IS 13047 (1991): Method for determination of strength of rock materials in triaxial compression [CED 48: Rock Mechanics]

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IS 13047 : 1991
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भारतीय मानक

त्रिजक्षीय संवीडन में शैल सामग्री की सामथ्र्य ज्ञात करने की पद्धति

Indian Standard

METHOD FOR DETERMINATION OF STRENGTH OF ROCK MATERIALS IN TRIAXIAL COMPRESSION

UDC 624·121·439·4

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Price Group 2

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TO
IS 13047:1991 METHOD FOR DETERMINATION OF STRENGTH OF ROCK MATERIALS IN TRIAXIAL COMPRESSION

(*Page* 3, *Fig* 3) — Substitute following for the existing figure

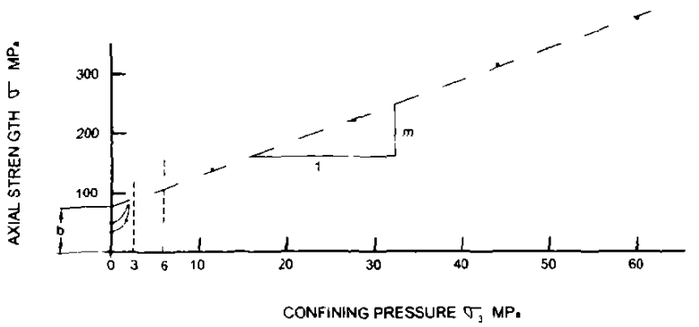


FIG 3 STRENGTH ENVELOPE

(*Page* 3, *clause* **6.3**, *line* 8) — Substitute 'axial strength' *for* 'axial stress'

(*Page* 3, *clause* **6.4**, *formulae*) — Substitute

$$\text{'sin}^{-1}\left\{\frac{m-1}{m+1}\right\}\text{'} \quad \textit{for} \quad \text{'arc sin}\ \frac{m-1}{m+1}\text{'}$$

Reprography Unit, BIS, New Delhi, India

Rock Mechanics Sectional Committee, CED 48

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Rock Mechanics Sectional Committee had been approved by the Civil Engineering Division Council.

Natural rock formations are in triaxially stressed state and the strength characteristic of rock under such a state is important in calculating the bearing capacity of foundation of rock and is also useful in slope stability analysis. This standard is based on the suggested method of International Society of Rock Mechanics.

In reporting the results of a test or analysis 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 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

METHOD FOR DETERMINATION OF STRENGTH OF ROCK MATERIALS IN TRIAXIAL COMPRESSION

1 SCOPE

1.1 This standard covers the mothod for determination of strength of cylindrical rock specimens subjected to triaxial compression. This test provides Individual points on the failure (peak strength) envelope from several tests. From this the value of the internal friction angle ϕ and the apparent cohesion C may be obtained.

1.2 This standard does not cover (a) the multiple failure state test, and (b) the continuous failure state test wherein the failure envelope is produced with a single test employing a stepwise or continuous procedure.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard.

IS No.	*Title*
1586 : 1968	Methods for Rockwell hardness test (B and C scales)
9179 : 1979	Method for preparation of rock specimen for laboratory testing

3 APPARATUS

3.1 The apparatus consists mainly of three parts (Fig. 1) : a triaxial cell, a loading device and a device for generating confining pressure.

3.2 A Triaxial Cell

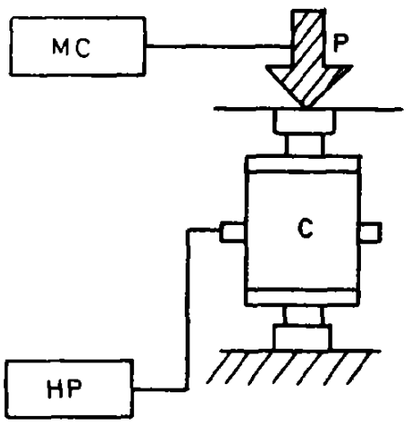
This comprises:

a) A triaxial cell to apply confining pressure to the specimen. The design of a simple triaxial cell made of suitable material capable of withstanding design pressure is schematically shown in Fig. 2. The body of the cell shall have an air bleeder valve, suitable entry port for filling the cylinder with hydraulic fluid, outlets for pore pressure measurement and/or drainage and electrical outlets for strain gauge instrumentation.

b) Platens having a Rockwell Hardness of not less than HRC 30 (*see* IS 1586 : 1968) for placing at both ends of the specimen, the diameter of the platens shall be between D and 1·02 D, where D is the diameter of the specimen. The thickness of the platens shall be at least 15 mm or D/3. Surfaces of the platens shall be ground and these shall not depart from plane surfaces by more than +0 005 mm.

