Designation: ~~D5780 – 10~~ D5780 – 18

Standard Test Methods for Individual Piles in Permafrost Under Static Axial Compressive Load[1]

This standard is issued under the fixed designation D5780; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

These test methods have been prepared to cover methods of axial load testing of piles in permafrost. The provisions permit the introduction of more detailed requirements and procedures when required to satisfy the objectives of the test program. The procedures herein produce a relationship between applied load and pile settlement for conditions of ground temperature at the time of test. The results may be interpreted to establish long-term load capacity of piles in permafrost.

1. ~~Scope*~~Scope

1.1 ~~These test methods cover procedures for testing individual vertical piles to determine response of the pile to static compressive load applied axially to the pile. These test methods are applicable~~ The test methods described in this standard measure the axial deflection of a vertical or inclined deep foundation when loaded in static axial compression. These methods apply to all deep ~~foundation units in permafrost~~ foundations, referred to herein as piles, that function in a manner similar to ~~piles~~ driven piles or cast-in-place piles, regardless of their method of ~~installation. This standard is divided into the following sections:~~installation, and may be used for testing single piles or pile groups. The test results may not represent the long-term performance of a deep foundation.

~~NOTE 1—Apparatus and procedures designated "optional" are to be required only when included in the project specifications or if not specified, may be used only with the approval of the engineer responsible for the foundation design. The word "shall" indicates a mandatory provision and "should" indicates a recommended or advisory provision. Imperative sentences indicate mandatory provisions. Notes, illustrations, and appendixes included herein are explanatory or advisory.~~

~~NOTE 2—This standard does not include the interpretation of test results or the application of test results to foundation design. See Appendix X1 for comments regarding some of the factors influencing the interpretation of test results. A qualified geotechnical engineer should interpret the test results for predicting pile performance and capacity.~~

1.2 ~~Three different test methods are included within this standard. Method A is the standard method combining the results from loading two separate piles with the possibility of a third alternate pile. Method B is the alternate method combining the results from loading three separate piles with the possibility of a fourth alternate pile. Method C is a confirmation method requiring the testing of one pile with the possibility of a second alternate. Method C is applicable only where prior data are available.~~This standard provides minimum requirements for testing deep foundations under static axial compressive load. Plans, specifications, and/or provisions prepared by a qualified engineer may provide additional requirements and procedures as needed to satisfy the objectives

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.19 on Frozen Soils and Rock.

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*A Summary of Changes section appears at the end of this standard of a particular test program. The engineer in responsible charge of the foundation design, referred to herein as the Engineer, shall approve any deviations, deletions, or additions to the requirements of this standard.

1.3 This standard allows the following test procedures:

Procedure A	Quick Test	8.1.2
Procedure B	Maintained Test (Optional)	8.1.3
Procedure C	Loading in Excess of Maintained Test (Optional)	8.1.4
Procedure D	Constant Time Interval Test (Optional)	8.1.5
Procedure E	Constant Rate of Penetration Test (Optional)	8.1.6
Procedure F	Constant Movement Increment Test (Optional)	8.1.7
Procedure G	Cyclic Loading Test (Optional)	8.1.8

1.4 Apparatus and procedures herein designated "optional" may produce different test results and may be used only when approved by the Engineer. The word "shall" indicates a mandatory provision, and the word "should" indicates a recommended or advisory provision. Imperative sentences indicate mandatory provisions.

1.5 ~~All recorded and calculated values shall conform to the guide~~ A qualified geotechnical engineer should interpret the test results obtained from the procedures of this standard so as to predict the actual performance and adequacy of piles used in the constructed foundation. See Appendix X1 for ~~significant digits and rounding established in Practice~~comments regarding some of the factors influencing ~~D6026.~~the interpretation of test results.

~~1.3.1 The procedures used to specify how data are collected/recorded and calculated in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that should generally be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives, and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering design.~~

~~1.3.2 Measurements made to more significant digits or better sensitivity than specified in this standard shall not be regarded a nonconformance with this standard.~~

1.6 A qualified engineer shall design and approve all loading apparatus, loaded members, support frames, and test procedures. The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard. This standard also includes illustrations and appendixes intended only for explanatory or advisory use.

1.7 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.8 The ~~values stated in inch-pound units are to be regarded as the standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.~~gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound [lbf] represents a unit of force [weight], while the unit for mass is slugs. The rationalized slug unit is not given, unless dynamic [F=ma] calculations are involved.

~~1.4.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is the slug.~~

~~1.4.2 The slug unit of mass is almost never used in commercial practice. Therefore, the standard unit for mass in this standard is either kilogram (kg) or gram (g), or both. The equivalent inch-pound unit (slug) is not given in parentheses.~~

~~1.4.3 It is common practice in the engineering/construction profession, in the United States, to concurrently use pounds to represent both a unit of mass (lbm) and of force (lbf). This implicitly combines two separate systems of units: that is, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. As stated, this standard includes the gravitational system of inch-pound units and does not use/present the slug unit for mass. However, the use of balances or scales recording pounds of mass (lbm) or recording density in lbm/ft^3) shall not be regarded as nonconformance with this standard.~~

1.9 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.10 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy to which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

1.11 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate ~~safety~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section ~~8~~9.

