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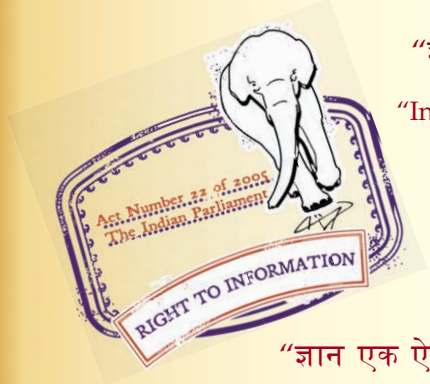

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Indian Standard

METHOD OF TEST FOR DETERMINATION OF TENSILE STRENGTH BY INDIRECT TESTS ON ROCK SPECIMENS

UDC 691·2 : 620·172

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 3

November 1982

Indian Standard

METHOD OF TEST FOR DETERMINATION OF TENSILE STRENGTH BY INDIRECT TESTS ON ROCK SPECIMENS

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Indian Standard

METHOD OF TEST FOR DETERMINATION OF TENSILE STRENGTH BY INDIRECT TESTS ON ROCK SPECIMENS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 24 December 1981, after the draft finalized by the Soil Engineering and Rock Mechanics Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 In order to assess the various properties of rock, Indian Standards covering standard method of tests are being formulated and this standard covers methods of tests for tensile strength. Because of difficulties in conducting a direct uniaxial tensile strength test, methods of indirect determination of tensile strength of rocks have become popular. Several such indirect methods are available. Brazilian test, though strictly not uniaxial in nature, has become quite widely known because the values obtained are comparable with those of direct tests. Ring test has come into vogue in order to initiate fracture from the centre of the specimen, which may be not so in some rocks and is also considered to be more appropriate from fracture mechanics view-point. While these two tests are conducted on cylindrical rock specimens, the line load test is used for testing rock prisms. The point load test may also be used for testing rock prisms and is also considered to be reliable. In a given project, it is preferable to use only one of these methods for evaluation of tensile strength, as it is highly dependent of the type of test, as well as the size of the specimen.

0.3 In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard covers the methods for the determination of tensile strength of rocks by indirect tests on rock specimens, namely, Brazilian Test, Ring Test, Point Load Test and Line Load Test.

*Rules for rounding off numerical values (*revised*).

1.2 The tests may be carried out either in the laboratory or at the drilling site.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Core — It is any single solid cylindrical piece of rock obtained from drilling process.

2.2 Disc — It is any single circular solid piece cut out of the rock core.

2.3 Ring — It is any single circular solid piece cut out of the rock core which has a central hole of specified radius.

2.4 Rock-Prism — It is any single solid prism of rock cut out of rock.

2.5 Tensile Strength — It is the maximum tensile stress at failure. However, it is not unique characteristic of a brittle material and is dependent upon the type of test and the size of specimen.

3. PREPARATION OF SAMPLES

3.1 The specimen shall be selected to represent a true average of the type of rock under consideration and shall be prepared as per IS : 9179-1979*.

3.2 In the laboratory, the rock specimens shall be obtained from the same block of rock as on site and drilled in the same direction.

3.3 In the field, the rock specimen shall be obtained from the same bore hole, and geological horizon and within the shortest possible difference in their elevations in the bore holes.

3.4 The diameter of the disc and ring specimens for the Brazilian Test and Ring Test respectively, shall not be less than 45 mm and thickness shall be approximately equal to half the diameter.

3.5 The inner radius of the ring in the ring test shall be approximately one tenth of the outer radius.

3.6 The hole in a core for the ring test shall be made by drilling on a lathe machine. Then the core shall be cut showly and carefully by a diamond saw to the required thickness.

*Method for preparation of rock specimen for laboratory testing.

3.7 The side of the square rock-prism to be used in the line load test shall not be less than 50 mm. The thickness of square prism should be about two-third of the side of the square base.

3.8 The diameter of the cores for point load test shall not be more than 35 mm and not less than 12 mm. The length of core shall be more than its diameter. For the point load test on rock-prism the length shall be greater than its width. The irregular shaped specimen shall be roughly egg shaped with the ratio of largest to shortest diameter of about 1·5 : 1 and volume of about 100 cm^3 obtained by breaking lumps of rock. The difference in mass of different specimens should be less than 2 percent.

