



Designation: D 2573 – 9401^{€1}

Standard Test Method for Field Vane Shear Test in Cohesive Soil¹

This standard is issued under the fixed designation D 2573; 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.

^{€1} NOTE—Figure 1 was corrected editorially in December 2003.

1. Scope*

1.1 This test method covers the field vane test ~~in soft, saturated, cohesive soils~~; saturated clay and silt soils for determination of undrained shear strength. Knowledge of the nature of the soil in which each vane test is to be made is necessary for assessment of the applicability and interpretation of the test. The test is not applicable for sandy soils which may allow drainage during the test.

1.2 This test method addresses testing on land and for testing in drill holes or by self drilling or continuous push methods from the ground surface. This method does not address marine testing where special test requirements or variations in equipment may

¹ This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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

be required. The user is referred to ASTM STP 1014 for additional information on in-place vane shear testing.²

1.3 This method is often used in conjunction with fluid rotary drilling (D 5783) or hollow-stem augers (D 6151). Some apparatuses have the vane retracted in protective shoe for advancement and incremental testing. Sampling, such as with thin wall tubes (D 1587) is often combined with vane testing. Subsurface geotechnical explorations are reported in accordance with practice (D 5434).

1.4 Undrained shear strength and sensitivity of cohesive soils can also be measured in Unconfined Compression D 2166 and Laboratory Vane Test (D 4648).

1.5 The values stated in ~~inch-pound~~ SI units are to be regarded as the standard. ~~The SI~~ English (Imperial) units are given in parentheses ~~are for information only.~~

~~1.3~~ parentheses.

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.*

2. Summary Referenced Documents

2.1 ASTM Standards:

D 653 Terminology Relating Soil and Rock and Contained Fluids³

D 1587 Practice for Thin-Walled Tube Sampling of Test Method

2.1 The vane shear test basically consists Soils³

D 2166 Test Method for Unconfined Compressive Strength of placing a four-bladed vane in the undisturbed soil Cohesive Soil³

D 2488 Practice for Description and rotating it from the surface to determine the torsional force required to cause a cylindrical surface to be sheared by the vane; this force is then converted to a unit shearing resistance Identification of Soils (Visual-Manual Procedure)³

D 3740 Minimum Requirements for Agencies Engaged in the cylindrical surface. It is Testing and/or Inspection of basic importance that the friction of the vane rod Soil and instrument be accounted for; otherwise, the friction would be improperly recorded Rock as soil strength. Friction measurements under no-load conditions (such as the use of a blank stem Used in-place Engineering Design and Construction³

D 4648 Test Method for Laboratory Miniature Vane Shear Test for Saturated Fine-Grained Clayey Soil³

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock³

D 5783 Guide for the vanes, or a vane that allows some free rotation Use of Direct-Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the rod prior to loading) are satisfactory only provided that the torque is applied by a balanced moment that does not result in a side thrust. As torsional forces become greater during a test, a side thrust in the instrument will result in an increase in friction that is not accounted Installation of Subsurface Water-Quality Monitoring⁴

D 6151 Practice for by initial no-load readings. Instruments involving side thrust are not recommended. The vane rod may be Hollow-Stem Auger Drilling and Sampling of sufficient rigidity that it does not twist under full load conditions; otherwise a correction must be made Soil for plotting torque-rotation curves. Geotechnical Purposes⁴

2.2 Other Standards:

Recommended Standard for Field Vane Shear Test, Swedish Geotechnical Society, SGF Report 2:93E, Swedish Geotechnical Institute, Linköping: www.swedgeo.se

EuroCode 7: Geotechnical Design—Part 3 Design Assisted by Field Testing, ENV 1997-3:1999E, CEN

3. Significance and Use

3.1 This test method provides an indication Terminology

3.1 Definitions:

3.1.1 For common definitions of in-situ terms in this standard, refer to Terminology D 653.

3.1.2 *sensitivity*—the effect of remolding on the consistency of cohesive soil.

3.1.3 *vane shear strength*.

3.2 This test method is used extensively (VST)—an in-place shear test in which a rod with thin radial vanes at the end is forced into the soil and the resistance to rotation of geotechnical explorations, such as the rod is determined.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *remolded undrained shear strength*—shear strength of fine-grained soil in rapid loading with little or no drainage of pore water pressure after significant failure and remolding of the initial soil structure. (Also see D 2166 and D 4648).

3.2.2 *undrained shear strength*—shear strength of fine-grained soil (primarily clays and clayey silts) in rapid loading with essentially no drainage of porewater pressure. (Also see D 2166 and D 4648).

² ASTM STP 1014 on Vane Shear Strength Testing in Soils (1988).

³ Annual Book of ASTM Standards, Vol 04.08.

⁴ Annual Book of ASTM Standards, Vol 04.09.

3.2.3 *vane*—a device with four, thin, flat metal blades or plates, fixed at an angle of 90 degrees to each other, which is inserted into the soil and then rotated about a sample vertical axis for laboratory shear testing cannot be obtained.

