Designation: D 3689 – 90 (Reapproved 1995)

Standard Test Method for Individual Piles 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

1.1 This 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:

1.2 This 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 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.

1.3 Apparatus 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.

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

1.5 The 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.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1143 Test Method for Piles Under Static Axial Compressive Load[2]

D 3966 Test Method for Piles Under Lateral Loads[2]

2.2 *ANSI Standard:*

B30.1 Safety Code for Jacks[3]

3. Significance and Use

3.1 The 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.

3.2 Testing 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.

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

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

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

4. Apparatus for Applying Loads

4.1 *General*:

4.1.1 The 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 4.6.

NOTE 1—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.

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.

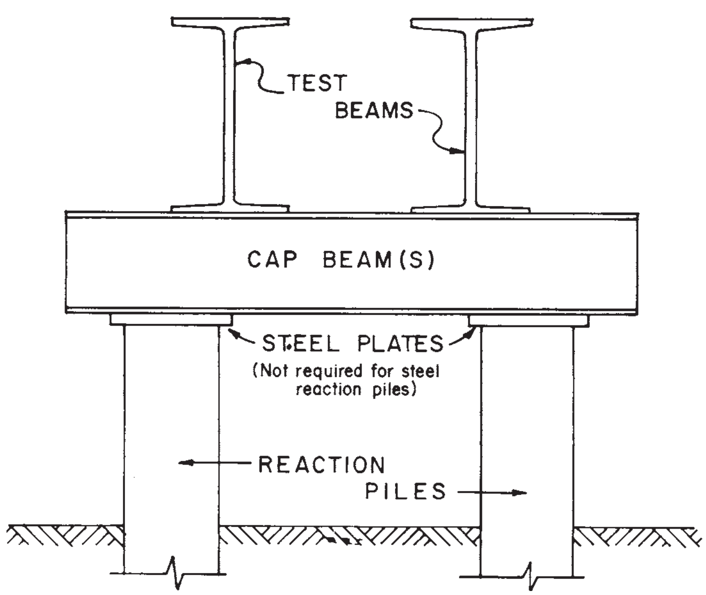
4.1.3 Reaction piles, if used, shall be of sufficient number and installed so as to provide adequate reactive capacity. When testing a batter pile, reaction piles shall be battered in the same direction and angle as the test pile; the test beam(s) shall be perpendicular to the direction of batter. If 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 (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).

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.

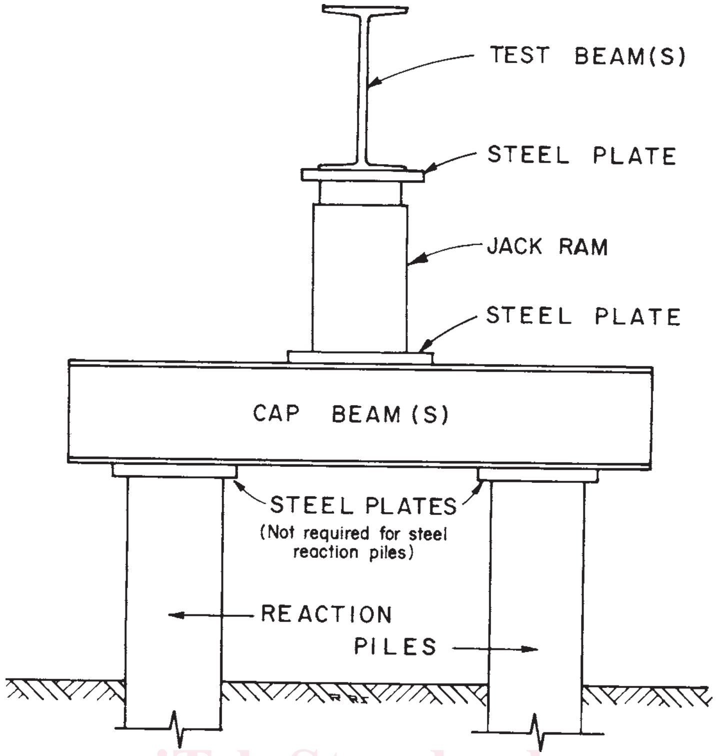
4.1.5 Steel bearing plates of appropriate thickness for the loads involved shall be used above and below the hydraulic jack ram(s) and load cell(s), except if full bearing is provided on steel reaction piles, and between cap beam(s) and the tops of concrete or timber reaction piles. The size of the bearing 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.