3.9 The total number of specimens should be such that at least 10 tests of any one of the types under consideration are possible.

3.10 The specimens may be air dried in open air for 15 to 20 days after their preparation and then tested. If the test is to be performed on saturated rock, the specimens should be saturated carefully before performing the tests.

3.11 The dimensions of the test specimens shall be measured to the nearest 0·1 mm. The thickness of the disc, ring or prism shall be measured at or near the centre.

4. BRAZILIAN TEST

4.1 Apparatus

4.1.1 Two steel loading jaws designed so as to contact a disc shaped rock samples at diametrically opposed surfaces over an arc of contact of about 10° at failure (*see* Fig. 1). The critical dimensions of the apparatus are the radius of curvature of the jaws, the clearance and length of the guide pins coupling the two curved jaws and the width of the jaws. Radius of jaws shall be 1·5 times specimen radius. Guide pin clearance shall be such as to permit rotation of one jaw relative to the other by 4×10^{-3} radians out of plane of the apparatus (25 mm penetration of guide pin with 0·1 mm clearance). The width of jaws shall be 1·1 times the specimen thickness. The remaining dimensions shall be as scaled from Fig. 1. The upper jaw contains a spherical seating conveniently formed by a 25 mm diameter half ball bearing.

4.1.2 Double thickness (0·2 to 0·4 mm) adhesive paper strip (masking tap) with a width equal to or slightly greater than the specimen thickness.

4.1.3 A suitable machine for applying and measuring compressive loads to the specimens. It shall be of sufficient capacity and be capable of applying loads at a rate conforming to the requirement set out.

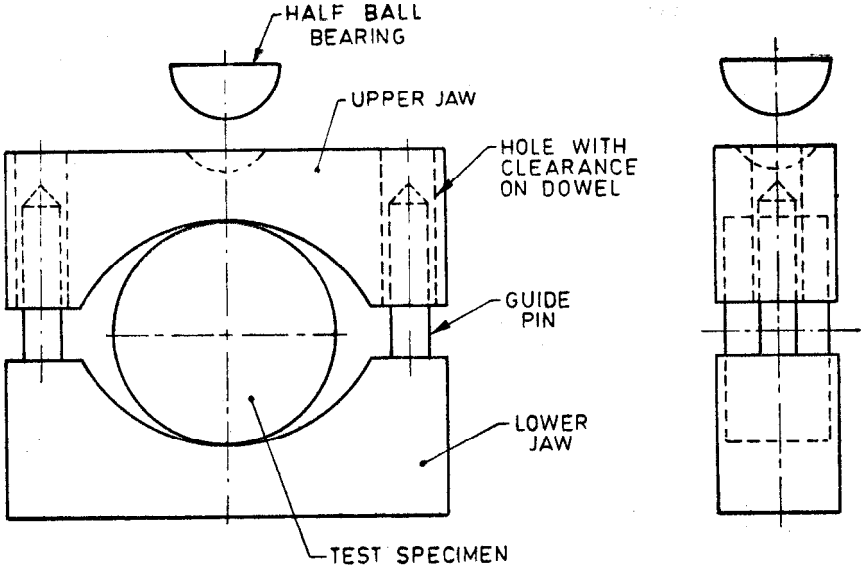


FIG. 1 APPARATUS FOR BRAZILIAN TEST

4.1.4 A spherical seat, if any, of the testing machine shall be placed in a locked position, the two loading surfaces of the machine being parallel to each other.

4.1.5 It is preferable but not obligatory that the testing machine be fitted with a chart recorder to record load against displacement to aid in the measurement of failure load.

4.2 Testing Procedure

4.2.1 The test specimen shall be wrapped around its periphery with one layer of the adhesive paper tape and mounted squarely in the test apparatus such that the curved platens load the specimen diametrically with the axes of rotation for specimen and apparatus coincident.