4. Apparatus

4.1 The vane shall consist of a four-bladed vane as illustrated in (see Fig. 1. The height).

3.2.4 *vane shoe*—a section of drill casing and cutting bit at the vane shall be twice the diameter. Vane dimensions shall be as specified end in Table 1. Sizes other than those specified in Table 1 shall be used only with which the permission of the engineer in charge of the boring program. The ends of the vane may can be tapered (see Fig. 1). The penetrating edge retracted while drilling or pushing

3.3 Symbols:

3.3.1 In accordance with ASTM D 653.

3.3.2 *shear strength, s_u* —the maximum (undrained) resistance of the vane blade shall be sharpened having an included angle of 90°.

4.2 The vane shall be connected soil to shearing stresses.

3.4 Symbols Specific to This Standard:

3.4.1 *peak undrained shear strength, $(s_u)_p$* —the peak undrained shearing resistance measured during the surface by means initial rotation of steel torque rods. These rods shall have sufficient diameter such that their elastic limit is not exceeded when the vane in a vane shear test.

3.4.2 *remolded undrained shear strength, $(s_{ur})_p$* —the remolded undrained shear strength is stressed measured after five to its capacity (Note 1). They shall be so coupled that the shoulders ten of the male and female ends shall meet to prevent any possibility of the coupling tightening when the torque is applied during the test. If vane rotations in a vane housing is used, the torque rods shall be equipped with well-lubricated bearings where they pass through the housing. These bearings shall be provided with seals shear test.

3.4.3 *sensitivity- $S_{T_{fv}}$* —the ratio of peak undrained shear strength to prevent soil from entering them. The torque rods shall be guided so as to prevent friction from developing between remolded undrained shear strength measured in the torque rods field vane shear test: $S_{T_{fv}} = (s_u)_p / (s_{ur})_p$. The remolded shear strength is measured after large shearing strains (see 8.7 and the walls of casing or boring, 9.3).

NOTE 1—If torque versus rotation curves are 1—Previous and existing standards have specified different amounts of rotation, from 5 to be determined, it 25 revolutions, for measurement of remolded strength.² If sensitivity is essential that reported, the torque rods be calibrated (prior to use in the field). The amount number of rod twist (if any) revolutions must also be established reported. Sensitivity can also be measured in degrees per foot per unit torque. This correction becomes progressively more important as unconfined compression testing (D 2166) and laboratory vane testing (D 4648).

3.4.4 *torque- T , (FL)*—the measured torque (or moment) required to rotate the depth vane.

3.4.5 *vane area ratio- V_A -%* —the ratio of the test increases and cross section area of the calibration must be made at least vane to the maximum depth circular area of testing anticipated:

4.3 Torque shall be applied to the torque rods, thence to the vane. The accuracy rotated vane expressed as a percent (see Fig. 2).

3.5 Acronyms:

3.5.1 VST—vane shear test.

3.5.2 FV—field vane.

4. Summary of Test Method

4.1 The vane shear test consists of placing a four-bladed vane in the torque reading should be such that undisturbed soil and rotating it will produce a variation not from the surface to exceed $\pm 25 \text{ lb/ft}^2$ (1.20 kPa) shear strength.

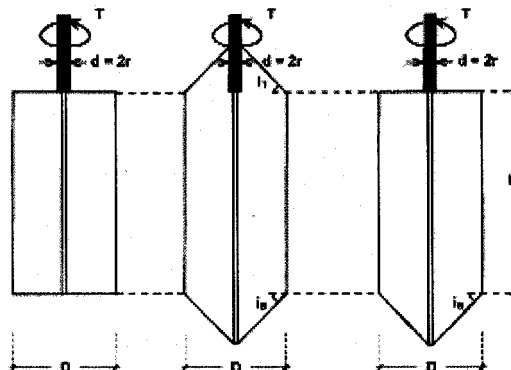
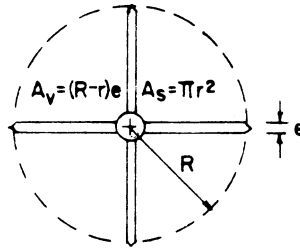


FIG. 1 Geometry of Field Vanes



$$V_A = \frac{4(R-r)e + \pi r^2}{\pi R^2}$$

Where: V_A = Vane Area Ratio
 R = Radius of Failure Cylinder (in or mm)
 r = Radius of Vane Shaft (in or mm)
 e = Vane Blade Thickness (in or mm)

VANE TYPE	BLADE DIA. in (mm)	SHAFT DIA. in (mm)	BLADE THICKNESS in (mm)	AREA RATIO (%)
Miniature	0.50 (12.7)	0.1275 (3.5)	0.019 (0.05)	13.7

FIG. 2 Definition of Vane Area Ratio (ASTM D 4648) (Note, r is radius of central shaft).

4.4 It is preferable to apply determine the torque required to the vane with shear a geared drive. In cylindrical surface with the absence of a geared drive, it vane. This torque, or moment, is acceptable then converted to apply a the torque directly unit shearing resistance of the failure surface by hand with a torque wrench or equivalent. The duration limit equilibrium analysis. Friction of the test should be controlled vane rod and instrument are either minimized during readings by special casings or housing, or else accounted for and subtracted from the requirements of 5.3. total torque to determine the torque applied to the vane.

