Designation: D 1143 – 81 (Reapproved 1994)$^{\epsilon 1}$

Standard Test Method for Piles Under Static Axial Compressive Load[1]

This standard is issued under the fixed designation D 1143; 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 Department of Defense.

ϵ^1 NOTE—Section 10 was added editorially in May 1994.

INTRODUCTION

This standard has been prepared to cover routine methods of testing to determine if a pile has adequate bearing capacity. 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 settlement, 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 groups of vertical piles to determine response of the pile or pile group to a static compressive load applied axially to the pile or piles within the 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 The values stated in inch-pound units are to be regarded as the standard.

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

NOTE 2—This test method does not include the interpretation of test results or the application of test results to foundation design. See Appendix X1 for comments regarding some of the factors influencing the interpretation of test results. A qualified geotechnical engineer should interpret the test results for predicting pile performance and capacity. The term "failure" as used in this method indicates rapid progressive settlement of the pile or pile group under a constant load.

1.3 *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:*

D 3689 Method of Testing Individual Piles Under Static Axial Tensile Load[2]

2.2 *American National Standards Institute Standard:*

B30.1 Safety Code for Jacks[3]

3. Apparatus for Applying Loads

3.1 *General*:

3.1.1 The apparatus for applying compressive loads to the test pile or pile group shall be as described in 3.3, 3.4, or 3.5 or as otherwise specified and shall be constructed so that the loads are applied to the central longitudinal axis of the pile or pile group to minimize eccentric loading. Paragraph 3.3 is suitable for applying axial loads to individual vertical or batter piles; 3.4 and 3.5 are suitable for applying vertical loads only.

NOTE 3—When a pile group is subject to vertical test loads, cap rotations and horizontal displacements could occur. The occurrence of such movements and the necessary reactions to resist such movements if

[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.

they are prohibited should be considered when designing and constructing the loading apparatus for the group test.

NOTE 4—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 axial bearing capacity of the batter pile.

3.1.2 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 observation of the instrumentation. Where necessary, the unsupported length of the test pile(s) shall be braced to prevent buckling without influencing the test results.

3.1.3 If the head of the pile has been damaged during driving, the damaged portion shall be removed prior to the test. For tests on piles groups, the piles shall be capped with a reinforced concrete cap designed and constructed in accordance with accepted engineering practice for the anticipated loads.

NOTE 5—Consideration should be given to providing a nominal clear space between the cap and the ground surface to eliminate any support offered by the soil under short-term loading. A properly constructed steel grillage may serve as an adequate pile cap for testing purposes.

3.1.4 In 3.3 and 3.4 and for a test on an individual pile in 3.5, a steel bearing plate(s) (test plate(s)) of sufficient thickness to prevent it from bending under the loads involved (but not less than 2 in. (50 mm)) shall be centered on the pile or pile cap and set perpendicular to the longitudinal axis of the pile or piles within the group, except that for tests on pile groups involving the use of two or more separate loading points, a test plate shall be used at each loading point and such plates shall be arranged symmetrically about the centroid of the group. For tests on individual piles, the size of the test plate shall be not less than the size of the pile butt nor less than the area covered by the base(s) of the hydraulic jack(s); for tests on pile groups, the size of the test plate(s) shall be not less than twice the area covered by the base(s) of the hydraulic jack(s).

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

3.1.6 In 3.3 and 3.4, the hydraulic jack(s) shall be centered on the test plate(s) with a steel bearing plate of adequate thickness between the top(s) of the jack ram(s) and the bottom(s) of the test beam(s). If a load cell(s) or equivalent device(s) is to be used, it shall be centered on the bearing plate above the ram(s) with another steel bearing plate of sufficient thickness between the load cell(s) or equivalent device(s) and the bottom(s) of the test beam(s). Bearing plates shall be of sufficient size to accommodate the jack ram(s) and the load cell(s) or equivalent device(s) and properly bear against the bottom(s) of the test beam(s).

3.1.7 In 3.5 for tests on pile groups a test plate may be used in accordance with the appropriate provisions of 3.1 or, alternatively, the test beam(s) may be set directly on the pile cap or the loading material applied directly on the cap. Test beam(s) set directly on the cap shall obtain full bearing using high-strength quick-setting grout, if necessary.