1.12 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D5882 Test Method for Low Strain Impact Integrity Testing of Deep Foundations

D6026 Practice for Using Significant Digits in Geotechnical Data

D7099 Terminology Relating to Frozen Soil and Rock

2.2 *ANSI Standard:*[3]

B 30.1 Safety Code for Jacks

3. Terminology

~~3.1 *Definitions:*~~

~~3.1.1 For definitions of terms relating to soil and rock mechanics refer to Terminology D653.~~

~~3.1.2 For definitions for terms related to frozen ground refer to Terminology D7099.~~

3.1 *Definitions:*

3.1.1 For definitions of terms relating to soil and rock mechanics refer to Terminology D653.

3.1.2 For definitions for terms related to frozen ground refer to Terminology D7099.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *adfreeze bond ~~strength—~~strength, n—*the strength of the bond developed between frozen soil and the surface of the pile.

3.2.2 *base ~~load—~~load, n—*a load equivalent to the design load adjusted for test pile geometry and expected ground temperature.

3.2.3 *creep ~~load—~~load, n—*that load applied to measure a rate of displacement.

3.2.4 *creep load ~~increment—~~increment, n—*an incremental load applied to a pile to determine the rate of displacement at 10 % of a failure load or at 100 % of a design load.

3.2.5 *design active ~~layer—~~layer, n—*the maximum depth of annual thaw anticipated surrounding the pile under design conditions.

3.2.6 *failure (in ~~piles)—~~piles), n—*pile displacement that is occurring at an increasing rate with time under the action of a constant load, incremental pile displacement that is increasing for uniform time increments, or a creep rate which exceeds 100 % of the design creep rate when loaded to 100 % of the design load.

3.2.7 *failure ~~load—~~load, n—*that load applied to a pile to cause failure to occur.

3.2.8 *failure load ~~increment—~~increment, n—*the load increment applied to a pile that causes failure within a specified time period.

3.2.9 *~~freezeback—~~freezeback, n—*for the purpose of this test method, freezeback shall be defined as the attainment of a subfreezing temperature at each ground temperature measuring point located below the design active layer, which have attained equilibrium with the surrounding soil.

3.2.10 *~~ice-poor—~~ice-poor, n—*frozen soil with a high solids concentration whose behavior is characterized mainly by soil particle contacts.

3.2.11 *~~ice-rich—~~ice-rich, n—*frozen soil with a moderate to low solids concentration whose behavior is characterized by ice particle contacts.

3.2.12 *pile, ~~driven—~~driven, n—*a pile driven into the ground with an impact or vibratory pile hammer.

3.2.13 *pile, ~~grouted—~~grouted, n—*a pile placed in an oversized, pre-drilled hole and backfilled with a sand, cement grout.

3.2.14 *pile, ~~slurried—~~slurried, n—*a pile placed in an oversized, pre-drilled hole and backfilled with a soil/water slurry.

3.2.15 *subfreezing ~~temperature—~~temperature, n—*any temperature below the actual freezing temperature of the soil water combination being used.

3.2.16 *time to ~~failure—~~failure, n—*the total time from the start of the current test load increment to the point at which failure begins to occur.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

4. Significance and Use

4.1 This test method will provide a relationship between time to failure, creep rate, and displacement to failure for specific failure loads at specific test temperatures as well as a relationship between creep rate and applied load at specific test temperatures for loads less than failure loads.

4.2 Pile design for specific soil temperatures may be controlled by either limiting long-term stress to below long-term strength or by limiting allowable settlement over the design life of the structure. It is the purpose of this test method to provide the basic information from which the limiting strength or long-term settlement may be evaluated by geotechnical engineers.

4.3 Data derived from pile tests at specific ground temperatures that differ from the design temperatures must be corrected to the design temperature by the use of data from additional pile tests, laboratory soil strength tests, or published correlations, if applicable, to provide a suitable means of correction.

4.4 For driven piles or grouted piles, failure will occur at the pile/soil interface. For ~~slurried~~slurry piles, failure can occur at either the pile/slurry interface or the slurry/soil interface, depending on the strength and deformation properties of the slurry material and the adfreeze bond strength. Location of the failure surface must be taken into account in the design of the test program and in the interpretation of the test results. Dynamic loads must be evaluated separately.

NOTE 1—The quality of the results produced by application of this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

5. Installation of Test Pile(s)

5.1 Install the test pile according to the procedures and specifications used for the installation of the production piles.

NOTE 2—Because the pile behavior will be influenced by the soil type, temperature, ice content, and pore water salinity, the engineer must ensure that adequate information is available for soil/ice conditions at the construction site to determine their effect on the pile performance (that is, test pile should be installed in the same condition as the production piles—preferably at the same site).

5.2 The design and installation of the test pile shall address the effects of end bearing, as opposed to the shear resistance on the shaft of the pile. Address end bearing by measuring its effect, eliminating its effect, or accounting for its effect analytically. Measure end bearing by attaching a load cell to the tip of the pile prior to installation or by attaching a series of strain ~~gages~~gauges along the length of the pile prior to installation. Eliminate end bearing by attaching a compressible layer to the tip of the pile prior to installation or by providing a void beneath the tip of the pile.

