Designation: D5607 – 16

Standard Test Method for
Performing Laboratory Direct Shear Strength Tests of Rock Specimens Under Constant Normal Force[1]

This standard is issued under the fixed designation D5607; 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 establishes requirements and laboratory procedures for performing direct shear strength tests on rock specimens under a constant normal load. It includes procedures for both intact rock strength and sliding friction tests, which can be performed on specimens that are homogeneous, or have planes of weakness, including natural or artificial discontinuities. Examples of an artificial discontinuity include a rock-concrete interface or a lift line from a concrete pour. Discontinuities may be open, partially or completely healed or filled (that is, clay fillings and gouge). Only one discontinuity per specimen can be tested. The test is usually conducted in the undrained state with an applied constant normal load. However, a clean, open discontinuity may be free draining, and, therefore, a test on a clean, open discontinuity could be considered a drained test. During the test, shear strength is determined at various applied stresses normal to the sheared plane and at various shear displacements. Relationships derived from the test data include shear strength versus normal stress and shear stress versus shear displacement (shear stiffness).

NOTE 1—The term "normal force" is used in the title instead of normal stress because of the indefinable area of contact and the minimal relative displacement between upper and lower halves of the specimen during testing. The actual contact areas during testing change, but the actual total contact surface is unmeasurable. Therefore nominal area is used for loading purposes and calculations.

NOTE 2—Since this test method makes no provision for the measurement of pore pressures, the strength values determined are expressed in terms of total stress, uncorrected for pore pressure.

1.2 This standard applies to hard rock, medium rock, soft rock, and concrete.

1.3 This test method is only applicable to quasi-static testing of rock or concrete specimens under monotonic shearing with a constant normal load boundary condition. The constant normal load boundary condition is appropriate for problems where the normal stress is constant along the discontinuity. The constant normal load boundary condition may not be appropriate for problems where shearing is dilatancy controlled and the normal stress is not constant along the discontinuity.

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

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 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 commensurate with these considerations. It is beyond the scope of these test methods to consider significant digits used in analysis methods for engineering design

1.5 *Units*—The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units, which are provided for information only and are not considered standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this test method.

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. 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

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[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.12 on Rock Mechanics.

Current edition approved Dec. 1, 2016. Published January 2017. Originally approved in 1994. Last previous edition approved in 2008 as D5607 – 08. DOI: 10.1520/D5607-16.

[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**

Used in Engineering Design and Construction

D5079 Practices for Preserving and Transporting Rock Core Samples (Withdrawn 2017)[3]

D6026 Practice for Using Significant Digits in Geotechnical Data

E4 Practices for Force Verification of Testing Machines

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

2.2 *ISRM Standard:*[4]

Suggested Methods for Laboratory Determination of the Shear Strength of Rock Joints: Revised Version

3. Terminology

3.1 *Definitions*—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 *apparent stress, n*—nominal stress, that is, external load per unit area; calculated by dividing the externally applied load by the nominal area.

3.2.2 *asperity:*

3.2.2.1 *quality, n*—the roughness of a surface.

3.2.2.2 *asperity feature, n*—a surface irregularity ranging from sharp or angular to rounded or wavy.

3.2.2.3 *asperities, n*—the collection of a surface's irregularities that account for the surface's roughness.

3.2.3 *discontinuity, n*—an abrupt change, interruption, or break in the integrity or physical properties of rock, such as a bedding plane, fracture, cleavage, crack, joint, or fault where the opposing rock surfaces may be *planar* to *nonplanar* and *matching* to *misfit*.

3.2.4 *gapped discontinuity, n*—consists of opposing rock surfaces separated by an open or filled space.

3.2.5 *tight discontinuity, n*—consists of opposing rock surfaces in intimate and generally continuous contact; it may be valid to treat such a discontinuity as a single surface.

3.2.6 *intact shear strength, n*—the peak shear resistance (in units of stress) of an intact rock specimen or of a specimen containing a completely healed discontinuity.

3.2.7 *nominal area, n*—area obtained by measuring or calculating the cross-sectional area of the shear plane and calculated after its relevant cross-sectional dimensions are determined.

3.2.8 *residual shear strength, n*—the shear stress, (see Fig. 1), corresponding to a specific normal stress, for which the shear stress remains essentially constant with increasing shear displacement.

3.2.8.1 *Discussion*—In most cases, the shear stress after reaching Point A is the residual shear strength.