3.2 *Testing Equipment*:

3.2.1 Hydraulic jacks including their operation shall conform to ANSI B30.1.

3.2.2 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.

NOTE 6—If it is not feasible to calibrate the complete jacking system as a unit, the pressure gage may be calibrated independently, in which case the jack piston(s) should be measured to verify the area(s).

3.2.3 When an accuracy greater than that obtainable with the 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).

3.2.4 If the hydraulic jack pump is to be left unattended at any time during the test, it shall be equipped with an automatic regulator to hold the load constant as pile settlement occurs.

3.2.5 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 7—Considerations should be given to employing a dual load-measuring system (gage and load cell) to provide as a check and as a back-up in case one system malfunctions. Hydraulic jack rams should have sufficient travel to provide for anticipated pile settlements, deflections of the test beam, and elongation of connections to anchoring devices with 3.3. The use of a single high-capacity jack is preferred to the use of multiple jack(s). If a multiple jacking system is used, each jack should be fitted with a pressure gage (in addition to the master gage) in order to detect malfunctions.

3.3 *Load Applied to Pile or Pile Group by Hydraulic Jack(s) Acting Against Anchored Reaction Frame* (See Fig. 1 and Fig. 2):

3.3.1 Install a sufficient number of anchor piles or suitable anchoring device(s) so as to provide adequate reactive capacity and a clear distance from the test pile or pile group at least five times the maximum diameter of the largest anchor or test pile(s) but not less than 7 ft (2 m). When testing individual batter piles, the anchor piles shall be battered in the same direction and angle as the test pile.

3.3.2 Center over the test pile or pile group a test beam(s) of sufficient size and strength to avoid excessive deflection under load with sufficient clearance between the bottom flange(s) of the test beam(s) and the top of the test pile or pile group to provide for the necessary bearing plates, hydraulic jack(s) (and load cell(s) if used). When applying axial loads to an individual

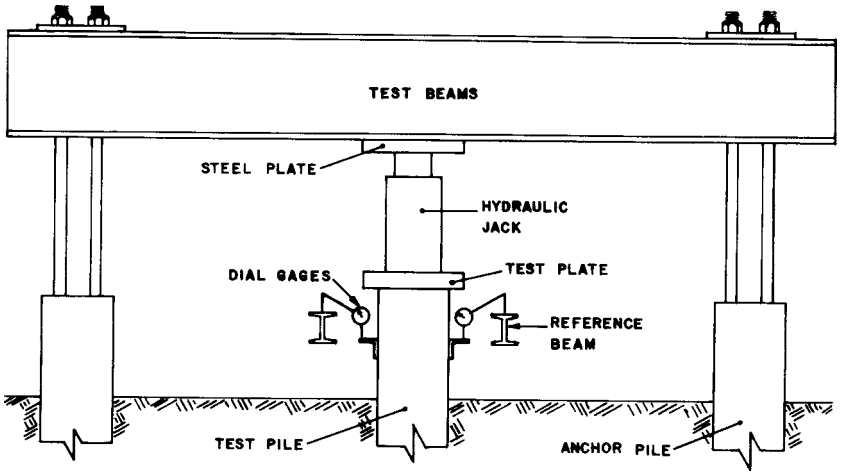
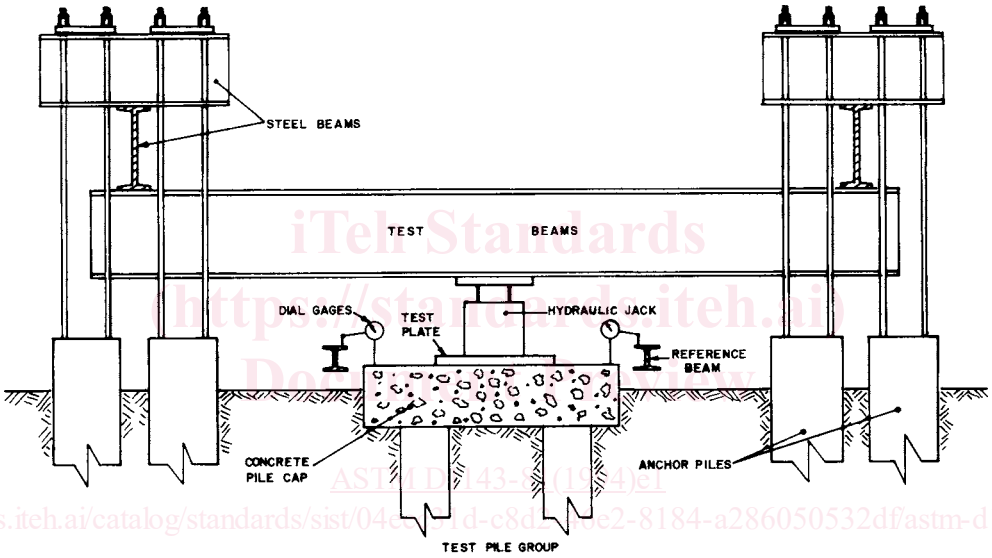


