IS 12634 (1989): Method of determination for direct shear strength of rock joints [CED 48: Rock Mechanics]

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IS 12634 : 1989
Reaffirmed 2010

Indian Standard

ROCK JOINTS − DIRECT SHEAR STRENGTH− LABORATORY METHOD OF DETERMINATION

भारतीय मानक

शिला जोड़ — प्रत्यक्ष अपरूपण सामर्थ्य — प्रयोगशाला में ज्ञात करने की पद्धति

UDC 624·121·37 : 624·131·439·5

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
. NEW DELHI 110002

August 1989 Price Group 2

AMENDMENT NO. 1 DECEMBER 2007
TO
IS 12634 : 1989 ROCK JOINTS — DIRECT SHEAR STRENGTH — LABORATORY METHOD OF DETERMINATION

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

'SHEAR STRESS' *for* 'SHEAR STRENGTH' in the title of τ-axis,

'0.8 MPa' *for* '0.8 MPa/mm^2', and

'2.5 MPa' *for* '2.5 MPa/mm^2'.

(*Page* 4, *clause* 7.3, *lines* 2 *and* 4) — Substitute 'Normal Force (P_n)' *for* 'Total normal stress (P_n)' *and* 'Shear Force (P_s)' *for* 'Total shear stress (P_s)' respectively.

(*Page* 4, *Fig.* 4) — Substitute 'SHEAR STRENGTH' *for* 'SHEAR STRESS'.

(*Page* 4, *clause* 8.1, *Note*, *line* 2) — Substitute 'correlation' *for* 'co-relation'.

(CED 48)

Reprography Unit, BIS, New Delhi, India

Rock Mechanics Sectional Committee, BDC 73

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards on 16 January 1989, after the draft finalized by the Rock Mechanics Sectional Committee had been approved by the Civil Engineering Division Council.

The direct shear strength measured in the laboratory can be used to realistically assess the strength of rock joints. This test measures the peak and residual direct shear strength of rock joint samples as a function of stress normal to the shearing plane. The results of this test can be used directly in the stability analysis only if the type and size of roughness irregularities of the tested plane are similar to those obtained in the field on a larger scale. If this is not the case, then the laboratory value of peak strength should be suitably modified. IS 11315 (Part 4) : 1987 'Method for the quantitative descriptions of discontinuities in rock masses : Part 4 Roughness' may be referred for non-linear shear strength criteria of joints.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the results of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ROCK JOINTS — DIRECT SHEAR STRENGTH — LABORATORY METHOD OF DETERMINATION

1 SCOPE

1.1 This standard covers a laboratory method for determination of direct shear strength of rock joints.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
IS 11315 (Part 4) : 1987	Method for the quantitative description of discontinuities in rock mass : Part 4 Roughness
IS 11358 : 1987	Glossary of terms and symbols relating to rock mechanics

3 TERMINOLOGY

3.1 For the purpose of this standard, the definitions given in IS 11358 : 1987 shall apply.

4 APPARATUS

4.1 Suitable materials to protect the specimen from mechanical damage and to maintain the water content both during cutting and transit to the laboratory, such as, protective packing and wax, or other similar water proofing materials. Suitable materials are also required for holding the specimen together, such as, binding wire or metal band.

4.2 Equipment for specimen preparation should include core drills, percussive drills of suitable diameter, rock saws, chisels and hammers for cutting the specimen and the equipment for measuring the dip, direction, roughness and other characteristics of the test horizon.

4.3 Equipment for mounting the specimen should include specimen carriers forming a dismountable part of the test equipment, mixing utensils along with strong encapsulating material, such as, cement, plaster or resin.

4.4 Test Equipment

Along with the shear box (*see* Fig. 1), the test system should comprise the following :

