~~Designation:D3689–90(Reapproved 1995)~~

~~Standard Test Method for Individual Piles Under Static Axial Tensile Load~~Designation: D 3689 – 07

Standard Test Methods for Deep Foundations Under Static Axial Tensile Load[1]

This standard is issued under the fixed designation D 3689; 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~~

~~This test method covers routine procedures to determine uplift capacity of piles. The provisions permit the introduction of more detailed requirements and procedures, when required to satisfy the objectives of the test program. While the procedures herein produce a relationship between applied load and pile movement, the results may not represent long-term performance.~~

1. Scope

~~1.1This test method covers procedures for testing vertical or batter piles, individually or in groups, to determine response of the pile or pile group to a static tensile load applied axially to the pile or pile group. This test method is applicable to all deep foundation units that function in a manner similar to piles, regardless of their method of installation. This test method is divided into the following sections:~~ *

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 tension. 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 tensile load. Plans, specifications, provisions, or any combination thereof 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:

~~Section~~

~~Referenced Documents~~Procedure	~~2~~		
~~Significance and Use~~	3		
Significance and UseTest	Section		
~~Apparatus for Applying Loads~~	~~4~~ A	Quick Test	8.1.2
~~Apparatus for Measuring Movements~~	~~5~~ B	Maintained Test (optional)	8.1.3
~~Safety Precautions~~	~~6~~ C	Loading in Excess of Maintained Test (optional)	8.1.4
~~Loading Procedures~~	~~7~~ D	Constant Time Interval Test (optional)	8.1.5
~~Procedures for Measuring Movements~~	~~8~~ E	Constant Rate of Uplift Test (optional)	8.1.6
~~Report~~	~~9~~		
~~Precision and Bias~~	~~10~~F	Cyclic Loading Test (optional)	8.1.7

~~1.2This test method only describes procedures for testing single piles or pile groups. It does not cover the interpretation or analysis of the test results or the application of the test results to foundation design. See~~

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] ~~This~~These test ~~method is~~methods are under the jurisdiction of ASTM Committee ~~D-18~~ D18 on Soil and Rock and ~~is~~are the direct responsibility of Subcommittee D18.11 on Deep Foundations.

~~Current edition approved May 25, 1990. Published July 1990. Originally published as D3689–78. Last previous edition D3689–83.~~

Current edition approved Sept. 1, 2007. Published October 2007. Originally approved in 1978. Last previous edition approved in 1995 as D 3689 – 90 (95) which was withdrawn December 2003 and reinstated in September 2007.

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

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. A qualified geotechnical engineer should interpret the test results for predicting pile performance and capacity. The term "failure", as used in this test method, indicates a rapid progressive movement of the pile or pile group in the direction of loading under a constant or decreasing load.

1.3Apparatus and procedures designated "optional" are to be required only when included in the project specifications and, 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 and illustrations included herein are explanatory or advisory.

1.4Wherever in this test method the term pile is used with reference to the test pile, it shall include test pile groups.

1.5The values stated in inch-pound units are to be regarded as the standard.

1.6*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.* For specific precautionary statements, see Section 6. 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 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 D 6026.

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 ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

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

2. Referenced Documents

2.1 *ASTM Standards:*

D1143Test Method for Piles Under Static Axial Compressive Load

D3966Test Method for Piles Under Lateral Loads[2] [2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 5882 Test Method for Low Strain Impact Integrity Testing of Deep Foundations

D 6026 Practice for Using Significant Digits in Geotechnical Data

D 6760 Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Crosshole Testing

2.2 *ANSI Standard:* *American National Standards:*

B30.1Safety Code for Jacks

ASME B30.1 Jacks[3]

ASME B40.100 Pressure Gages and Gauge Attachments[3]

ASME B89.1.10.M Dial Indicators (For Linear Measurements)[3]

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[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* , Vol 04.08.volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute, 1430 Broadway, New York, NY 10018.

[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. Significance and Use

3.1The actual load capacity of a pile-soil system can best be determined by testing. Testing measures the response of a pile-soil system to loads and may provide data for research and development, engineering design, quality assurance, or acceptance or rejection in accordance with the specifications and contract documents.

3.2Testing as covered herein, when combined with an acceptance criterion, is suitable for assurance of pile foundation design and installation under building codes, standards, and other regulatory statutes.

4.Apparatus for Applying Loads

4.1*General*:

4.1.1The apparatus for applying known tensile loads to the test pile shall be as described in 4.3, 4.4, 4.5, or 4.6 and shall be constructed so that the loads are applied axially minimizing eccentric loading. The method in 4.3 is recommended. The method in 4.5 should not be used for ultimatetests or for tests where large upward movements are anticipated. The method in 4.5 can be used to develop high tensile loads with relatively low jacking capacity. See 1.3 for use of the method in 4.6Terminology

3.1 *Definitions*—For common definitions of terms used in this standard see Terminology D 653.

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, e.g. 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 tensile load test*, the test load at which 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.

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 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 tensile 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.