5. Procedure

5.1 In the case Significance and Use

5.1 This test method provides an indication of in-situ undrained shear strength of fine-grained clays and silts or other fine geomaterials such as mine tailings, organic muck, and substances where a vane housing undrained strength determination is used, advance the housing to a depth which required. The test is at least five vane housing diameters applicable to soils with undrained strengths of less than the desired depth of the 200 kPa (2 tsf). Very sensitive soils can be remolded during vane tip. Where no vane housing insertion.

5.2 This test method is used, stop the hole used extensively in which the vane is lowered at a depth such that the vane tip may penetrate undisturbed soil variety of geotechnical explorations to evaluate rapid loading strength for a depth total stress analysis of saturated fine-grained clays and silts. The test is routinely performed in conjunction with other field and laboratory tests.

5.3 The peak undrained shear resistance of the hole.

5.2 Advance the vane from the bottom of the hole or the vane housing in a single thrust to the depth at which the test is commonly corrected to be conducted. Take precautions to make sure no torque is applied to determine the torque rods during undrained shear strength for geotechnical analysis. The agency requesting the thrust:

5.3 With the vane in position, apply the torque testing must interpret these data to determine applicability for strength analysis. It is beyond the vane at a rate which should not exceed 0.1°/s. This generally requires a time to failure scope of from 2 this standard to 5 min, except in very soft clays where the time to failure may be as much as 10 to 15 min. In stiffer materials, which reach failure at small deformations, it may be desirable to reduce the rate recommend applicability of angular displacement so that a reasonable determination of vane testing for geotechnical analysis. For information on the stress-strain properties can be obtained. During the rotation general use of the vane, hold it at a fixed elevation. Record the maximum torque. With apparatus with geared drives, it these correction factors, consult Appendix X1.

5.4 This method is desirable to record intermediate values of torque at intervals of 15 s not applicable in sands, gravels, or at lesser frequency if conditions require.

5.4 Following other high permeability soils. With the determination of the maximum torque, rotate the vane rapidly through a minimum of 10 revolutions; the determination of the remoulded strength should be started immediately after completion of shearing rates described in this standard, sand lenses, if present, will allow total or partial drainage. Soils with higher permeability, in rapid rotation shear, can dilate or collapse and generate negative or positive pore pressures which may, or may not, dissipate in all cases within 1 min after the remoulding process.

5.5 In shearing process. It is important to check the ease where soil type being tested. It is in contact with very beneficial to sample the torque rods, determine the friction between the soil either before or after testing, to understand the rod by means drainage conditions (permeability) of torque tests conducted on similar rods at similar depths with no vane attached. Conduct the rod friction soil tested.

5.5 This test at least once on each site; this shall consist of a series of torque tests at varying depths.

5.6 In apparatus in which the torque rod is completely isolated from the soil, conduct a friction test often performed in drilled boreholes or with a blank rod (Note 2) at least once on each site self-push or self-drilling or pushed (vane shoe) methods. This method also applies to determine the magnitude of the friction of the bearings. In a properly functioning hand held vane apparatus, this friction should shear tests performed at shallow depths, however, hand held equipment may be negligible less accurate, because it may be more difficult to maintain vane/rod stability and verticality.

NOTE 2—In some cases it 2—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 D 3740 are generally considered capable of competent and objective testing. Users of this standard are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Standard Practice D 3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 The vane shall consist of a four-bladed vane as illustrated in Fig. 1. Vanes are normally constructed of steel. Different alloys of steel such as nickel-chromium, or steel treatment processes such as hardening, can be used to remove reduce blade thickness. The ends of the vane may be flat or tapered. Vane dimensions are as follows with notation from Fig. 1.

Vane Diameter, D: 35 to 100 mm (1.5 to 4 in.)
 Vane Shaft Diameter, d: 12.5 to 16.5 mm (0.5 in.)
 Vane Height, H: $1D \leq H \leq 2.5D$
 Taper Angle, \bar{i} : usually 0 (rectangular) or 45 degrees (tapered)

6.1.1 For good torque resolution, select a vane diameter that is large enough to provide optimum torque resolution. The diameter selected is directly related to the consistency of the soil being tested. For softer soils, larger sizes are required for good resolution. In stiffer soils, smaller vanes are required to avoid damage to the friction test. As long as torque measurement device (6.2). When used in drill holes, the maximum vane size is dependent on the inside diameter of the boring or casing.

6.1.2 *Blade Thickness*—Maximum blade thickness is limited to $e < 3$ mm (0.006 to 0.125 in.). The average thickness shall be $e = 2$ mm. Vane blade edge or dimension (e) on Fig. 2 can be tapered to be thinner at the edges to reduce disturbance from insertion.²

6.1.3 The vane shaft diameter, d (shown also as 2r in Fig. 1) above the top of the vane blades shall be less than 17 mm. The vane shaft diameter (d) shall not exceed 14 mm at the center of the vane.

6.1.4 *Vane Area Ratio*—As shown on the detail in Fig. 2, the vane blade edges and fillet rod and welds shall be sufficiently small to minimize soil disturbance during insertion. The Vane Area Ratio, V_A , must be less than 12 %. With blade tapering and tapering reduction of the vane shaft ($d = 2r$), V_A can be reduced less than 10 %.

