INTERNATIONAL

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Standard Test Methods for Prebored Pressuremeter Testing in Soils[1]

This standard is issued under the fixed designation D4719; 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.

1. Scope*

1.1 This test method covers pressuremeter testing of soils at a given depth in the ground within a suitable prebored, open test cavity. The pressuremeter test is an in situ, stress-strain test performed on the wall of a test cavity using a circular cylindrical probe that is expanded radially. To obtain viable test results, disturbance of the test cavity must be minimized with minimal clearance between the diameter of the probe and the test cavity. Alternatively, when preboring does not provide an acceptable test cavity, the probe may be directly inserted into the ground to form the test cavity.

1.2 This test method includes the procedure for test cavity preparation, inserting the probe, and conducting pressuremeter tests in both granular and cohesive soils, but does not include high pressure testing in rock. Knowledge of the type of soil to be tested is necessary for assessment of (*1*) the method of preparing the test cavity, (*2*) the interpretation of the test data, and (*3*) the acceptability of the test results.

1.3 This test method does not cover the self-boring pressuremeter, for which the hole is drilled by a mechanical or jetting tool inside the hollow core of the probe. This test method is limited to the type of pressuremeter that is inserted into predrilled boreholes or, under certain circumstances, is inserted by driving or pushing.

1.4 Two alternative testing procedures are provided as follows:

1.4.1 *Procedure A*—Equal Pressure Increments

1.4.2 *Procedure B*—Equal Volume Increments

NOTE 1—Pressuremeter tests performed in rock or using the self-boring pressuremeter follow similar test procedures to those described herein, but do not fall within the scope of this test method.

NOTE 2—Strain-controlled tests also can be performed, whereby the probe volume is increased at a constant rate and corresponding pressures are measured. Strain-controlled tests may yield different results than the procedures described in this test method.

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

1.6 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 design.

1.7 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.

1.8 The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard. Reporting of test results in units other than SI shall not be regarded as non-conformance with this test method.

1.9 *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.*

1.10 *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

[1] These test methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

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

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

D1586 Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
D1587 Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes
D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Exploration
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D5778 Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils
D6026 Practice for Using Significant Digits in Geotechnical Data

3. Terminology

3.1 *Definitions:*

3.1.1 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 *limit pressure (p_l), n*—the pressure at which the probe volume reaches twice the original soil cavity volume.

3.2.2 *pressuremeter modulus (E_p), n*—the modulus calculated from the slope of the pseudo-elastic portion of the corrected pressure-volume curve, which includes little to no creep.

3.2.3 *unload-reload modulus (E_R), n*—the pressuremeter modulus calculated from an unload-reload loop.

4. Summary of Test Method

4.1 The pressuremeter test consists of placing an inflatable, cylindrical probe into a test cavity in the ground and then expanding the probe in the radial direction while measuring the changes in volume and pressure of the probe. The probe is inflated by equal pressure increments (Procedure A) or by equal volume increments (Procedure B), and the test is terminated when yielding in the soil becomes disproportionately large. A conventional limit pressure for the soil is estimated from the last few readings of the test, and a soil pressuremeter modulus is calculated from pressure-volume changes read during the test. The test must be performed in a test cavity with a diameter only slightly larger than that of the probe. If this requirement is not met, the test could terminate without reaching sufficient probe expansion in the soil to permit evaluation of the limit pressure. The test cavity should be of circular cylindrical shape. The instrument is either of the type where the change in volume of the probe is directly measured by an incompressible liquid or the type where feeler gages are used to determine the change in radius in the probe. The volume-measuring type of system must be well protected against any volume losses throughout the system, while the feeler-type probe must be sensitive to relatively small displacements. Both types of measuring systems must be calibrated for the effects of system pressurization.

NOTE 3—This test method refers primarily to the type of apparatus where volume changes are recorded during the test. For the system measuring probe radius change, alternate evaluation methods are given in the notes.