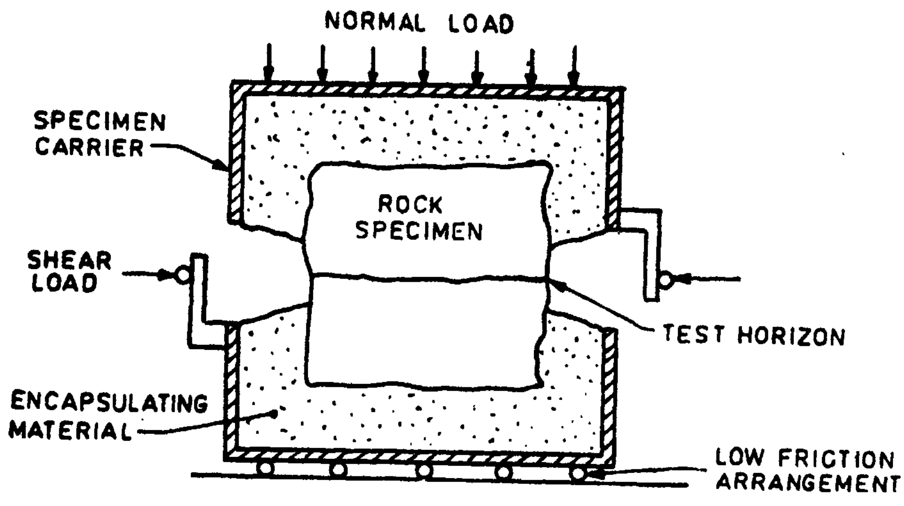

Fig. 1 Arrangement for the Laboratory Direct Shear Test on Rocks

4.4.1 *A Suitable Hydraulic, Pneumatic or Mechanical System*

It shall be capable of applying normal loads on the shear plane of the specimen in such a manner that the load is uniformly distributed over the plane to be tested. The normal load should pass through the centre of the shearing area. The system should be capable of maintaining the normal loads consistent to within ±2 percent of the desired load.

4.4.2 *A Suitable Hydraulic Jack or a Mechanical Gear Drive System*

This system is for applying shear loads uniformly along the half-face of the specimen with the resultant acting in the plane of shearing. It should have rollers, cables or other low friction device to ensure that the resistance of the equipment to shear displacement is within 1 percent of the maximum shear force applied during a test.

4.4.3 *Equipment for Measuring the Normal and Shear Forces Independently*

The accuracy shall be ±1 percent of the maximum values of these forces during a test. This equipment should be calibrated before the test and the relevent charts/tables should be supplied with the report.

4.4.4 *Suitable Devices for Measuring the Normal and Shear Displacements During the Test*

These may include micrometer dial gauges, displacement transducers, etc. The shear displacement measuring system should have a travel greater than 10 percent of the specimen length and with an accuracy of 0·1 mm. The normal and lateral displacement measuring system should have a travel more than 20 mm and an accuracy of 0·05 mm. In the case of displacement transducers, the relevant calibration data should be included in the report.

5 SPECIMEN PREPARATION

5.1 A suitable test horizon should be selected and its relevant geological characteristics, such as, dip, dip direction, etc, are recorded. Block or core specimens are then collected from the said test horizon in such a manner that the specimen is subjected to least disturbances and its location within the test horizon should be such as to allow mounting without any further trimming in the laboratory and with sufficient clearance for adequate encapsulation. The test plane should be square as far as possible and with a minimum area of 2 500 mm^2. It should be smooth and flat in comparison with the size of the specimen. The mechanical integrity of the specimen should be preserved by binding tightly with wire or tape which is to be kept in position until the commencement of the test.

5.2 Specimens which are not encapsulated immediately for testing should be given a waterproof coating, labelled and packed to avoid possible damage in transit to the laboratory. Special care should be taken while transporting fragile specimens.

5.3 After the specimen is taken to the laboratory, its protective packing is removed and the block supported in one of the carriers so that the horizon to be tested is secured in proper position and orientation. The encapsulating material is then poured and allowed to set. The other half of the specimen is also similarly encapsulated. A clear zone of about 5 mm on either side of the shear plane should be free from the encapsulation. For rock joints, plaster of Paris may be used as the encapsulating material.

6 TEST PROCEDURE

6.1 Consolidation

6.1.1 Before the actural commencement of the test, the specimen is allowed to consolidate under full normal load for dissipation of pore water pressure in the rock material and the filling material adjacent to the shear plane.

NOTE — The sample should be saturated before test for finding values in saturated condition.

6.1.2 After mounting the specimen in the shear box, all gauges are checked and a preliminary set of load-displacement readings are taken.

6.1.3 Normal load is then gradually increased to the specific value. The normal displacement (consolidation) of the specimen is recorded as a function of applied loads and time as shown in Fig. 2.

6.1.4 The consolidation of the specimen is considered complete when the rate of change of normal displacement is less than 0·05 mm in 10 minutes.

6.2 Shearing

6.2.1 The object of shearing is to establish the peak and residual values of direct shear strength of the test horison.

6.2.2 The shear force should be applied either in increments or continuously in such a way as to control the rate of shear displacement.