NOTE1—When a pile group is subject to vertical test loads, cap rotations and horizontal displacements may occur. The occurrence of such horizontal movements, and the necessary reactions to resist such movements if they are to be prohibited, should be considered when designing and constructing the load apparatus for the group test. 1—The quality of the result produced by these test methods 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 D 3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of these test methods are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 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 Design and construct the test pile(s) so that any location along the depth of the pile will safely sustain the maximum anticipated axial compressive and tensile load to be developed at that location. Cut off or build up the test pile(s) 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 as necessary to properly install the apparatus for measuring movement, for applying load, and for measuring load.

5.3 For tests on pile groups, cap the pile group with steel-reinforced concrete or a steel load frame designed to safely sustain the anticipated loads.

5.4 Install structural tension connectors extending from the test pile or pile cap, constructed of steel straps, bars, cables, and/or other devices bolted, welded, cast into, or otherwise firmly affixed to the test pile or pile cap to safely apply the maximum required tensile test load without slippage, rupture, or excessive elongation. Carefully inspect these tension members for any damage that may reduce their tensile capacity. Tension members with a cross-sectional area reduced by corrosion or damage, or material properties compromised by fatigue, bending, or excessive heat, may rupture suddenly under load. Do not use brittle materials for tension connections.

NOTE 2—If it is not feasible to apply axial test loads to a batter pile, the results of a test on a similar nearby vertical pile generally may be used to evaluate the uplift capacity of the batter pile.

4.1.2 Where feasible, the immediate area of the test pile or pile group shall be excavated to the proposed pile cut-off elevation. The test pile(s) shall be cut off or built up to the proper grade as necessary to permit construction of the load-application apparatus, placement of the necessary testing and instrumentation equipment, and observations of the instrumentation.

4.1.3 Reaction piles, if used, shall be of sufficient number and installed so as to provide adequate reactive capacity. When testing a batter pile, reaction piles shall be battered in the same direction and angle as the test pile; the test beam(s) shall be perpendicular to the direction of batter. If two or more reaction piles are used at each end of the test beam(s), they shall be capped with a suitable steel beam(s) set on steel bearing plates or directly on and welded to steel reaction piles (2—Deep foundations sometimes include hidden defects that may go unnoticed prior to static testing. Low strain integrity tests as described in Test Method D 5882 and ultrasonic crosshole integrity tests as described in Test Method D 6760 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 tensile loads to a test pile or pile group shall conform to one of the methods described in 6.3-6.6. The method in 6.3 is recommended. The method in 6.5 can develop high tensile loads with relatively low jacking capacity, but does not perform well for tests to failure or for large upward movements.

6.1.2 Reaction piles, if used, shall be of sufficient number and installed so as to safely provide adequate reaction capacity without excessive movement. When using two or more reaction piles at each end of the test beam(s), cap them with reaction beams (Fig. 1, Fig. 2, and Fig. 3). Cribbing, if used as a reaction, shall be of sufficient plan dimensions to transfer the reaction loads to the soil without settling at a rate that would prevent maintaining the applied loads.

4.1.4 The clear distance between the test pile and the reaction pile(s) or cribbing shall be at least five times the butt diameter or diagonal dimension of the test pile, but not less than 8 ft (2.5 m).). Locate reaction piles so that resultant test beam load supported by them acts at the center of the reaction pile group. Cribbing, if used as a reaction, shall be of sufficient plan dimensions to transfer the reaction loads to the soil without settling at a rate that would prevent maintaining the applied loads.

6.1.3 Cut off or build up reaction piles as necessary to place the reaction or test beam(s). Remove any damaged or unsound material from the top of the reaction piles, and provide a smooth bearing surface parallel to the reaction or test beam(s). To minimize stress concentrations due to minor surface irregularities, set steel bearing plates on the top of precast or cast-in-place

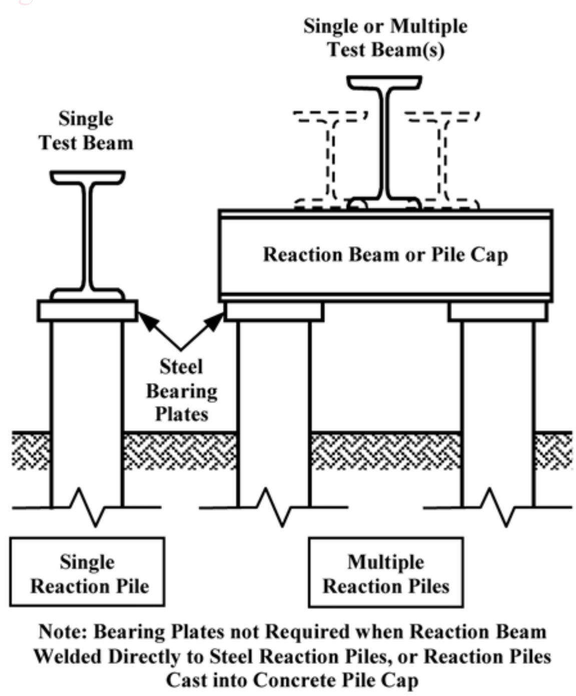

FIG. 1 Typical End Views of Test Beam(s) and Reaction Pile(s)

