



Designation: D1143/D1143M – 07^{e1}

Standard Test Methods for Deep Foundations Under Static Axial Compressive Load¹

This standard is issued under the fixed designation D1143/D1143M; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

This standard has been approved for use by agencies of the Department of Defense.

^{e1} NOTE—Section references were editorially corrected in Sections 8.1.4, 8.1.8, and Note 12 in January 2009.

1. Scope*

1.1 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 foundations, referred to herein as *piles*, that function in a manner similar to driven piles or cast-in-place piles, regardless of their method of 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.

1.2 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 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 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 comments regarding some of the factors influencing the interpretation of test results.

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 appendices intended only for explanatory or advisory use.

1.7 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 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.

1.9 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 This test method is under the jurisdiction of ASTM Committee **D18** on Soil and Rock and is the direct responsibility of Subcommittee **D18.11** on Deep Foundations.

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*A Summary of Changes section appears at the end of this standard

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 and health practices and determine the applicability of regulatory limitations prior to use.*

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

D6760 Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Crosshole Testing

2.2 American National Standards:³

ASME B30.1 Jacks

ASME B40.100 Pressure Gages and Gauge Attachments

ASME B89.1.10.M Dial Indicators (For Linear Measurements)

3. Terminology

3.1 For common definitions of terms used in this standard see Terminology **D653 Terminology Relating to Soil, Rock, and Contained Fluids**.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *cast in-place pile, n*—a deep foundation unit made of cement grout or concrete and constructed in its final location, for example, drilled shafts, bored piles, caissons, auger cast piles, pressure-injected footings, etc

3.2.2 *deep foundation, n*— a relatively slender structural element that transmits some or all of the load it supports to soil or rock well below the ground surface, such as a steel pipe pile or concrete drilled shaft

3.2.3 *driven pile, n*—a deep foundation unit made of preformed material with a predetermined shape and size and typically installed by impact hammering, vibrating, or pushing.

3.2.4 *failure load, n*—for the purpose of terminating an axial compressive load test, the test load at which rapid continuing, progressive movement occurs, or at which the total axial movement exceeds 15 % of the pile diameter or width, or as specified by the engineer.

3.2.5 *telltale rod, n*—an unstrained metal rod extended through the test pile from a specific point to be used as a reference from which to measure the change in the length of the loaded pile.

²For 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.

³Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

3.2.6 *wireline, n*—a steel wire mounted with a constant tension force between two supports and used as a reference line to read a scale indicating movement of the test pile.

4. Significance and Use

4.1 Field tests provide the most reliable relationship between the axial load applied to a deep foundation and the resulting axial movement. Test results may also provide information used to assess the distribution of side shear resistance along the pile shaft, the amount of end bearing developed at the pile toe, and the long-term load-deflection behavior. A foundation designer may evaluate the test results to determine if, after applying an appropriate factor of safety, the pile or pile group has an ultimate static capacity and a deflection at service load satisfactory to support a specific foundation. When performed as part of a multiple-pile test program, the designer may also use the results to assess the viability of different piling types and the variability of the test site.

4.2 If feasible, without exceeding the safe structural load on the pile(s) or pile cap, the maximum load applied should reach a failure load from which the Engineer may determine the ultimate axial static compressive load capacity of the pile(s). Tests that achieve a failure load may help the designer improve the efficiency of the foundation by reducing the piling length, quantity, or size.

4.3 If deemed impractical to apply axial test loads to an inclined pile, the Engineer may elect to use axial test results from a nearby vertical pile to evaluate the axial capacity of the inclined pile.

NOTE 1—The quality of the result produced by this test method is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice **D3740** are generally considered capable of competent and objective testing/sampling/ inspection/etc. Users of this test method 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. Test Foundation Preparation

5.1 Excavate or add fill to the ground surface around the test pile or pile group to the final design elevation unless otherwise approved by the Engineer.

5.2 Cut off or build up the test pile as necessary to permit construction of the load-application apparatus, placement of the necessary testing and instrumentation equipment, and observation of the instrumentation. Remove any damaged or unsound material from the pile top and prepare the surface so that it is perpendicular to the pile axis with minimal irregularity to provide a good bearing surface for a test plate.