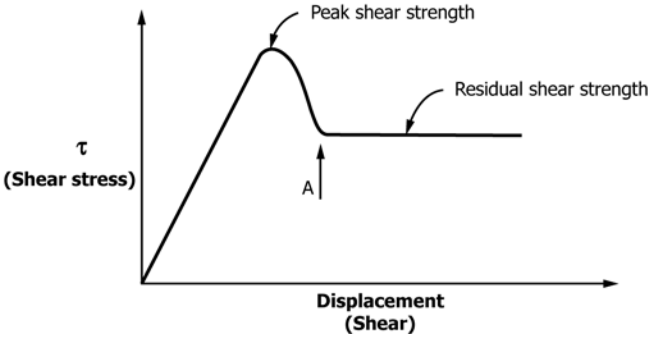

FIG. 1 Generalized Shear Stress and Shear Displacement Curve

3.2.9 *shear stiffness, n*—represents the resistance of the specimen to shear displacements under an applied shear force prior to reaching the peak shear strength, which is calculated by dividing the applied apparent shear stress by the resulting shear displacement (slope of the curve prior to peak shear strength, Fig. 1).

3.2.10 *sliding friction shear strength, n*—the peak shear resistance (in units of stress) of a rock specimen along an open discontinuity.

4. Summary of Test Method

4.1 While maintaining a constant force normal to the nominal shear plane of the specimen, an increasing external shear force is applied along the designated shear plane to cause shear displacement. The applied normal and shear forces and the corresponding normal and shear displacements are measured and recorded. These data are the basis for calculating the required parameters.

5. Significance and Use

5.1 Determination of shear strength of a rock specimen is an important aspect in the design of structures such as rock slopes, dam foundations, tunnels, shafts, waste repositories, caverns for storage, and other purposes. Pervasive discontinuities (joints, bedding planes, shear zones, fault zones, schistosity) in a rock mass, and genesis, crystallography, texture, fabric, and other factors can cause the rock mass to behave as an anisotropic and heterogeneous discontinuum. Therefore, the precise prediction of rock mass behavior is difficult.

5.2 For nonplanar joints or discontinuities, shear strength is derived from a combination base material friction and overriding of asperities (dilatancy), shearing or breaking of the asperities, and rotations at or wedging of the asperities. Sliding on and shearing of the asperities can occur simultaneously. When the normal force is not sufficient to restrain dilation, the shear mechanism consists of the overriding of the asperities. When the normal load is large enough to completely restrain dilation, the shear mechanism consists of the shearing off of the asperities.

5.3 Using this test method to determine the shear strength of an intact specimen may generate overturning moments which could result in an inclined shear break.

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[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] "ISRM Suggested Methods for Laboratory Determination of the Shear Strength of Rock Joints: Revised Version", R. Ulusay (ed.), The ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 2007-2014, DOI: 10.1007/978-3-319-07713-0, Springer-Verlag Wien 2013.

5.4 Shear strength is influenced by the overburden or normal pressure; therefore, the larger the overburden pressure, the larger the shear strength.

5.5 In some cases, it may be desirable to conduct tests in situ rather than in the laboratory to determine the representative shear strength of the rock mass, particularly when design is controlled by discontinuities filled with very weak material. In situ direct shear testing limits the inherent scale effects found in rock mechanics problems where the laboratory scale may not be representative of the field scale.

5.6 The results can be highly influenced by how the specimen is treated from the time it is obtained until the time it is tested. Therefore, it may be necessary to handle specimens in accordance with Practice D5079 and to document moisture conditions in some manner in the data collection.

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 and the like. 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 *Testing Machine*—Loading device, to apply and register normal and shear forces on the specimens. It must have adequate capability to apply the shear force at a rate conforming to the specified requirements in 6.2-6.9. It shall be verified at suitable time intervals in accordance with the procedures given in Practices E4, and comply with the requirements prescribed therein. The resultant of the shear force passes through the center of the intended shear zone or the centroid of the shear plane surface area to reduce the potential for adverse moments. If possible, the testing machine should include both a stiff frame and a stiff specimen holder sufficiently rigid to inhibit distortions during testing for accurate determination of residual behavior.

NOTE 4—There are many different direct shear device designs. Although details may vary concerning how to encapsulate specimens into shear boxes as well as details for assembling the machine, the determinations are usually similar.

6.2 Fig. 2 is a schematic of an example shear box, an integral part of the machine.

6.3 *Load Monitoring Devices*—The load monitoring devices (such as load cells, proving rings, hydraulic gauges) should be accurate to within 1 % of the specified load and be calibrated in accordance with Practices E4.