5.3 Install thermistors or other temperature-measuring devices adjacent to the test pile to determine the ground temperature profile adjacent to the pile. Measure ground temperature in frozen ground at a minimum of three locations along the length of pile; for piles longer than 10 ft ~~(3 m),~~[3 m], it is recommended that ground temperatures be measured at 5-ft ~~(1.5-m)~~[1.5-m] depth intervals. Install the temperature-measuring devices in contact with the exterior pile surface; for ~~slurried~~slurry piles, installation may be as shown in Fig. 1; for driven piles, installation may be as shown in Fig. 2.

5.4 Measure ground temperatures periodically using the installed temperature-measuring devices to determine when freezeback occurs.

5.5 Where freezeback of soils adjacent to the pile is aided by the circulation of cold air or liquid coolant, discontinue such cooling when the measured ground temperatures become equal to the desired ground temperature for the pile test; significant overcooling shall not be permitted to occur. When freezeback of soils adjacent to the test piles is aided by a designed cooling system, such designed cooling system shall also be applied in a similar manner to all reaction piles to ensure freezeback of the reaction piles.

5.6 Isolate the surface of the test pile from the surrounding soil or ice over the depth of the design active layer. This may be accomplished by using a sleeve or casing. For slurried piles, a greased wrapping or other technique that will essentially eliminate the transfer of shear forces between the pile and the surrounding soil/ice in the design active layer may be used.

5.7 Where feasible, excavate the immediate area of the test pile or fill to the proposed finished grade elevation. Cut off test piles or build up to the proper grade necessary to permit construction of the load-application apparatus, placement of the necessary testing and instrumentation equipment, and observation of the instrumentation. Where necessary, brace the unsupported length of the test pile(s) to prevent buckling without influencing the test results.

5.8 If the top of the pile has been damaged during installation, remove the damaged portion prior to the test.

NOTE 3—Consideration should be given to placing insulation on the ground surface around the test pile in order to reduce the variation in ground temperatures with time during the testing period. Where used, ground surface insulation should be placed all around the test pile to a distance of 5 ft ~~(1.5 m),~~[1.5 m], two times the depth of thawed soil or one third of the installed pile length, whichever is greater. The effect of insulation at the surface should be taken into account in the design of production piles, which could be done analytically.

5.9 Allow the lateral normal stresses between the pile surface and the surrounding soil that develop during pile installation or freezeback, or both, to dissipate to a nominal level prior to pile testing. For purposes of this test method, the delay time

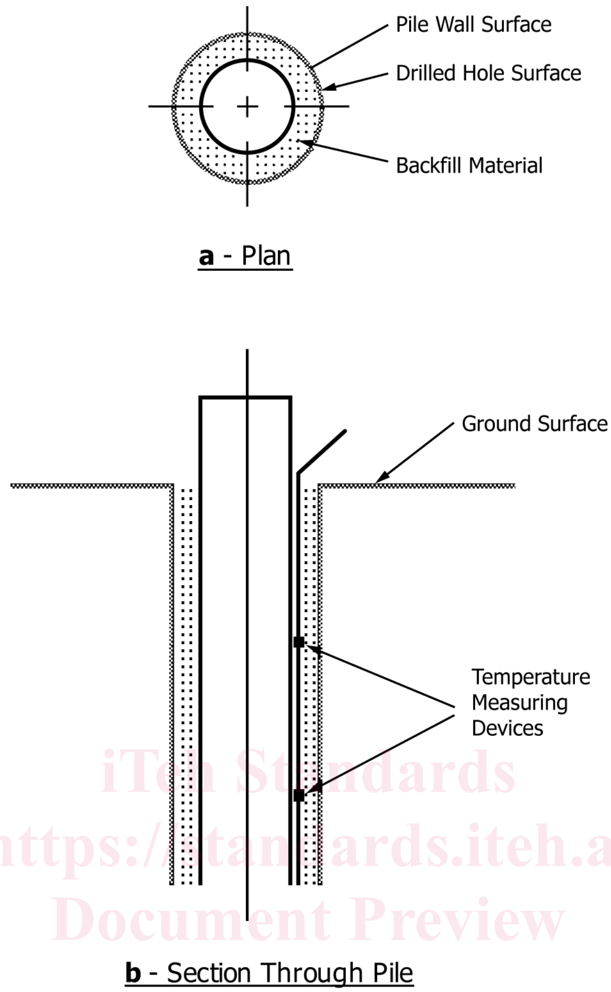

FIG. 1 Placement of Temperature Measuring Devices for ~~Slurried~~Slurry Test Pile

corresponding to the approximate test condition from Table 1 shall be permitted to occur prior to commencing load application to allow for the dissipation of normal stresses on the pile shaft as discussed above.

NOTE 4—The engineer may direct that delay times other than those shown in Table 1 be implemented, based on other completed pile test results, laboratory test results, or analytical results. Such other time interval shall allow for the dissipation of normal stresses developed due to pile installation or freezeback, or both, to a level of 1 % or less of their maximum value.

