Designation: ~~D3967 – 16~~ D3967 – 23

Standard Test Method for Splitting Tensile Strength of Intact Rock Core Specimens with Flat Loading Platens[1]

This standard is issued under the fixed designation D3967; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers testing apparatus, specimen preparation, and testing procedures for determining the splitting tensile strength of rock by diametral line compression of disk ~~shape~~shaped specimens.

NOTE 1—The tensile strength of rock determined by tests other than the straight pull test is designated as the "indirect" tensile strength and, specifically, the value obtained in Section 9 of this test is termed the "splitting" tensile strength. This test method is also sometimes referred to as the Brazilian test method.

1.2 *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.

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

1.3.1 The procedures used to specify how data are collected/recorded or 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, the purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering ~~design~~design.

1.4 *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~~safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

[1] 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 ~~Nov. 1, 2016~~May 15, 2023. Published ~~November 2016~~June 2023. Originally approved in 1981. Last previous edition approved in ~~2008~~2016 as ~~D3967 – 08.~~D3967 – 16. DOI: ~~10.1520/D3967-16.~~10.1520/D3967-23.

[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**

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
D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data
E4 Practices for Force Calibration and Verification of Testing Machines
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E2586 Practice for Calculating and Using Basic Statistics

3. Terminology

3.1 *Definitions:*

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

4. Summary of Test Method

4.1 Samples are selected from rock cores or cored from platen samples for testing as described. A section of rock core sample is cut perpendicular to the core axis to produce disk shape specimens until the required number of specimens are obtained. Each specimen is then marked to indicate the desired orientation of the applied loading on the specimen by drawing a diametral line on each end surface ~~on~~of the specimen. Each specimen is positioned inside the testing machine in such a way that ~~diametrical~~ the diametral line is coincidental with the loading axis of the testing machine ~~either curved or flat~~ fitted with flat loading platens. Each specimen is then tested by applying a continuously increasing compressive load until it fails within 1 to 10 minutes of the start of loading.

5. Significance and Use

5.1 By definition, the tensile strength is obtained by the direct tensile test. However, the direct tensile test is difficult and expensive for routine application. The splitting tensile test appears to offer a desirable ~~alternative,~~alternative because it is much simpler and inexpensive. Furthermore, engineers involved in rock mechanics design usually deal with ~~complicated~~complex stress fields, including various combinations of compressive and tensile stress fields. Under such conditions, the tensile strength should be obtained with the presence of compressive stresses to be representative of the field conditions.

5.2 The splitting tensile strength test is one of the simplest tests in which such stress fields occur. Also, by testing across different ~~diametrical directions, possible~~diametral directions, any variations in tensile strength for anisotropic rocks can be determined. Since it is widely used in practice, a uniform test method is needed for data to be comparable. A uniform test is also needed to make sure that the disk specimens break diametrically due to tensile stresses perpendicular to the loading ~~diameter.~~axis.

NOTE 2—The quality of the results 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 *Loading Device*—A device of sufficient capacity to apply and measure the load at a rate conforming to the requirements in ~~8.3~~8.5. It shall be verified at suitable time intervals in accordance with Practices E4 and shall comply with the requirements prescribed therein.

6.1.1 *Bearing Platens*—The loading device shall be equipped with two opposing steel bearing platens having a Rockwell hardness of not less than 58 HRC through which loading is transmitted. The bearing faces shall not depart from a plane by more than 0.0125 mm (0.0005 in.) when the platens are new and shall be maintained within a permissible variation of 0.025 mm. The bearing ~~platens~~platens' diameter shall be at least as great as the specimen's thickness (see Note 3~~Note 3).~~).