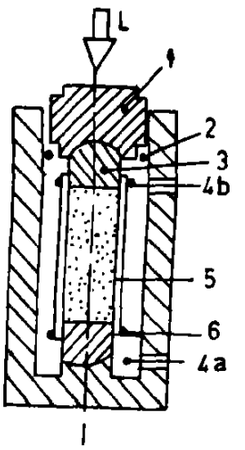
c) The top platen which shall incorporate a spherical seat. The centre of curvature of the spherical seat should coincide with the centre of the top surface of the specimen. The spherical seat shall be lightly lubricated with mineral oil. The specimen, the platens and the spherical seat shall be accurately central with respect to one another.

d) A flexible membrane of suitable material (like neoprene or butyl rubber or any other), to prevent the hydraulic fluid from entering the specimen. The membrane shall not penetrate significantly into the surface pores and it shall be sufficiently long to extend well on to the platens. When slightly stretched, it shall be of the same diameter as the specimen. When strain gauged specimens are tested, a moulded silicon rubber membrane is satisfactory.



P = Testing machine
MC = Control unit for applying and controlling axial load
C = Triaxial cell
HP = Equipment for generating and controlling confining pressure

FIG. 1 BLOCK DIAGRAM SHOWING TEST ARRANGEMENT FOR DETERMINING THE TRIAXIAL COMPRESSIVE STRENGTH



1 Loading piston
2 Seals
3 Platens with spherical seating
4a Hydraulic connection
4b Bleeder hole
5 Flexible membrane
6 O-ring clamps
L Load applied by the loading device

FIG. 2 TYPICAL DESIGN FOR TRIAXIAL CHAMBER

3.3 A Loading Device for Applying and Controlling Axial Load

a) A suitable loading machine shall be used for applying, controlling and measuring the axial load on the rock specimen. It shall be of sufficient capacity and capable of applying load at a rate conforming to the requirements set out in **5.6** It shall be verified and calibrated at suitable time intervals depending upon the workload. The two loading faces of the machine shall be parallel to each other. The spherical seat of the loading machine, if any, shall also satisfy the requirements *laid down under* **3.2** *(c) above.*

3.4 Device for Generating and Measuring the Confining Pressure

This includes the following:

a) A hydraulic pump or pressure intensifier or some other system of sufficient capacity and capable of maintaining constant confining pressure within 2 percent of the desired value.

b) A pressure indicating device (pressure gauge or pressure transducer) which shall be accurate to ± 2 percent.

4 PREPARATION OF THE TEST SPECIMEN

4.1 The specimen shall be prepared according to IS 9179 : 1979.

4.2 Tbe moisture content of the specimen shall be as close to the field condition as possible.

4.3 Shape and Dimension of the Specimen

4.3.1 Test specimen shall be a right circular cylinder.

4.3.2 The length to diameter ratio of the test specimen shall preferably between 2 to 3

4.3.3 The diameter of the specimen shall not be less than ten times the largest mineral grain in the rock and preferably not less than NX size (approximately 54 mm) .

4.3.4 Ends of the specimen shall be flat to 0·02mm and shall not depart from perpendicularity to the longitudinal axis of the specimen by more than 0 001 radians (about 3·5 minutes) or 0·05 mm in 50 mm.

4.3.5 The cylindrical surface shall be smooth and free from abrupt irregularities and straight to within 0 3 mm over the full length of the specimen. The dimensions of the specimen shall not vary by more than 0·2 mm over the length of the specimen.

4.3.6 The diameter of the test specimen shall be measured to the nearest 0 1 mm by averaging two diameters measured at right angles to each other at about the upper height, the mid height and the lower height of the specimen. It shall not vary by more than 0 3 mm, over the length of the specimen The average diameter shall be used for calculating the cross sectional area. The height of the specimen shall be determined to the nearest 1 0 mm.

4.3.7 The core shall be given a specimen number and marked with *in-situ* orientation.

5 TEST PROCEDURE

5.1 The cell shall be assembled with the specimen aligned between steel platens and surrounded by the flexible membrane. The specimen, the platens and the spherical seat shall be accurately aligned so that each is coaxial with the others.