6.4 *Pressure-Maintaining Device*—A hydraulic component that will hold a pressure, within 1 % of the target load, within the hydraulic system.

6.5 *Specimen Holding Rings*—Aluminum or steel holding rings (see Fig. 3) with internal dimensions sufficient to accommodate specimens mounted in an encapsulating medium.

6.6 *Spacer Plates:*

6.6.1 *Split Spacer Plates*—Plastic (or other suitable material) plates of varying thicknesses for isolating an intact specimen's shear zone from the encapsulating compound (see Fig. 3).

6.6.2 *Non-split Spacer Plates*—Plastic (or other suitable material) plates of varying thicknesses that have a circular or oval hole in the center and are used for non-intact specimens.

6.7 *Displacement Measuring Device*—Linear variable differential transformers (LVDTs) may be used as normal and shear displacement measuring devices. Other devices such as dial indicators and direct current differential transformers (DCDTs), are satisfactory. Four devices are used to measure the normal displacement and provide a check on specimen rotation about an axis parallel to the shear zone and perpendicular to the shearing direction. Another device measures the shear displacement. These displacement devices should have adequate ranges of travel to accommodate the displacements, ±13 mm (±0.5 in.). Sensitivities of these devices should be 0.025 mm (0.001 in.) for shear displacement and 0.0025 mm (0.0001 in.) for normal displacement. Make sure that the devices are located away from the loading direction so as not to be damaged in sudden failures. Measuring devices are to be calibrated/verified at least once a year.

6.8 *Data Acquisition Equipment*—A computer may be used to control the test, collect data, and plot results. Typical data acquisition rates are near continuous (greater than 1 Hz sampling rate) with computer based systems.

6.9 *Computer System (Optional)*—Capable of 3D contact measurements using CAD software.

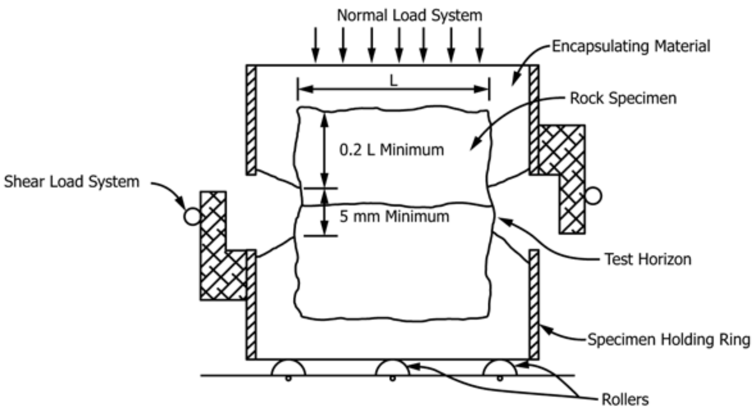

FIG. 2 Schematic Test Setup—Direct Shear Box with Encapsulated Specimen

NOTE 1—Note the split plastic plates for isolating the shear zone.

FIG. 3 View Showing Pouring Encapsulating Material Around Upper Half of Specimen

6.10 *3D Noncontact Measuring Device (Optional)*—Laser scanner, photogrammetry, slit scanner or stereo-topometric camera.

6.11 *Miscellaneous Items*—Carpenter's contour gauge for measuring joint surface roughness, roughness chart (see Fig. 4[5]), filler or modelling clay, calipers or micrometer accurately readable to 0.001 mm, spatula, circular clamps, utility knife, towels, indelible markers, plotting papers, encapsulating compound, and camera.

7. Test Specimens

7.1 *Sampling*—A rock sample is grouped based on rock type, discontinuity orientation, and condition of discontinuities. Each sample is comprised of specimens having similar characteristics. A rock sample is collected and shipped using methods that reduce the potential for disturbance of test specimens (Practice D5079).

7.1.1 *Intact Specimen*—Care should be exercised in core drilling, handling, and sawing the sample to reduce the potential for mechanical damage to test specimens. No liquids other than water should be in contact with a test specimen.

NOTE 5—To obtain relevant parameters for the design, construction, or maintenance of major engineering structures, test specimens should be representative of the host properties as nearly as practicable.

7.1.2 *Specimen with a Single Discontinuity*—A specimen's dimensions and the location of a discontinuity to be tested should allow sufficient clearance for adequate encapsulation. The in situ integrity of discontinuities in a sample is to be maintained from the time of sampling until the discontinuity is tested. Tape, plastic wrap, or other means may be utilized to preserve the in situ moisture content along the test zone. Plastic half rounds, core boxes, freezing, or other methods may be utilized to bridge the discontinuities and prevent differential movement from occurring along the discontinuity. This is especially important for discontinuities containing any soft, or weak material.