4.2 An open test cavity is typically prepared for the probe by preboring a hole with an appropriate diameter. The various tools and methods available to prepare the cavity produce different degrees of disturbance. The test cavity may also be created by inserting the pressuremeter probe directly into the ground, usually within a slotted tube. However, direct insertion may significantly affect test results. Recommended method(s) of test cavity preparation, described below, depend on soil conditions at the test site.

NOTE 4—It is recommended that several drilling techniques be available on the site to determine which method will provide the most suitable test hole.

5. Significance and Use

5.1 This test method provides a radial stress-strain response of the soil in situ. A pressuremeter modulus and a limit pressure are obtained for use in geotechnical analysis and foundation design. Correlations of the test results to soil strength and stiffness and to engineering design applications are generally empirical, and deviation from the methodology described in this test method may have undesirable effects.

NOTE 5—As with other in situ and laboratory test methods, the user should consider whether results from this test are appropriate for the intended design use. Considerations may include whether the test directly measures strength or stiffness, the orientation of loading, the level of induced strain, insertion or borehole disturbance effects, soil sensitivity, soil saturation, drainage effects, and the robustness of the test equipment, etc.

5.2 The results of this test method are dependent on the clearance between the test cavity and probe and the degree of ground disturbance caused by test cavity preparation and probe insertion, all of which shall be considered during interpretation of the test results. This disturbance is particularly significant in very soft clays and very loose sands. Disturbance may not be eliminated completely but shall be minimized for the prebored pressuremeter design rules to be applicable.

NOTE 6—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/ inspection/etc. Users of this test method are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 The pressuremeter apparatus consists of an inflatable probe placed inside a test cavity formed in the ground, lines connecting the probe to ground surface, and a control unit at the ground surface that is used to pressurize and monitor the probe during the test. The same rods used to prepare the test cavity are typically used to place the probe for testing.

6.2 *Probe*—The probe shall be cylindrical and flexible for inflation against the wall of the test cavity. The design of the probe shall allow drill fluid in a borehole to flow freely past it without disturbing the borehole wall during insertion or removal. Typical probe dimensions are indicated in Table 1.

6.2.1 *Hydraulic or Electronic Probe*—The probe is either of the hydraulic type or of the electronic type. A hydraulic probe

TABLE 1 Typical Probe and Borehole Dimensions

Probe Diameter (mm)	Hole Diameter Designation	Borehole Diameter Nominal (mm)	Borehole Diameter Max. (mm)
44	AX	45	53
58	BX	60	70
74	NX	76	89

is one in which all test data are measured indirectly at the ground surface; no data are transmitted electronically from the probe to the surface. In hydraulic probes, the test cell expansion is computed by measuring the quantity of fluid injected into the test system and adjusting this volume for the system compliance. The pressure in the test cell is computed as the sum of the pressure measured at the ground surface and the hydrostatic pressure between the surface gage and the test cell. An electronic probe is one in which the pressure in the test cell, or the expansion of the test cell, or both, are measured by devices inside the test cell, and the data are transmitted electronically to a recorder at the ground surface. In the electronic probe, the test cell expansion may be measured electronically by the change in length of radial feelers using linear variable differential transformers (LVDTs) or by strain gages. The pressure inside the test cell may be measured electronically by a pressure transducer.

6.2.2 *Types of Probe*—The hydraulic probe is of a single-cell or triple-cell design. Electronic probes typically have a single-cell design. The single-cell contains only a test cell that changes in volume as the probe is pressurized. The triple-cell probe contains upper and lower cells (guard cells) to provide effective end restraint against vertical expansion of the central test cell and ensure purely radial expansion of the test cell (Fig. 1a[3]). The stresses induced in the ground surrounding the test cavity by the guard cells also enable the test cell to induce more uniform, purely radial stresses in the ground. For both single cell and triple-cell pressuremeters the combined height of all of the cells shall be at least six probe diameters.