5.3 For tests of single piles, install a solid steel test plate at least 25 mm (1 in) thick perpendicular to the long axis of the test pile that covers the complete pile top area. The test plate shall span across and between any unbraced flanges on the test pile.

5.4 For tests on pile groups, cap the pile group with steel-reinforced concrete or a steel load frame designed for the anticipated loads. Provide a clear space beneath the pile cap as

specified by the Engineer to eliminate any bearing on the underlying ground surface. For each loading point on the pile cap, provide a solid steel test plate oriented perpendicular to the axis of the pile group with a minimum thickness of 25 mm (1 in), as needed to safely apply load to the pile cap. Center a single bearing plate on the centroid of the pile group. Locate multiple bearing plates symmetrically about the centroid of the pile group. Boxes and beams may bear directly on the pile cap when designed to bear uniformly along their contact surface with the cap.

5.5 To minimize stress concentrations due to minor irregularities of the pile top surface, set test plates bearing on the top of precast or cast-in-place concrete piles in a thin layer of quick-setting, non-shrink grout, less than 6 mm (0.25 in) thick and having a compressive strength greater than the test pile at the time of the test. Set test plates, boxes, and beams designed to bear on a concrete pile cap in a thin layer of quick-setting, non-shrink grout, less than 6 mm (0.25 in) thick and having a compressive strength greater than the pile cap at the time of the test. For tests on steel piles, or a steel load frame, weld the test plate to the pile or load frame. For tests on individual timber piles, set the test plate directly on the cleanly cut top of the pile, or in grout as described for concrete piles.

NOTE 2—Deep foundations sometimes include hidden defects that may go unnoticed prior to the static testing. Low strain integrity tests as described in D5882 and ultrasonic crosshole integrity tests as described in D6760 may provide a useful pre-test evaluation of the test foundation.

6. Apparatus for Applying and Measuring Loads

6.1 General:

6.1.1 The apparatus for applying compressive loads to a test pile or pile group shall conform to one of the methods described in 6.3–6.6 Unless otherwise specified by the 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 method described in 6.3 to apply axial loads to either vertical or inclined piles or pile groups. Use the methods described in 6.4–6.6 to apply only vertical loads.

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.

6.1.4 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 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.

6.1.5 Unless otherwise specified, 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 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 A 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 shall have sufficient size, strength, and stiffness to prevent excessive deflection and instability up to the maximum anticipated test load.

NOTE 3—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 Hydraulic Jacks, Gages, Transducers, and Load Cells:

6.2.1 The hydraulic jack(s) and their operation shall conform to 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, gages, 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 gage to detect malfunctions and imbalances.

6.2.3 Unless otherwise specified, the hydraulic jack(s), pressure gage(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 Each complete jacking and pressure measurement system, including the hydraulic pump, should be calibrated as a unit when practicable. The hydraulic jack(s) shall be calibrated over the complete range of ram travel for increasing and decreasing applied loads. If two or more jacks are to be used to apply the test load, they shall be of the same make, model, and size, connected to a common manifold and pressure gage, and operated by a single hydraulic pump. The calibrated jacking system(s) shall have accuracy less than 5% of the maximum applied load. When not feasible to calibrate a jacking system as

a unit, calibrate the jack, pressure gages, and pressure transducers separately, and each of these components shall have accuracy less than 2% of the applied load.

6.2.5 Pressure gages shall have minimum graduations less than or equal to 1% of the maximum applied load and shall conform to ASME B40.100 Pressure Gages and Gauge Attachments with an accuracy grade 1A having a permissible error $\pm 1\%$ of the span. Pressure transducers shall have a minimum resolution less than or equal to 1% of the maximum applied load and shall conform to ASME B40.100 with an accuracy grade 1A having a permissible error $\pm 1\%$ of the span. When used for control of the test, pressure transducers shall include a real-time display.

6.2.6 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 1 in. (25 mm). 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 gages located in close proximity to the jack to confirm the applied load.