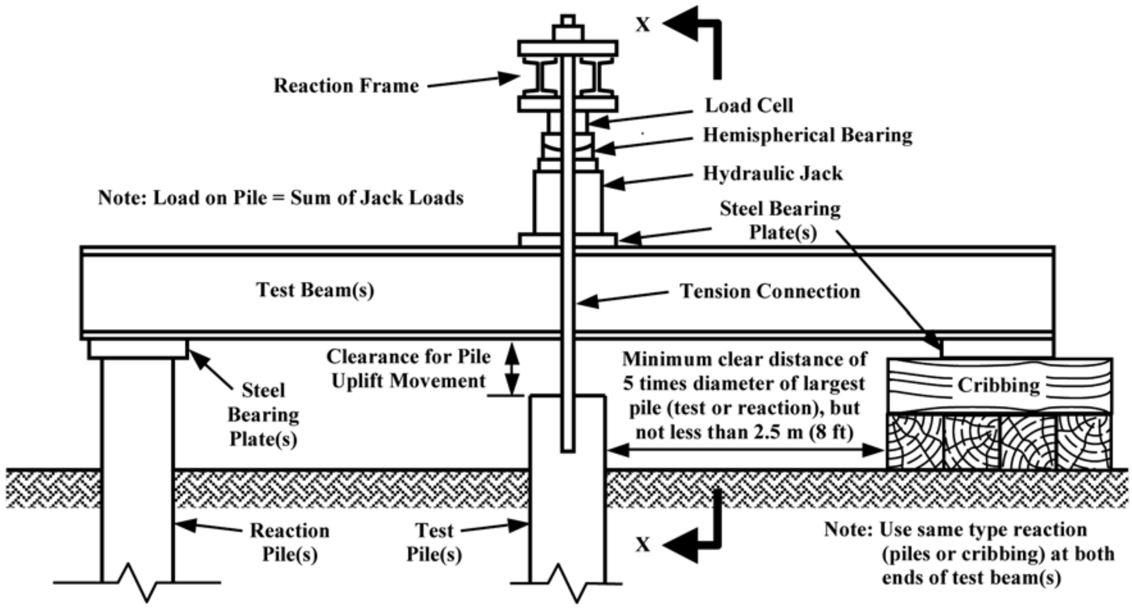

FIG. 2 Typical Setup for Tensile Load Test Using Hydraulic Jack(s) Supported on Test Beams

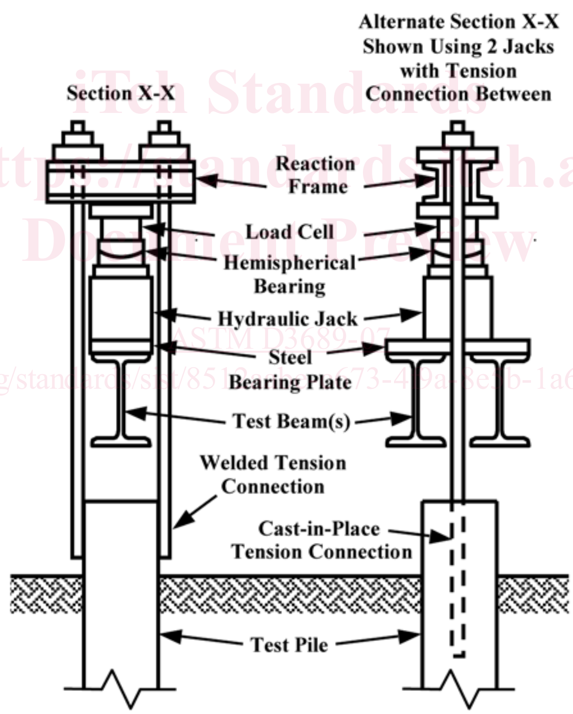

FIG. 3 Typical Section X-X (Fig. 1) of Test Beam(s) at Test Pile

concrete reaction 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 reaction pile at the time of the test. For steel reaction piles, weld a bearing plate to each pile, or weld the cap or test beam(s) directly to each pile. For timber reaction piles, set the bearing plate(s) directly on the cleanly cut top of the pile, or in grout as described for concrete piles.