6.2.3 The rate of shear displacement should be less than 0·1 mm/min in the 10 minute period just

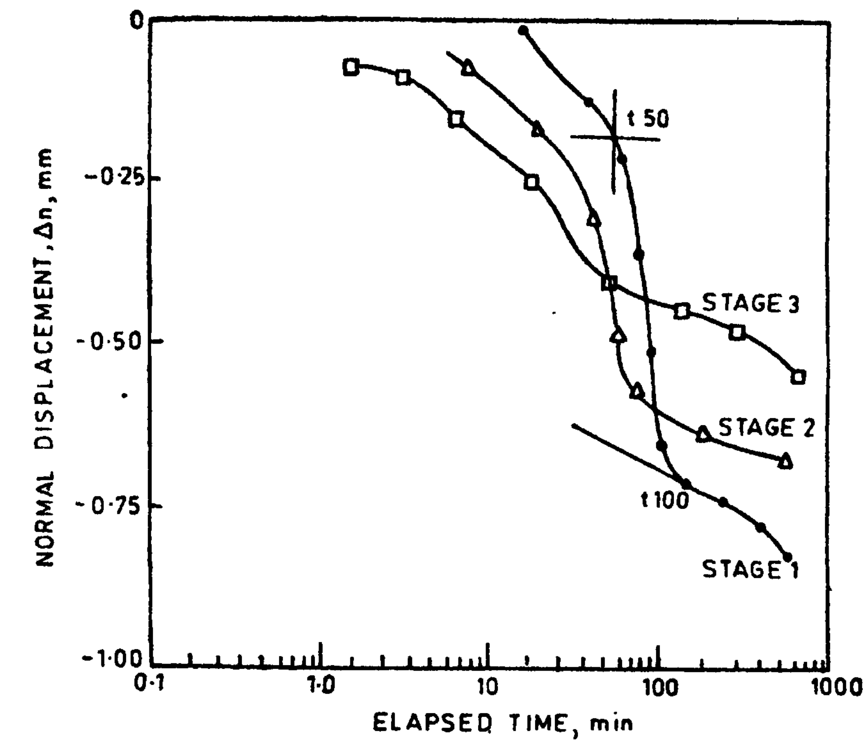

FIG. 2 CONSOLIDATION CURVES FOR DIRECT SHEAR TEST SHOWING ESTIMATION OF t 100

prior to taking readings. This rate may be increased to not more than 0·5 mm/min between consecutive sets of readings provided that the peak strength is properly recorded. When testing clay filled discontinuities, or in a drained test, the total time to reach the peak strength should exceed 6 times t 100 as determined from the consolidation curve in Fig. 2. If required, the rate of shear can be reduced or the application of subsequent shear force increments delayed so as to meet this requirement. Approximately, 10 sets of readings should be taken before the peak strength is reached.

6.2.4 Once the peak strength is reached, the readings should be taken at increments of 0·5 mm shear displacements as required to adequately define the force-displacement curve shown in Fig. 3. The rate of shear displacement should be 0·02 to 0·2 mm/min in the 10 minute period just before a set of readings is taken and may be increased to not more than 1 mm/min between sets of readings.

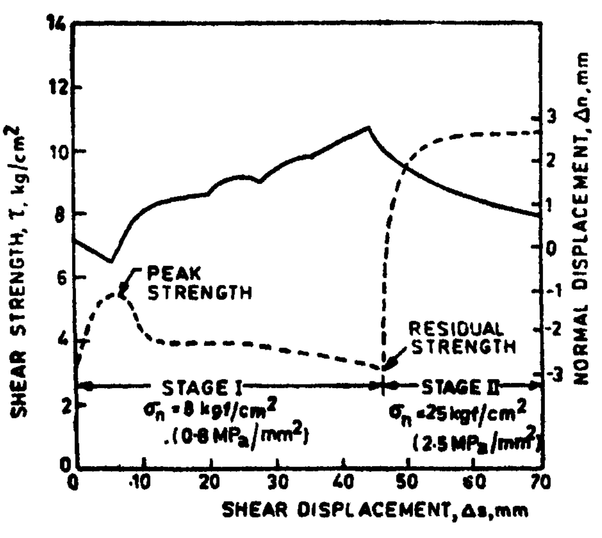

FIG. 3 SHEAR STRESS — DISPLACEMENT GRAPH

6.2.5 The residual shear strength value can be established when the sample is sheared at a constant normal stress and a sufficient number of sets of readings show less than 5 percent variation in shear stress over a shear displacement of 10 mm.

