Designation: D1143/D1143M – 20

Standard Test Methods for Deep Foundation Elements Under Static Axial Compressive Load[1]

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 reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope*

1.1 The test methods described in this standard measure the axial deflection of an individual vertical or inclined deep foundation element or group of elements when loaded in static axial compression. These methods apply to all types of deep foundations, or deep foundation systems as they are practical to test. The individual components of which are referred to herein as *elements* that function as, or in a manner similar to, drilled shafts, cast-in-place piles (augered cast-in-place piles, barrettes, and slurry walls), driven piles, such as pre-cast concrete piles, timber piles or steel sections (steel pipes or wide flange beams) or any number of other element types, regardless of their method of installation. Although the test methods may be used for testing single elements or element groups, the test results may not represent the long-term performance of the entire deep foundation system.

1.2 This standard provides minimum requirements for testing deep foundation elements 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 charge of the foundation design referred to herein as the engineer, shall approve any deviations, deletions, or additions to the requirements of this standard. (Exception: the test load applied to the testing apparatus shall not exceed the rated capacity established by the engineer who designed the testing apparatus).

1.3 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.

1.4 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 elements used in the constructed foundation.

1.5 A qualified engineer (qualified to perform such work) shall design and approve all loading apparatus, loaded members, and support frames. The geotechnical engineer shall design or specify the 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.

1.6 *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.

1.7 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 slug. The rationalized slug unit is not given, unless dynamic [F=ma] calculations are involved.

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

1.8.1 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 data.

1.9 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

[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 uses, or both. How one applies the results obtained using this standard is beyond its scope.

1.10 The text of this standard references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.11 *This standard offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this standard may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

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

1.13 *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

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

D7949 Test Methods for Thermal Integrity Profiling of Concrete Deep Foundations

D8169 Test Methods for Deep Foundations Under Bi-Directional Static Axial Compressive Load

2.2 *American National Standards:*[3]

ASME B30.1 Jacks

ASME B40.100 Pressure Gauges and Gauge Attachments

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

[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 Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

3. Terminology

3.1 *Definitions*—For definitions of common technical terms used in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anchor, n*—a device or deep foundation element or elements designed to resist the upward movement.

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

3.2.3 *deep foundation element, 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 or concrete-filled drilled shaft.

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

3.2.5 *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 element diameter or width, or as specified by the engineer.

3.2.6 *gage or gauge, n*—an instrument used for measuring load, pressure, displacement, strain or such other physical properties associated with load testing as may be required.

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

3.2.8 *toe, n*—the bottom of a deep foundation element, sometimes referred to as tip or base.

3.2.9 *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 element.

4. Summary of Test Method

4.1 This standard provides minimum requirements for testing deep foundation elements under static axial compressive load. The test is a specific type of test, most commonly referred to as deep foundation load testing or static load testing. This standard is confined to test methods for loading a deep foundation element or elements from the top, in the downward direction. The loading requires structural elements be constructed that resist upward movement, often referred to collectively as a reaction system. The principal measurements taken in addition to load are displacements.

4.2 This standard allows the following test procedures:

Procedure A	Quick Test	9.1.2
Procedure B	Maintained Test (optional)	9.1.3
Procedure C	Constant Rate of Penetration Test (optional)	9.1.4

5. Significance and Use

5.1 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 element, the amount of end bearing developed at the element toe, and the long-term load-deflection behavior. The engineer may evaluate the test results to determine if, after applying appropriate factors, the element or group of elements has a static capacity, load response and a deflection at service load satisfactory to support the foundation. When performed as part of a multiple-element test program, the engineer may also use the results to assess the viability of different sizes and types of foundation elements and the variability of the test site.

5.2 If feasible, and without exceeding the safe structural load on the element or element cap (hereinafter unless otherwise indicated, "element" and "element group" are interchangeable as appropriate), the maximum load applied should reach a failure load from which the engineer may determine the axial static compressive load capacity of the element. Tests that achieve a failure load may help the engineer improve the efficiency of the foundation design by reducing the foundation element length, quantity, or size.

5.3 If deemed impractical to apply axial test loads to an inclined element, the engineer may elect to use axial test results from a nearby vertical element to evaluate the axial capacity of the inclined element. Or, the engineer may elect to use a bi-directional axial test on an inclined element (Test Methods D8169).

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/and the like. 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.

5.4 Different loading test procedures may result in different load-displacement curves. The Quick Test (10.1.2) and Constant Rate of Penetration Test (10.1.4) typically can be completed in a few hours. Both are simple in concept, loading the element relatively quickly as load is increased. The Maintained Test (10.1.3) loads the element in larger increments and for longer intervals which could cause the test duration to be significantly longer. Because of the larger load increments the determination of the failure load can be less precise, but the Maintained Test is thought to give more information on creep settlements (settlement due to consolidation is beyond the capability of the test procedures described in this standard). Although control of the Constant Rate of Penetration Test is somewhat more complicated (and uncommon for large diameter or capacity elements), the test may produce the smoothest curve and thus the best possible definition of capacity. The engineer must weigh the complexity of the procedure and other limitations against any perceived benefit of a smoother curve.

5.5 The scope of this standard does not include analysis for foundation capacity, but in order to analyze the test data appropriately it is important that information on factors that affect the derived mobilized axial static capacity are properly documented. These factors may include, but are not limited to the following:

5.5.1 Potential residual loads in the element which could influence the interpreted distribution of load at the element tip and along the element shaft.

5.5.2 Possible interaction of friction loads from test element with upward friction transferred to the soil from anchor elements obtaining part or all of their support in soil at levels above the tip level of the test element.

5.5.3 Changes in pore water pressure in the soil caused by element driving, construction fill, and other construction operations which may influence the test results for frictional support in relatively impervious soils such as clay and silt.

5.5.4 Differences between conditions at time of testing and after final construction such as changes in grade or groundwater level.

5.5.5 Potential loss of soil supporting the test element from such activities as excavation and scour.

5.5.6 Possible differences in the performance of an element in a group or of an element group from that of a single isolated element.

5.5.7 Effect on long-term element performance of factors such as creep, environmental effects on element material, negative friction loads not previously accounted for, and strength losses.

5.5.8 Type of structure to be supported, including sensitivity of structure to settlements and relation between live and dead loads.

5.5.9 Special testing procedures which may be required for the application of certain acceptance criteria or methods of interpretation.

5.5.10 Requirement that non-tested element(s) have essentially identical conditions to those for tested element(s) including, but not limited to, subsurface conditions, element type, length, size and stiffness, and element installation methods and equipment so that application or extrapolation of the test results to such other elements is valid.

6. Test Foundation Preparation

6.1 Excavate or add fill to the ground surface around the test element to the final design elevation unless otherwise approved by the engineer.

6.2 Cut off or build up the test element 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 element top and prepare the surface so that it is perpendicular to the element axis with minimal irregularity to provide a good bearing surface for a test plate.

6.3 For tests of single elements, install a solid steel test plate at least 25 mm [1 in.] thick perpendicular to the long axis of the test element that covers the complete element top area. The test plate shall span across and between any unbraced flanges on the test element. Thicker plates may be required for larger elements or imperfect or rough element tops.