4.1.6 Bearing 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



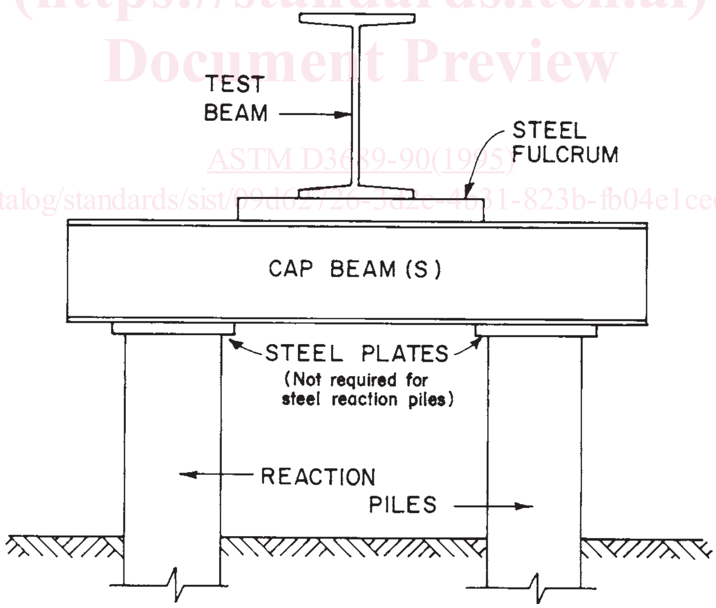
NOTE 1—Use stiffener plates between flanges of all beams where structurally required.

FIG. 1 Typical Arrangement Where Two or More Reaction Piles are Used at End of Test Beam Using Set-Up Shown in Fig. 4



NOTE 1—Use stiffener plates between flanges of all beams where structurally required.

FIG. 2 Typical Arrangement Where Two or More Reaction Piles are Used at End of Test Beam Using Set-Up Shown in Fig. 5 or Fig. 6



NOTE 1—Use stiffener plates between flanges of all beams where structurally required.

FIG. 3 Typical Arrangement Where Two or More Reaction Piles are Used at End of Test Beam Using Set-Up Shown in Fig. 6

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.

4.2.2 Unless 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.

4.2.3 When 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.

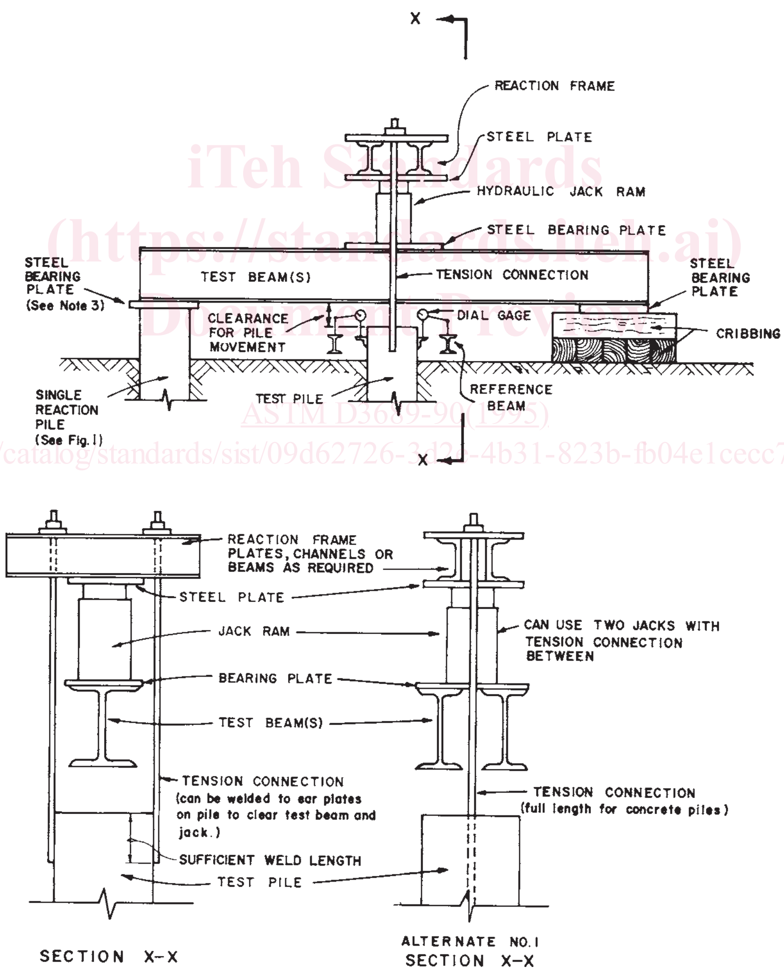
4.2.4 Calibration reports shall be furnished for all testing equipment for which calibration is required, and shall show the temperature at which the calibration was done.