FIG. 1 Schematic Set-Up for Applying Loads to Pile Using Hydraulic Jack Acting Against Anchored Reaction Frame



Methods shown in Fig. 3 and Fig. 4 could be used.

FIG. 2 Typical Arrangement for Applying Load Test to Pile Group Using Method Illustrated in Fig. 1

batter pile, the test beam(s) should be oriented perpendicular to the direction of batter. 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.

3.3.3 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.

3.3.4 Apply the test load in accordance with the standard loading procedure 5.1 or as otherwise specified to the test pile or pile group with the hydraulic jack(s) reacting against the test beam(s).

3.4 *Load Applied to Pile or Pile Group by Hydraulic Jack(s) Acting Against a Weighted Box or Platform* (See Fig. 3):

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

3.4.2 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 5 ft (1.5 m). 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.

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

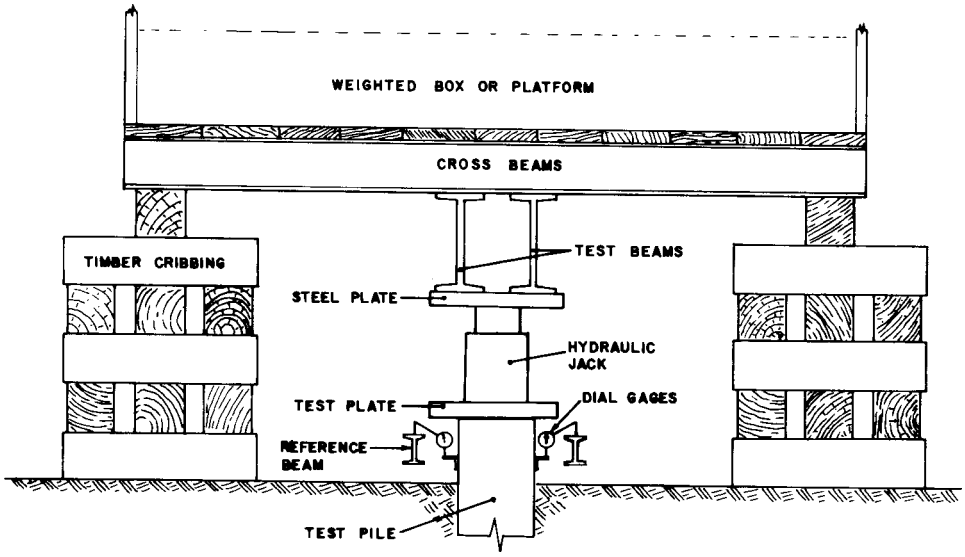


FIG. 3 Schematic Set-Up for Applying Loads to Pile Using Hydraulic Jack Acting Against Weighted Box or Platform

3.4.4 Apply the test loads to the pile or pile group in accordance with the standard procedure in 5.1 or as otherwise specified with the hydraulic jack(s) reacting against the test beam(s).

3.5 *Load Applied Directly to the Pile or Pile Group with Known Weights* (See Fig. 4, Fig. 5, and Fig. 6):

3.5.1 Center on the test plate 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.

3.5.2 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 5 ft. (1.5 m) is maintained between the supports and the test pile or pile group.