6.1.2 *Spherical Seating*—One of the bearing surfaces on the loading device should be spherically seated, and the other one a plain rigid platen. The diameter of the spherical seat shall be at least as large as the test specimen, but the diameter of the ~~sperical~~spherical seat shall not exceed ~~from~~ twice the diameter of the specimen. Center of the sphere in the spherical seat coincides with the center of the loaded side of the specimen. The spherical seat shall be lubricated to ~~assure~~ensure its free movement. The movable part of the platen shall be held closely in the spherical seat, but the design shall be such that the bearing face can be rotated

and tilted through small angles in any direction. If the spherical seat's diameter exceeds twice the diameter of the test specimen, then the spherical seat shall be placed in the locked position with the faces of the bearing platens meeting the requirements of 6.1.1.

6.1.3 *Rigid Seating*—If a spherical seat is not used, then the opposing faces of the loading device bearing platens shall be parallel to 0.0005 mm/mm of the platen diameter. This criterion shall be met when the platens are in the loading device and separated approximately by the diameter of the test specimen.

~~NOTE 3—False platens, due to the contact with abrasive rocks, these platens tend to roughen after a number of specimens have been tested, and hence need to be surfaced from time to time.~~

6.2 *False, Flat ~~or Curved~~ Bearing Platens*—During testing, the specimen can be placed in direct contact with the loading device bearing platens or false platens with bearing faces conforming to the requirements of this standard, may be used (see Fig. 1 for false flat platens). These shall be oil hardened to more than 58 HRC, and surface ground. ~~With contact by abrasive rocks, these platens tend to roughen after a number of specimens have been tested, and hence need to be re-surfaced from time to time.~~

6.2.1 *False Flat ~~Bearing—~~Bearing Platens*—The bearing faces of false flat bearing platens shall not depart from a plane by more than 0.0125 mm (0.0005 in.) when the platens are new and shall be maintained within a permissible variation of 0.025 mm. The bearing platen's diameter shall be at least as great as the specimen thickness.

NOTE 3—The apparatus bearing or false platens, due to the contact with abrasive rocks, these platens tend to roughen after a number of specimens have been tested, and hence need to be surfaced from time to time. Bearing platens can be round or rectangular.

~~6.2.2 *Curved Supplementary Bearing Platens*—These may be used to reduce the contact stresses on the test specimen. The radius of curvature of the supplementary bearing platens shall be so designed that their arc of contact with the specimen will in no case exceed 15° or that the width of contact is less than *D*/6, where *D* is the diameter of the specimen.~~

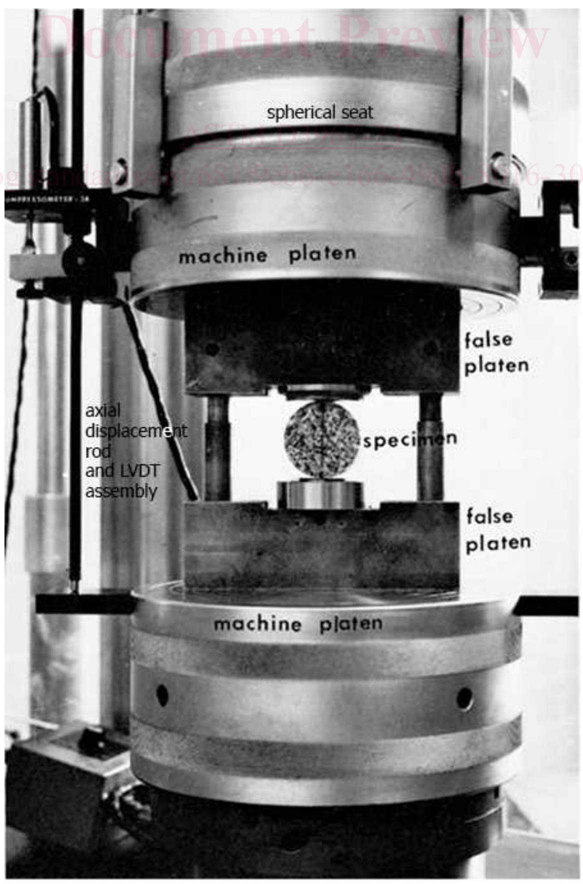

FIG. 1 One Proposed Testing Setup for Splitting Tensile Strength

~~NOTE 4—Since the equation used in 9.1 for splitting tensile strength is derived based on a line load, the applied load should be confined to a very narrow strip if the splitting tensile strength test is to be valid. But a line load creates extremely high contact stresses which cause premature cracking. A wider contact strip can reduce the problems significantly. Studies show that an arc of contact smaller than 15° causes no more than 2 % of error in principal tensile stress while reducing the incidence of premature cracking greatly.~~

