Designation: ~~D8121/D8121M – 18~~ D8121/D8121M – 19

Standard Test Method for Approximating the Shear Strength of Cohesive Soils by the Handheld Vane Shear Device[1]

This standard is issued under the fixed designation D8121/D8121M; 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 describes approximating the shear strength of cohesive soils using a handheld (pocket) vane shear device.

1.2 The device allows for a simple and portable method for measuring the approximate undrained shear strength of saturated, fine-grained, cohesive soils. The test method can be used in the field or in the laboratory, on the ends of sample tubes, on the surface of block samples or excavations, or on the surface of other test specimens with rigid confinement.

1.3 *Units*—The values stated in either inch-pound units or SI units [given in brackets] are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. Tables of critical dimensions and tolerances of the described vanes are provided in separate units of inches and mm.

NOTE 1—The original shear vane device was developed when shear strength was often reported in tons per square foot (TSF) or kilograms per square centimeter (kg/cm^2) which are approximately equivalent. These units have prevailed within the industry and are adopted herein.

1.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this test method.

1.4.1 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 generally should 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 test method to consider significant digits used in analysis methods for engineering design.

1.5 *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.*

1.6 *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
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4648 Test Methods for Laboratory Miniature Vane Shear Test for SaturatedFine-Grained Clayey Soil
D6026 Practice for Using Significant Digits in Geotechnical Data

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.05 on Strength and Compressibility of Soils.

Current edition approved ~~June 1, 2018~~May 1, 2019. Published ~~July 2018~~June 2019. Originally approved in 2018. Last previous edition approved in 2018 as D8121/D8121M – 18. DOI: ~~10.1520/D8121_D8121M-18~~10.1520/D8121_D8121M-19

[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.

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of technical terms used in this test method, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *vane multiplier (VM), n*—a multiplier to correct the vane's dial reading based on the standard (mid-size) vane to the larger or smaller vane (4.2).

3.2.2 *calibration factor (CF), n*—correction to the vane's dial reading based upon the physical calibration of the torsional shear device in accordance with Annex A1.

4. Summary of Test Method

4.1 The handheld vane shear device is comprised of a calibrated torque spring, post, measuring scale, and one of three vanes. A flat surface is prepared on a specimen of cohesive soil, usually confined by a sampling tube or specimen ring; the side walls of a test pit; or exposed footing. The vane is pressed into the soil surface and the device is rotated at a specified rate until the soil shears. The failure surface is prescribed by the face of the vane and the depth of the blades. A pointer retains the maximum value on the measuring scale, ranging from 0 to 1 TSF [0 to 100 kPa], with major divisions of 0.05 TSF [5 kPa] when a standard (mid-size) shear vane is used.

4.2 Typically, three vane sizes are provided with the device. The standard (mid-sized) vane has a multiplier of 1. The smaller vane is used for stiffer soils and typically has a multiplier of 2.5. The larger vane is used for softer soils and typically has a multiplier of 0.2. The reading on the scale is multiplied by the factor for the specific vane to obtain the correct measure of strength.

5. Significance and Use

5.1 The handheld shear vane method provides a rapid method of measuring the approximate undrained shear strength of a fine-grained, cohesive soil either in the field or laboratory. This standard does not supplement or replace D4648.

5.2 The device is intended for use in saturated cohesive soils for determining their approximate undrained shear strength. Cohesive soils with appreciable amounts of silt or fine sand may experience some degree of drainage during shear and adversely affect the results.

NOTE 2—The user will probably not know at the time of testing if the material is saturated. However, that would not preclude using the device for less than saturated conditions based on the knowledge and experience of the user.

5.3 The presence of coarse materials or heterogeneous soils within the testing volume will adversely affect the results and may preclude the use of this test method.

5.4 The handheld shear vane test is not used to duplicate any particular field conditions but supplements the overall investigative program. However, consistent physical parameters are used in the test such that correlations of shear strength data can be made to evaluate variability of a deposit, assess sample quality, assist in planning of laboratory testing programs, and to classify the consistency.