6.1.5 The distance, 1, from the top edge of the vane to an increase in torque rod diameter (6.3) is 5d where d is the vane shaft diameter at the top of the vane. If a large diameter friction coupler or torque rod sleeve is used, distance 1 is 150 mm (6-in.).

6.1.6 A vane with the soil; upper tapered edges has the advantage that the vane will not get caught on an exterior casing upon withdrawal.

6.1.7 The bottom edge of the vane blades can be sharpened to facilitate penetration into the soil. The edges of the blades can be sharpened and beveled to counter-rotate against a friction coupler (6.4).

6.2 *Torque Measurement Device*—Torque shall be applied to the rods, hence to the vane. This is accomplished with a clamping device and torque application apparatus set at the top of the rods. The accuracy of the torque reading shall be such that it will produce a variation not to exceed ± 1.0 kPa (± 25 lb/ft²) in computed shear strength.

6.2.1 It is retracted into preferable to apply torque to the vane with a casing, geared drive. In the absence of a geared drive, it is acceptable to apply the torque directly by hand with a torque wrench or equivalent. If torque is applied by hand an asterisk shall be placed next to the resultant shear stress and “hand torqued” shall be noted. The duration of the test shall be controlled by the requirements of 8.6.

6.2.2 Some torque measurement devices are capable of making hard copy or computer records of the load-displacement history. Other manually read systems use torque rings and dial gauges. These automatic reading systems have an advantage over manually read systems, because operator error is not affected.

5.7 Conduct undisturbed reduced, and remoulded a permanent record of the test is generated during the test.

6.3 *Torque Rods*—The vane tests at intervals shall be connected to the surface by means of not less than 2 ln\$ ft (0.76 m) throughout the soil profile steel torque rods. Typical rod diameter ranges from 18 to 25 mm (0.5 to 1 in.). These rods shall have sufficient diameter such that their elastic limit is not exceeded when conditions will permit the vane testing is stressed to its capacity (Note 3). Do not conduct They shall be so coupled that the vane test in shoulders of the male and female ends meet to prevent any soil that will permit drainage or dilates possibility of the coupling tightening when the torque is applied during the test p.

6.3.1 *Protective Casing and Vane Shoe*—Torque rods can be sleeved in an small diameter casing to reduce rod friction. If a

torque rod sleeve or casing and vane shoe is used, the torque rods shall be equipped with well-lubricated bearings where they pass through the housing.⁵ These bearings shall be provided with seals that prevent soil from entering them. The casing may require venting of water pressures. The torque rods shall be guided so as to prevent friction from developing between the torque rods and the walls of the casing or ~~sills or the boring.~~

6.3.2 Rod friction measurements under no-load conditions (such as the use of a blank stem in soils where stones place of the vanes, or ~~shells~~ a vane that allows some free rotation of the rod prior to loading) are ~~encountered~~ permissible only if the torque is applied by a balanced moment that does not result in a side thrust. As torque becomes greater during a test, a side thrust in the instrument will result in an increase in friction that is not accounted for by initial no-load readings. Instruments involving side thrust are not allowable. The vane rod may be of sufficient rigidity that it does not twist excessively under full load conditions; otherwise a correction must be made for plotting torque-rotation curves. Most steel torque rod meeting the requirements in ~~such~~ this standard does twist during testing and requires a ~~m~~ correction if vane rotation is to ~~influence the results.~~ be determined.

NOTE 3—~~This spacing may 3—If torque versus rotation curves are to be varied only by determined, the torque rods can be calibrated. The amount of rod twist are established in charge~~ degrees per meter (foot) per unit torque. This correction becomes progressively more important as the depth of the boring program.

6. Calculation

6.1 Calculate test increases and the shear strength calibration must be made at least to the maximum depth of testing anticipated. Alternately, rod twist can be calculated based on the properties of the rod. If twist is calculated, the material property assumption must be reported.

6.4 *Friction Coupling*—The connection between the vane and the rods may include a friction coupling or slip coupling device. This device is used with single rod systems where the vane may be advanced far in advance of the protective casing. This device is designed not to engage the vane until a certain amount of rotation, typically 15 degrees has occurred, and thus allows for determination of rod friction prior to the test. Use of this coupling is preferred over blank rod testing for determination of rod friction, because measurements are made directly in the soil tested.

6.5 *Centralizers*—For tests performed in drill holes, it will be necessary to equip the torque rods with centralizers to assure a vertical push and to prevent torque rod buckling. They are designed to support the rods, while minimizing any rod friction when deflected. Centralizers must be smaller in diameter than the drill hole. They shall be designed to allow the passage of drill fluids.

6.6 *Advancement Equipment*—When used in drill holes, the drive head and pull-down capability of the drill rig can be used to push the vane below the base of the hole. Some equipment is designed to push the vane from the surface. It is important to push the vane vertically and straight. A top centralizer and rod centralizers can be used with casings to assure straight push.

6.7 *Reaction Casing*—In drill hole applications, where the torque head clamps to the casing, it may be necessary to use an upper finned casing to assure torque reaction. Typically, hollowstem augers (D 6151) provide sufficient reaction for a torque head without fins. The need for casing reaction can be determined by slippage of the casing or augers during testing causing periodic/intermittent drops in torque. If slippage occurs, use finned casing, or perform less cleaning of the augers flights.