6. Apparatus for Applying Loads

6.1 *General:*

6.1.1 The apparatus for applying compressive loads to ~~the~~a test pile ~~shall be as~~ or pile group shall conform to one of the methods described in 6.3~~, -6.4~~-6.6~~, or~~. Unless 6.5~~, or as~~ otherwise specified by the ~~engineer of record and shall be constructed so that the loads are applied to the central longitudinal axis of the pile to minimize eccentric loading. Subsections~~Engineer, the apparatus for applying and measuring loads described in this section shall be capable of safely applying at least 120 % of the maximum anticipated test load. Use the 6.3 – 6.5 ~~are suitable for~~method described in 6.3 ~~applying~~ to apply axial loads to ~~individual vertical piles.~~ either vertical or inclined piles or pile groups. Use the methods described in 6.4-6.6 to apply only vertical loads.

~~NOTE 7—Consideration should be given to providing sufficient clear space between the pile cap and the ground surface to eliminate any support of the cap by the soil. A properly constructed steel grillage may serve as an adequate pile cap for testing purposes.~~

6.1.2 Align the test load apparatus with the longitudinal axis of the pile or pile group to minimize eccentric loading. When necessary to prevent lateral deflection and buckling along the unsupported pile length, provide lateral braces that do not influence the axial movement of the pile, or pile cap.

6.1.3 Each jack shall include a hemispherical bearing or similar device to minimize lateral loading of the pile or group. The hemispherical bearing should include a locking mechanism for safe handling and setup. Center bearing plates, hydraulic jack(s), load cell(s), and hemispherical bearings on the test beam(s), test pile, or test pile cap.

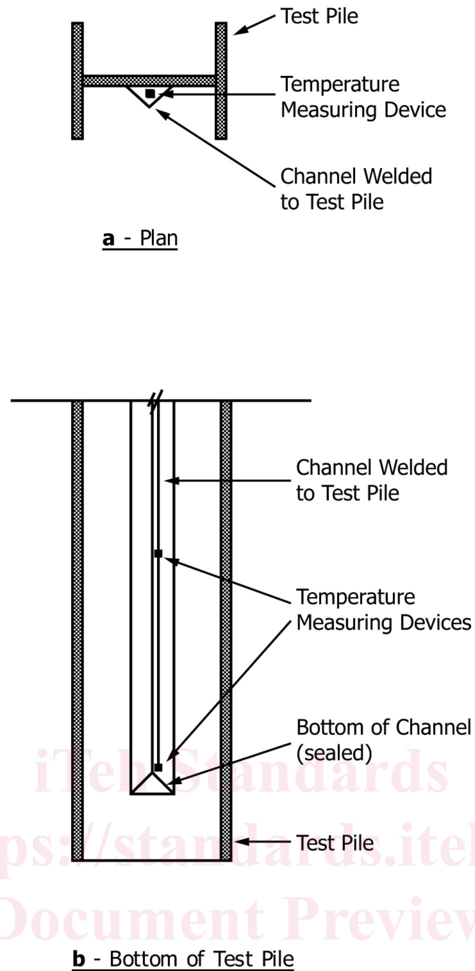

FIG. 2 Potential Placement of Temperature Measuring Devices for Driven Structural-Shaped Test Pile

TABLE 1 Minimum Delay Times (Days After Freezeback)

Permafrost Condition	Ground Temperature, – °F (°C)	Delay Times, Days	
		Driven Piles	Slurried Piles
Ice-poor	above 28 (–2)	10	14
	23 to 28 (–2 to – 5)	5	7
	below 23 (–5)	2	3
Ice-rich	above 28 (–2)	14	20
	23 to 28 (–2 to – 5)	7	10
	below 23 (–5)	5	7

6.1.4 ~~For testing an individual pile, center a steel-bearing plate(s) on the pile and set perpendicular to the longitudinal axis of the pile. It shall be of sufficient thickness to prevent it from bending under the loads involved (but not less than 2 in. (50 mm) thick). The size~~ Provide bearing stiffeners as needed between the flanges of test and reaction beams. Provide steel bearing plates as needed to spread the load from the outer perimeter of the jack(s), or the bearing surface of beams or boxes, to bear on the surface of the test ~~plate shall be not less than the size of the pile top nor less than the area covered by the base(s) of the hydraulic jack(s).~~pile or pile cap. Also provide steel bearing plates to spread the load between the jack(s), load cells, and hemispherical bearings, and to spread the load to the test beam(s), test pile, or pile cap. Bearing plates shall extend the full flange width of steel beams and the complete top area of piles, or as specified by the Engineer, so as to provide full bearing and distribution of the load.

~~6.1.3 For tests on precast or cast-in-place concrete piles, set the test plate, when used, in high-strength quick-setting grout. For tests on individual steel H-piles or pipe piles, weld the test plate to the pile. For tests on individual timber piles, the test plate may be set directly on the top of the pile that shall be sawed off to provide full bearing of the test plate, or alternatively, the test plate may be set in high-strength quick-setting grout.~~

6.1.5 ~~In~~Unless ~~6.3 and~~otherwise specified, ~~6.4, center the hydraulic jack(s) on the test plate(s) with a steel-bearing plate of adequate thickness between the top(s) of the jack ram(s) and the bottom(s) of the test beam(s). If a load cell(s) or equivalent~~

~~device(s) is to be used, center it on the bearing plate above the ram(s) with another steel bearing plate of sufficient thickness between the load cell(s) or equivalent device(s) and the bottom(s) of the test beam(s).~~ provide steel bearing plates that have a total thickness adequate to spread the bearing load between the outer perimeters of loaded surfaces at a maximum angle of 45° to the loaded axis. For center hole jacks and center hole load cells, also provide steel plates adequate to spread the load from their inner diameter to the their central axis at a maximum angle of 45°, or per manufacturer recommendations. Bearing plates shall ~~be of sufficient size to accommodate the jack ram(s) and the load cell(s) or equivalent device(s) and properly bear against the bottom(s) of the test beam(s).~~extend the full width of the test beam(s) or any steel reaction members so as to provide full bearing and distribution of the load.