6.1.4 Provide a clear distance between the test pile(s) and the reaction piles or cribbing of at least five times the maximum diameter of the largest test or reaction 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 3—~~The reactions should be far enough away from the test pile so that there is not significant effect on the performance of the test pile due to external loading. Factors such as type and depth of reaction, soil conditions, and magnitude of loads should be considered. When testing large diameter~~

~~drilled shafts or caissons, the practicality of a spacing of five times the butt diameter or diagonal dimension should be considered and the standard modified as warranted.~~

~~4.1.5Steel bearing plates of appropriate thickness for the loads involved shall be used above and below the hydraulic jack ram(s) and load cell(s), except if full bearing is provided on steel reaction piles, and between cap beam(s) and the tops of concrete or timber reaction piles. The size of the bearing plates shall be not less than the area covered by the base(s) of the hydraulic ram(s) or load cell(s) nor less than the total width of the test beam(s), cap beam(s), reaction piles, or any steel reaction member(s) so as to provide full bearing and distribution of the load. Bearing plates supporting the hydraulic jack ram(s) on timber cribbing shall have an area not less than five times the base area of the ram(s). Bearing plates that support test beam(s) on timber cribbing shall have a side dimension not less than 1 ft (0.3 m) greater than the total flange width of the test beam or overall width of double test beams.~~

~~4.1.6Bearing plates, hydraulic jack ram(s), and load cell(s) shall be centered on test beam(s), cap beam(s), reaction member(s), reactions piles, or cribbing. Bearing plates shall be set perpendicular to the longitudinal axis of the pile. Plates shall be set in high-strength, quick-setting grout for concrete reaction piles, or welded to steel reaction piles, or, in the case of timber reaction piles, set on the pile top which shall be sawed off on a plane perpendicular to the longitudinal axis of the pile. Bearing plates on cribbing shall be set in a horizontal plane.~~

~~4.2*Testing Equipment*:~~

~~4.2.1*Hydraulic jacks*, including their operation, shall conform to ANSI B30.1.~~

~~4.2.2Unless a calibrated load cell(s) is used, the complete jacking system including the hydraulic jack(s), hydraulic pump, and pressure gage shall be calibrated as a unit before each test or series of tests in a test program to an accuracy of not less than 5% of the applied load. The hydraulic jack(s) shall be calibrated over its 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 ram diameter, connected to a common manifold and pressure gage, and operated by a single hydraulic pump.~~

~~4.2.3When an accuracy greater than that obtainable withthe jacking system is required, a properly constructed load cell(s) or equivalent device(s) shall be used in series with the hydraulic jack(s). Load cell(s) or equivalent device(s) shall be calibrated prior to the test to an accuracy of not less than 2% of the applied load and shall be equipped with a spherical bearing(s). Calibration of load cells shall include eccentric loading of 1:100 with an off-center of 1 in. (25 mm). After calibration, load cells shall not be subjected to impact loads.~~

~~4.2.4Calibration reports shall be furnished for all testing equipment for which calibration is required, and shall show the temperature at which the calibration was done.~~ 3—Excessive vibrations during reaction pile installation in non-cohesive soils may affect test results. Reaction 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.

6.1.5 Each jack shall include a lubricated hemispherical bearing or similar device to minimize lateral loading of the pile or pile group. The hemispherical bearing(s) should include a locking mechanism for safe handling and setup.

6.1.6 Provide bearing stiffeners as needed between the flanges of test and reaction beams.

6.1.7 Provide steel bearing plates to spread the load to and between the jack(s), load cell(s), hemispherical bearing(s), test beam(s), reaction beam(s), and reaction pile(s). Unless otherwise specified by the engineer, the size of the bearing plates shall be not less than the outer perimeter of the jack(s), load cell(s), or hemispherical bearing(s), nor less than the total width of the test beam(s), reaction beam(s), reaction piles so as to provide full bearing and distribution of the load. Bearing plates supporting the jack(s), test beam(s), or reaction beams on timber or concrete cribbing shall have an area adequate for safe bearing on the cribbing.

6.1.8 Unless otherwise specified, where using steel bearing plates, provide a total plate thickness adequate to spread the bearing load between the outer perimeters of loaded surfaces at a maximum angle of 45 degrees 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 degrees, or per manufacturer recommendations.

6.1.9 Align the test load apparatus with the longitudinal axis of the test pile or pile group to minimize eccentric loading. Align bearing plate(s), jack(s), load cell(s), and hemispherical bearing(s) on the same longitudinal axis. Place jacks to center the load on the test beam(s). Place test beam(s) to center the load on reaction beams or cribbing, and reaction beams to center the load on reaction piles or cribbing. These plates, beams, and devices shall have flat, parallel bearing surfaces. Set bearing plates on cribbing in the horizontal plane.

6.1.10 When testing inclined piles, align the test apparatus and reaction piles parallel to the inclined longitudinal axis of the test pile(s) and orient the test beam(s) perpendicular to the direction of incline.

6.1.11 A qualified engineer shall design and approve all loading apparatus, loaded members, support frames, and loading procedures. Unless otherwise specified by the engineer, the apparatus for applying and measuring loads, including all structural members, shall have sufficient size, strength, and stiffness to safely prevent excessive deflection and instability up to 120 % of the maximum anticipated test load.

NOTE~~4—Unless the hydraulic jack pump is attended at all times, it is recommended that the jacking system be equipped with an automatic regulator to hold the load constant as pile movement occurs.~~

~~NOTE5—Considerations should be given to employing a dual load-measuring system (pressure gage and load cell) to provide as a check and as a backup in case one system malfunctions. Hydraulic jack rams should have sufficient travel to provide for anticipated pile movements deflections of the test beam and elongation of connections to the test pile. 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 calibrated pressure gage (in addition to the master gage) in order to detect malfunctions and imbalances.