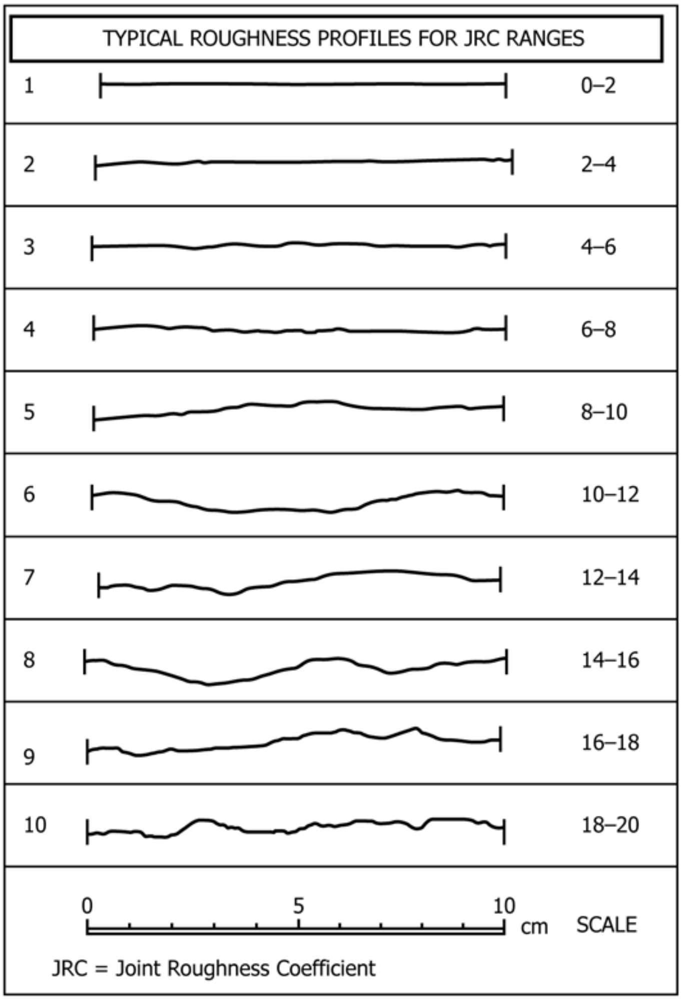

FIG. 4 Roughness Profiles and Corresponding JRC Values Associated With Each One[5]

7.2 *Size and Shape:*

7.2.1 *Height*—The height of each specimen shall be greater than the thickness of the shear (test) zone and sufficient to embed the specimen in the holding rings.

7.2.2 *Shape*—Specimens may have any shape such that the cross-sectional areas can be determined. In most cases the least cross-sectional dimension of the specimen should be at least 10 times the largest grain size in the specimen or maximum asperity height along the shear surface.

7.2.3 *Area*—The test plane should have a minimum area of 1900 mm^2 (3 in.^{2}). The width should not change significantly during testing. The minimum width should be greater than 75 % of the maximum width.

7.2.4 *Orientation*—The portion of the specimen that remains fixed during testing should be of greater length than the moving half so that the joint is always supported and the nominal contact area remains constant. If this is not feasible, a reduction in the nominal area during shear may be required.

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[5] Barton, N., and Choubey, V., *The Shear Strength of Rock Joints in Theory and Practice*, *Rock Mechanics*, 10, 1977.

7.3 *Storage*—Samples should be stored out of the weather after they are obtained at the work site (field) in order to preserve their integrity.

7.4 *Moisture Condition*—If specimens are to be tested near the natural moisture condition of the host material, they should be stored and transported in accordance with Practice D5079.

8. Procedure

8.1 *Moisture Condition*—If required, the moisture condition of the shear zone is determined and recorded in accordance with Test Methods D2216.

8.2 *Test Specimen:*

8.2.1 *Measurements:*

8.2.1.1 *Cross-Sectional Area of Regular Geometrical Shapes*—Measure and record the relevant dimensions of the specimen at the shear zone cross section to the nearest 0.025 mm (0.001 in.) using a caliper or micrometer. For inclined core, the apparent area can be determined by measuring the diameter and angle of dip θ.

8.2.1.2 *Cross-Sectional Area of Nongeometrical Shapes*—The outline of the cross-sectional area of the specimen or shear plane is traced on paper and the area is measured with a planimeter and then recorded to the nearest 0.1 mm. The area can also be measured using a 3D contact measurement device and CAD software and then recorded.