6.2.3 *Probe Walls*—The flexible walls of the probe consist of a single rubber membrane (single-cell design) or of an inner rubber membrane fitted with an outer flexible sheath or cover (triple-cell design), which will initially expand to contact the test cavity wall as pressure is applied in the test cell and then will deform the test cavity as pressure is further increased. In a coarse-grained material like gravel, a steel sheath made of thin overlapping metal strips is often used. The accuracy of the test will be impaired if the membrane cannot conform to the shape of the test cavity.

NOTE 7—Various membrane and sheath, or cover, materials may be used to better accommodate different soil types; identify the membrane and sheath, or cover, used in the report.

6.2.4 *Measuring Devices*—For the hydraulic probe, changes in volume of the test cell of the probe are measured by the control unit. Alternatively, changes in the probe radius can be measured by the use of feelers in the electronic apparatus. Provisions to measure the change in probe radius in three directions at 120° angles shall be provided with the electronic apparatus. The measuring cell shall be prevented from expanding in the vertical direction by guard cells or other effective restraints in the hydraulic apparatus.

6.3 *Lines*—In the hydraulic apparatus, the lines connecting the probe to the readout device typically consist of plastic tubing. To reduce measuring errors, a coaxial tubing can be used, whereby the inner tubing is prevented from expanding by gas pressure acting on its exterior surface. By applying the correct gas pressure, expansion of the inner tubing is reduced to a minimum. Single tubing can also be used. In both cases, the correction for volume losses given in 7.3 applies. Electronic lines need special protection against groundwater.

6.4 *Control Unit*—The control unit includes a mechanism to apply pressure (Procedure A) or volume (Procedure B) in equal increments to the probe and readout devices to display the pressure and volume. The equipment using the hydraulic system and guard cells shall also include a regulator that maintains the pressure in the gas circuit below the fluid pressure in the measuring cell. The magnitude of pressure difference between gas and fluid must be adjustable to compensate for hydrostatic pressures developing in the probe. In the electronic system the volume change readings are replaced by an electronic readout of the change in the probe radius.

6.5 *Slotted Tube*—A steel tube (Fig. 1b) with a series of longitudinal slots (usually six) cut through it to allow for lateral expansion is used sometimes as a protective housing when the probe is driven, vibrodriven, or pushed into deposits where this technique is applicable (Table 2). The pressuremeter test is then performed within the slotted tube.

6.6 *Accuracy and Readability of Measurements*—Pressure gages or transducers used to measure pressure shall have an accuracy of 0.25 % or less of their full-scale span (FS) and shall be readable to the nearest 10 kPa or less. Volume change measurements shall have an accuracy of 0.25 % or less of their FS and shall be readable to the nearest 1 mL or less. Systems used to directly measure changes in test cell radius shall

[3] Baguelin, F., Jézéquel, J.F., and Shields, D.H., "The Pressuremeter and Foundation Engineering," Trans Tech Publications, Series on Rock and Soil Mechanics, Vol 2, No. 4, 1978, p. 47.

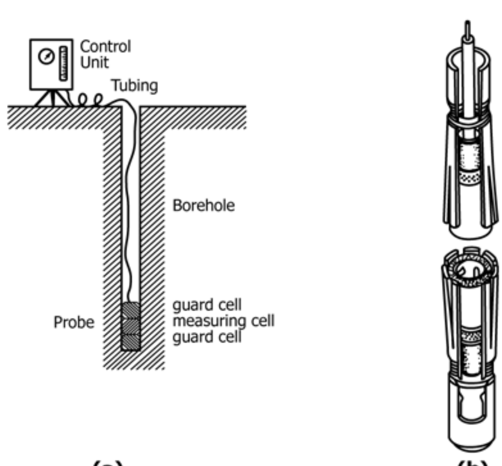


FIG. 1 a) Basic Principles of the Triple Cell Design Pressuremeter (Baguelin, Jézéquel and Shields, 1978), b) Slotted Tube with Probe

TABLE 2 Guidelines for Selection of Borehole Preparation Methods and Tools[A]