NOTE 3—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 standard 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 *Torsional Shear Device*—A mechanical device consisting of a calibrated torque spring attached to a measuring scale and outfitted with one or multiple interchangeable vanes. Fig. 1 shows an example of a typical torsional shear device with standard (mid-size) vane attached, along with a smaller and a larger sized vane. Fig. 2~~.~~ is ~~an example~~ a schematic of the torsional shear device.

6.1.1 *Torque Spring*—The torque spring shall be calibrated for the appropriate measuring scale. This is typically performed by the manufacturer at the time of assembly.

6.1.2 *Measuring Scale*—The measuring scale shall measure from 0 to 1 TSF [0 to 100 kPa], with major divisions of 0.05 TSF [5 kPa], allowing interpolation to the nearest half division 0.025 TSF [2.5kPa] when the standard (mid-size) shear vane is attached. The measuring scale shall be outfitted with a pointer that retains the maximum value.

NOTE 4—The scale of some handheld shear vanes is provided in kilograms per square centimeter (kg/cm^2) which are generally regarded as equivalent in value to tons per square foot (TSF) for this test method.

6.1.3 *Knob*—The device shall have a knob that allows for gripping and rotating of the device without impacting the measured value on the scale.

6.2 *Vane(s)*—Vanes are constructed of stiff material such as machined steel or aluminum, or plastic either injected molded or 3D printed. At least one vane of known multiplier is required. Each vane shall have blades along the face of the vane. Each blade

FIG. 1 Example of a Typical Torsional Shear Device with Standard (mid-size) Vane Attached, Along with Smaller and Larger Sized Vanes