8.2.1.3 *Joint Roughness of a Clean Discontinuity*—Use a carpenter contour gauge before and after testing to measure the joint roughness in the direction of anticipated shear displacement. To use the carpenter contour gauge, lower the prongs of the gauge onto a flat, hard surface until all of the tips of the prongs form a straight line. Place this straight line pronged gauge onto the shear plane and lower all the prongs to make contact with the shear surface. Remove the gauge. The tips of the gauge trace the shear plane surface along the line of shearing. Trace the tips of the prongs onto paper, and compare this tracing to match with one of the lines on Fig. 4; then, select and record the corresponding joint roughness coefficient. Discontinuity roughness can also be digitized using 3D non-contact measurement devices (that is, laser scanner, photogrammetry, slit scanner or stereo-topometric camera).

8.2.1.4 *Joint Roughness for Partially or Fully Healed Discontinuity*—After failure occurs in a shear test, contour gauges and the standard roughness chart are used to determine the joint roughness coefficient. The discontinuity roughness can also be digitized using the 3D non-contact measurement devices detailed in 8.2.1.3.

8.2.1.5 Take before and after test photographs of each specimen.

8.2.2 *Encapsulation:*

8.2.2.1 *Specimen Encapsulation*—Place a thick plastic sheet on a suitable level surface. Place the lower half of the specimen holding ring on the plastic sheet.

(a) Porous rock that is to be tested at its natural water content should be coated with a non-absorbing sealer to prevent absorption of water from the encapsulating compound.

(b) Encapsulating Compound—Prepare the encapsulating compound in accordance with the directions of the manufacturer. The preparation is necessary to impart required properties of quick setting and adequate strength to the cured encapsulating compound. A super strength gypsum cement is recommended.

(c) For a Specimen Containing a Discontinuity—Position the lower half of the specimen (if the discontinuity is gapped, that is, open jointed) centrally in the lower half of the specimen holder. Make sure that the shear horizon to be tested is secured in the correct position and orientation so that the shear force will be in the same plane as the test zone. Make sure that the bottom of the lower half of the specimen is resting on the plastic sheet. Provide adequate support to the specimen so that it is maintained in its position while the encapsulating material cures (see Fig. 5). Pour the encapsulating material carefully into the annular space between the lower half of specimen and the lower half of the specimen holding ring. Stop pouring just below the general plane of the test zone (see Fig. 6). Do not disturb the specimen holding ring assembly after pouring the encapsulating compound. After the bottom encapsulated material has sufficiently cured, place a split spacer plate of specified thickness on the lower ring such that its cutout edge encircles the encapsulated lower half of the specimen and encompasses the test zone thickness. If needed, apply a layer of silicon grease over the surface of the encapsulated material. Place the upper half of the test specimen onto the encapsulated lower half. Fill the annular space between the specimen testing surface and the semicircular or circular edge of the spacer plate with modeling clay. Adjust the position of the upper half of the specimen until the surfaces of the test horizon are correctly mated. Lower the upper half of the specimen holder onto the split spacer plate without disturbing the position of the top half of the specimen. Connect the two halves of the specimen holding ring with bolts. Pour encapsulating compound into the annular space between the top half of the specimen holder and the top half of the specimen. Do not disturb the assembly until the encapsulating compound cures. Remove the spacer plates to expose the test horizon for shear testing (see Fig. 7).

(d) For a Specimen With A Partially or Fully Tight Discontinuity or an Intact Specimen—Position the specimen

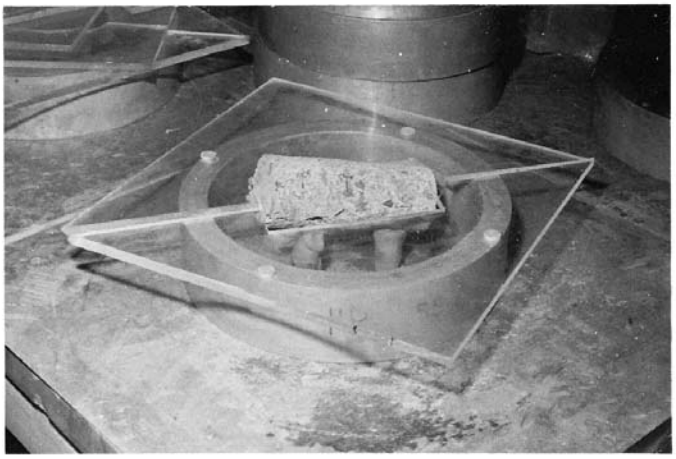


FIG. 5 Specimen Supported in Place By Modeling Clay Pins Which Are Removed After Encapsulating Material Cures and the Resulting Holes Filled With Encapsulating Material

Note 1—In both Fig. 5 and Fig. 6 the shear box is cylindrical. Square boxes work just as well.

