CHAPTER 9.0
PILE LOAD TESTING

9.1 INTRODUCTION

Pile load testing is an important tool for design engineers to verify that assumptions made in the design of the deep foundation are appropriate for the site. Pile load testing may be conducted prior to the final design of the deep foundation system in order to provide the designer with the design properties to be used for the final design of the pile foundation. Load tests for timber pile foundations are routinely used to prove the adequacy of the soil-pile system for the proposed pile design load.

Static load tests are conducted to measure the response of piles under applied load. Conventional static load test types include axial compression, axial tension and lateral load testing. The cost and engineering time associated with a load testing program should be justified by a thorough foundation investigation and engineering analysis of pile capacity. A thorough timber pile foundation design requires detailed subsurface exploration, appropriate soil testing, subsurface profile development, and static pile analysis. This manual will cover the axial compression load test only. For information on the axial tension or lateral load test refer to Federal Highway Administration *"Static Testing of Deep Foundations"* (FHWA-SA-91-042).

9.2 AXIAL COMPRESSION STATIC LOAD TEST

The location of load tests should be selected by the geotechnical engineer responsible for the pile design where the subsurface conditions have been established directly by SPT or CPT testing. The number of load tests to be performed should also be determined by the geotechnical engineer. The number of load tests will depend on the variability of subsurface conditions throughout the site, and the pile loading.

The magnitude to which the test piles are loaded has in the past been limited to twice the design load. This does not permit a determination of the pile/soil capacity and negates design knowledge obtained from a load test that may otherwise be used to reduce the number or the length of production piles. Load testing to failure is recommended. This will disclose the real safety factor inherent in the design and will provide the geotechnical engineer with the necessary information to economize the design.

The test pile should be the same as the production piles (e.g., same proposed length toe and butt diameters, same pressure treatment, etc.). The test pile should be installed with the same equipment and procedures as is proposed for the production piles. Complete driving records should be maintained during the installation of the piles.

Procedures for conducting axial compression tests are provided in ASTM D 1143 *Standard test Method for Piles Under Axial Compression Load.* Three procedures are provided in this test standard; maintained load test, quick test, and constant rate of penetration test. The quick test is recommended for timber pile projects. This test is conducted to pile failure, or 300% of the design load; the load increments are 10 – 15% of the design load; the duration of each load increment is 2.5 minutes; and the test duration is 2-3 hours. The advantages of this test procedure are that:

- A load test may be performed in a matter of hours versus 1 – 2 days, typical of the maintained load test.
- Load testing becomes feasible for small projects.
- Test results are more nearly "undrained" conditions of shear failure.

The maintained load test, quick test, and constant rate of penetration test should all be regarded as tests of short duration which may not reflect long-term pile settlements of either individual or group piles. Any attempt to determine the long-term settlements by means of a load test would be uneconomical because of the excessive amount of time that would be required. When the time dependent or drained condition (i.e., creep) performance is desired, the test duration would have to be measured in weeks, months or even years (Fellenius, 1980).

9.2.1 Interpretation of Load Test

The load displacement curve generated from the pile load test is used to determine the allowable pile capacity. The allowable capacity of a pile was defined in chapter 5 as the ultimate capacity of the pile divided by a factor of safety. In order to determine the actual factor of safety for the installed pile, a definition of what constitutes a failure must be established. Piles founded in cohesionless soils seldom experience a plunging failure. Therefore, it is important to define failure, so that engineers are in agreement on what is failure and what factor of safety a design has. The following methods have been used to define failure:

Offset Limit Method (Davisson 1972)**:** The failure load is defined as the load corresponding to a movement which exceeds the elastic compression of the pile, when considered as a free column, by a value of 0.15 inches plus a factor depending on the diameter of the pile (D/120), where D is the diameter of the pile in inches. AASHTO (1992) and FHWA recommend that the offset method be used to determine the failure load.

De Beers Method (Fellenius, 1980)**:** The load displacement values are plotted on a double logarithmic scale, where the values may be shown to fall on two straight lines. The intersection of the lines corresponds to the failure load.

90% Criterion (Brinch Hansen, 1963)**:** The failure load is defined as the load at which the movement is twice that obtained for 90% of that load.

Slope and Tangent (Butler and Hoy, 1977)**:** The failure load is defined as the load at the intersection of a line tangent to the initial straight line portion of the load displacement curve and a line tangent to the load displacement curve where the slope of the line reaches 0.05 inches/ton).

