

**STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION**

**METHOD OF TEST FOR THE DETERMINATION OF STATIC
AXIAL LOAD CARRYING CAPACITY OF FOUNDATION PILES**

SCOPE

This test method is used to determine the ultimate static axial load carrying capacity of foundation piles by subjecting a representative pile within a pile group to axial loads in the manner outlined below. The ultimate pile capacity, as determined by this test method, shall then be used to assess the adequacy of individual piles and pile groups used to support structure(s) at the test site.

A. APPARATUS

Unless otherwise specified the apparatus used to conduct this test shall conform to the following minimum specifications:

1. Reaction System

The reaction system supplied by the Contractor shall be of adequate strength to safely withstand four (4) times the specified maximum allowable pile capacity, as shown in the Contract plans, applied at the center span of the reaction beam without excessive deflection. This system shall conform to the current requirements stated in section 508 of NDOT's Standard Specifications for Road and Bridge Construction. The reaction system shall also conform to the current requirements set forth in ASTM D 1143, "Standard Test Method for Piles Under Static Axial Compressive Load".

2. Load Application System

This system shall be capable of applying a total load of at least four (4) times the specified maximum allowable pile capacity, as stated in the Contract plans. The load application system shall conform to the current requirements set forth in ASTM D 1143. This system shall have two independent methods of measuring applied loads. Unless two calibrated load cells are used, the complete jacking system shall be load calibrated as specified in ASTM D 1143. Load cells shall conform to the current specifications and calibration requirements stated in ASTM D 1143.

All calibrations shall be performed by an AASHTO or ASTM certified laboratory within six months of the pile load test date(s). Certified calibration reports shall be furnished to the Geotechnical Section of the Materials Division for all testing equipment requiring calibration no less than two weeks prior to the pile load test date(s).

3. Movement Monitoring System

Two independent systems for measuring axial movement of the test pile butt shall be provided. Additionally, provisions shall be made to monitor movement of the reaction system to insure that excessive deflection of this system does not take place during the load test. All reference pile settlement beams, dial gauges, or any other types of measuring apparatus shall conform to the current minimum specifications set forth in ASTM D 1143.

B. APPARATUS SET-UP DETAILS

Apparatus set-up details shall conform to the current specifications set forth in both ASTM D 1143 and Section 508 of NDOT's Standard Specifications for Road and Bridge Construction.

If the Department furnishes the loading system, the reaction beam shall be positioned such that a clear distance between the bottom of the reaction beam and the top of the test pile bearing plate will be between 25.5 inches (647.7 mm) and 28.5 inches (723.9 mm) unless steel plates of sufficient thickness are provided by the Contractor to make up for any excess space.

If the Department provides pile settlement indicator beams, they shall be assembled as follows:

1. The bracket for the support of the test pile end of the beam(s) shall be fastened to the test pile (See figure 1). In cases where there is insufficient pile length remaining above ground to accomplish this, the bracket may be fastened to the main body of the hydraulic jack.
2. A one inch (25.4 mm) inside diameter steel pipe shall be driven into the ground directly under the level adjustment screw of each beam. These pipes should be driven to a sufficient depth to insure that a level and stable placement of the settlement indicator beams can be achieved. Additionally, the location of these supporting pipes shall be placed as far as practical from reaction system supports.

3. The stem of the static platforms shall then be placed into the supporting 1 inch (25.4 mm) pipes. Settlement indicator beams shall then be positioned onto their supports with the stems of the dial indicators fully extended and resting on the static platforms.
4. The settlement indicator beams shall then be leveled with the adjustment screws and the dial indicators gauges shall be set to zero just prior to the load test.

C. PROTECTION OF TEST SITE

The Contractor shall make provisions to provide complete protection for the test pile and associated testing equipment during the load test from rain, snow, wind and direct sunlight. The Contractor shall also be responsible for providing adequate lighting and maintaining a temperature of at least 50 degrees Fahrenheit (10 degrees Celsius) throughout the duration of the pile load test. In order to meet the above requirements, it may be necessary to construct a suitable test site enclosure. Tarps, fiber board or any other materials used by the Contractor to build this enclosure shall be subject to approval by the Engineer.