FIG. 6 Lower Half of a Specimen Encapsulated in Holding Ring

FIG. 7 Removing Spacer Plates After Encapsulating Material Has Cured

concentrically into the lower half of the holding ring, and pour the prepared encapsulating compound into the annular space between the specimen and the lower half of the specimen holding ring. Allow the compound to cure without disturbing the assembly. Place a split spacer plate of a thickness equal to the height of the shear test zone, and fill the annular space between the circular or semicircular edge of the spacer plate and the specimen with clay. While not disturbing the encapsulated lower half of the specimen, place the upper half of the specimen holding ring onto the lower half, and connect the two halves of the specimen holding ring with bolts. Pour the encapsulating compound into the annular space between the upper half of the bolted holding ring and the upper half of the specimen (see Fig. 3). Allow the encapsulating compound to cure without disturbance. Remove the spacer plate, and expose the test zone for shear testing.

(e) Discard the specimen if the test zone is contaminated with the encapsulating compound.

8.3 *Soaking of Encapsulated Specimen*—If the shear strength of a saturated specimen is desired, allow the encapsulated specimen to soak in water for at least 48 h before testing. The soaking period can be altered. Soaking is not recommended for rocks that may react with water such as evaporites.

8.4 *Mounting into the Shear Box*—Mount and orient the encapsulated specimen with its top and bottom holding rings in the bottom shear box of the testing machine. Lower the top half of the shear box onto the upper half of the specimen. Remove the bolts that connect the upper and lower halves of the specimen holding rings.

8.5 *Mounting of Displacement Devices*—Place four displacement measuring devices on the lower surface of the testing machine at the four corners of the lower half of the shear box and contacting the upper half of the shear box. These devices are used to measure and record the normal displacement and to provide a check on rotation of the specimen during testing. Mount one displacement device on the machine in such a manner to measure and record the shear displacement of the specimen during the test. Make sure that there is sufficient travel and contact for the device to measure displacements. Zero displacement sensors prior to application of load. Begin recording of shear and normal displacements prior to application of load.

8.6 *Load Application:*

8.6.1 *Seating Load*—Apply a small seating normal load on the order of 450 to 900 N (100 to 200 lb), depending on specimen size. Account for the mass of the normal load system, including the specimen ring and encapsulating compound, when placing a specified normal stress on the specimen. Measure and record load to the nearest 1 %.

8.6.2 *Sliding Friction Test:*

8.6.2.1 *Normal Load*—Continuously increase the load normal to the shear zone at a constant rate until the lowest selected load is attained, and record consequent normal displacements. The normal loading rate should be such that each loading or unloading path takes about five minutes. Do not apply the shear load until normal displacement has stabilized. Maintain a constant normal load (force) during shear testing.

8.6.2.2 *Shear Load*—After the selected normal load has been stabilized, apply the shear load continuously at the selected rate of shear displacement. Typical shear displacement rates are between 0.1 to 0.2 mm/min (0.004 to 0.008 in./min) but may be increased to 0.5 mm/min (0.020 in./min) for determination of residual strength. Special cases, such as clayey infilling, may require shear displacement rates be reduced to 0.05 mm/min (0.002 in./min). A minimum of 10 sets of readings is suggested to be taken before reaching the peak shear strength. After reaching the peak shear strength, loading should continue and readings taken until a residual shear strength is established (Fig. 1). An *X-Y* recorder may be used if continuous readings are required.

8.6.2.3 *Single Stage Shear*—Repeat 8.6.2.1 and 8.6.2.2 using several normal loads on multiple specimens from the discontinuity or test horizon. Each specimen is tested at a specified normal load, with at least three to five specimens required to define the strength envelope.

8.6.2.4 *Multi-Stage Shear*—Repeat 8.6.2.1 and 8.6.2.2 on the same specimen under several normal loads. Two possible techniques are available for performing the multi-stage shear: without repositioning the specimen to its natural position between normal loads before each shearing stage, or with repositioning the specimen to its natural position between normal loads before each shearing stage. Typically, at least three to five different normal loads are required to define the strength envelope. In order to reduce the potential for the effects of specimen degradation and wear, each consecutive stage should be performed with a higher normal load.