The results of a pile load test are typically plotted as load versus displacement (movement of the pile butt). The scale of the plot should be arithmetic and should be selected so that the slope of the elastic deformation of the pile is inclined at an approximate angle of 20°.

The elastic deformation of a pile may be determined using the following equation:

$$\Delta = (QL)/(AE) \qquad (9\text{-}1)$$

where: Δ = Elastic deformation (inches)
Q = Test load (kips)
L = Pile length (inches)
A = Pile cross-sectional area (in^2)
E = Modulus of Elasticity of Pile material (ksi)

This equation is accurate for end bearing piles where no stress transfer occurs along the length of the pile. Timber piles, however, are typically friction piles or a combination of friction and end bearing. The elastic deformation will, therefore, typically be less than that determined from equation 9-1. Equation 9-1 will, however, be used in establishing the failure criteria for timber piles.

The failure load (offset limit method) of a timber pile is the load that produces a movement of the pile butt (s_f) equal to:

$$s_f = \Delta + \left(0.15 + D/120\right) \quad (9\text{-}2)$$

where: D = Pile diameter (inches)

Figure 9-1 presents a typical pile load test load movement curve. The elastic deformation and the offset limit failure criteria are also plotted. The intersection of the failure criterion line and load movement line yields the ultimate capacity of the pile.

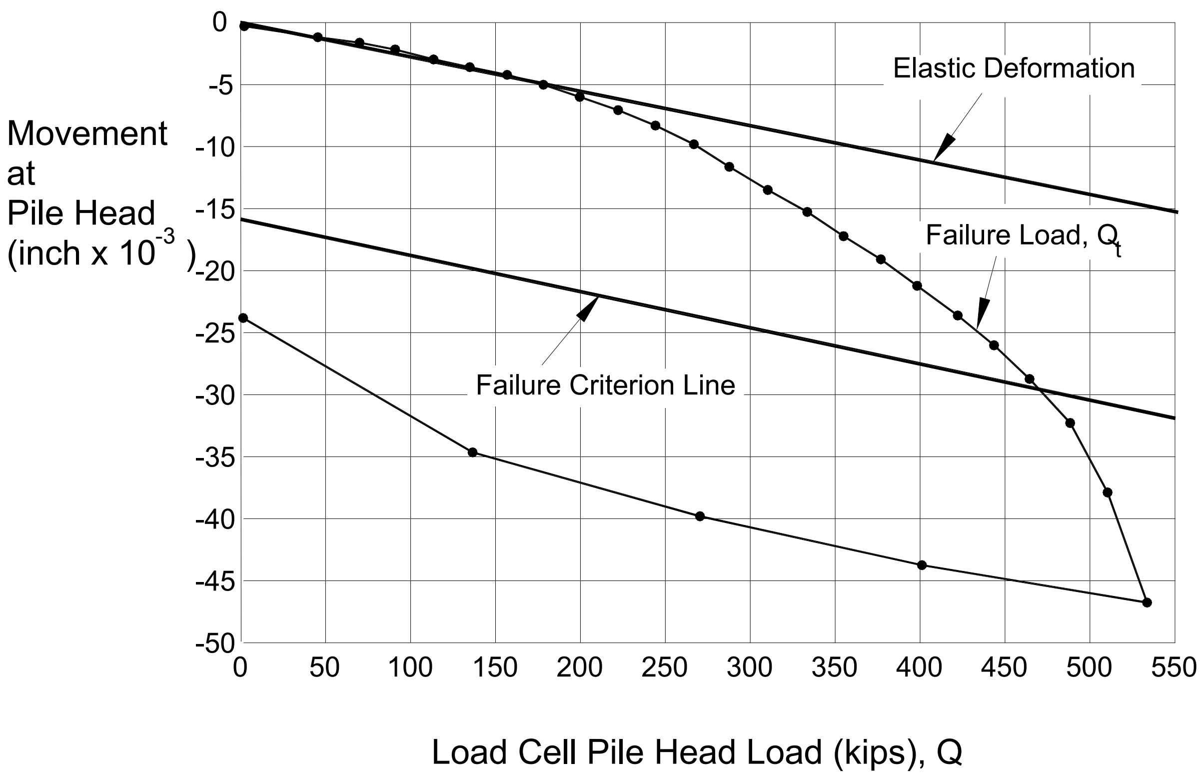

Figure 9-1: Typical static pile load test results (FHWA-HI-97-013)