Designation: D 2936 – 95 (Reapproved 2001)$^{\epsilon 1}$

Standard Test Method for Direct Tensile Strength of Intact Rock Core Specimens[1]

This standard is issued under the fixed designation D 2936; 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.

ϵ^1 NOTE—Figure 1 was added editorially in August 2002.

1. Scope

1.1 This test method covers the determination of the direct tensile strength of intact cylindrical rock specimens.

1.2 The values stated in SI units are to be regarded as standard.

1.3 *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:*

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass[2]

D 4543 Practice for Preparing Rock Core Specimens and Determining Dimensional and Shape Tolerances[2]

E 4 Practices for Force Verification of Testing Machines[3]

E 122 Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, the Average for Characteristic of a Lot or Process[4]

3. Summary of Test Method

3.1 A rock core sample is cut to length and its ends are cemented to metal caps. The metal caps are attached to a testing machine and the specimen is loaded in tension until it fails.

4. Significance and Use

4.1 Rock is much weaker in tension than in compression. Thus, in determining the failure condition for a rock structure, many investigators employ tensile strength of the component rock as the failure strength for the structure. Direct tensile stressing of rock is the most basic test for determining the tensile strength of rock.

5. Apparatus

5.1 *Loading Device*, to apply and measure axial load on the specimen, of sufficient capacity to apply the load at a rate conforming to the requirements of 8.2. The device shall be verified at suitable time intervals in accordance with the procedures given in Practices E 4 and shall comply with the requirements prescribed therein.

5.2 *Caps*—Cylindrical metal caps that, when cemented to the specimen ends, provide a means through which the direct tensile load can be applied. The diameter of the metal caps shall not be less than that of the test specimen, nor shall it exceed the test specimen diameter by more than 1.10 times. Caps shall have a thickness of at least 30 mm (1¼ in.). Caps shall be provided with a suitable linkage system for load transfer from the loading device to the test specimen. The linkage system shall be so designed that the load will be transmitted through the axis of the test specimen without the application of bending or torsional stresses. The length of the linkages at each end shall be at least two times the diameter of the metal end caps. One such system is shown in Fig. 1.

NOTE 1—Roller of link chain of suitable capacity has been found to perform quite well in this application. Because roller chain flexes in one plane only, the upper and lower segments should be positioned at right angles to each other to effectively reduce bending in the specimen. Ball-and-socket, cable, or similar arrangements have been found to be generally unsuitable as their tendency for bending and twisting makes the assembly unable to transmit a purely direct tensile stress to the test specimen.

6. Sampling

6.1 Select the specimen from the cores to represent a valid average of the type of rock under consideration. This can be achieved by visual observations of mineral constituents, grain sizes and shape, partings, and defects such as pores and fissures, or by other methods such as ultrasonic velocity measurements.

7. Test Specimens

7.1 *Preparation*—Prepare test specimens in accordance with Practice D 4543, except that the degree of flatness and smoothness of the specimen ends is not critical. End surfaces, such as result from sawing with a diamond cutoff wheel, are

[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 June 15, 1995. Published August 1995. Originally published as D 2936 – 71. Last previous edition D 2936 – 84 (1989)$^{\epsilon 2}$.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vols 03.01.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

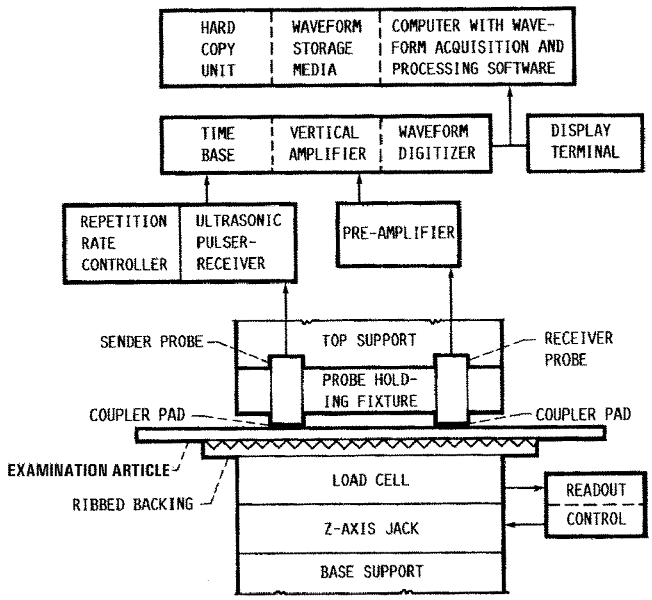

FIG. 1 Direct Tensile Strength Test Assembly

entirely adequate. Grinding, lapping, or polishing beyond this point serves no useful purpose, and in fact, may adversely affect the adhesion of the cementing medium.

