Then a second upper

Figure 11.1 - Test Frame for Applying Compressive Load



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bearing plate is centered on top of the load cell and bears against the centered test frame.

Clear space should be provided between the foundation cap and soil to eliminate any unwanted support from the soil surface during testing.

Reaction Anchors

Typically, four helical tension anchors provide support for the test frame and resist the test load as it is applied. All reaction anchors should be installed to approximately the same depth and installation torque. The combined ultimate capacity of the reaction anchors should be twice the intended test pile load.

Measuring Deflection

A minimum of two dial indicators with at least 2" inches of travel measure the deflection of the test pile. Each dial indicator is mounted on a separate reference beam. These reference beams are typically parallel and must be independent of the test frame and cribbing. The reference beams are placed on each side of the foundation to be tested so that the dial indicators can be mounted equidistant from the center and on opposite sides of the test foundation.

Other types of measuring systems may be used such as a wire-mirror-scale system, surveyor's level or laser beam. The measuring system must have proven reliability with an accuracy of 0.01" (0.25 mm). It is recommended to use a secondary deflection measuring system as a back-up.

Reading for the Quick Load Test Method

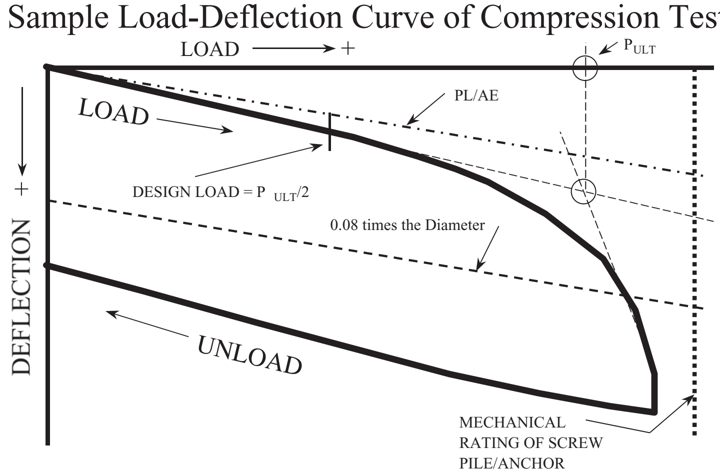
Record readings of load, time and settlement immediately before and after each load increment or decrement. All deflection devices should be read simultaneously or as close to simultaneously as possible.

Acceptance Criteria

Acceptance of the load test results is generally governed by the building code for that jurisdiction and subject to review by the structural designer. The structural designer determines the maximum deflection the structure can withstand without undue loss of function or distress. The acceptance criteria must be defined prior to conducting the load test.

Figure 11.2

Sample Load-Deflection Curve of Compression Test



The load-deflection data may be plotted for a fast overview of the results. Figure 11.2 shows a sample test plot. Various building codes have their own acceptance criteria, generally a limit on deflection at the factored load. A fast way to determine the ultimate load is by use of a technique called the "intersection of tangents." This is accomplished by graphically constructing two tangent lines. One line is drawn tangent to the second "straight line" portion of the load curve. The other line is drawn tangent to the initial "straight line" portion of the load-deflection curve which is beyond the curved or non-linear portion of the load-deflection curve. The point where the two tangents intersect identifies an estimate of the ultimate load. An example of acceptance criteria is the New York City code which calls for the design load to be the lesser of:

1. 50% of the applied load causing a net settlement (total settlement less rebound) of the pile of 0.01" per ton of applied load