6.2.7 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 by Hydraulic Jack(s) Acting Against Anchored Reaction Frame (See Fig. 1 and Fig. 2):

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 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), 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 4—Excessive vibrations during anchor pile installation in non-cohesive 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 Provide 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). 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 or excessive elongation of the connections under maximum required test load.

6.4 Load Applied by Hydraulic Jack(s) Acting Against a Weighted Box or Platform: (Fig. 3)

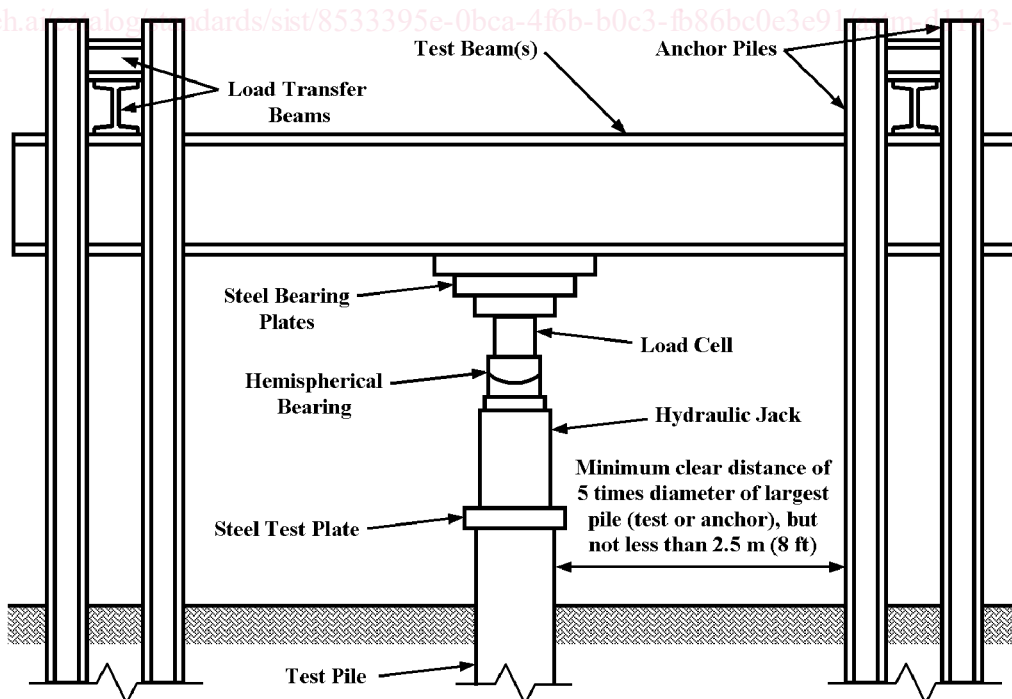


FIG. 1 Schematic of Hydraulic Jack Acting Against Anchored Reaction Frame

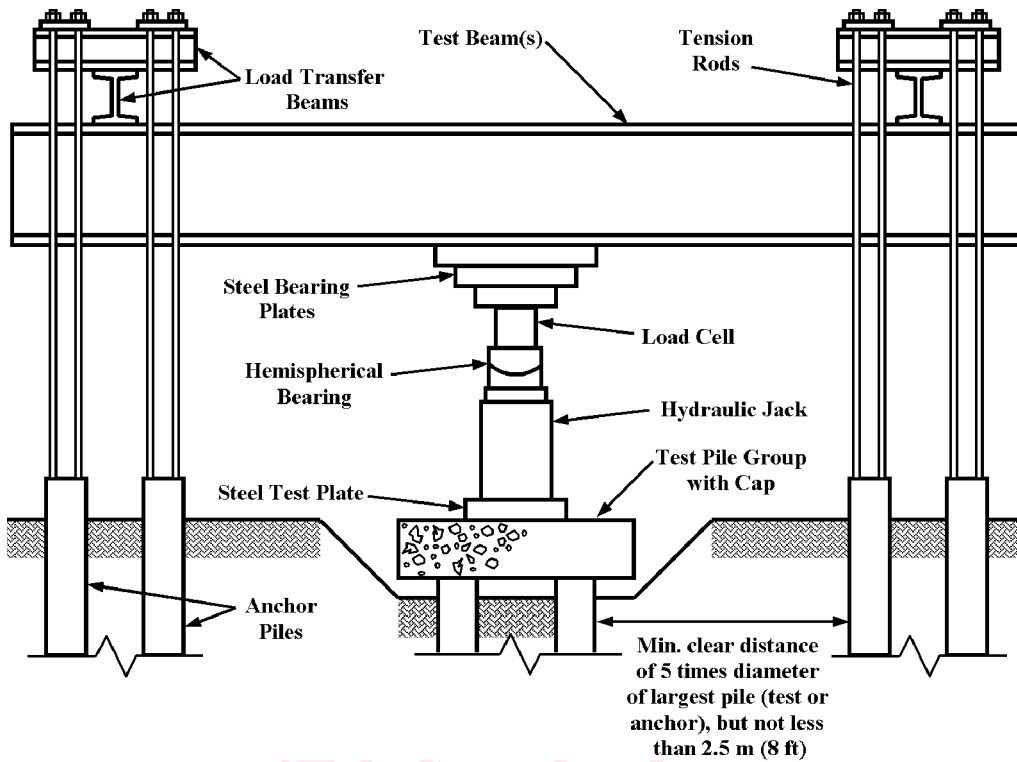


FIG. 2 Schematic of Hydraulic Jack on a Pipe Group Acting Against Anchored Reaction Frame

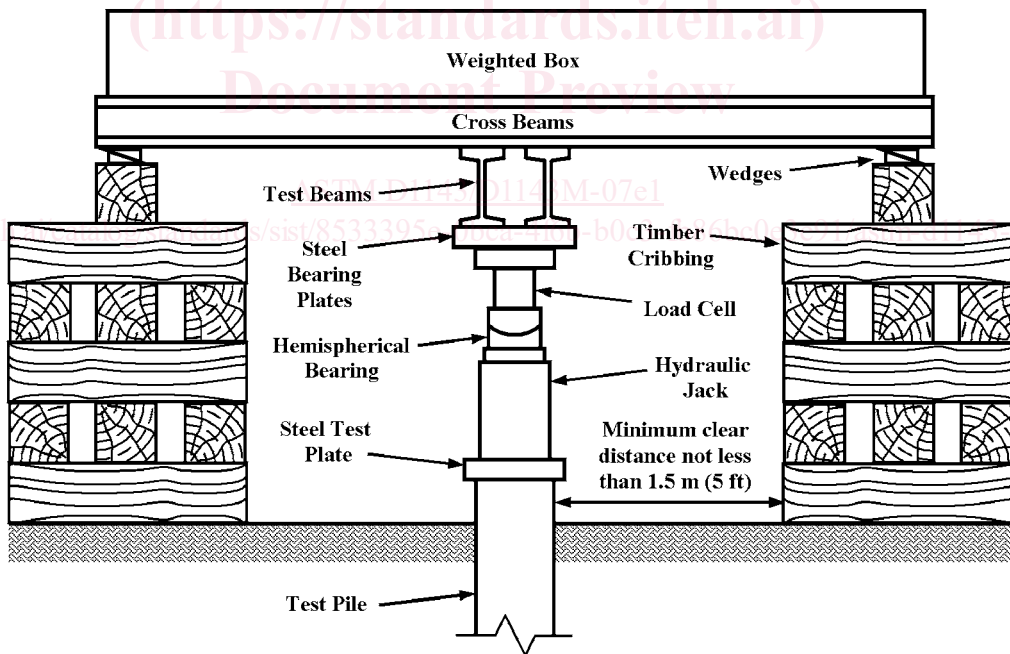


FIG. 3 Schematic Hydraulic Jack Acting Against Weighted Box or Platform

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 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 or pile group as practicable, but in no case

less than a clear distance of 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.

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 maximum anticipated test load.