7.2 Water content of the specimen at the time of test can have a significant effect upon the deformation of the rock. Good practice generally dictates that laboratory tests be made upon specimens representative of field conditions. Thus, it follows that the field water content of the specimen should be preserved until the time of test. On the other hand, there may be reasons for testing specimens at other water contents, including zero. In any case, the water content of the test specimen should be tailored to the problem at hand and reported in accordance with 10.1.6. If the water content of the specimen is to be determined, follow the procedures given in Test Method D 2216.

7.3 If water content is to be maintained, and the elevated temperature enclosure is not equipped with humidity control, seal the specimen using a flexible membrane or apply a plastic or silicone rubber coating to the specimen sides.

8. Procedure

8.1 Cement the metal caps to the test specimen to ensure alignment of the cap axes with the longitudinal axis of the specimen (see Note 2). The thickness of the cement layer should not exceed 1.5 mm (1⁄16 in.) at each end. The cement layer must be of uniform thickness to ensure parallelism between the top surfaces of the metal caps attached to both ends of the specimens. This should be checked before the cement is hardened (see Note 2) by measuring the length of the end-cap assembly at three locations 120° apart and near the edge. The maximum difference between these measurements should be less than 0.10 mm (0.005 in.) for each 25.0 mm (1.0 in.) of specimen diameter. After the cement has hardened sufficiently to exceed the tensile strength of the rock, place the specimen in the testing machine, making certain that the load transfer system is properly aligned.

NOTE 2—In cementing the metal caps to the test specimens, use jugs and fixtures of suitable design to hold the caps and specimens in proper alignment until the cement has hardened. The chucking arrangement of a machine lathe or drill press is also suitable. Epoxy resin formulations of rather stiff consistency and similar to those used as a patching and filling compound in automobile body repair work have been found to be a suitable cementing medium.

8.2 Apply the tensile load continuously and without shock to failure. Apply the load or deformation at an approximately constant rate such that failure will occur in not less than five nor more than 15 min. Note and record the maximum load carried by the specimen during the test.

NOTE 3—In this test arrangement failure often occurs near one of the capped ends. Discard the results for those tests in which failure occurs either partly or wholly within the cementing medium.

9. Calculation

9.1 Calculate the tensile strength of the rock by dividing the maximum load carried by the specimen during the test by the cross-sectional area; express the result to the nearest 35.0 kPa (5 psi).

10. Report

10.1 Report the following information:

10.1.1 Source of sample including project name and location, and if known, storage environment (often location is frequently specified in terms of the borehole number and depth of specimen from the collar of the hole),

10.1.2 Physical description of the sample including: rock type, location and orientation of apparent planes, bedding planes, and schistosity; and large inclusions or inhomogeneities, if any,

10.1.3 Date of sampling and testing,

10.1.4 Specimen length and diameter, also conformance with dimensional requirements,

10.1.5 Rate of loading or deformation rate,

10.1.6 General indication of water condition of sample at time of test, such as, as-received, saturated, laboratory air dry, or oven dry (it is recommended that the moisture condition be more precisely determined when possible and reported as either water content or degree of saturation,

10.1.7 Direct tensile strength for each specimen as calculated, average direct tensile strength of all specimens, standard deviation, or coefficient of variation,

10.1.8 Type and location of failure (a sketch of the fractured specimen is recommended), and

10.1.9 Other available physical data.

NOTE 4—The number of specimens tested may depend upon the availability of specimens, but normally a minimum of ten is preferred. The number of specimens tested should be indicated. The statistical basis for relating the number of specimens to the variability of measurements is given in Practice E 122.

11. Precision and Bias

11.1 *Precision*—Due to the nature of the rock materials tested by this test method, it is, at this time, either not feasible or too costly at this time to produce multiple specimens which have uniform mechanical properties. Therefore, since specimens which would yield the same test results cannot be tested, Subcommittee D18.12 cannot determine the variation between tests since any variation observed is just as likely to be due to specimen variation as to operator or laboratory testing variation. Subcommittee D18.12 welcomes proposals to resolve this problem that would allow for development of a valid precision statement.

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

12. Keywords

12.1 loading tests; rock; tension (tensile) properties/tests; tensile strength