8.6.2.5 *Normal Load Increment*—Establish the residual shear strength. This may require reversing the shear load or resetting to account for travel restrictions of the displacement measuring instruments. If performing multi-stage shear, increase the normal load to another level. Again, apply the shear load to establish a second level of peak shear strength and residual shear strength. Bear in mind that with each repetition the surface will be further damaged. Repeat 8.6.2.1 and 8.6.2.2 as required. Prior to each repetition, make sure that adequate travel is available for each displacement device.

8.6.2.6 *Measurements of Normal Displacements*—Measure and record the normal displacements with the four vertical displacement measuring devices at each shear load observation. Compare the four readings and determine possible specimen rotation which would be indicated by differences in the readings of the four devices. Record the normal displacement of the specimen as the average of the four readings. Degree of joint closure and dilation angle can be determined from these measurements.

8.6.2.7 *Measurements of Shear Displacements*—Measure and record shear displacement at intervals of 0.025 or 0.05 mm (0.001 or 0.002 in.), with the horizontal displacement measuring device mounted on the shear box. If available, a computer measurement system should be used with a sampling frequency of 1 Hz or greater.

8.6.3 *Intact Shear Strength Test:*

8.6.3.1 *Normal Load*—Continuously increase normal load at a constant rate until the selected load is attained. Maintain a constant normal load on the shear surface during the test. The normal loading rate should be such that each loading or unloading path takes about five minutes.

8.6.3.2 *Shear Load*—After stabilization of normal load, increase the shear load continuously in such a way as to attain failure. An *X-Y* recorder may be used if continuous readings are required. If available, a computer measurement system should be used with a sampling frequency of 1 Hz or greater.

8.6.3.3 Sliding friction tests (8.6.2) may then be performed.

8.6.3.4 Repeat 8.6.3.1 and 8.6.3.3 on other specimens. The number of specimens to be tested depends upon material availability, however, a minimum of three is recommended.

8.7 *Photographic Record*—Photograph each specimen before and after testing.

NOTE 6—In situations of seismic loading, a specimen may slide back and forth along joints or other discontinuities. Reversed shearing can also occur following vibrations of rock slopes or tunnels that may cause new shear stresses on discontinuities in a direction opposite to the initial shear stress. In such cases, determination of shear strength properties under reversible shear loads may be required.

9. Calculations

9.1 Calculate the nominal cross-sectional areas of test specimens from initial cross-sectional dimensions (see 8.2.1.1 or 8.2.1.2), and express results to the nearest 6.5 mm^2 (0.01 in.^{2}). For specimens that have a test feature, which is not normal to the core axis, the area is determined by:

$$A = \frac{\pi D^2}{4 cos\Theta} \tag{1}$$

where:

D = core diameter, and
Θ = angle of dip measured to the nearest 0.1 degree.

9.2 Calculate the following engineering stresses:

$$\text{Apparent normal stress } \sigma = \frac{P_n}{A} \tag{2}$$

$$\text{Apparent shear stress } \tau = \frac{P_s}{A} \tag{3}$$

where:

P_n = normal load,
P_s = shear load, and
A = nominal initial cross-sectional area (see Note 1).

9.3 Make the following data plots:

9.3.1 Curves to depict relationships of (a) shear stress versus shear displacement, (b) peak shear strength versus normal stress as shown on Fig. 8, and (c) residual shear strength versus shear displacement.

9.3.2 Curves for preselected normal stresses to show the relationships between (a) shear stress versus shear displacement, and (b) normal displacement versus shear displacement as shown in the example plot on Fig. 8.

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

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

10.2 Record as a minimum, the following information:

10.2.1 Source of sample including project name, feature, location, depth, drill hole number and angle, and conditions of storage environment. Also describe how specimens were prepared for storage, handling, and transportation.

10.2.2 Physical description of specimen including material type, and location and orientation (strike, dip) of discontinuities, such as: apparent weakness planes, bedding planes, schistosity, and large inclusions, if any.