3.5.3 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.

3.5.4 When ready to load the platform, remove any temporary supports at the ends of the test beam(s) and tighten the wedges along the bottom edges of the platform so that the platform is stable. Load the platform in accordance with the standard loading procedures in 5.1 or as otherwise specified using material such as steel or concrete so that the weight of incremental loads can be determined within 5 %.

NOTE 8—With the loading apparatus described in 3.5, provisions can be made for taking target rod level readings directly on the center of the pile butt or pile cap or center of the test plate to measure pile butt movements in 4.2.3. For tests on concrete piles, or on pile groups, a hole would be required in the center of the test plate through which would extend a steel pin embedded in the top of the pile or pile cap. For tests on steel H or timber piles, readings would be taken on the test plate. To accommodate

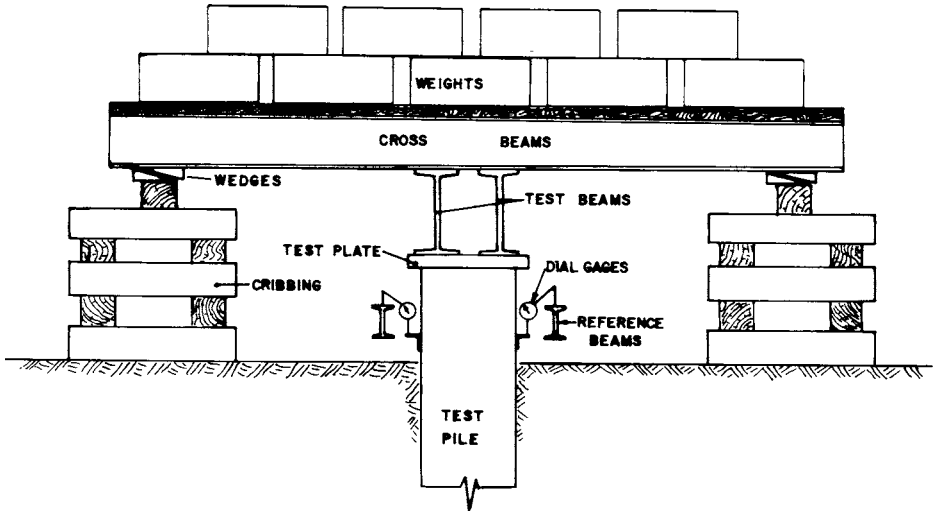


FIG. 4 Schematic Set-Up for Applying Loads Directly to Pile Using Weighted Platform

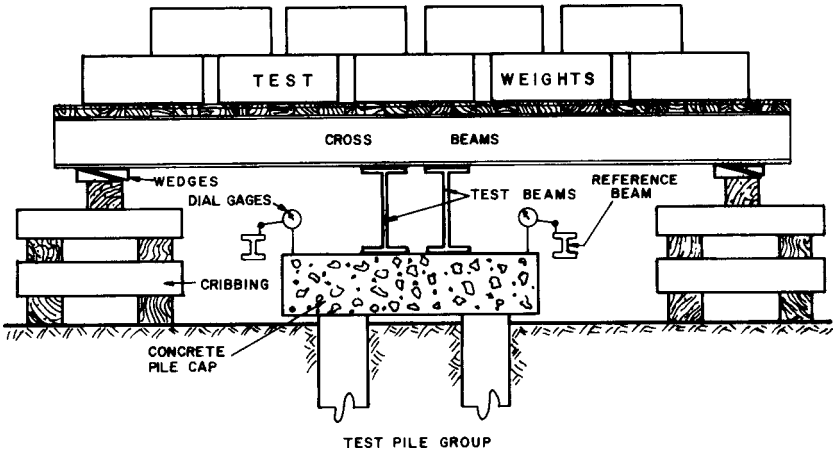


FIG. 5 Possible Arrangement for Applying Load Test to Pile Group Using Weighted Platform