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.

NOTE 5—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



NOTE 1—Load on pile equals applied load.
NOTE 2—Use same type reaction (piles or cribbing) at both ends of test beam.
NOTE 3—Plate not required for steel reaction pile.
NOTE 4—Use stiffener plates between flanges of all beams where structurally required.

FIG. 4 Typical Set-Up for Applying Tensile Loads to Pile Using Hydraulic Jack Acting Between Test Beam and Reaction Frame Anchored to Pile

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.

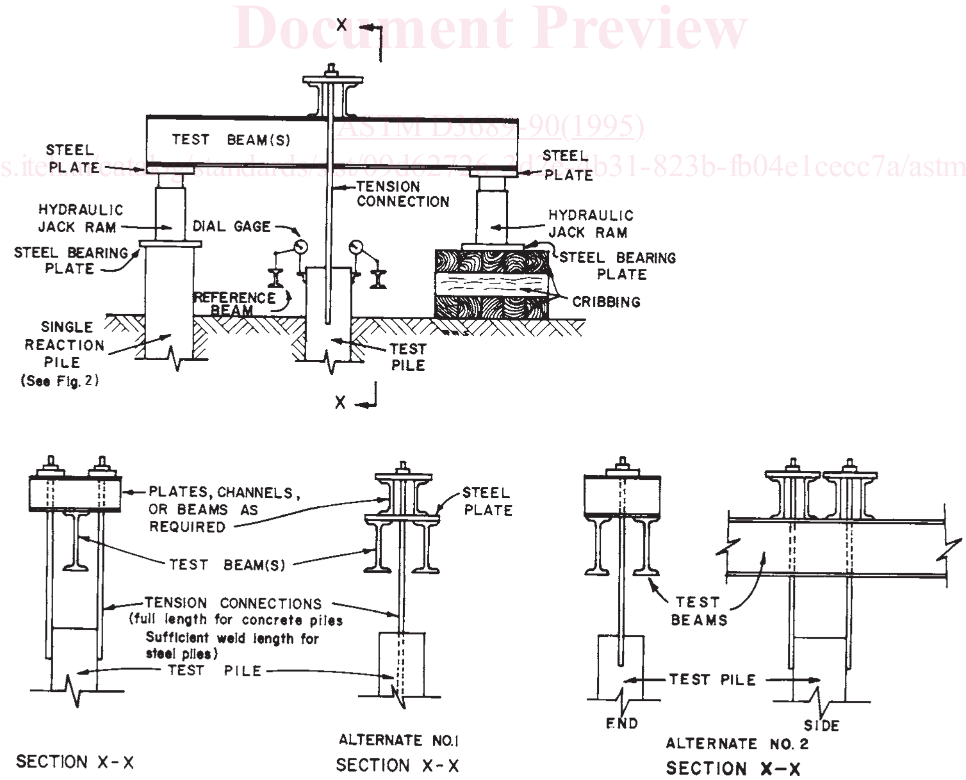
4.4 *Load Applied to Pile by Hydraulic Jacks Acting at Both Ends of Test Beam(s) Anchored to the Pile* (Fig. 5)—Center over the test pile a test beam(s) of sufficient size and strength to avoid excessive deflection under load. Anchor the test beam(s) to the test pile by means of steel straps, bars, cables, 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