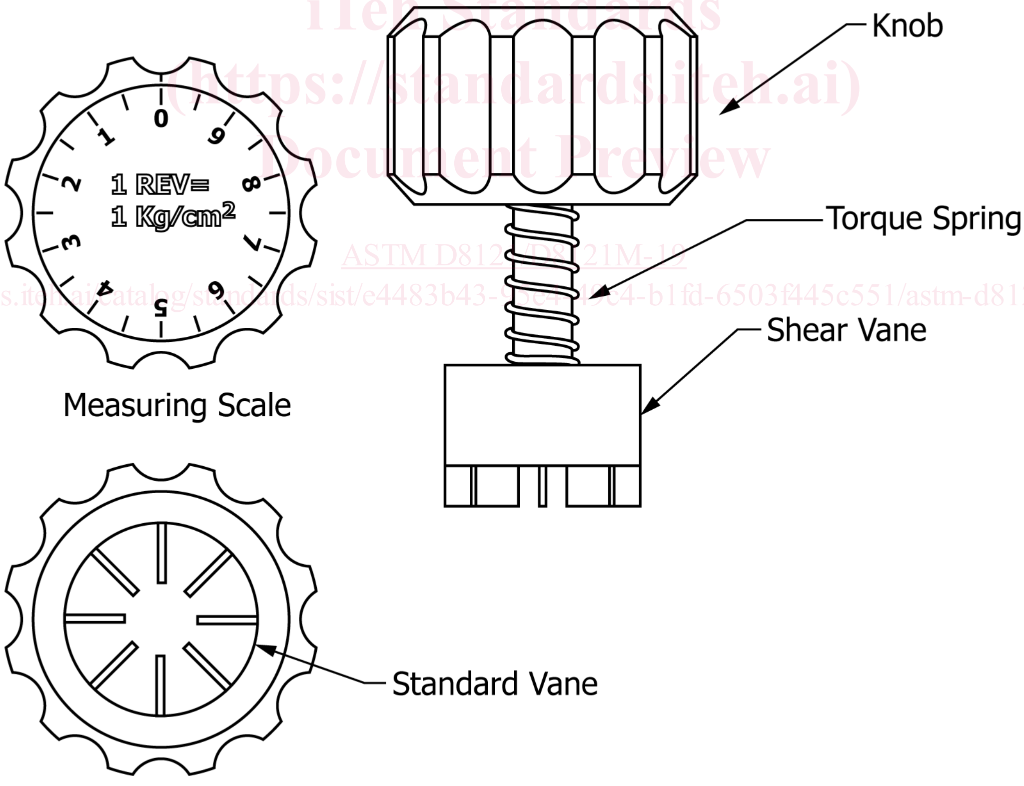

FIG. 2 ~~Example~~ Schematic of ~~the~~ Torsional Shear Device

shall extend from the face of the vane. The depth of the blade affects the multiplier for the vane. The multiplier for the vane is provided by the manufacturer and generally 1 by the standard 1 in. [25.4 mm] vane; 2.5 for the high capacity ¾-in. [19.0 mm] vane and 0.2 for the sensitive 1-⅞-in. [47.6 mm] vane. Fig. 3 illustrates the configuration of the vanes.

6.2.1 Table 1 provides the critical dimensions and tolerances in inches for the three vane sizes. Table 2 provides similar information as Table 1, but in mm. Table 3 provides thickness in in. and mm for vanes of machined stainless steel or aluminum, and injected plastic. See Appendix X1 for the equations used to determine the multiplier for a vane, given its dimensions.

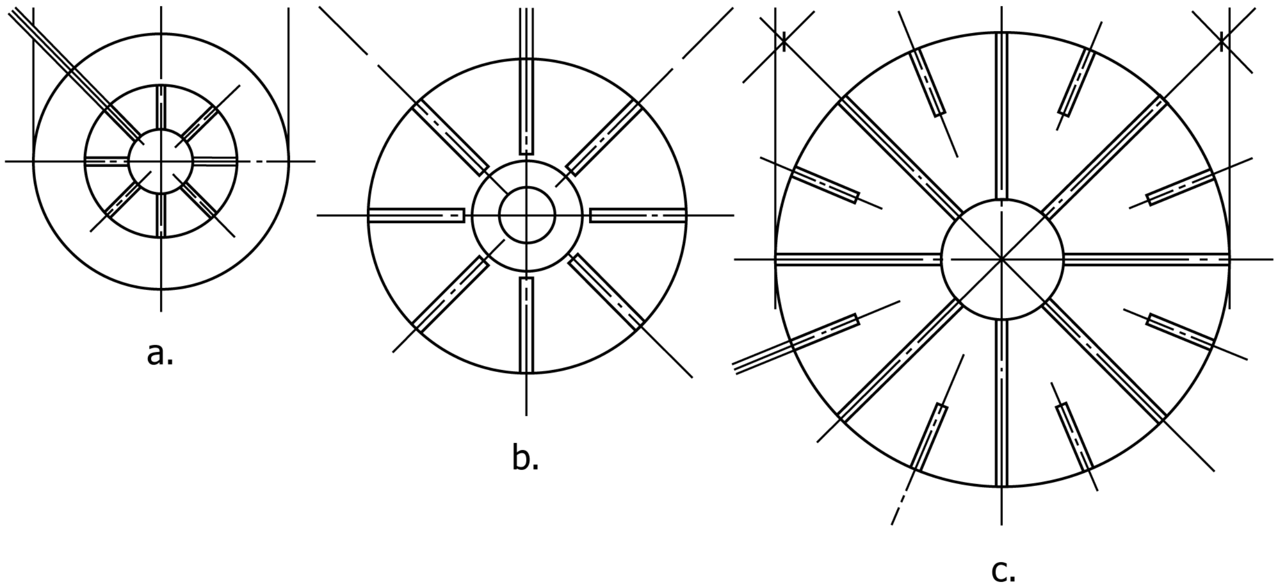

FIG. 3 Vane Configuration (a) High Capacity, (b) Standard, (c) Sensitive

TABLE 1 Vane Critical Inch Dimensions and Tolerances

Vane Head	Blade Length	No. Blades	Blade Length		Blade Height		Blade OD		
			Length, in.	Tol., in.	Height, in.	Tol., in.	Nominal, in.	OD, in.	Tol., in.
Standard	NA	8	0.312	±0.003	0.200	±0.004	1	1.000	±0.002
High Capacity	NA	8	0.215	±0.003	0.137	±0.004	¾	0.750	±0.002
Sensitive	Long	8	0.690	±0.003	0.200	±0.004	1-⅞	1.875	±0.004
	Short	8	0.285	±0.003	0.200	±0.004	1-⅞	1.875	±0.004