Soil	Type	Rotary Drilling With Bottom Discharge of Prepared Mud	Pushed Thin Wall Sampler	Pilot Hole Drilling and Subsequent Sampler Pushing	Pilot Hole Drilling and Simul-taneous Shaving	Contin-uous Flight Auger	Hand Auger in the Dry	Hand Auger With Bottom Discharge of Prepared Mud	Driven or Vibro-driven Sampler	Core Barrel Drilling	Rotary Percus-sion	Driven Vibro-driven or Pushed Slotted Tube
Clayey soils	Soft	2[B]	2[B]	2	2	1[B]	NR	1	NR	NR	NR	NR
	Firm to stiff	1[B]	1	2	2	NR	1	1	NR	NR	NR	NR
	Stiff to hard	1	2	1	1	1[B]	NA	NA	NA	1[B]	2[B]	NR
Silty soils	Above GWL[C]	1[B]	2[B]	2	2[B]	1	1	2	2	NR	NR	NR
	Under GWL[C]	1[B]	NR	NR	2[B]	NR	NR	1	NR	NR	NR	NR
Sandy soils	Loose and above GWL[C]	1[B]	NR	NR	2	2	2	1	2	NA	NR	NR
	Loose and below GWL[C]	1[B]	NR	NR	2	NR	NR	1	NR	NA	NR	NR
	Medium to dense	1[B]	NR	NR	2	1	1	1	2	NR	2[B]	NR
Sandy gravel or gravely sands below GWL	Loose	2	NA	NA	NA	NA	NA	NA	NR	NA	2	2
	Dense	NR	NA	NA	NA	NR	NA	NA	NR	NA	2	1[D]
Weathered rock	...	1	NA	2[B]	NA	1	NA	NA	1	2	2	NR

[A] 1 is first choice; 2 is second choice; NR is not recommended; and NA is nonapplicable.
[B] Method applicable only under certain conditions (see text for details).
[C] GWL is groundwater level.
[D] Pilot hole drilling required beforehand.

provide an accuracy of 0.25 % or less of the probe diameter and shall be readable to the nearest 0.1 mm or less.

7. Calibration of the Test Apparatus

7.1 Perform calibrations for pressure and volume losses after making any change in the test equipment that could affect these losses, that is, new membrane, lines, etc. In addition, repeat the pressure loss calibration after no more than ten tests, and the volume loss calibration at the beginning of each testing day. Pressure loss calibrations have a more significant effect on test results in soft or loose soils, and in this case, require additional calibrations for better accuracy. Additional calibrations are also appropriate following tests performed to high deformation or high pressure and when the membrane has visible signs of wear or damage.

7.1.1 The control unit, lines, and probe of hydraulic systems must be calibrated as a complete system, and must be deaired following manufacturer recommendations prior to calibration.

7.1.2 If measuring radius increase, then substitute radius readings for all references to volume readings in this section.

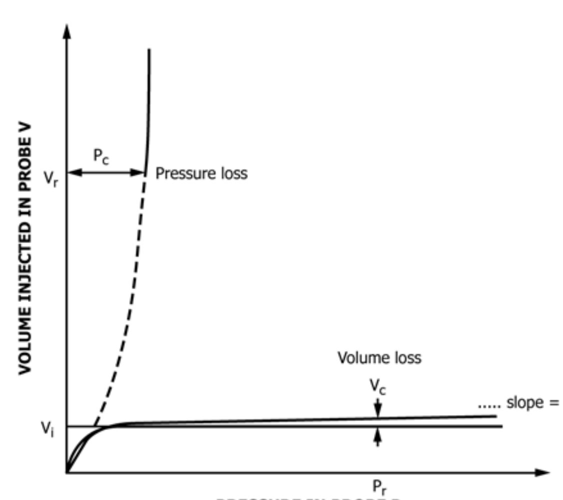
7.1.3 The volume of the probe with the test apparatus at atmospheric pressure shall be established during the calibration process so that all tests begin with the same deflated volume as during the calibrations. This is the zero volume, V_0, of the probe. The volume readout of the control unit used for hydraulic systems shall be adjusted to read zero with the probe at the zero volume.