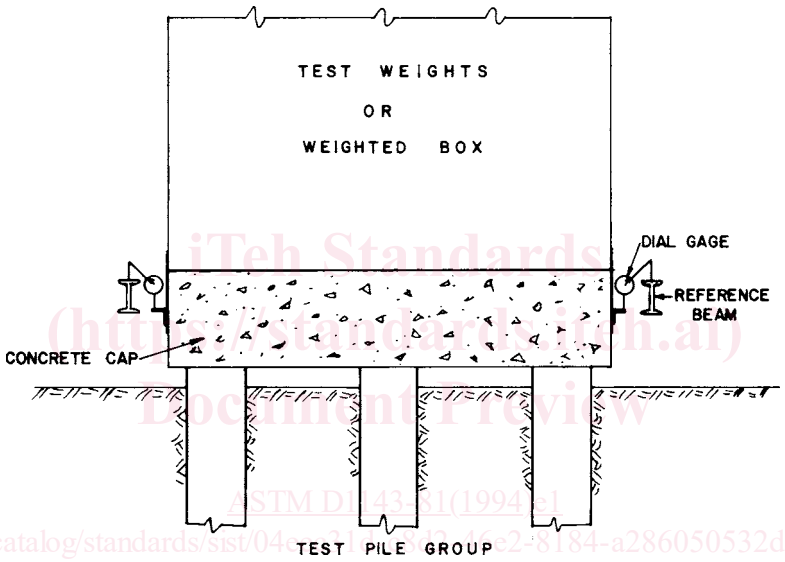


FIG. 6 Arrangement for Applying Tests Loads Directly on Pile Cap for Group Tests

the target rod, a double test beam must be used with sufficient space between the beams and a hole must be left through the platform. To permit sighting on the target rod it may be necessary to leave a space between the test weights in line with the line of sight.

3.6 *Other Types of Loading Apparatus* (Optional)—Any other type of loading apparatus satisfying the basic requirements of 3.3 or 3.4 may be used.

4. Apparatus for Measuring Movement

4.1 *General*:

4.1.1 All reference beams and wires shall be independently supported with supports firmly embedded in the ground at a clear distance of not less than 8 ft (2.5 m) from the test pile or pile group and as far as practical from the anchor piles or cribbing. Reference beams shall be sufficiently stiff to support the instrumentation such that excessive variations in readings do not occur and should be cross connected to provide additional rigidity. If steel reference beams are used, one end of each beam shall be free to move horizontally as the beam length changes with temperature variations.

4.1.2 Dial gages shall have at least a 2-in. (50-mm) travel; longer gage stems or sufficient gage blocks shall be provided to allow for greater travel if anticipated. Except as required in 4.4.2, gages shall have a precision of at least 0.01 in. (0.25 mm). Smooth bearing surfaces (such as glass) perpendicular to the direction of gage-stem travel shall be provided for the gage stems. Scales used to measure pile movements shall read to 1/64th of an inch or to 0.01 in. (0.25 mm). Target rods shall read to 0.001 ft (0.3 mm).

4.1.3 All 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 measuring system, reference system, and instrumentation from adverse temperature variations and from disturbance. All gages, scales, or reference points attached to the test pile or pile cap shall be mounted so as to prevent movement relative to the test pile or pile cap during the test.

4.2 *Pile Butt Axial Movements* (See Fig. 7)—The apparatus for measuring axial movement of the butt of the test pile or piles within the group shall consist of a primary and secondary system in accordance with the following methods.

NOTE 9—Two separate measuring systems are required in order to have a check on the observed data, to provide for accidental disturbance of the