4.3 *Load Applied to Pile by Hydraulic Jack(s) Acting Between Supported Test Beam(s) and a Reaction Frame Anchored to the Pile* (Fig. 4):

4.3.1 Center over the test pile a test beam(s) of sufficient size and strength to avoid excessive deflection under load with adequate space between the bottom flange(s) of the test beam(s) (including any projecting parts of the connection system to the reaction frame) and the top of the test pile to provide for the total anticipated upward movement of the test pile under test. Support the ends of the test beam(s) with reaction piles or cribbing. If two or more reaction piles are used at each end of the test beam(s), they shall be capped with a suitable steel beam(s) set on the piles or on bearing plates (Fig. 1).

4.3.2 Center over the test pile and on the test beam(s) a hydraulic jack ram(s) (and load cell(s), if used) of sufficient capacity for the required load. Center a reaction frame over the jack ram(s) (or load cell(s), if used).

4.3.3 Anchor the reaction frame to the test pile by means of straps or bars welded to the pile or by bars or cables embedded in the pile. Tension connections between test pile and reaction frame shall be constructed so as to prevent slippage, rupture, or excessive elongation of the connection under the maximum required test load.

4.4 *Load Applied to Pile by Hydraulic Jacks Acting at Both Ends of Test Beam(s) Anchored to the Pile (*Fig. 5*)*—Center over the test pile a test beam(s) of sufficient size and strength to avoid excessive deflection under load. Anchor the test beam(s) to the test pile by means of steel straps, bars, cables, or other devices so that the connection between test pile and test beam(s) will resist the maximum required test load without slippage, rupture, or excessive elongation. Support each end of the test beam(s) on a hydraulic jack ram(s) (and load cell(s), if used) with the jack ram(s) supported on reaction pile(s) or cribbing.

4.5 *Load Applied to Pile By Hydraulic Jack(s) Acting at One End of Test Beam(s) Anchored to the Pile (*Fig. 6*)* —Center over the test pile a test beam(s) of sufficient size and strength to avoid excessive deflection under load. Anchor the test beam(s) to the test pile by means of steel straps, bars, cables, or other devices so that the connection between test pile and test beam(s) will resist the maximum required test load without slippage, rupture, or excessive elongation. Support one of the test beam(s) on a hydraulic jack ram(s) (and load cell(s), if used) with the jack ram(s) supported on a reaction pile(s) or cribbing. Support the other end of the test beam(s) on a steel fulcrum or similar device placed on a steel plate supported on a reaction pile(s) or cribbing.

4.6 *Load Applied to Pile by Hydraulic Jack(s) Acting Against Top of A-Frame or Tripod* (Fig. 7) (Optional):

4.6.1 Center over the test pile an A-frame or tripod of sufficient size and strength to avoid excessive deflection under load. Support the A-frame or tripod on concrete footings, cribbing, or reaction piles. Tie together the bottoms of the A-frame or tripod legs or their supports, with tension members of sufficient strength to prevent spreading of the legs under load. If an A-frame is used, secure the top against lateral movement with not less than four guy cables anchored firmly to the ground.

4.6.2 Center over the test pile and on top of the A-frame or tripod a hydraulic ram(s) of sufficient capacity for the required load. If a center-hole jack ram is not used, center a reaction frame over the jack ram(s) and anchor the reaction frame to the test pile with tension straps or bars welded to the test pile or with bars or cables embedded in the test pile. If a center-hole jack ram is used, attach the tension bar passing through the ram to the center of the test pile. Tension connections between test pile and reaction