7.1.4 The temperature of the system shall be maintained as closely as possible to the temperatures the system will encounter during testing. Avoid calibration in temperatures that are significantly different than those that will be tested. If significant temperature variations cannot be controlled during calibration, the ambient temperature during calibration shall be noted.

7.2 *Pressure Losses*—Pressure losses (P_c) occur due to the elasticity of the probe walls. The pressure readings obtained during the test on the readout device include the pressure required to expand the probe walls. This membrane resistance must be deducted to obtain the actual pressure applied to the soil. Calibrations for membrane resistance shall be performed by inflating the probe, completely exposed to the atmosphere, with the probe placed at the level of the pressure gage.

7.2.1 Apply pressure in 10-kPa increments for Procedure A and hold each increment for 60 s. Make volume readings after 60 s of elapsed time. When Procedure B is used, increase the volume of the probe in increments equal to 5 % of the probe's zero volume. Apply each volume increase in about 10 s and hold constant for 30 s. Continue steps in both procedures until the maximum probe volume is reached. Plot results on a pressure versus volume plot. The resulting curve is the pressure calibration curve. The pressure correction (P_c) is the pressure loss obtained from the calibration curve for the volume reading (V_r) (Fig. 2).

7.2.2 The appropriate pressure correction (P_c) must be deducted from each of the pressure readings obtained during



NOTE 1—The schematic graphs are not to scale; each calibration requires different volumes and pressures.

FIG. 2 Calibration for Volume and Pressure Losses the test. The maximum value of P_c shall be less than 50 % of the limit pressure as defined in 10.6.

7.3 *Volume Losses*—Volume losses (V_c) occur due to expansion of the tubing and compressibility of any part of the test apparatus, including the probe and the liquid. Calibration is performed by pressurizing the equipment with the probe inside heavy duty steel casing or pipe with an inside diameter that is slightly larger than the probe diameter and a wall thickness of at least 6 mm. A suggested procedure is to increase the pressure in steps of 100 kPa or 500 kPa, depending on whether the probe is designed for a maximum expansion pressure of 2.5 MPa or 5.0 MPa, respectively. Each pressure increment shall be reached within 20 s and, once in contact with the steel tube, be held constant for 60 s. Record all volumes to the nearest 1 mL. The resulting graph of injected volume (V_r) at the end of each pressure increment (P_r) is the volume calibration curve. The zero volume (V_0) is obtained by fitting a straight line to the curve and determining the intercept V_i at zero pressure, as shown in Fig. 2. V_i can be used to estimate (V_0) as follows:

$$V_0 = (\pi / 4) L D_i^2 - V_i \qquad (1)$$

where:

D_i = inside diameter of the heavy duty steel casing or pipe recorded to the nearest 1 mm, and
L = length of the measuring cell recorded to the nearest 1 mm.

7.3.1 The volume loss correction (V_c) of the test apparatus for a particular pressure is obtained by using the factor (a) corresponding to the slope of the volume versus pressure calibration plot (Fig. 2) as follows:

$$V_c = V_r - aP_r \qquad (2)$$

7.3.2 The appropriate volume loss correction (V_c) must be deducted from each volume measured during the test. This correction is relatively small in soils and can be neglected if the correction is less than 0.1 % of the nominal volume of the probe's uninflated test cell (V_0) per 100 kPa of pressure. In very hard soils or rock, the correction is significant and must be applied. In no case shall this correction exceed 0.5 % of the nominal volume of the probe's uninflated test cell (V_0) per 100 kPa of pressure.

7.4 Corrections for temperature changes and head losses due to circulating liquid are usually small and disregarded in routine tests for soils. For tests at depths greater than 50 m, special procedures are required to account for head losses.

7.5 Unless the pressure within the test cell is measured directly by a pressure transducer, the hydrostatic pressure (P_δ) in kPa exerted on the probe by the column of liquid in the testing equipment must be determined as follows:

$$P_\delta = H \times \delta_t \qquad (3)$$

where:

H = depth of probe below the control unit, m, and
δ_t = unit weight of the test liquid in the instrument, kN/m^3.