6.1.6 ~~In~~A ~~6.5, a test plate may be used in accordance with the appropriate provisions of~~ qualified engineer shall design and approve all loading apparatus, loaded members, support frames, and loading procedures. The test beam(s), load platforms, and support structures ~~6.1 or, alternatively, the test beam(s) may be set directly on the pile cap or the loading material applied directly on the cap. Test beam(s) set directly on the cap shall obtain full bearing using high-strength quick-setting grout, if necessary.~~shall have sufficient size, strength, and stiffness to prevent excessive deflection and instability up to the maximum anticipated test load.

NOTE 5—Rotations and lateral displacements of the test pile or pile cap may occur during loading, especially for piles extending above the soil surface or through weak soils. Design and construct the support reactions to resist any undesirable rotations or lateral displacements.

6.2 ~~*Testing Equipment:*~~ *Hydraulic Jacks, Gauges, Transducers, and Load Cells:*

6.2.1 ~~Hydraulic jacks including~~ The hydraulic jack(s) and their operation shall conform to ~~ANSI B30.1.~~ASME B30.1 Jacks and shall have a nominal load capacity exceeding the maximum anticipated jack load by at least 20 %. The jack, pump, and any hoses, pipes, fittings, gauges, or transducers used to pressurize it shall be rated to a safe pressure corresponding to the nominal jack capacity.

6.2.2 The hydraulic jack ram(s) shall have a travel greater than the sum of the anticipated maximum axial movement of the pile plus the deflection of the test beam and the elongation and movement of any anchoring system, but not less than 15 % of the average pile diameter or width. Use a single high-capacity jack when possible. When using a multiple jack system, provide jacks of the same make, model, and capacity, and supply the jack pressure through a common manifold. Fit the manifold and each jack with a pressure gauge to detect malfunctions and imbalances.

6.2.3 Unless otherwise specified, the hydraulic jack(s), pressure gauge(s), and pressure transducer(s) shall have a calibration to at least the maximum anticipated jack load performed within the six months prior to each test or series of tests. Furnish the calibration report(s) prior to performing a test, which shall include the ambient temperature and calibrations performed for multiple ram strokes up to the maximum stroke of the jack.

6.2.4 ~~Unless a calibrated load cell(s) is used, calibrate the complete jacking system~~ Each complete jacking and pressure measurement system, including the hydraulic ~~jack(s), hydraulic pump, and pressure gauge~~pump, should be calibrated as a unit ~~before each test or series of tests in a test program to provide an accuracy of less than 1 % of the applied load. Calibrate the hydraulic jack(s) over its~~when practicable. The hydraulic jack(s) shall be calibrated over the complete range of ram travel for increasing and decreasing applied ~~loads at a temperature within the air temperature range expected to occur during the load test.~~ loads. If two or more jacks are to be used to apply the test load, they shall be of the same ~~ram diameter,~~ make, model, and size, connected to a common manifold and pressure gauge, and operated by a single hydraulic pump. The calibrated jacking system(s) shall have accuracy within 5 % of the maximum applied load. When not feasible to calibrate a jacking system as a unit, calibrate the jack, pressure gauges, and pressure transducers separately, and each of these components shall have accuracy within 2 % of the applied load.

~~NOTE 8—Where tests will be carried out in subfreezing fluctuating air temperatures, it is recommended that thermal insulation be applied to the hydraulic jack, the hydraulic lines, and other components of the loading system.~~

6.2.5 ~~When an accuracy greater than that obtainable with the jacking system is required, use a properly constructed load cell(s) or equivalent device(s) in series with the hydraulic jack(s). Calibrate load cell(s) or equivalent device(s) prior to the test to provide an accuracy of less than~~ Pressure gauges shall have minimum graduations less than or equal to 1 % of the maximum applied load and shall conform to ASME B40.100 Pressure Gauges and Gauge Attachments with an accuracy grade 1A having a permissible error 61 % of the span. Pressure transducers shall have a minimum resolution less than or equal to 1 % of the maximum applied load and ~~equipped with a spherical bearing(s).~~shall conform to ASME B40.100 with an accuracy grade 1A having a permissible error 61 % of the span. When used for control of the test, pressure transducers shall include a real-time display.