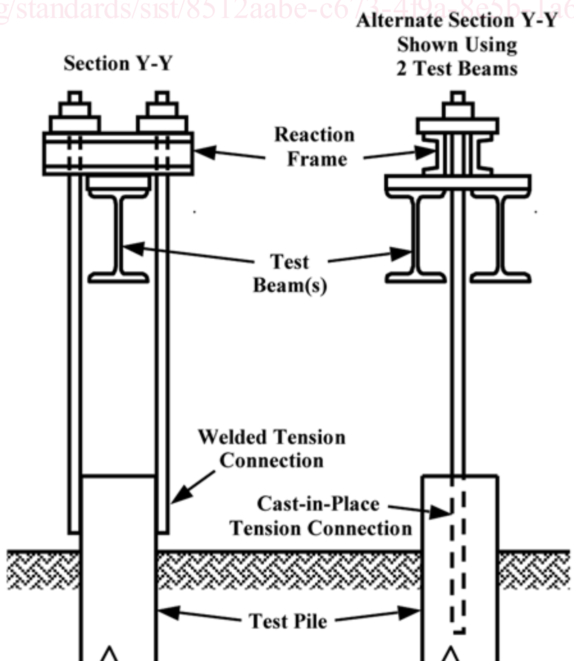

FIG. 5 Typical Section Y-Y (Fig. 4, Fig. 6) of Test Beam(s) at Test Pile

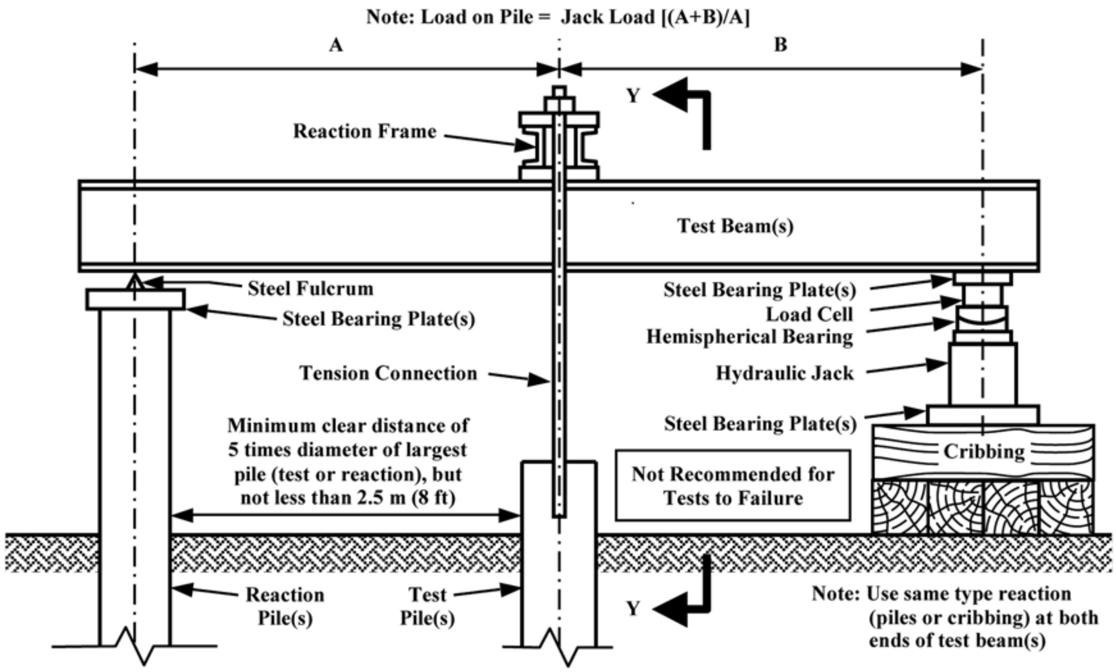

FIG. 6 Typical Setup for Tensile Load Test Using Hydraulic Jack(s) Acting Upward on One End of Test Beam(s)