6.3 *Bearing Strips (optional)*—~~0.01~~The ~~D~~load ~~thick cardboard cushions, where~~bearing strips shall be ~~D~~made of plywood, free of imperfections, 3 mm thick, width less than 8 % of the specimen diameter and equal in length to the specimen thickness or slightly longer (Fig. 2~~is the specimen's diameter; or up to 6.4 mm (0.25 in.) thick plywood cushions are recommended~~). The use of other sheet wood material, like OSB, MDF, or Hardboard shall not be regarded as non-conformance with this test method, so long as the material is shown to be of the correct hardness for the test specimens and is free of defects and does not significantly affect the test. The bearing strips shall not be reused and can be adhered to the specimen in the correct position as long as the adherent does not significantly affect the test. Load bearing strips are to be placed between the machine bearing surfaces ~~(or supplementary bearing plates; if used)~~ and the specimen to reduce high stress concentration.[3]

NOTE 4—Since the equation used in 9.1 for splitting tensile strength is derived based on a line load, the applied load should be confined to a very narrow strip if the splitting tensile strength test is valid. But a line load creates extremely high contact stresses, which cause premature cracking. A wider contact strip can reduce the problems significantly. Studies show that an arc of contact smaller than 15° causes no more than a 2 % of error in principal tensile stress while reducing the incidence of premature cracking greatly.[3].

NOTE 5—Experience has indicated that ~~test results using the curved supplementary bearing plates and bearing strips, as specified~~ in the range of specimen sizes typical in ~~6.2.2~~ and laboratory testing, ~~6.3, respectively, do not significantly differ from each other, but there may be some consistent difference from the results of tests in which direct contact between the specimen and the machine platen is used.~~an approximately constant value of the splitting tensile strength can be obtained when the relative width of the bearing strip is less than 8 % of the specimen diameter.

6.4 *Miscellaneous*—Camera.

7. Sampling, Test Specimens, and Test Units

7.1 The samples shall be selected by visual observation to include a range of specimens or grouped together based on rock type, mineral constituents, grain sizes and shape, partings, and defects such as ~~pores~~ pores, discontinuities, and fissures.

7.2 *Test Specimens:*

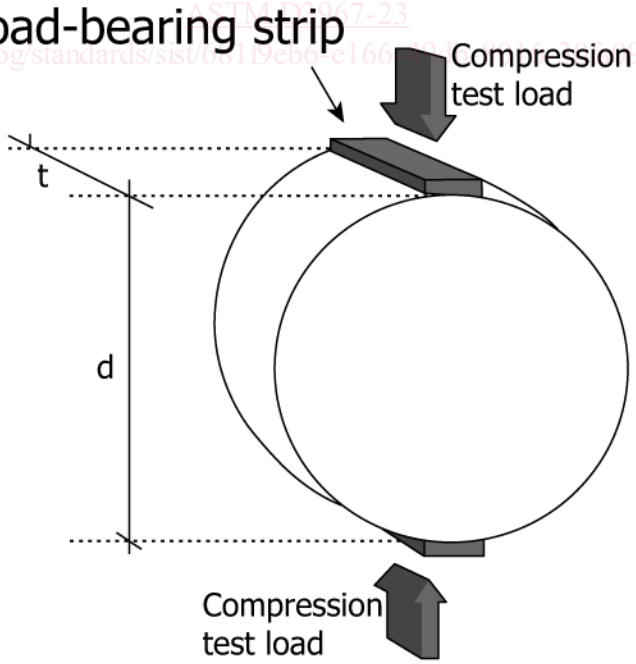

FIG. 2 Optional Load-bearing Strips for Cylindrical Specimens for the Splitting Tensile Strength Test