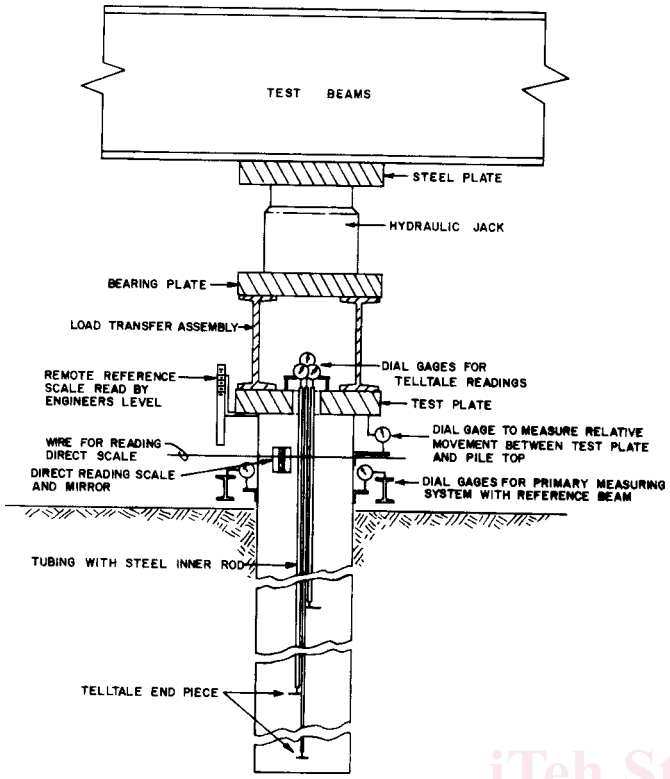


FIG. 7 Possible Arrangement of Instrumentation for Measuring Vertical Movements of Pile

measuring system, and to permit continuity of data in case it becomes necessary to reset the gages or scales.

4.2.1 *Dial Gages*—Two parallel reference beams, one on each side of the test pile or pile cap, shall be oriented in a direction that permits placing their supports as far as practicable from anchor piles or cribbing. A minimum of two dial gages shall be mounted on the reference beams approximately equidistant from the center of and on opposite sides of the test pile or pile cap 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 below the test plate. Alternatively, the two dial gages shall be mounted on opposite sides of the test pile or pile cap below the test plate 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 or on the test plate provided that two additional gages shall be mounted on opposite sides of the test plate to measure relative movements between the test plate and the pile or pile cap (see Fig. 7). For tests on individual batter piles, the dial gages shall be mounted along a line perpendicular to the direction of batter.

NOTE 10—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.

NOTE 11—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.

4.2.2 *Wire, Mirror, and Scale*—Two parallel wires, one on each side of the test pile or pile cap, shall be oriented in a direction that permits placing the wire supports as far as practicable from anchor piles or cribbing. 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 or piles within the group 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.

4.2.3 *Surveyor's Level or Laser Beam*—Readings using a surveyor's level or laser beam shall be taken on a target rod or a scale and shall be referenced to a permanent bench mark located outside of the immediate test area or, alternatively, the surveyor's level 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, test plate or pile cap or on scales mounted on the test plate provided that relative movements between the test plate and the top of the pile are measured in accordance with 4.2.1 (see Fig. 7).

4.2.4 *Other Types of Measuring Apparatus* (Optional)—Any other type of measuring device such as electric or optical gages of proven reliability and that yield an accuracy of 0.01 in. (0.25 mm) may be used.

4.3 *Lateral Movements* (Optional) The lateral movements of the top of the test pile or pile group shall be measured to an accuracy of 0.1 in. (2.5 mm) using either of the following methods: (*a*) two dial gages mounted on the reference beam 90° apart with their stems perpendicular to the longitudinal axis of the test pile(s) and bearing against the sides of the test pile or pile cap, or (*b*) an engineer's transit reading from fixed positions scales mounted horizontally on the sides of the test pile or pile cap 90° apart with readings referenced to fixed foresights or backsights. For tests on batter piles, one of the gages or scales shall be oriented in the direction of the batter.

4.4 *Incremental Strain Measurements* (Optional):

4.4.1 The test pile(s) shall be instrumented as specified to determine distribution of load transfer from the pile to the soil. If strain rods or telltales (see Fig. 7, Fig. 8, Fig. 9, and Fig. 10) are used, they shall be installed in or on the test pile terminating at the pile tip and at other points along the pile as required and shall be sheathed or encased to insure free movement of the rods during the test. The influence of the sheathing on the elastic properties of the pile section shall be considered. If electric resistant strain gages are used, the gage type and installation shall be as specified and shall include temperature compensating gages.

NOTE 12—Where feasible, measurement programs involving strain gages should include calibration of the fully instrumented pile and a complete strain history starting before the pile is installed.

4.4.2 Pile butt axial movements shall be measured with dial gages (see 4.2.1). The movements of the top of each strain rod