7.5.1 The test depth of the probe (H) is the distance from the center of the pressure gage to the center of the probe (Fig. 3). Pressure P_δ is exerted on the probe but is not registered by the pressure gages. This pressure must accordingly be added to the pressure readings obtained on the readout device.

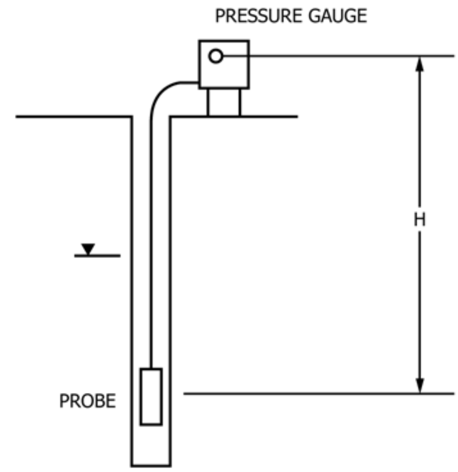


FIG. 3 Depth *H* for Determination of Hydrostatic Pressure in Probe

7.6 For triple cell pressuremeters, the pressure of the guard cells (P_G) must be set below the actual pressure generated in the probe to provide effective end restraint. This is obtained by subtracting this pressure from the test pressures as follows:

$$P_G = P_R + P_\delta - P_d \qquad (4)$$

where:

P_G = guard cell pressure, kPa,
P_R = pressure reading on control unit, kPa,
P_δ = hydrostatic pressure between control unit and probe, kPa (see 7.5), and
P_d = pressure differences between guard cells and measuring cell, kPa (usually twice the limit pressure of the membrane).

7.6.1 A tabulation of gas and liquid pressures for a pressure difference of P_d = 100 kPa for various test depths is shown in Table 3.

8. Test Cavity Preparation

8.1 The pressuremeter test is performed within a test cavity in the ground. Whenever possible, prebore an open test cavity. Alternatively, the test cavity may be formed by inserting the probe directly into the ground. Two conditions are necessary to obtain a satisfactory test cavity: the diameter of the prebored hole shall meet the specified tolerances, and the equipment and

TABLE 3 Pressure Compensation for Guard Cells Based on Test Depth

Test Depth *H*, m	Pressure from Head of Test Liquid on Probe *P*, kPa	Gas Pressure Reduction on Readout Gages[A] P_d, kPa
0	0	−100
5	50	−50
10	100	0
15	150	+50
20	200	+100

[A] To maintain guard cell pressure 100 kPa below the measuring cell pressure, deduct (−) or add (+) these pressures to the guard cell circuit.

methods used to prepare the test cavity shall cause the least possible disturbance to the surrounding soil. Pressuremeter tests in soil must be performed immediately after the test cavity is formed.

8.2 The preparation of a satisfactory borehole is the most important step in obtaining an acceptable pressuremeter test. An indication of the quality of the test cavity is given by the magnitude of scatter of the test points and by the shape of the pressuremeter curve obtained. Fig. 4 shows the typical shape of a pressuremeter curve obtained from a prebored test cavity. Fig. 5 shows a pressuremeter curve obtained when the borehole is too small or when the test is performed in a swelling soil. Fig. 6 shows a curve obtained when the borehole is too large.

8.3 *Requirements of Prebored Test Cavity with Respect to Probe Diameter:*

8.3.1 *Hole Diameter*—Dimensions used in this test method are as follows:

8.3.1.1 *Diameter of the Pressuremeter Probe, D*—The typical diameter D of pressuremeter probes varies from approximately 30 to 100 mm.

8.3.1.2 *Diameter of Test Cavity, DH*—The diameter of the test cavity DH shall satisfy the following condition derived from experience:

$$1.03D < D_H < 1.2D \quad (5)$$

8.3.2 *Cutting Tool Diameter:*

8.3.2.1 When determining the diameter of the necessary cutting tool for a bored hole, three factors must be considered: (*a*) the required diameter of the cavity, (*b*) the overcutting of the cavity resulting from the wobble of the cutting tool or the wall erosion by the drilling mud circulation in medium- to large-grained soils, or both, and (*c*) the inward yielding or swelling that occurs between the removal of the cutting tool and the placement of the probe. Inward yielding can be reduced by the use of drilling mud; in expansive clays, inward swelling can be increased by the use of drilling mud.