6.8 *Vane Housing/Casing*—Some vane systems are designed to retract into a casing equipped with a cutting bit (four-bladed drag bit). Fluid can be circulated through the cutting bit. When the test depth is reached, the vane can be pushed into the test interval.

7. Calibration

7.1 The torque measurement device is calibrated by inserting a rod with a moment wheel in the device. Known weights are hung from the wheel with set radius (R_w), and the torque measurements are taken and compared with the applied moments ($T = W \cdot R_w$).

7.2 The torque measurement device must be calibrated at regularly scheduled intervals of time or amount of use, in accordance with a systematic quality assurance plan of the company performing the testing. Records of the calibrations of each instrument shall be maintained and available for review during testing.

7.3 If the torque measurement device is damaged or repaired, a new calibration shall be performed.

7.4 The report must include the calibration data for the instrument, date of calibration, and a note on the amount of use since the last calibration.

8. Procedure

8.1 Locate the advancement equipment over the test location. The test can be performed in a pre-drilled hole, pushing from the surface, or with drilling through a vane housing.

8.2 If necessary, set a reaction casing to ~~shear~~ transfer forces to the torque head without twist or slippage.

8.3 When drilling, stop the drill hole at a depth such that the vane tip may penetrate undisturbed soil for a depth of at least five times the outside diameter of the hole. In the case where a vane housing is as follows:

$$T = s \times K$$

used, advance the housing to a depth which that is at least five vane housing diameters less than the desired depth of the vane tip.

⁵ Earth Manual, Part II, Third Edition, 1990, U.S. Department of the Interior, Bureau of Reclamation, U.S. Government Printing Office.

8.4 Advance the vane from the bottom of the hole or the vane housing in a single thrust to the depth at which the test is to be conducted. The vane shall be pushed down without any use of blows, vibration, or rotation. No torque should be applied to the rods during the thrust.

8.5 Friction Determinations:

8.5.1 Friction from Slip Couplings—For vanes equipped with slip couplings, after pushing the vane, the first part of the test will be to apply torque and measure the force to turn the torque rods above the slip coupling. Apply the force at the same rate as the actual vane loading given in 8.6. Record the rod friction.

8.5.2 Blank Rod Friction Tests—In the case where soil is in contact with the torque rods, and there is no slip coupling, determine the friction between the soil and the rod by means of torque tests conducted on similar rods at similar depths with no vane attached. These tests can be performed in between vane tests. Conduct the rod friction test at least once on each site; this shall consist of a series of torque tests at varying depths.

8.5.2.1 When using an apparatus in which the torque rod is completely isolated from the soil (vane shoe push/drill system), testing is performed in increments. The vane is retracted in the casing, when the test zone is reached the vane is pushed out of the shoe 35 to 50 cm. Vane rod friction in this case should be negligible.

8.6 The time from the end of vane penetration to beginning rotation shall be no more than 5 minutes. With the vane in position, apply the torque to the vane at a rate of 0.1 deg/s. Permissible variations are in the range of 0.05 to 0.2 deg/s. This generally requires a time to failure of from 2 to 5 min, except in very soft clays where the time to failure may be as much as 10 to 20 min. In stiffer materials, which reach failure at small deformations, it may be desirable to reduce the rate of angular displacement so that a reasonable determination of the stress-strain properties can be obtained. During the rotation of the vane, hold it at a fixed elevation. Record the maximum torque. With apparatus with manually read gauges, it is desirable to record intermediate values of torque at intervals of 15 s or at lesser frequency if conditions allow. Note all unusual occurrences during testing, such as slippage or shape of the loading curve.

8.7 Following the determination of the maximum torque, rotate the vane rapidly through a minimum of five to ten revolutions. The determination of the remolded strength shall be started immediately after completion of rapid rotation and never more than 1 min after the remolding process (Note 4).

NOTE 4—In many sensitive clayey soils, residual strength may be obtained within one to two revolutions or less. If such soils are being tested, it is recommended that several remolded strengths be obtained using the standard five to ten revolutions for verification. If no major remolded strength differences are noted, remolded strengths may be obtained at less than the recommended five to ten revolutions.

8.8 When combined with rotary drilling methods it may be advantageous to take thin wall tube or double tube auger (D 6151) samples over the tested interval. Over-sampling will allow for inspection of soil in the test zone. Often evidence of the shear zone can be found in the sample. If a sample is recovered and the shear zone is detected, describe the soil sample (D 2488) and the soils in the shear zone.

8.9 Conduct undisturbed and remolded vane tests at intervals of not less than 0.5 to 0.75 m throughout the soil profile when conditions will permit vane testing (Note 5). Do not conduct the vane test in any soil that permits drainage or dilates during the test period, such as stiff clays, sands or sandy silts, or soils where stones or shells are encountered by the vane in such a manner as to influence the results. Unreliable data can be evaluated by the torque rotation curves, or by subsequent sampling of the test zone.

NOTE 5—This spacing may be varied only by the engineer in charge of the boring program.