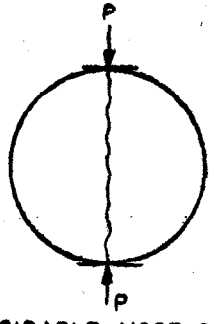
4.2.2 Load on the specimen shall be applied continuously at a constant rate such that failure in the weakest rocks occurs within 15 to 30 seconds. A loading rate of 200 N/s is recommended.

4.2.3 The maximum load on the specimen shall be recorded in Newtons with one percent accuracy.

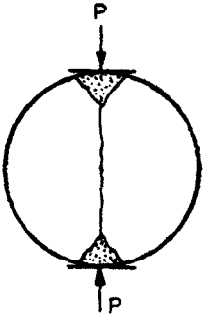
4.2.4 Where the testing machine is fitted with a force/displacement recorder, a record should be taken during testing so that the load for primary fracture can be precisely determined (in some cases load continues to increase after primary failure as the split specimen is still bearing load). If a load/displacement recorder is not available on the testing machine, care shall be taken by the operator to detect the load at primary failure. At primary failure, there shall be a brief pause in the motion of the indicator needle. However, the difference between the load of primary failure and ultimate load bearing capacity is at the most only 5 percent.

4.3 Mode of Failure

4.3.1 The correct mode of failure is vertical splitting starting from the centre towards loading points. This failure mode is an indication of a successful test (*see* Fig. 2).

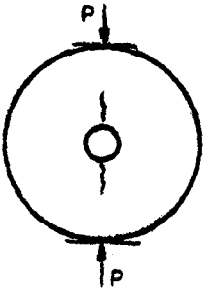


DESIRABLE MODE OF FAILURE

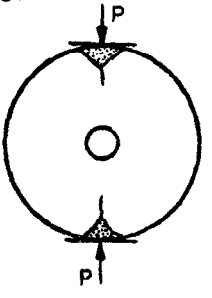


UNDESIRABLE MODE OF FAILURE

2A BRAZILIAN TEST



DESIRABLE MODE OF FAILURE



UNDESIRABLE MODE OF FAILURE

2B RING TEST

FIG. 2 MODES OF FAILURE

4.3.2 In a few cases, failure may initiate from loading points, with formation of wedges (*see* Fig. 2). This undesirable mode of failure may be due to lack of load distribution on 10° arc. In such cases, instead of Brazilian test, a ring test may be performed.

4.4 Calculation

4.4.1 Tensile strength of rock shall be calculated from the following expression provided the mode of failure is as indicated in **4.3.1**.

$$q_t = \frac{2P}{\pi Dt} \ldots\ldots (1)$$

where

q_t = Tensile strength in MN/m²,

P = Load at failure in Newtons,

D = Diameter of test specimen in mm, and

t = Thickness of test specimen measured at the centre in mm.

5. RING TEST

5.1 Apparatus and Procedure

5.1.1 The apparatus shall be the same as for the Brazilian Test (*see* **4.1**).

5.1.2 The procedure as given in **4.2** shall be followed.

5.2 Mode of Failure

5.2.1 The ring test is considered to have ideal condition from fracture mechanics consideration.

5.2.2 The chances of vertical splitting increase considerably in the ring test because the central hole acts as a stress raiser. The cracks initiate from top and bottom of the hole and propagate towards loading points (*see* Fig. 2).

5.2.3 In a few cases, fractures may initiate from loading points. In such cases, the diameter of the hole should be increased slightly so that the hole acts effectively as a stress raiser.

5.3 Calculation

5.3.1 The tensile strength of rock shall be calculated from the following expression if the mode of failure is as indicated in **5.2.2**.

$$q_t = \frac{2P\,[\,6+38\,(\,Do/D\,)^2\,]}{\pi Dt}$$

where 'D', 'Do' are outer and inner diameters of ring in mm, and q_t, P, t are same as specified in **4.4.1**.

6. LINE LOAD TEST

6.1 Apparatus

6.1.1 The apparatus shall have two flat loading platens with sufficient loading capacity.

6.1.2 Packings of steel bar of square cross-section, 12 mm side and a double layer of adhesive paper tape shall be used at top and bottom. The packings shall be of width equal to one-twelfth of the side of a square-prism.