D. TEST PROCEDURE

The load test procedure shall conform to the current requirements outlined in Section 5 of ASTM D 1143 for the Optional Quick Load Test Method. If The Department provides the loading system and the pile settlement indicator beams the following test procedure shall be adhered to:

1. A five ton (44.48 kN) load shall be applied to the test pile at the fastest possible rate permitted by the jacking equipment. This load shall be maintained on the test pile for a period of 2.5 minutes. Settlement indicator beams shall be maintained in level positions during loading by adjustment of the leveling screws. Immediately after the 5 ton (44.48 kN) load has been attained, the gross pile settlement as reflected by the dial indicator gauges shall be recorded. Settlement readings shall also be observed and recorded immediately after the 2.5 minute waiting period has passed.
2. Immediately subsequent to the final settlement readings taken for the initial load increment, additional five ton (44.48 kN) load increments shall be applied and held on the test pile for a time interval of 2.5 minutes each. Pile settlement readings shall be observed and recorded just prior to the application of each load increment and immediately after the required 2.5 minute waiting period.

3. Loading of the test pile shall continue in the above manner until the capacity of the jacking equipment is reached or until the load on the pile can only be maintained by constant pumping (ie..plunging failure) while pile is being driven into the ground. At this time pumping shall cease. Pile settlement shall be recorded immediately after the cessation of pumping and at time intervals of 2.5 minutes and 5 minutes later.
4. After settlement readings have been observed and recorded as required in step 3 the full pile test load shall be unloaded in 4 approximately equal load decrements. A waiting period of 5 minutes between decrements shall be observed. Pile settlement measurements shall be observed and recorded immediately after the release of each load decrement and again at the end of each waiting period in order to determine the shape of the pile rebound curve.

E. DETERMINATION OF ULTIMATE PILE FAILURE LOAD

A graph shall be made plotting the pile test load versus pile head settlement, measured after each two and one-half minute holding period, for each load increment. The estimated or measured elastic pile compression curve, and corresponding Davisson failure criterion curve shall also be plotted for each load increment. An example of this graph is shown in Figure 2. To facilitate the interpretation of the test results, the graph scales for load and displacement should be selected such that the line representing the elastic deformation of the pile δ is inclined at an angle of about 20 degrees from the load axis.

1) Determination of Elastic Pile Compression.

The elastic pile deformation δ shall be computed from the general equation:

$$\delta = (Q_p + (\alpha_s * Q_s)) * L/AE$$

where:

- δ = elastic pile shortening (inch or mm)
- Q_p = amount of test load carried in end bearing (lb or N)
- Q_s = amount of test load carried in skin friction (lb or N)
- L = pile length (inch or mm)
- A = cross-sectional area of the pile (in² or mm²)
- E = Young's modulus of the pile (psi or N/mm²)
- α_s = dimensionless constant corresponding to skin friction distribution, equals 0.0 for end bearing pile, equals 0.5 for uniform distribution (cohesive soils), equals 0.67 for triangular distribution (cohesionless soils)

Unless otherwise specified the theoretical elastic shortening of the test pile may be computed assuming that the pile transfers all the imposed load in end bearing resistance. Alternatively, the elastic shortening of the test pile may be estimated using the ultimate end bearing capacity and ultimate skin friction capacity, along with the assumed skin friction distribution, as determined from static analyses used for pile design. Finally, direct measurement of elastic pile compression by the proper use of pile instrumentation and correct interpretation of their test results shall be used if available.

2. Determination of the Ultimate Capacity of Test Pile.

Unless a plunging failure occurs, the ultimate axial capacity or "interpreted failure load" of the test pile is that load which produces a total settlement of the pile head equal to:

$$S_f = \delta + (0.15 + D/120) \quad \text{English units}$$

$$S_f = \delta + (3.81 + D/120) \quad \text{Metric units}$$

where: S_f = settlement of pile head at failure in inches or millimeters
 D = equivalent pile diameter in inches or millimeters
 δ = elastic deformation of pile shaft in inches or millimeters

The above equations should be used for piles with diameters less than or equal to 24 inches (609.6 mm). For piles having diameters greater than 24 inches (609.6 mm) the above equations should be modified to:

$$S_f = \delta + D/30 \quad \text{Metric or English units}$$

A failure criterion line should be plotted parallel to the elastic compression line as shown in Figure 2. The load-settlement test curve shown intersects the failure criterion line at point F, the abscissa of which, by definition, is the "interpreted failure load" or ultimate axial load applied to the pile during the test. If the load-settlement curve does not intersect the failure criterion line, the maximum test load should be taken as the ultimate capacity or "interpreted failure load" of the test pile.