6.5 *Load Applied Directly Using Known Weights* (See Fig. 4, Fig. 5, and Fig. 6):

6.5.1 Center on the test 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.

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 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 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. Use loading materials such as steel or concrete so that the weight of incremental loads can be determined with accuracy of 5 %.

NOTE 5— Depending on the magnitude of the applied load and axial movement, platform stability may be difficult to control at or near a failure

load when applying the load directly. The user should consider using a different load method when anticipating a failure load.

NOTE 6— The loading apparatus described in 6.5 may allow target rod level readings directly on the center of the pile top or pile cap to measure the pile top movement described in 7.2.4. To accommodate the target rod, use a double test beam with sufficient space between the beams, leave a hole through the platform, and leave a line of sight between the test weights for survey level readings.

6.6 *Other Types of Loading Apparatus (optional)*— The Engineer may specify another type of loading apparatus satisfying the basic requirements of 6.3 or 6.4.

7. Apparatus for Measuring Movement

7.1 General:

7.1.1 Reference beams and wirelines shall be supported independent of the loading system, with supports firmly embedded in the ground at a clear distance from the test pile of at least five times the diameter of the test pile(s) but not less than 2.5 m (8 ft), and at a clear distance from any anchor piles of at least five times the diameter of the anchor pile(s) but not less than 2.5 m (8 ft). Reference supports shall also be located as far as practicable from any cribbing supports but not less than a clear distance of 2.5 m (8 ft).

7.1.2 Reference beams shall have adequate strength, stiffness, and cross bracing to support the test instrumentation and minimize vibrations that may degrade measurement of the pile movement. One end of each beam shall be free to move laterally as the beam length changes with temperature variations. Supports for reference beams and wirelines shall be isolated from moving water and wave action. Provide a tarp or shelter to prevent direct sunlight and precipitation from affecting the measuring and reference systems.

7.1.3 Dial and electronic displacement indicators shall conform to ASME B89.1.10.M Dial Indicators (For Linear Measurements) and should generally have a travel of 100 mm (4 in), but shall have a minimum travel of at least 50 mm (2 in). Provide greater travel, longer stems, or sufficient calibrated

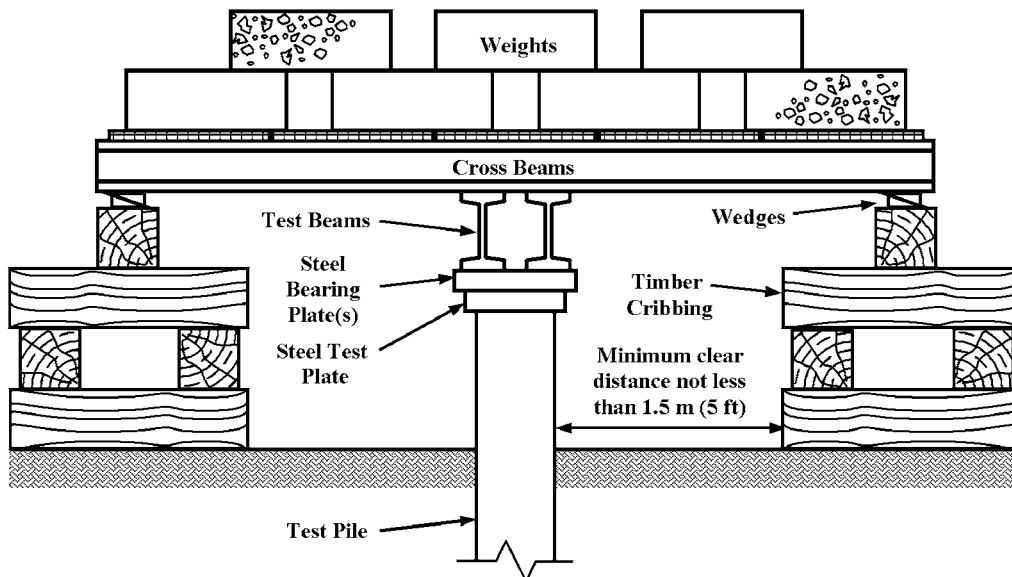


FIG. 4 Schematic of Direct Loading on a Single Pile Using Weighted Platform