6.1.3 The line load test is suited to test rock-prism of building materials.

6.2 Testing Procedure

6.2.1 The square prism shall be laid horizontally, the thickness shall be parallel to the loading platens (*see* Fig. 3).

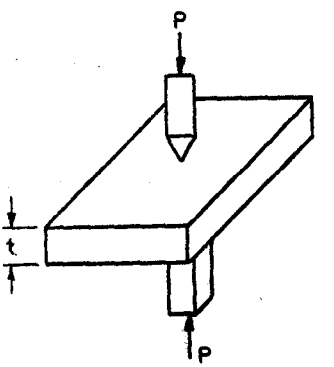


FIG. 3 POINT LOAD TEST ON ROCK-PRISM

6.2.2 The load on the specimen shall be applied continuously at a constant rate of about 200 N/s. The maximum load shall be recorded with one percent accuracy.

6.3 Calculation

6.3.1 The tensile strength of rock shall be calculated from the following expression (*see* Fig. 4).

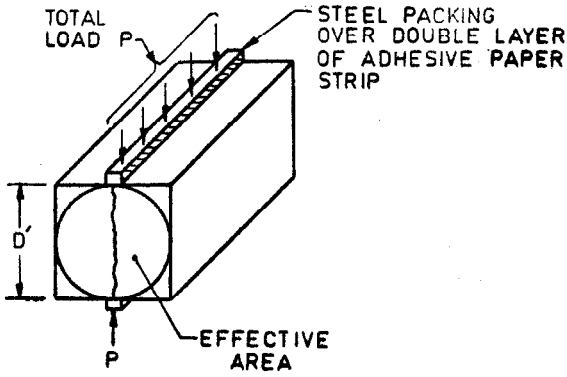


FIG. 4 LINE LOAD TEST ON ROCK-PRISM

a) For the case where specimen is supported on packing of steel bar

$$q_t = \frac{0{\cdot}98 \times 2P}{\pi D' t}$$

b) For the case where the specimen rests directly on the lower platen

$$q_t = \frac{P}{\pi D'_t}$$

where D' is the side of square base in mm, and q_t, P and 't' are same as specified in **4.4**.

7. POINT LOAD TEST

7.1 Apparatus

7.1.1 The apparatus used for point load test is given in IS : 8764-1978*.

7.1.2 The point load test is the only test suitable for field testing of cores because there is no need of cutting or finishing the ends of the core.

*Method for determination of point load strength index of rocks.

7.2 Test Procedure

7.2.1 The testing procedure is same as given in IS : 8764-1978*.

7.3 Calculation

a) The tensile strength of the rock cores shall be calculated from the following expression:

$$q_t = 0{\cdot}96\, P/D^2$$

b) The tensile strength of rock prisms shall be obtained from the following expression:

$$q_t = \frac{0{\cdot}70\, P}{W D}$$

c) The tensile strength of irregular shaped specimens shall be obtained by either of the following equations:

$$q_t = \frac{P}{V^{2/3}} \text{ or } \frac{9P}{D^2}$$

where

D = Distance between the loading points in mm;

V = volume of specimen in mm^3;

W = width of the specimen (lesser of the base dimension) in mm; and q_t P are same as specified in **4.4.1**.

8. REPORTING OF TEST RESULTS

8.1 The report of tests shall include the following information:

a) Lithologic description of the rock;

b) Orientation of the axis of loading with respect to specimens anisotrophy, for example, bedding planes, foliations, etc;

c) Source of sample, including geographic location, depth and orientation, dates and method of sampling and storage history and environment;

d) Type of indirect tensile strength test;

e) Number of specimens tested;

*Method for determination of point load strength index of rocks.

f) Specimen diameter and height;

g) Water content and degree of saturation at the time of test;

h) Test duration and stress rate;

j) Date of testing and type of testing machine;

k) Mode of failure; and

m) Any other observations or available physical data such as specific gravity, porosity and permeability citing the method of determination for each.

8.2 The tensile strength for each specimen in the sample, expressed to three significant decimal places together with the average result for the same.