9. Calculations

9.1 Calculate the undrained shear strength (S_{uv}) in the following manner. The equations below can be in any units as long as shear strength, torque, and diameter are in consistent units:

9.1.1 For a rectangular vane of $H/D = 2$;

$$(S_{u})_{fv} = \frac{6 T_{max}}{7\pi D^3} \tag{1}$$

T_{maxD}

where: F

$(S_{u})_{fv}$ = torque, lbf-ft (or N·m);

*s-und-
rained
shear
strength
from the
vane,*

T_{max} = shear strength maximum value of the clay, lbf/ft² (or kPa), and

K measured torque corrected for apparatus and rod friction, and

D = constant, depending on dimensions and shape of the vane, ft³ (or m³); vane diameter (Fig. 1).

6.2 Assuming the distribution of the shear strength is uniform across the ends of a cylinder

9.1.2 For Tapered and around the perimeter, calculate the value of K Other Vanes—The general expression for rectangular, both ends tapered, bottom taper only, as follows:

Inch-Pound Units: well as rhomboidal vanes for any angles (for example, Silvestri & Aubertin, ASTM STP 1014, pp. 88-103) is given by:

$$K = (\pi/1728) \times (D^{2H/2}) \times [1 + (D/3H)]$$

$$(s_{ur})_{fv} = \frac{12 \cdot T_{max}}{\pi D^2 \cdot \left(\frac{D}{\cos(i_T)} + \frac{D}{\cos(i_B)} + 6H \right)} \quad (2)$$

Metric Units:

$$K = (\pi/10^6) \times (D^{2H/2}) \times [1 + D/3H]$$

where: D

s_{ur} = measured diameter of undrained shear strength from the vane, in. (or cm), and

H = measured height of vane, in. (or cm);

It is important that these dimensions are checked periodically to ensure the vane is not distorted or worn.

6.3 As the ratio of length to breadth of the vane is 2:1, the maximum value of K may be simplified in terms of the diameter so that it becomes the following:

Inch-Pound Units:

$$K = 0.0021D^3$$

Metric Units:

$$K = 0.00000366D^3$$

6.4 Since the value of s is required, it is more useful to write the equation as follows:

$$s = T \times k$$

where: measured torque corrected for apparatus and rod friction,

kD = 1/K and T, the torque, is measured so that s can be calculated; vane diameter (Fig. 1),

H = height of vane (Fig. 1),

i_T = angle of taper at vane top (Fig. 1), and

i_B = angle of taper at vane bottom (Fig. 1).

6.5 For

9.1.3 The torque reading from the tapered vane instrument may require use of Fig. 1, a calibration constant for the following modified equation may be used torque measurement device.

9.2 Peak Undrained Shear Strength— Calculate the peak undrained shear strength, (S_u)_{fv}, from the maximum recorded torque for the first loading of the vane constant; test in accordance with 9.1. (Note 6).

NOTE 6—The peak undrained shear strength from the field vane test needs to be multiplied by a vane correction factor (μ) to give a mobilized field value of undrained strength (s_u)_{field} for geotechnical analysis. It is essential in reports to discern between raw field results and corrected data. See 5.3 and Appendix X1.

9.3 Remolded Undrained Shear Strength, (s_{ur} Inch-Pound Units)_{fv2}— Calculate the remolded shear strength in accordance with 9.1, after rotating the vane as specified in 8.7 and measuring the residual torque. The remolded shear stress can be reported as remolded undrained shear strength, (S_{ur})_{fv2}.

9.4 Sensitivity, S_T— Calculate the sensitivity of the soil as follows:

$$K = 1/1728 [\pi D^3 + 0.37 (2D^3 - d^3)]$$

$$S_{Tfv} = (s_u)_{fv} / (s_{ur})_{fv} \tag{3}$$

Metric Units:

$$K = 1/10^6 [\pi D^3 + 0.37 (2D^3 - d^3)]$$

where:

$d_{S_{Tfv}}$ = rod diameter, in. (cm). For a 1/2-in. (1.27-cm) rod this reduces to sensitivity (dimensionless),

$(s_u)_{fv}$ = peak undrained shear strength, and

$(s_{ur})_{fv}$ = remolded undrained shear strength.

Inch-Pound Units:

$$K = 0.00225D^3 - 0.00003$$

Metric Units:

$$K = 0.00000388D^3 - 0.0000076$$

7.

10. Report

710.1 For each vane test record the following observations:

710.1.1 Date of the test;

710.1.2 Boring or sounding number;

710.1.3 Size and shape of the vane (double tapered, single tapered, or rectangular);

710.1.4 Depth of the vane tip;

710.1.5 Depth of the vane tip below the housing or bottom of the hole;

710.1.6 Time from end of penetration to beginning of rotation.

10.1.7 Maximum torque reading, and intermediate readings if required for the undisturbed test;

710.1.78 Time to soil failure.

10.1.9 Peak undrained shear strength, $(s_u)_{fv}$ (9.2).

10.1.10 Remolded strength, number of the test;

7.1.8 Rate revolutions (8.7)

10.1.11 Rate of remoulding;

710.1.912 Maximum torque reading for the remoulded test(s).

10.1.13 Remolded strength, $(S_{ur})_{fv}$ (9.3).

10.1.14 Friction determinations.

710.1.15 Sensitivity, S_{Tfv} , for determination of sensitivity (9.4).

10.1.16 Notes on any deviations from standard test procedure.

7.2 In addition, record the following observations for the boring:

7.2.1 Boring number;

7.2.2 Location;

7.2.3 Log

10.2 *Summary Report*—The summary report will include information below. The report will include plots of the soil conditions;