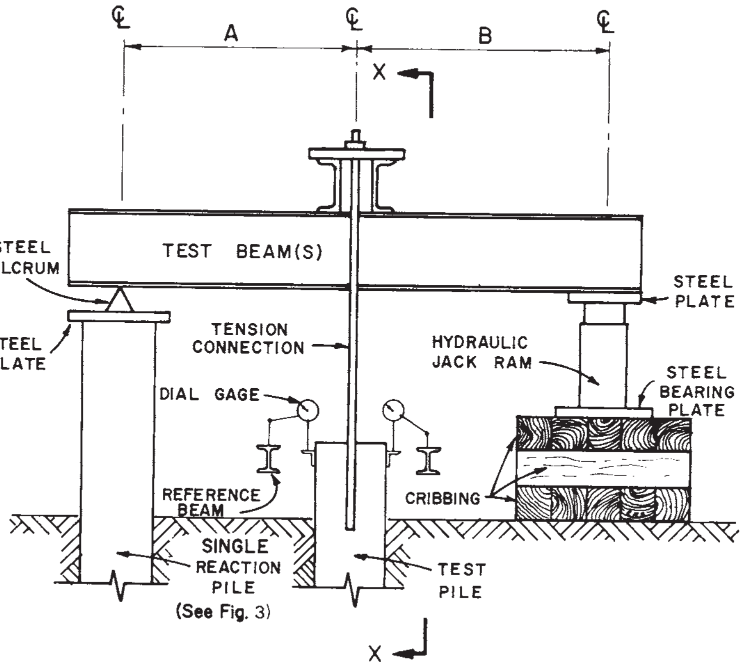


NOTE 1—Use same type reaction (piles or cribbing) at both ends of test beam.

NOTE 2—Load on pile is twice the jacking load unless the pressure gage has been calibrated for the two-jack system.

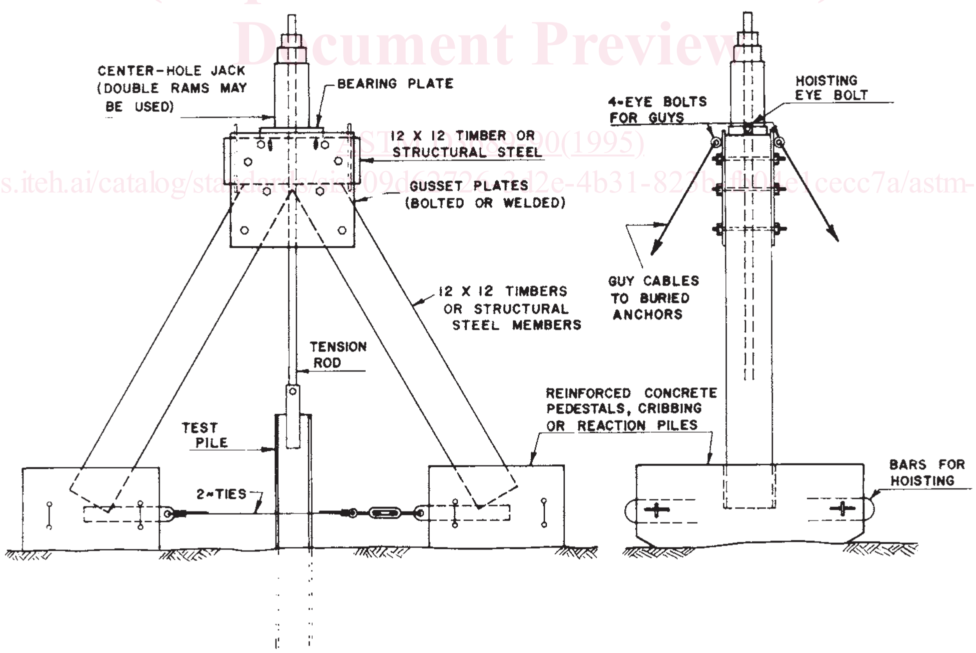
NOTE 3—Use stiffener plates between flanges of all beams where structurally required.

FIG. 5 Typical Set-Up for Applying Tensile Loads to Pile Using Hydraulic Jacks Acting at Ends of Test Beam Anchored to Pile



NOTE 1—Load on pile × A = jacking load × (A + B).
NOTE 2—Use same type reaction (piles or cribbing) at both ends of test beam.
NOTE 3—Not recommended for ultimate tests.
NOTE 4—For section X-X, see Fig. 5.
NOTE 5—Use stiffener plates between flanges of all beams where structurally required.

FIG. 6 Typical Set-Up for Applying Tensile Loads to Pile Using Hydraulic Jack Acting at One End of Test Beam Anchored to Pile



NOTE 1—The A-frame may be guyed at various angles for testing batter piles or for special directional pull test.

FIG. 7 Typical Set-Up for Applying Tensile Loads to Pile Using Hydraulic Jack(s) Acting at Top of A-Frame

to the center of the test pile. Tension connections between test pile and reaction 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.