5.2 The spherical seat shall be lightly lubricated with mineral oil.

5.3 The cell shall be filled with hydraulic oil, allowing the air to escape through an air bleeder valve. The air bleeder valve shall than be closed.

5.4 The cell shall be placed into the axial loading device.

5.5 The axial load and the confining pressure should be increased simultaneously and in such a way that axial stress and confining pressure be approximately equal, until the predetermined test level for the confining pressure is reached. Subsequently the confining pressure shall be maintained within 2 percent of the prescribed value.

5.6 The axial load on the test specimen shall then be increased continuously and without shock to produce an approximately constant rate of load or deformation; such that failure will occur within 5 to 15 minutes of initiation of loading if carried to failure Alternatively the stress rate shall be within the limits of 0·5 to 1·0 MPa/s. The axial failure load shall be measured within 1 percent accuracy.

5.7 The maximum axial load and the corresponding confining pressure on the specimen shall be recorded.

5.8 The axial displacement shall be measured to an accuracy not less than 0 5 percent.

5.9 The number of specimens to be tested, as well as, the number of different confining pressure values should be determined from practical considerations. *However, at least five specimens per* rock sample are preferred.

6 CALCULATIONS

6.1 The compressive strength of the specimen shall be calculated by dividing the maximum axial load, applied to the specimen during the test, by the original cross sectional area of the specimen.

6.2 The confining pressures and the corresponding strength values for different specimen as worked out in **6.1**, are plotted with the confining pressures as abscissa and strength as ordinates (*see* Fig 3) .

6.3 A strength envelope is obtained by fitting a mean curve to the above points. From practical considerations it may be advisable to fit a straight line to only the most relevant part of the curve or to fit several straight lines to different parts of the curve. Each straight line is characterised by calculating its gradient m (tangent of the inclination) its intercept b on the vertical (axial stress) axis (*see* Fig. 3) . In each case the range of confining pressure in which the respective straight line is valid shall be shown on the abscissa.

6.4 Using parameters m and b, the angle of internal friction ϕ and a value for the apparent cohesion c (in the sense of coulomb's failure theory) may be calculated using the formulae:

$$\phi = \text{arc sin}\frac{m-1}{m+1}$$

$$c = b\ \frac{1-\sin\phi}{2\cos\phi}$$

7 REPORT

7.1 The report shall give a plot of axial strength versus confining pressure as discussed in **6.2** (Fig. 3), along with the values of apparent cohesion c and angle of internal friction ϕ citing the range of confining pressures in which they are valid.

7.2 The report of test shall also include the following information:

a) Lithologic description of rock.

b) Orientation of the axis of loading with respect to anisotropy, bedding planes, foliations, etc.

c) Source of sample, location, depth, orientation and date of sampling.

d) Storage history and environment.

e) Moisture content of sample and room temperature at the time of the test.

f) Duration of the test and stress rate.

g) Date of testing and type of machine used.

h) Number of specimens tested.

j) Mode of failure of each specimen (with sketch showing failure pattern).

k) Other physical properties such as specific gravity, absorption, permeability and porosity, citing the Indian Standard available for the determination of the above properties.

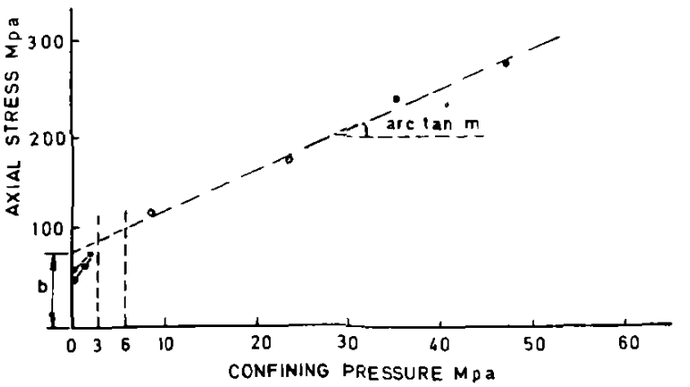


FIG. 3 STRENGTH ENVELOPE

m) Should it be necessary to test specimens of shape other than cylindrical, suitable mention of these facts shall be made in the report.

n) A table giving specimen number, specimen height, specimen diameter, confining pressure and the corresponding axial strength to three significant figures.

p) Any other observation.

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