7.2.4 Reference elevation;

7.2.5 Method of making torque rotation data. The report shall also include summary plots and tables showing the hole;

7.2.6 Description strength data.

10.2.1 Description of the vane; equipment and advancement methods, housed or not;

710.2.72 Description of the method of applying and measuring the torque.

10.2.3 Calculations, including rod friction measurements.

710.2.84 Notes on the driving resistance;

7.2.9 Name of resistance to pushing the vane.

10.2.5 Calibration information for the torque measurement device.

10.3 In addition, record the information that may be required in ASTM standard D 5435 Guide for Field Logging of Subsurface Explorations of Soil and Rock. This guide is used for logging explorations by drilling foreman, and

7.2.10 Name and sampling. Some examples of the information include:

10.3.1 Boring number.

10.3.2 Location.

10.3.3 Log of the soil conditions.

10.3.4 Reference elevation.

10.3.5 Method of making the hole.

10.3.6 Name of the drilling foreman.

10.3.7 Name of the supervising engineer.

811. Precision and Bias

~~811.1 Precision—A valid estimate of test—Test data on precision has is not been determined because it presented due to the nature of this test method. It is either not feasible or too costly at this time to conduct the necessary inter-laboratory (field) tests. Subcommittee D18.02 welcomes proposals to allow development have ten or more agencies participate in an in situ testing program at a given site.~~

~~11.1.1 Subcommittee D 18.02 is seeking any data from users of this method that might be used to make a valid precision statement.~~

~~8.2— limited statement on precision.~~

~~11.2 Bias—Because there—There is no accepted reference material value for this test method, there can be no therefore, bias statement.~~

~~9— cannot be determined.~~

12. Keywords

912.1 clay; exploration; in-situ test; sensitivity; shear strength; undrained strength; vane shear

APPENDIX

(Nonmandatory Information)

X1. VANE CORRECTION FACTOR

X1.1 It is very important that the measured vane strength be corrected prior to use in stability analyses involving embankments on soft ground, bearing capacity, and excavations in soft clays (Bjerrum, 1972, 1973). The mobilized shear strength is given by:

$$\tau_{mobilized} = \mu_v (s_u)_{fv} \quad (X1.1)$$

where μ_v = empirical correction factor that has been related to plasticity index (PI) and/or liquid limit (LL) and/or other parameters based on back calculation from failure case history records of full-scale projects. The sensitivity, S_r , is based on the ratio of raw measured peak and remolded strengths and is not corrected.

X1.2 One proposed correction factor for field vane data is presented below. Other correction methods have been proposed. Additional information can be found in the references. The application of correction factors shall be performed by a qualified professional. The ASTM committee does not recommend or endorse any single method for adjusting the data. This information is presented to bring attention to the fact that a correction factor of some method is normally required to raw vane shear data.

X1.2.1 Based on an extensive review of the factors and relationships affecting vane measurements in clays and silts with PI > 5 % recommends the following expression (Chandler, 1988):

$$\mu_v = 1.05 - b (PI)^{0.5} \quad (X1.2)$$

where the parameter b is a rate factor that depends upon the time-to-failure (t_f in minutes) in the actual failure (not in the field test) and given by:

$$b = 0.015 + 0.0075 \log t_f \quad (X1.3)$$

The combined relationships are shown in Fig. X1.1. For guidance, embankments on soft ground are normally associated with t_f on the order of 10^4 minutes because of the time involved in construction using large equipment. For this case, Eq X1.2 becomes:

$$\mu_v = 1.05 - 0.045 (PI)^{0.5} \quad (X1.4)$$

X1.2.2 Interestingly, the raw vane strength ratio (s_{uv}/σ_{vo}') has long been observed to increase with plasticity index (for example, Skempton, 1948). Conversely, the vane correction factor (μ_v) decreases with PI. The net effect is that the mobilized strength back calculated from failure case histories involving embankments, foundations, and excavations in soft clays is essentially independent of plasticity index (for example, Mesri, 1989). Aas, et.al.(1986) have proposed a correction method which uses (s_{uv}/σ_{vo}') as the independent variable rather than PI.

X1.2.3 Alternative correction factors are given based on compilations of back calculated failures of foundations, embankments, and excavations (Bjerrum, 1973), field load tests and laboratory data (Larsson, 1980), three-dimensional stability considerations (Azzouz, et al., 1983), laboratory shear data (Mesri, 1989), and oedometer data (Mayne & Mitchell, 1988), as well as effective stress analyses (Morris & Williams, 1993, 1994).