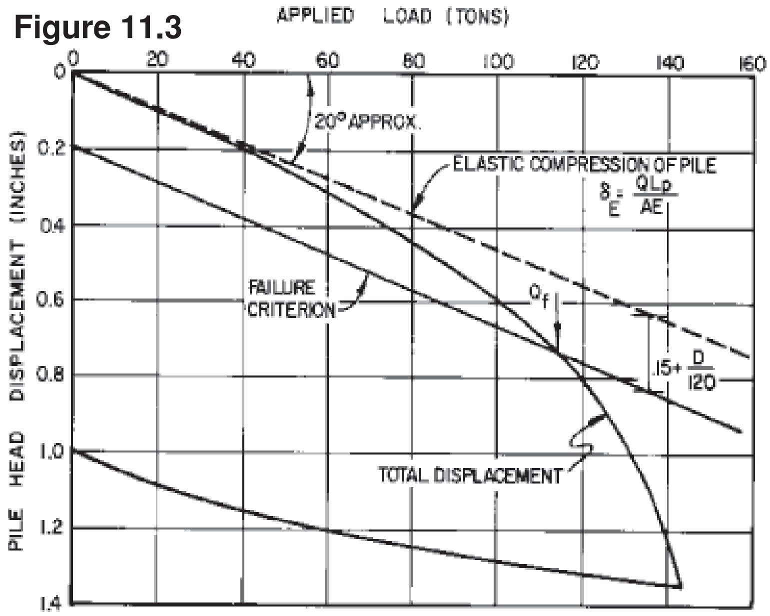
or

2. 50% of the applied load causing a net settlement of the pile of ½". Net settlement is here defined as the gross settlement at the test load less the elastic compression.

Other acceptance criteria include:

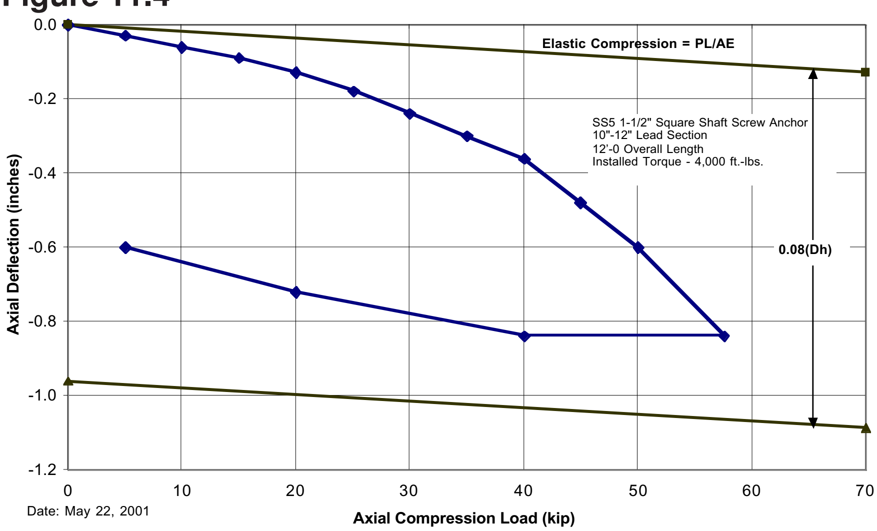
1. Maximum total settlement under a specified load
2. Maximum net settlement after the test load
3. Maximum settlement under the design load, or various techniques such as defined by the Davisson Method (1973), and shown in Figure 11.3.

Figure 11.3



The recommended acceptance criteria for helical screw foundations is one-half of the applied test load causing a net settlement (gross settlement less the elastic compression) not to exceed 0.08 times the diameter of the largest helical plate.

Figure 11.4



When relatively low foundation capacities are required, the acceptance criteria for a helical screw foundation might be based on minimum depth and minimum torque criteria (see Step 9, Field Production Control). This is similar to what the New York City code for driven piles up to 30 tons requires, which is to define capacity by the minimum "blows per foot of set." The subject of load tests and acceptance criteria are discussed by Crowther (1988) and may be referred to for a more complete treatment of the subject.

Figure 11.4 is a plot of results from a "quick test" per ASTM D1143 of a 12 ft long 1½" square shaft helical screw foundation having 10" and 12" helical plates. It was installed in the residual fine grained soils of Roanoke, VA and tested immediately after installation. The displacement curve is completely below the elastic compression line, indicating no skin friction was acting on the shaft during the test.

References

1. ASTM D 1143, "Standard Load Test Method for Piles under Static Axial Compressive Load," American Society for Testing and Materials, Philadelphia, PA
2. Canadian Foundation Engineering Manual, Canadian Geotechnical Society, 1985
3. Crowther, Carroll L., *Load Testing of Deep Foundations*, John Wiley and Sons, 1988
4. Davisson, M.T., High Capacity Piles, Department of Civil Engineering Department, Illinois Institute of Technology, Chicago, 1973