8.3.2.2 When selecting equipment for the site, several bits of various sizes should be available to allow the size of the bit to be varied depending on whether overcutting, inward yielding or inward swelling dominates.

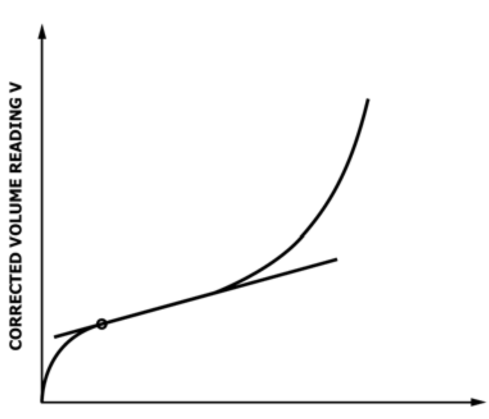


FIG. 4 Ideal Shape of the Pressuremeter Corrected Curve

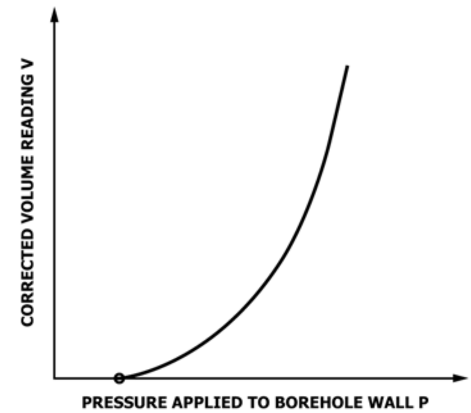


FIG. 5 Pressuremeter Corrected Curve When the Borehole is too Small

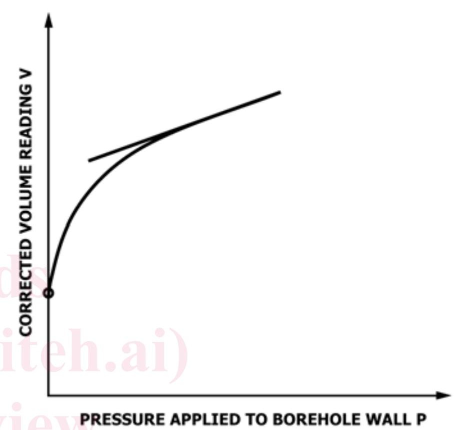


FIG. 6 Pressuremeter Corrected Curve When the Borehole is too Large

8.3.2.3 When selecting the tool also consider that the wall of the test cavity must be as smooth as possible, and the diameter DH must be as constant as possible over the test interval.

NOTE 8—If DH varies significantly over the length of the probe, because of raveling for example, or if the borehole is noncylindrical, the quality of the test will be impaired.

8.4 *Methods and Tools Used to Prepare the Test Cavity:*

8.4.1 Any method and tool that can satisfy the general requirements of 8.1 through 8.3 may be used.

8.4.2 This section describes methods used to prepare the test cavity for the pressuremeter probe and must be read in conjunction with Table 2, which summarizes guidelines for selecting methods for borehole preparation in typical soils.

8.4.2.1 *Rotary Drilling*—The drill bits used are usually drag bits in clays and roller bits in sands and gravels. Advance the rotating drill bit into the soil while satisfying the following conditions: low vertical pressure on the drilling tool (200 kPa maximum), slow rotation (less than 60 revolutions per minute) and a regulated low drilling fluid flow (to less than 15 L/min). Inject the drilling fluid by axial bottom discharge to cause the least damage to the borehole wall. The fluid must have a viscosity high enough to remove the cuttings at low pumping rates.