6.2.6 After establishing one value of the residual shear strength, the normal stress may be varied suitably and the specimen reconsolidated under each new normal stress and the shearing continued as in earlier clauses to get additional values of residual shear strength.

6.2.7 At the end of each test, the shear plane should be exposed and fully described in the report. The area of the shearing surface should be measured and photographs of the same should be taken, if required. Samples of rock, the fill material and the shear debris should be subjected to index tests.

7 CALCULATIONS

7.1 A consolidation curve as shown in Fig. 2 should be plotted for the consolidation stage of the test. The time *t* 100 required for complete primary consolidation is determined by constructing tangents to the curve. The time required to reach the peak strength value should be greater than 6 times *t* 100 to allow complete dissipation of pore pressure.

7.2 The displacement readings are averaged to obtain mean values of normal and shear displacements. Lateral displacements are recorded only to observe the specimen behaviour during the test. If these are appreciable, they should be used in calculating the correct contact area.

7.3 The normal and shear stresses are calculated as

$$\text{Normal stress } \sigma n = \frac{\text{Total normal stress } (P_n)}{\text{Shearing Area } (A)}$$

$$\text{Shear Stress } \tau = \frac{\text{Total shear stress } (P_s)}{\text{Shearing Area } (A)}$$

NOTES

1 The effect of primary wakeness of joint surface in rock mass should be accounted for [*see* IS : 11315 (Part 4) : 1987].

2 Effective stress should be used if the joint surface is in water.

7.4 For each test, graphs of shear stress and normal displacements *vs* shear displacement are plotted as shown in Fig. 3. The graphs are annotated to indicate the nominal normal stress and any changes in normal stress during shearing. The values of peak and residual shear strength, the normal stresses, and shear and normal displacements can be abstracted from these graphs.

7.5 From the combined results of all test specimens, graphs of peak and residual shear strength *vs* normal stress are plotted to obtain the strength parameters, ϕa, ϕb, ϕr, *c* and *c'* as shown in Fig. 4.

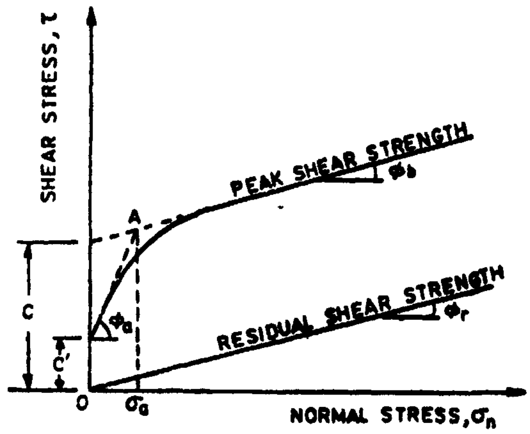

Fig. 4 Shear Stress — Normal Stress Relations

8 REPORTING OF RESULTS

8.1 The report of tests should include a schematic diagram and description of the test equipment; description of the methods used for taking, packing, transporting, storing and mounting of the specimen; and the method of testing.

NOTE — The non-linear peak strength curve may be reported by co-relation [*see* IS 11315 (Part 4) : 1987].

8.2 Full geological description of the intact rock mass, sheared surfaces, filling material and the debris should be given along with index tests data providing information about the roughness profiller water content, grain size distribution and Atterberg limits of the fill material.

8.2.1 Diagrams or preferably photographs showing the sample location, dip and dip direction of the test horizon and any other features of importance.

8.2.2 For each test conducted, a set of data tables, consolidation, curve, graphs of shear stress and normal displacement *vs* shear displacement (as shown in Fig. 2 and 3) should be given.

8.2.3 Abstracted values of peak and residual shear strength should be tabulated with corresponding values of normal stress, shear and normal displacement.

8.2.4 For shear strength determination as a whole, graphs of peak and residual shear strength *vs* normal stress together with the derived values of shear strength parameters (*see* Fig. 4) should also be given.

Standard Mark

The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

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BUREAU OF INDIAN STANDARDS

Headquarters :

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 331 01 31, 331 13 75

Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices :	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	331 01 31 331 13 75
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola CALCUTTA 700054	36 24 99
Northern : SCO 445-446, Sector 35-C, CHANDIGARH 160036	2 18 43 3 16 41
Southern : C. I. T. Campus, IV Cross Road, MADRAS 600113	41 24 42 41 25 19 41 29 16
Western : Manakalaya, E9 MIDC, Marol, Andheri (East) BOMBAY 400093	6 32 92 95

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