TABLE 2 Vane Critical SI Dimensions and Tolerances

Vane Head	Blade Length	No. Blades	Blade Length		Blade Height		Blade OD	
			Length, mm	Tol., mm	Height, mm	Tol., mm	OD, mm	Tol., mm
Standard	NA	8	7.70	±0.005	5.2	±0.1	25.4	+0/–0.05
High Capacity	NA	8	5.55	±0.005	5.2	±0.1	19.1	±0.05
Sensitive	Long	8	17.50	±0.005	5.2	±0.1	48.0	±0.1
	Short	8	7.25	±0.005	5.2	±0.1	48.0	±0.1

TABLE 3 Blade Width for Machined ~~Stainless~~ Steel or Aluminum and Injected or 3D Printed Plastic

	Blade Width, in.		Blade Width, mm	
	Width, in.	Tol., in.	Width, mm	Tol., mm
~~Machined SS~~	~~0.030~~	~~±0.002~~	~~0.75~~	~~±0.05~~
Machined Metal	0.030	±0.002	0.75	±0.05
Injected or 3D Plastic	0.035	±0.004	0.90	±0.1

6.2.2 *Calibration Masses*—Calibration masses causing approximately 30 percent, 60 percent, and 90 percent of the full-scale reading. See Annex A1 for calibration procedures.

6.3 *Straight Edge*—Steel straight edge at least 6 in. [150 mm] in length with one beveled edge or a flat edged paint scraper.

6.4 *Measuring Device*—The device to measure the vane dimensions shall be capable of measuring to the nearest 0.001 in. [0.01 mm] or better.

6.5 If the user elects to determine water contents of the test sample, that apparatus required to perform D2216 will be required.

7. Specimen Preparation

7.1 Using a straight edge, create a flat surface on the end of a confinement ring or test area. The surface should be prepared with minimal disturbance. If disturbance does occur the user should prepare an alternate surface if feasible or document the observed disturbance in the data record.

8. Preparation of Apparatus

8.1 Select the vane size appropriate for the estimated shear strength. Several trials may be required to determine which vane will cause an acceptable measurement as described in 9.8.

9. Procedure

9.1 Record the vane size, vane multiplier, and calibration factor.

9.2 Move the scale pointer to read zero.

9.3 Press the handheld shear vane into the soil surface such that the axis of the post is normal to the soil surface.

9.4 Penetrate the blades of the vane until the face of the vane is flush with the soil surface.

9.5 Place the thumb of one hand against the back of the vane. Apply only sufficient force to the axis of the handheld shear vane to maintain contact between the face of the vane and the soil surface without penetrating the face of the vane into the soil surface. Excess thumb pressure will hinder the vane rotation during shear.

9.6 Place the tips of the fingers of the free hand on the edge of the knob. Take care that the fingers do not hang over the edge of the dial and touch the scale or the pointer. Rotate the vane clockwise using one smooth motion at a rate that causes failure in 5 to 10 seconds.

9.7 Record the value indicated by the pointer to the nearest half division, 0.025 TSF [2.5 kPa].

9.8 If the value indicated by the pointer is less than 10 percent of the scale and the largest vane is not being used, use the next largest vane to check the results. Likewise, if the value is more than 90 percent of the scale and the smallest vane is not being used, use the next smallest vane to check the results. If possible, repeat the measurement in an untested location on the soil surface. Take care to space the measurements far enough apart that the failure disk of one measurement does not cause premature failure of the adjacent test.

9.9 For optional water content determination, remove the soil from between the blades. Place the soil in a pre-measured tare for water content determination in accordance with D2216.

9.10 If required to meet the minimum mass requirements for the water content determination, remove additional soil to the depth of the device blades in the tested areas. Place the soil in the water content tare, and obtain the water content.