[3] Size effect and boundary conditions in the Brazilian test Experimental verification, C. Rocco 1, G. V. Guinea2,j. Planas 2 and M. Elices *Materials and Structures/Matriaux et Constructions*, Vol. 32, April 1999, pp 210-217

7.2.1 *Dimensions*—The test specimen shall be a circular disk with a thickness-to-diameter ratio (*t/D*) between 0.2 and 0.75. The diameter of the specimen shall be at least 10 times greater than the largest mineral grain constituent. A diameter of 54 mm (NX core) will generally satisfy this criterion.

NOTE 6—When cores smaller than the specified minimum must be tested because of the unavailability of material, make notation of the fact ~~shall be made~~ in the test report.

NOTE 7—If the specimen shows apparent anisotropic features such as bedding or schistosity, ~~care shall be exercised~~ the user of this standard may be required to exercise care in preparing the specimen so that the test orientation of the ~~loading diameter~~ cross sectional area subject to the load relative to anisotropic features can be determined ~~precisely.~~separately.

7.2.2 *Number of Specimens*—~~At least ten specimens shall be tested to obtain a meaningful average value.~~It is suggested that at least ten tests be performed on the same stratigraphy and isotropic. If the reproducibility of the test results is good (coefficient of variation less than 5 %), a smaller number of specimens is acceptable. More than ten specimens may be required for more complex rock specimens where anisotropy may affect the results and such data is essential to the user. Unless specified by the client, professional judgment shall be exercised to determine the number of specimens necessary to estimate the tensile strength adequately for the intended use of the data.

7.2.3 The circumferential surface of the specimen shall be smooth and straight to 0.50 mm (0.02 in.).

7.2.4 Cut the ends of the specimen parallel to each other and at right angles to the longitudinal axis. The ends of the specimen shall not deviate from perpendicular to the core axis by more than 0.5°. This requirement can be generally met by cutting the specimen with a precision diamond saw.

7.2.5 Determine the diameter of the specimen to the nearest 0.25 mm (0.01 in.) by recording at least three measurements, one of which shall be along the ~~loading diameter,~~ cross sectional area of loading and calculating the average.

7.2.6 Determine the thickness of the specimen to the nearest 0.25 mm (0.01 in.) by recording at least three measurements, one of which shall be at the center of the disk, and calculating the average.

7.2.7 The moisture conditions of the specimen at the time of the test can have a significant effect upon the indicated strength of the rock. The field moisture condition for the specimen shall be preserved until the time of ~~test.~~testing. On the other hand, there may be reasons for testing specimens at other moisture ~~contents, including zero,~~ contents and preconditioning of specimen when ~~moisture control~~a specific moisture content is needed. In any case, tailor the moisture content of the test specimen to the problem at hand and record it in accordance with 10.4.2.

NOTE 8—It is recommended that the moisture condition be more precisely determined when possible and reported as ~~either~~ water content by Test Methods D2216 or degree of saturation.

8. Procedure

8.1 ~~*Marking—*~~*Test Orientation*—The desired ~~vertical~~test orientation of the specimen shall be indicated by marking a diametral line on each end of the specimen. These lines shall be used in centering the specimen in the testing machine to make sure proper orientation, and they are also used as the reference lines for thickness and diameter measurements.

~~NOTE 9—If the specimen is anisotropic, take care to make sure that the marked lines in each specimen refer to the same orientation.~~

8.2 *Optional Bearing Strips*—Add bearing strips on each side of the disc where indicated by the reference line, in accordance with 6.3, when the test specimen surface may not provide a perfect line load. Bearing strips maybe attached with a small amount of adhesive or double stick tape to hold in place.

8.3 Take photographs of each test specimen prior to testing.

NOTE 9—If the specimen is anisotropic, take care to make sure that the marked lines in each specimen refer to the same orientation.

8.4 Set up specimen in the testing machine.