F. DETERMINATION OF ALLOWABLE PILE CAPACITY

Unless otherwise specified in the Contract Plans or Specifications, the maximum allowable pile capacity shall be determined by dividing the "interpreted failure load" found above by a factor of safety equal to 2.0.

G. APPLICATION OF LOAD TEST RESULTS TO SUBSEQUENT PILE DRIVING

The results of the load test may be used to establish the relationship between the measured static ultimate pile capacity and the dynamic driving resistance as determined by wave equation analysis. This relationship is defined by the following equation:

$$K = Q_{ult} / Q_{ult\ weap}$$

where:

K = constant relating measured pile capacity with predicted pile capacity determined by WEAP

Q_{ult} = ultimate pile capacity determined from load test

Q_{weap} = predicted ultimate pile capacity as determined by WEAP

Once the "K" factor has been determined it can be used to establish a new target value for $Q_{ult\ weap}$ to control pile driving operations. This is done by using the established "K" factor, replacing Q_{ult} with the required ultimate pile capacity, and solving for $Q_{ult\ weap}$ in the above equation. The predicted driving resistance (ie.. blows/ft) corresponding to this new $Q_{ult\ weap}$ can then be used to control pile driving operations within the limits of influence of the load test. However, minimum and design pile tip elevations requirements should be adhered to unless changes are approved by the Department.