6.2.6 ~~The hydraulic jack pump shall be equipped with an automatic regulator or accumulator to maintain the load within 1 % of the specified load as pile settlement occurs.~~If the maximum test load will exceed 900 kN [100 tons], place a properly constructed load cell or equivalent device in series with each hydraulic jack. Unless otherwise specified the load cell(s) shall have a calibration to at least the maximum anticipated jack load performed within the six months prior to each test or series of tests. The calibrated load cell(s) or equivalent device(s) shall have accuracy within 1 % of the applied load, including an eccentric loading of up to 1 % applied at an eccentric distance of 25 mm [1 in.]. After calibration, load cells shall not be subjected to impact loads. A load cell is recommended, but not required, for lesser load. If not practicable to use a load cell, include embedded strain gauges located in close proximity to the jack to confirm the applied load.

~~6.2.5 Furnish calibration reports for all testing equipment for which calibration is required, and show the temperature at which the calibration was done.~~

~~NOTE 9—Considerations should be given to employing a dual load-measuring system (jack pressure and load cell) to provide a check and as a backup in case one system malfunctions. Hydraulic jack rams should have sufficient travel to allow for anticipated pile settlements, deflections of the test beam, and elongation of connections to anchoring devices.~~

6.2.7 ~~The use of a single high-capacity jack is preferred to the use of multiple jacks. If a multiple jacking system is used, each jack should be fitted with a pressure gauge (in addition to the master gauge) in order to detect malfunctions.~~ Do not leave the hydraulic jack pump unattended at any time during the test. Automated jacking systems shall include a clearly marked mechanical override to safely reduce hydraulic pressure in an emergency.

6.3 *Load Applied ~~to Pile~~ by Hydraulic Jack(s) Acting Against Anchored Reaction Frame (see* Figs. 3 and 4~~Fig. 3~~*):*

6.3.1 Apply the test load to the pile or pile group with the hydraulic jack(s) reacting against the test beam(s) centered over the test pile, or pile group. Install a sufficient number of anchor piles or suitable anchoring device(s) to provide adequate reactive ~~capacity.~~ capacity for the test beam(s). Provide a clear distance from the test pile or pile group of at least five times the maximum diameter of the largest anchor or test ~~pile(s) or 6 ft (2 m), whichever is greater.~~ pile(s), but not less than 2.5 m [8 ft]. The Engineer may increase or decrease this minimum clear distance based on factors such as the type and depth of reaction, soil conditions, and magnitude of loads so that reaction forces do not significantly effect the test results.

NOTE 6—Excessive vibrations during anchor pile installation in noncohesive soils may affect test results. Anchor piles that penetrate deeper than the test pile may affect test results. Install the anchor piles nearest the test pile first to help reduce installation effects.

6.3.2 ~~Center a test beam(s) of sufficient size and strength over the test pile to avoid excessive deflection under load.~~ Provide sufficient clearance between the bottom flange(s) of the test beam(s) and the top of the test pile ~~for~~ or pile group to place the necessary bearing plates, hydraulic ~~jack(s) or load cell(s), or both, if used. For large test loads~~ jack(s), hemispherical bearing, and load cell(s). For test loads of high magnitude requiring several anchors, a steel framework may be required to transfer the applied loads from the test beam(s) to the anchors.

6.3.3 When testing individual inclined piles, align the jack(s), test beam(s), and anchor piles with the inclined longitudinal axis of the test pile.

6.3.4 Attach the test beam(s) (or reaction framework if used) to the anchoring devices with connections designed to adequately transfer the applied loads to the anchors so as to prevent slippage, ~~rupture,~~rupture or excessive elongation of the connections under ~~the~~ maximum required test load.

~~6.3.4 Apply the test load to the test pile with the hydraulic jack(s) reacting against the test beam(s) in accordance with the loading procedure in 8.1 or as otherwise specified.~~

6.4 *Load Applied ~~to Pile~~ by Hydraulic Jack(s) Acting Against a Weighted Box or Platform ~~(see~~ (*Fig. ~~4~~5*):*

~~6.4.1 Center the test pile under a test beam(s) of sufficient size and strength to avoid excessive deflection under load allowing sufficient clearance between the top of the test pile or pile cap and the bottom(s) of the beam(s) after deflection under load to accommodate the necessary bearing plates, hydraulic jack(s), (and load cell(s) if used). Support the ends of the test beam(s) on temporary cribbing or other devices.~~

6.4.1 Apply the test load to the pile or pile group with the hydraulic jack(s) reacting against the test beam(s) centered over the test pile, or pile group. Center a box or platform ~~over~~on the test beam(s) with the edges of the box or platform parallel to the test beam(s) supported by cribbing or piles placed as far from the test pile ~~as practicable~~or pile group as practicable, but in no case