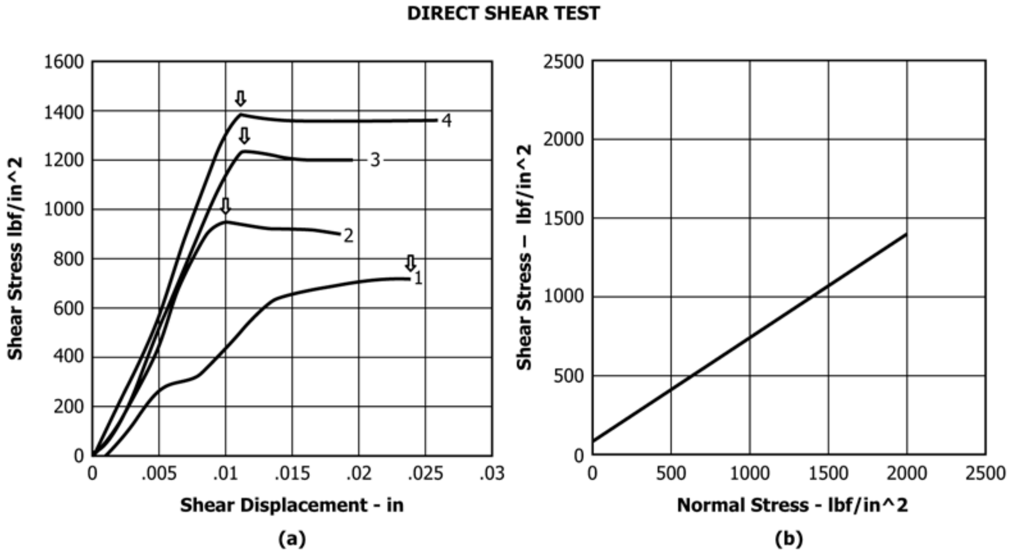
10.2.3 Qualitative indication of the moisture condition of the test specimen at the time of testing, such as, moist, saturated, as-received, laboratory air dry, or oven dry. In some cases, it may be necessary to record the quantitative moisture content as determined using Test Method D2216.

10.2.4 The initial shape and nominal cross-sectional area of the specimen to three significant digits. Include joint roughness coefficient from chart.

10.2.5 Date of sampling and testing.

10.2.6 Name or initials of person(s) performing the sampling, if known, and testing.

10.2.7 The number of specimens tested.



Project:
Feature:
Type:
Spec. no.:
Index no.:
Tested By:
Date Tested:
Area:

NORMAL SHEAR
STRESS STRESS
lbf/in^2 lbf/in^2

DISP
in.

CYCLE
NO.

SLIDING FRICTION RESULTS
S= + (N)
COHESION= lbf/in^2
PHI= deg COR COEF=

FIG. 8 Typical Presentation Sliding Friction Test Results Plots: (a) Shear Stress and Shear Displacement and (b) Shear Strength and Normal Stress

10.2.8 The type of encapsulating material used.

10.2.9 The displacement measuring device readings and reduced displacements to three significant digits.

10.2.10 The applied loads (normal and shear) during testing to three significant digits.

10.2.11 Description of failure, including photographs of the specimen before and after the test.

10.2.12 Tables and graphical plots of individual and combined test results include the following:

(1) Presentation Sliding Friction Test Results (a) Shear Stress and Shear Displacement, and (b) Shear Strength and Normal Stress, recorded to three significant digits.

(2) (a) Shear Stress and Shear Displacement, and (b) Normal Displacement and Shear Displacement, recorded to three significant digits.

11. Precision and Bias

11.1 *Precision*—Test data on precision is not presented due to the nature of the rock 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 in the data is just as likely due to specimen variation as to operator or laboratory testing variation.

11.1.1 The subcommittee D18.12 is seeking any data from the users of this test method that might be used to make a limited statement on precision.

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

12. Keywords

12.1 asperity; direct shear strength; discontinuity; displacement; rock; roughness; sliding friction; stress

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D5607 – 08) that may impact the use of this standard. (December 1, 2016)

(1) Revised 1.1.
(2) Added 1.3 on limits of boundary condition.
(3) Added 1.4 about significant digits.
(4) Added 1.5.
(5) Added section header to 1.6
(6) Added referenced documents to Section 2 including D5079, D6026, and the ISRM Suggested Methods.
(7) Added 3.1.1.
(8) Revised Section 3.
(9) Added 3.2.10.1.
(10) Revised 5.5.
(11) Added 5.6 about sample handling (D5079).
(12) Revised 6.1.
(13) Added 6.3
(14) Revised 6.8.
(15) Added 6.9.
(16) Added 6.10.
(17) Added 6.11.
(18) Removed old Section 7.
(19) Revised 7.1
(20) Revised 7.1.1.
(21) Revised 7.1.2.
(22) Revised 7.2.
(23) Removed old Section 9.
(24) Revised 8.1
(25) Revised 8.2.1.
(26) Revised 8.2.2.
(27) Revised 8.5
(28) Revised 8.6.
(29) Revised 9.1.
(30) Revised 10.1.
(31) Revised 10.2.
(32) Revised 11.1.

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