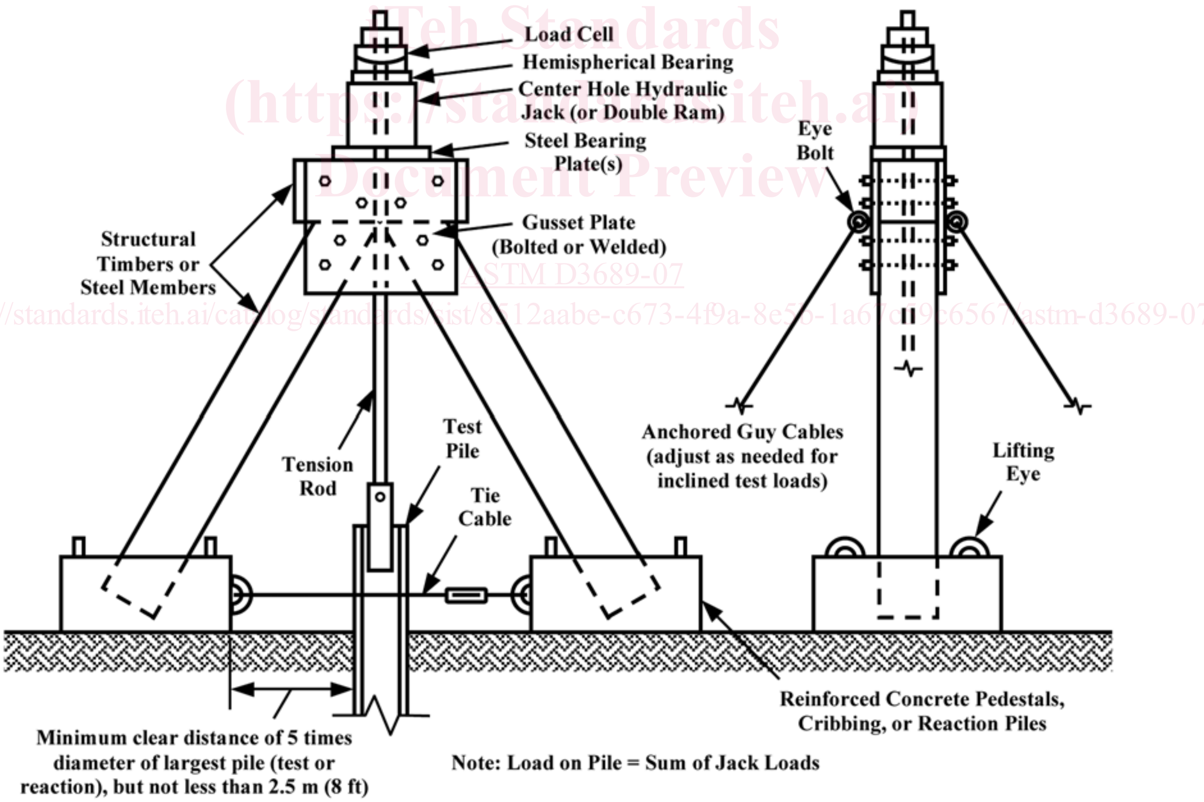

FIG. 7 Typical Setup for Tensile Load Test Using Hydraulic Jack(s) Acting at Top of an A-frame

~~frame or center-hole ram shall be constructed so as to prevent slippage, rupture, or excessive elongation of the connection under the maximum required test load.~~

~~5.Apparatus for Measuring Movements~~

~~5.1*General*~~ 4—Rotations and lateral displacements of the test pile or test pile group, reaction piles, cribbing support(s), or pile cap(s) may occur during loading, especially for sites with weak soils. The user should design and construct the support reactions to prevent instability and to limit undesired rotations or lateral displacements.

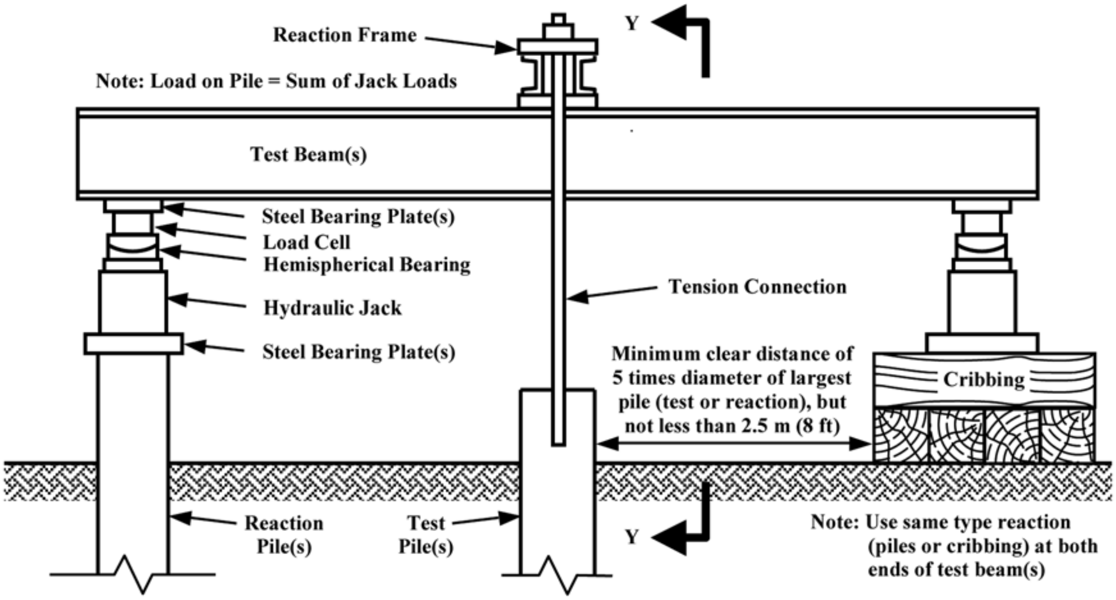

FIG. 4 Typical Setup for Tensile Load Test Using Hydraulic Jacks Acting Upward on Both Ends of Test Beam(s)

6.2 *Hydraulic Jacks, Gages, Transducers, and Load Cells*:

5.1.1All reference beams and wires shall be independently supported, with supports firmly embedded in the ground and at a clear distance of not less than 8 ft (2.5 m) from the test pile and from the reaction piles or cribbing. Reference beams shall be of sufficient stiffness to support the instrumentation so that excessive variations in readings do not occur. If steel reference beams are used, one end of the beams shall be free to move horizontally as the length of beams change with temperature variations. Reference beams should be cross-connected if necessary for rigidity.

NOTE6—The use of sufficiently stiff reference beams is recommended to avoid the necessity of cross connecting. If the beams must be cross connected, extra precautions must be taken to avoid accidental disturbance of the reference system since both beams would be affected.

5.1.2Dial gages shall have at least a 3-in. (75-mm) travel or sufficient gage blocks shall be provided to allow this travel with shorter gage stems. The gages should read to 0.001 in. (0.025 mm). Smooth-bearing surfaces perpendicular to the direction of gage-stem travel shall be provided for the gage stems. Scales used to measure pile movements shall read to 1⁄64 or 0.01 in. (0.25 mm). Target rods shall read to 0.001 ft (0.3 mm).

5.1.3All dial gages, scales, and reference points shall be clearly marked with a reference number or letter to assist in recording data accurately. Provisions shall be made to protect the instrumentation measuring system and reference system from adverse temperature variations and from disturbance. All gages, scales, or reference points shall be mounted so as to prevent movement relative to the test pile during the test.