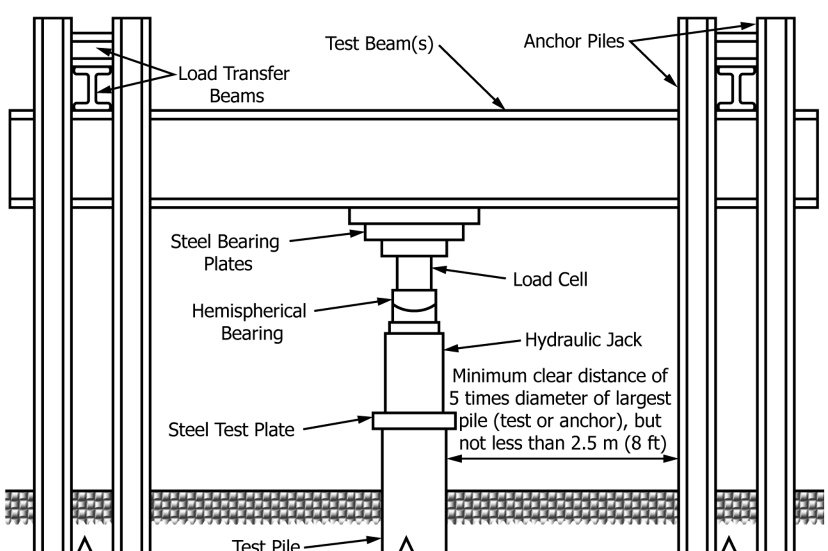

FIG. 3 Schematic ~~Setup for Applying Loads to Pile Using~~ of Hydraulic Jack Acting Against Anchored Reaction Frame

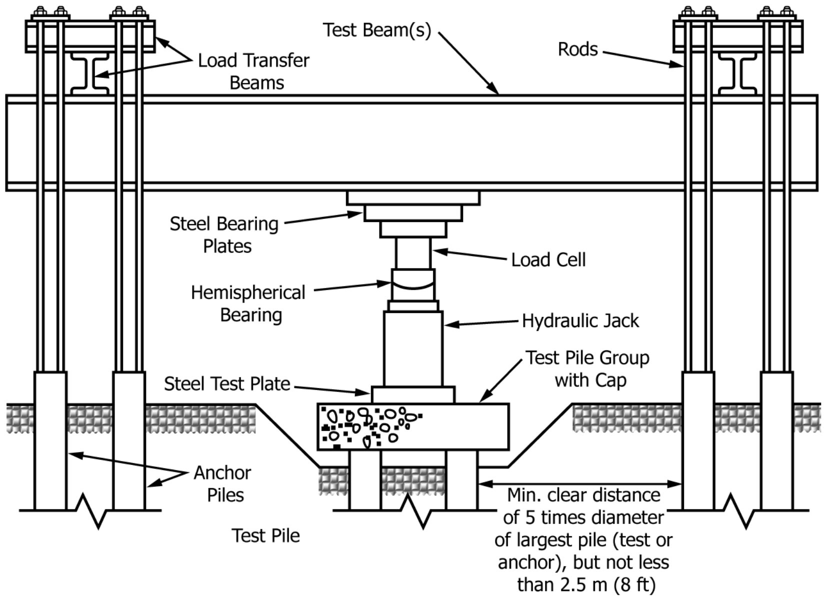

FIG. 4 Schematic ~~Setup for Applying Loads to Pile Using Hydraulic Jack Acting Against Weighted Box or Platform~~of Hydraulic Jack on a Pipe Group Acting Against Anchored Reaction Frame

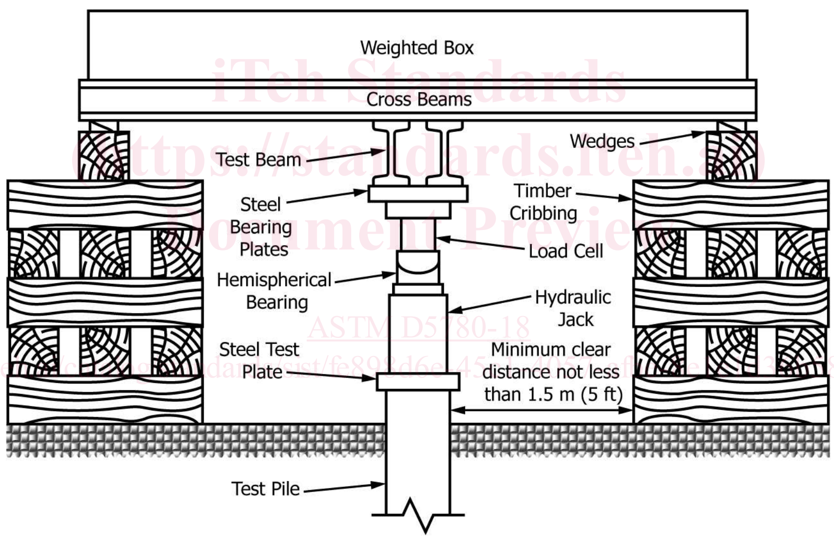

FIG. 5 Schematic ~~Setup for Applying Loads Directly to Pile Using Weighted~~ of Hydraulic Jack Acting Against Weighted Box or Platform

less than a clear distance of ~~6 ft (2.0 m).~~1.5 m [5 ft]. If cribbing is used, the bearing area of the cribbing at ground surface shall be sufficient to prevent adverse settlement of the weighted box or platform. ~~Insulation may be placed beneath the cribbing to mitigate the effects of thaw settlement.~~

6.4.2 The test beam(s) shall have sufficient size and strength to prevent excessive deflection under the maximum load, and sufficient clearance between the bottom flange(s) of the test beam(s) and the top of the test pile or pile group to place the necessary bearing plates, hydraulic jack(s), hemispherical bearing, and load cell(s). Support the ends of the test beam(s) on temporary cribbing or other devices.