10. Calculations

10.1 Correct each reading by the calibration factor, if required, and the vane multiplier for the vane used for the determination:

$$S_u = s_{reading} \times VM \times CF \qquad (1)$$

where:

S_u = corrected shear strength, TSF [kPa],
$S_{reading}$ = reading from vane's measuring scale, TSF [kPa],
VM = vane multiplier, that is, VM = 1 for mid-size vane; 0.2 for largest vane; 2.5 for smallest vane, and
CF = calibration factor associated with S_{reading} (Annex A1).

10.2 If several determinations were performed at the same location, calculate the average of the readings.

11. Report: Test Data Sheet(s)/Form(s)

11.1 The methodology used to specify how data are recorded on the test data sheet(s)/form(s), as described below, is covered in 1.4.

11.2 Record as a minimum the following general information (data):

11.2.1 General information, such as project number, project name, operator name, and date.

11.2.2 Sample and specimen identifying information, such as boring or test pit number, sample number, depth interval of the sample, and location of the test specimen within the sample tube to the nearest 1 in. [25 mm] or depth below the test pit surface.

11.2.3 Any special selection or preparation process, such as removal of gravel or other materials, or identification of their presence.

11.2.4 If the specimen is reconstituted, remolded, or trimmed in a specialized manner, provide information on the method of preparation.

11.3 Record as a minimum the following test specimen data:

11.3.1 If a water content determination was made, the companion water content shall be reported to the precision in accordance with Test Method D2216.

11.3.2 The vane size, vane multiplier and calibration factor used for the handheld shear vane determinations.

11.4 Report the vane dial reading or averaged readings of the results taken at each location.

11.5 Reported the calculated shear strength, S_u, to the nearest 0.025 TSF [2.5 kPa] corrected in accordance with 10.1.

NOTE 5—It is customary to designate the shear strength from vane shear as S_u.

12. Precision and Bias

12.1 *Precision*—Test data on precision is not presented due to the nature of the soil materials tested by this test method. It is either not feasible or too costly at this time to have ten or more laboratories participate in a round-robin testing program. Also, it is either not feasible or too costly to produce multiple specimens that have uniform physical properties. Any variation observed in the data is just as likely to be due to specimen variation as to operator or laboratory testing variation.

12.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

13. Keywords

13.1 consistency; handheld shear vane; pocket shear meter; pocket shear vane; pocket vane shear; strength index; Torvane

ANNEXES

(Mandatory Information)

A1. CALIBRATION

A1.1 *Scope:*

A1.1.1 The manufacturer will have assembled the torsional shear device and adjusted the torque spring such that the measuring scale registers a value of shear strength directly when using the standard (mid-size) vane.

A1.1.2 The calibration procedures of this annex can be used to provide a check on those values when the device is received initially, and as a periodic check over time as the device is used or in accordance with the agency's quality control requirements.

A1.1.3 Calibration is performed by applying a known torque to the vane shear device, converting that torque to equivalent shear strength and comparing that value to reading on the dial face (measuring scale). The calibration procedure results in a calibration curve and correction factor as the torque spring wears over time, or the calibration process can be used to designate a device as out of calibration when the correction factor exceeds the established criteria. Out of calibration devices shall be taken out of service and discarded or returned to the manufacturer for servicing.

A1.1.4 Three calibration methods are presented:

A1.1.4.1 *Method A*—Commercially available torque wrench.

A1.1.4.2 *Method B*—Calibration device modeled after the USBR Procedure 1445[3] that applies three torques to the torsional shear device resulting from lifting three masses with a pulley system and creating a linear regression line to correct the vane shear readings (if needed).

A1.1.4.3 *Method C*—Calibration device consisting of a mechanical lever where the torsional shear device is used to apply a torque at the fulcrum to lift a known mass at a fixed lever distances.

A1.1.5 The vanes produced by manufacturers shall fall within the dimensions and tolerance of Tables 1-3. Some manufacturers have the ¾-in., [19-mm] vane attached to the torsional shear device with the other two heads made to slip over the ¾-in. [19-mm] vane. Other manufacturers have a square drive that fits into a box socket located on the back of each vane. These variations result in the need to fabricate custom adapters to attach the torsional shear device to the user's calibration device.

[3] USBR Procedure 1445, Procedure for Calibrating the Torvane Shear Device (Pocket Vane Shear Meter)