5.2*Pile Butt Movements*—The apparatus for measuring axial movement of the test pile butt shall consist of a primary and secondary system in accordance with the following methods. The method in 5.2.3 shall be used as a check system for all tests except those on batter piles. The method in 5.2.1 is recommended for the primary measuring system for all tests and shall be used for tests on batter piles. The requirements of 5.2.1 and 5.2.2 shall apply to both the primary and secondary systems except that for the secondary system only one dial gage or one wire-mirror-scale shall be required.

NOTE7—Two separate measuring systems are required in order to provide a check on the observed data, to accommodate accidental disturbance of the measuring system, and to permit continuity of data in case it becomes necessary to reset the gages or scales.

5.2.1*Dial Gages*—Two reference beams, one on each side of the test pile, shall be oriented perpendicular to the direction of the test beam(s). At least two dial gages shall be mounted on the reference beams approximately equidistant from the center of and on opposite sides of the test pile with stems parallel to the longitudinal axis of the pile(s) and bearing on lugs firmly attached to the sides of the pile or pile cap. Alternatively, the two dial gages shall be mounted on opposite sides of the test pile with stems parallel to the longitudinal axis of the pile(s) and bearing on lugs firmly attached to the reference beams. However, gages may be mounted to bear on the top of the pile cap. For tests on individual batter piles, the dial gages shall be mounted along a line perpendicular to the direction of batter.

NOTE8—The use of four dial gages mounted 90° apart is recommended to compensate for lateral movement or rotation of the pile butt due to accidental eccentric loading.

NOTE9—For tests on batter piles, it is recommended that a dial gage be mounted in line with the direction of batter through the center of the test pile with the gage stem perpendicular to the longitudinal axis of the pile and bearing against a lubricated glass plate to measure lateral movements.

5.2.2*Wire, Mirror, and Scale*—Two wires, one on each side of the test pile, shall be oriented perpendicular to the test beam(s) and shall be approximately perpendicular to the longitudinal axis of the test pile. Each wire shall pass across and be clear of the face of a scale that is mounted parallel to the axis of the test pile and that is attached to a mirror fixed to the test pile or pile cap so that consistent readings of axial movement can be made directly from the scale by lining up the wire and its image in the mirror. The wire shall be not more than 1 in. (25 mm) from the face of the scale. A suitable method shall be used to maintain tension in the wires throughout the test so that when plucked or tapped, the wire will return to its original position. Piano wire or equivalent type shall be used.

5.2.3*Surveyor's Level or Laser Beam*— Readings using a surveyor's level or laser shall be taken on a target rod or a scale and shall be reference to a permanent bench mark located outside of the immediate test area or, alternatively, the surveyor's level or laser shall be mounted on an object of fixed elevation (for example a driven pile) outside of the immediate test area. Reference points or scales used in taking settlement readings shall be mounted on the sides of the test pile or pile cap and located on opposite sides except that reference points may be on top of the pile cap, or readings may be taken on a single fixed point in the center of the test pile top or pile cap (see

6.2.1 The hydraulic jack(s) and their operation shall conform to ASME B30.1 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 of the tension connection, 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 with a master pressure gage. 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 within 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 within 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 with an accuracy grade 1A having a permissible error ±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 ±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 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 when required, 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. An automatic regulator is recommended to help hold the load constant as pile movement occurs. Automated jacking systems shall include a clearly marked mechanical override to safely reduce hydraulic pressure in an emergency.

6.3 *Tensile Load Applied by Hydraulic Jack(s) Supported on Test Beam(s) (*Figs. 2 and 3*)* —Support the ends of the test beam(s) on reaction piles or cribbing, using reaction beams as needed to cap multiple reaction piles as shown in Fig. 1. Place the hydraulic jack(s), load cell(s), hemispherical bearing(s), and bearing plates on top of the test beam(s). Center a reaction frame over the jack(s), and anchor it to the tension connections (see 5.4) extending from the test pile or pile group. Design and construct the test beam(s), reaction frame, and reaction piles or cribbing, and arrange the jack(s) symmetrically so as to apply the resultant tensile load at, and parallel to, to the longitudinal axis of the test pile or pile group. Leave adequate clear space beneath the bottom flange(s) of the test beam(s) to allow for the maximum anticipated upward movement of the test pile or pile cap plus the deflection of the test beam(s).

6.4 *Tensile Load Applied by Hydraulic Jacks Acting Upward at Both Ends of Test Beam(s) (*Figs. 4 and 5*)*—Support each end of the test beam(s) on hydraulic jack(s) centered beneath the beam web(s) and placed equidistant from the longitudinal axis of the test pile or pile group. Support the jacks on reaction piles or cribbing, using reaction beams as needed to cap multiple reaction piles. Center a reaction frame over the test beam(s) and anchor it to the tension connections (see 5.4) extending from the test pile or pile group. Place a single load cell and hemispherical bearing between the reaction frame and the test beam(s) (preferred), or