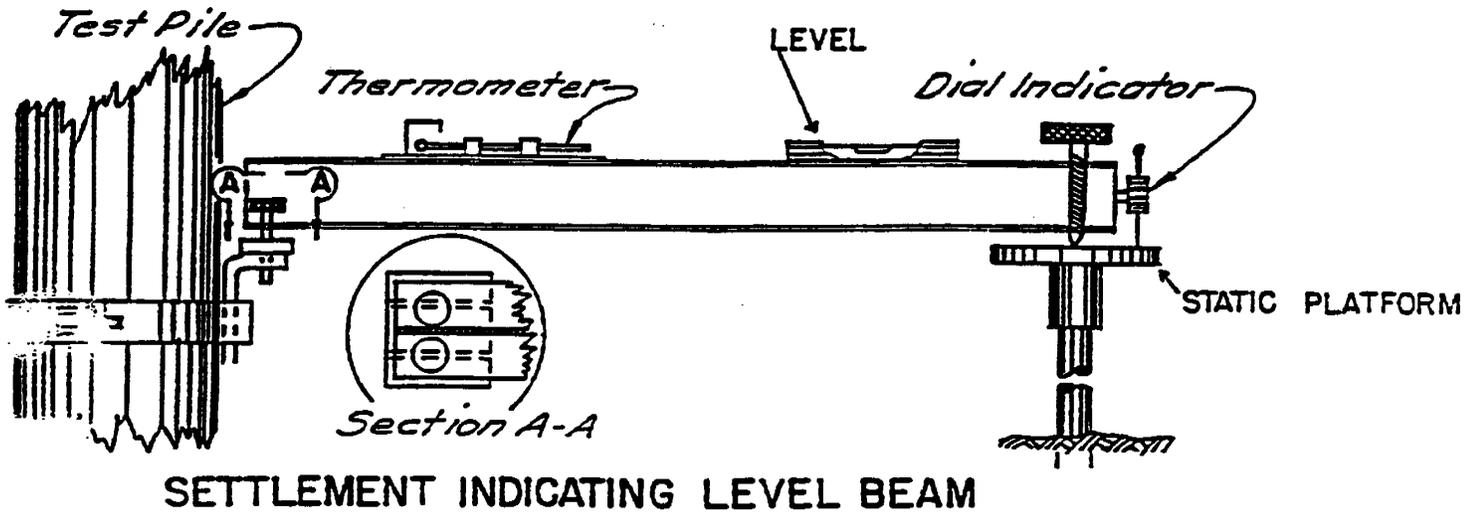


Figure 1

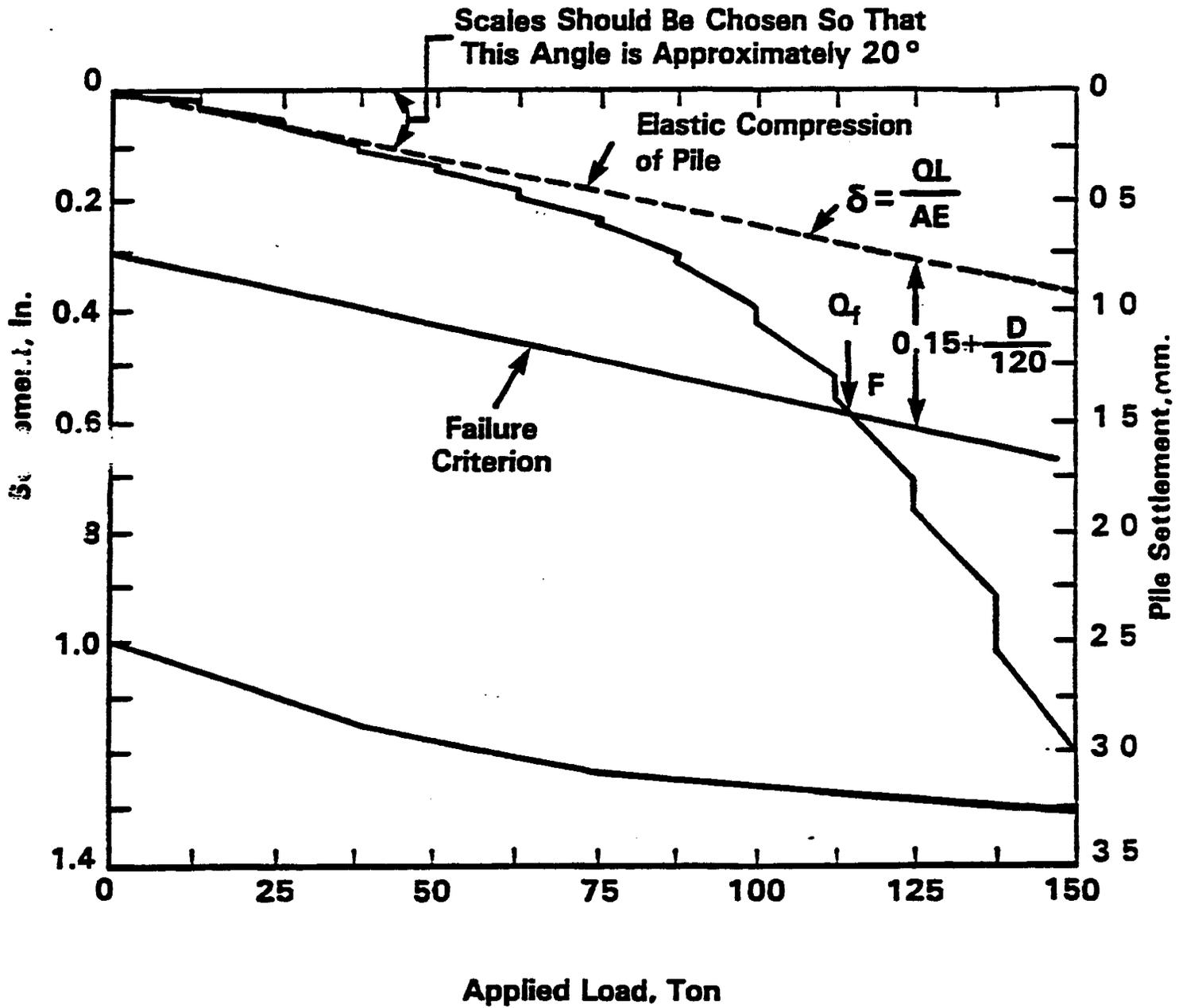


Figure 2