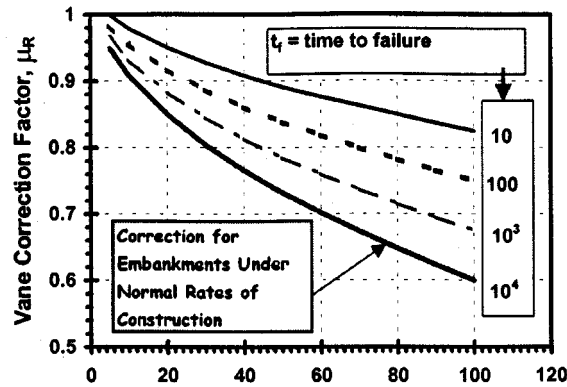


FIG. X1.1 Proposed Correction Factor to Raw Field Vane Shear Data from Plasticity Index (after Chandler, 1988)

REFERENCES

- (1) Aas, G., Lacasse, S., Lunne, T., and Hoeg, K., "Use of In Situ Tests for Foundation Design on Clay," Use of In Situ Tests in Geotechnical Engineering, S.P., Clemence, Ed., American Society of Civil Engineers, New York, 1986, pp. 1-30.
- (2) Azzouz, A., Baligh, M. and Ladd, C.C. (1983). Corrected field vane strength for embankment design. Journal of Geotechnical Engineering 109 (5), 730-734.
- (3) Bjerrum, L. (1972). Embankments on soft ground. Performance of Earth and Earth-Supported Structures, Vol. II, (Purdue Conference), ASCE, Reston, VA, 1-54.
- (4) Bjerrum, L. (1973). Problems of soil mechanics & construction on soft clays. Proceedings, 8th International Conference on Soil Mechanics & Foundation Engineering, Vol. 3, Session 4, Moscow, 111-159.
- (5) Chandler, R.J. (1988). The in-situ measurement of the undrained shear strength of clays using the field vane. Vane Shear Strength Testing in Soils: Field & Lab Studies, STP 1014, ASTM, West Conshohocken, PA, 13-44.
- (6) Larsson, R. (1980). Undrained shear strength in stability calculation of embankments & foundations on clays. Canadian Geotechnical Journal 17 (4), 591-602.
- (7) Mayne, P.W. and Mitchell, J.K. (1988). Profiling of overconsolidation ratio in clays by field vane. Canadian Geotechnical Journal 25 (1), 150-157.
- (8) Mesh, G. (1989). A re-evaluation of suv using laboratory shear tests. Canadian Geotechnical Journal 26 (1), 162-164.
- (9) Morris, P.H. and Williams, D.J. (1993). A new model of vane shear strength testing in soils. Geotechnique 43 (3), 489-500.
- (10) Morris, P.H. and Williams, D.J. (1994). Effective stress vane strength correction factor correlations. Canadian Geotechnical Journal 31 (3), 335-342.
- (11) Skempton, A.W. (1948). Vane tests in the alluvial plain of River Forth near Grangemouth. Geotechnique Vol. 1 (2), 111-124.

SUMMARY OF CHANGES This

In accordance with committee D-18 policy, this section identifies the principle location of changes to this test method that have been incorporated standard since the last edition, 1994, that may impact the use of this standard.

(1) Scope

Added 1.2 not applicable to marine testing, refer to ASTM STP 1014.

Added 1.3 references to drilling and sampling methods used in conjunction to Adopted SI units.

(†2) Added section Referenced Documents and referred to related standards.

(3) Added Terminology pertinent to the standard, defined peak shear stress, strength, remolded shear strength, and sensitivity.

(4) Summary of Method

Removed discussion about the effects of rod friction and inclination; moved them to apparatus and procedure sections.

(5) Significance and Use

Added 5.3 Precaution that field vane strength, requires correction for geotechnical analysis.

Added 5.4 on use in sand and partial drainage precautions.

Added 5.5 on drilling methods, and hand vanes.

(6) Apparatus

Fig. 1—Added Bottom Tapered Field Vane.

Fig. 2—Added Vane Area Ratio.

Removed Table 1 - provided a range of allowable dimensions for vane blades (6.1).

6.1.2 added criteria for size selection.

6.1.3 added vane area ratio for allowable vane dimensions.

6.1.4 added advantage of tapered vane.

6.2 added information on the torque measurement apparatus.

6.2.2 Added section on hard copy or computer records.

6.3.1 Moved side thrust precautions from summary of method to apparatus/torque rods area.

6.4 Added friction coupling.

6.5 Added section on centralizers.

6.6 Added section on advancement equipment.

6.7 Added section on reaction casing.

6.8 Added section on vane housing system.

(7) Calibration

Added information on how and when to calibrate the torque measurement device.

(8) Procedure

Added 8.1 on locating drill/push equipment.

Added 8.2 to set reaction casing if needed.

Added 8.5, 8.5.1, 8.5.2, 8.5.2.1 explaining how friction determinations are made, using slip coupling or vane housing systems.

8.6 Changed speed range from 0.05 to 0.2 degrees/second. Require less than 5 minutes to failure. Note occurrences during testing.

8.8 Added section on taking tube samples after testing.

(9) Calculations

Added section 9.1.1 - simplified equation for rectangular vane $H/D = 2$.

Changed Section 9.1.2 - simplified equation for any shape vane.

Added section 9.2 - determination of peak shear stress and strength.

Added section 9.3 - determination of remolded shear stress and strength.

Added section 9.4 - determination of sensitivity.

Removed sections ~~were added~~; 1, 2, 3, 7 with complex vane constants - K value.

(10) Report

Added basic details required for each test.

Added section on summary report and ~~8~~ summary report requirements.

Added reference to D 5434 on logging of subsurface investigations.

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