6.4.3 Load the box or platform with any suitable material such as soil, rock, concrete, steel, or water-filled tanks with a total weight (including that of the test beam(s) and the box or platform) at least 10 % greater than the ~~anticipated~~ maximum anticipated test load.

~~6.4.4 Apply the test loads to the pile with the hydraulic jack(s) reacting against the test beam(s) in accordance with 8.1 or as otherwise specified.~~

6.5 *Load Applied Directly ~~to the Pile With~~ Using Known Weights (see Figs. 6-8~~Fig. 5~~):*

6.5.1 Center on the test ~~plate~~pile or pile cap a test beam(s) of known weight and of sufficient size and strength to avoid excessive deflection under load with the ends supported on temporary cribbing if necessary to stabilize the beam(s). Alternatively, the known test weights or loading material may be applied directly on the pile or pile cap.

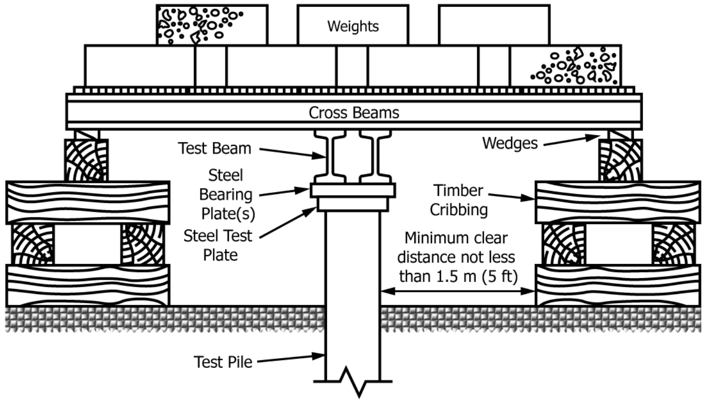

FIG. 6 ~~Possible Arrangement of Instrumentation for Measuring Vertical Movements of Pile~~Schematic of Direct Loading on a Single Pile Using a Weighted Platform

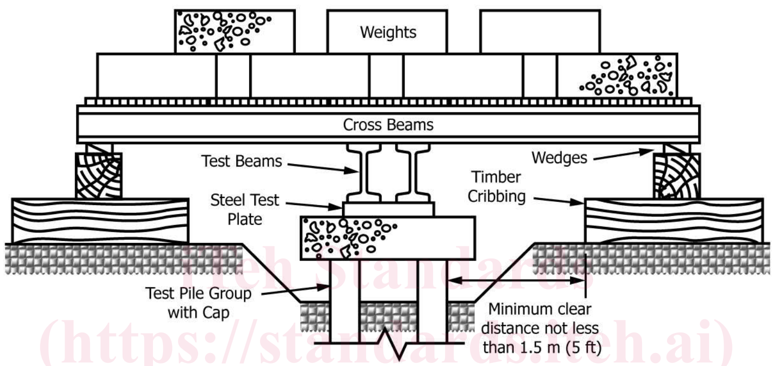

FIG. 7 Schematic of Direct Loading on a Pile Group Using a Weighted Platform

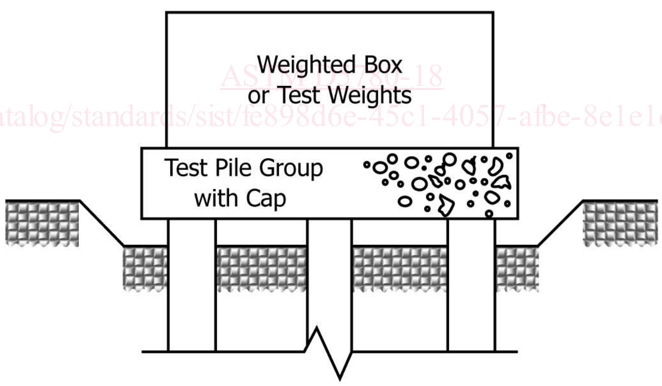

FIG. 8 Schematic of Direct Loading on a Pile Group

6.5.2 Center and balance a platform of known weight on the test beam(s) or directly on the pile cap with overhanging edges of the platform parallel to the test beam(s) supported by cribbing or by piles capped with timber beams, so that a clear distance of not less than ~~6 ft (2.0 m)~~1.5 m [5 ft] is maintained between the supports and the test pile or pile group.

6.5.3 Place sufficient pairs of timber wedges between the top of the cribbing or timber cap beams and the bottom edges of the platform so that the platform can be stabilized during loading or unloading.

6.5.4 ~~When the platform is ready to load,~~ Apply the test loads to the pile or pile group using known weights. When loading the platform, remove any temporary supports at the ends of the test beam(s) and tighten the wedges along the bottom edges of the platform so that the platform is stable. ~~Load the platform in accordance with the standard loading procedures in~~ Use loading materials ~~8.1 or as otherwise specified using material~~ such as steel or concrete so that the weight of incremental loads can be determined ~~within 1 %.~~with accuracy of 5 %.

~~NOTE 10—With the loading apparatus described in 6.5, provisions can be made for taking target rod level readings directly on the center of the pile or pile cap or center of the test plate to measure pile top movements as specified in 7.2.3. For tests on concrete piles, a hole is required in the center of~~