IS 8764 (1998): Method of determination of point load strength index of rocks [CED 48: Rock Mechanics]

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REAFFIRMED 2008

भारतीय मानक

चट्टानों के बिन्दुभार सामर्थ्य (प्वाइंट लोड स्ट्रेंथ) — निर्धारण की विधि

(पहला पुनरीक्षण)

Indian Standard

METHOD FOR DETERMINATION OF POINT LOAD STRENGTH INDEX OF ROCKS

(First Revision)

ICS 19.060;91.100.20

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

September 1998 Price Group 5

AMENDMENT NO. 1 DECEMBER 2006
TO
IS 8764 : 1998 METHOD FOR DETERMINATION OF POINT LOAD STRENGTH INDEX OF ROCKS

(First Revision)

(*Page* 6, *clause* **7.1.1**) — Substitute the following for the existing formula:

$$I_s\ (50) = \frac{P}{D^{1.5}\sqrt{D_{50}}}$$

where

$I_s(50)$ = point load strength index in MPa (for the standard core size),
P = failure load in N,
D = core diameter in mm, and
D_{50} = standard core diameter (50 mm).

(*Page* 6, *clause* **7.3**) — Substitute the following for the existing formula:

$$I_L\ (50) = \frac{P}{(DW)^{0.75}\ \sqrt{D_{50}}}$$

where

P = peak load in N at failure,
(DW) = the minimum cross sectional area passing through point loads in mm^2,
$I_L\ (50)$ = point load lump strength index in MPa,
D_{50} = standard size of lump (50 mm),
D = distance between point loads in mm, and
W = average width of minimum cross sectional area in mm.

(*Page* 6, *clause* **7.4**, *last line*) — Delete 'This ------- only' and insert the following Note:

NOTE — The correlations in **7.2** and **7.4** are approximate for the purpose of classification of rock masses and valid for mainly unweathered and isotropic rocks.

(CED 48)

Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 2 OCTOBER 2011
TO
IS 8764 : 1998 METHOD FOR DETERMINATION OF POINT LOAD STRENGTH INDEX OF ROCKS

(First Revision)

(*Page* 5, *clause* **6.4.1**, *line* 2) — Substitute ‘1.0’ *for* ‘1.5’.

(*Page* 5, *clause* **6.4.3**, *line* 4) — Substitute ‘0.50’ *for* ‘0.75’.

(CED 48)

Reprography Unit, BIS, New Delhi, India

Rock Mechanics Sectional Committee, CED 48

FOREWORD

This Indian Standard (First Revision) 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.

The point load test is primarily an index test for strength classification of rock materials. Although it may be used in the laboratory, it is mainly intended for field measurements on rock core and lump specimens. The results of the test should be used to predict the uniaxial compressive strength of unweathered rock for the purpose of Rock Mass Classification. The apparatus used in the test is light and portable and can be used in the laboratory as well as in the field.

When first introduced, the point load strength test was used mainly to predict uniaxial compressive strength which was then the established test for general purpose rock strength classification. Point load strength now often replaces uniaxial compressive strength in this role, since (when properly conducted) it is as reliable and much quicker to measure. It should be used directly for rock classification, since correlations with uniaxial compressive strength are only approximate. On average, uniaxial compressive strength is 20-25 times point load strength index of rock cores. However, in tests on many different rock types, the ratio can vary between 15 and 50 especially for anisotropic rocks, so that errors of up to 100 percent are possible in using an arbitrary ratio value to predict compressive strength from point load strength. The point load strength test is a form of 'indirect tensile' test, but this is largely irrelevant to its primary role in rock classification and strength characterization. $I_s(50)$ is approximately 0.80 times the uniaxial tensile or Brazilian tensile strength.

This standard is revision and synthesis of two old standard on point load strength index and point load lump strength index. Revision is needed because of advances in the interpretations of the test data and development of new correlations for estimating uniaxial compressive strength of rock material. This standard includes diametrical test for determining point strength index, axial test and lump test for determining point load lump strength index. The standard size of rock cores and lumps is common, that is, 50 mm. The size correlation chart is not included as it is accounted for in calculation of indices strength anisotropy index is introduced to test the anisotropic and laminated rock materials.

In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

IS 10785 : 1983 'Method for determination of compressive and tensile strength for point load tests on rock lumps' has been withdrawn and its provisions have been included in this revision.

Technical Committee responsible for the formulation of this standard is given at Annex A.

In reporting the result of a test or analysis 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 POINT LOAD STRENGTH INDEX OF ROCKS

(First Revision)

1 SCOPE

1.1 This standard lays down the procedure for determination of diametral and axial point load strength index of rock cores, cut blocks or irregular lumps, which may be tested without any treatment.

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

1.3 These tests are not reliable if point load strength index (I_s or I_L) is less than 1 MPa.

2 REFERENCES

The Indian Standards given below contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
11358 : 1987	Glossary of terms and symbols applicable to rock mechanics
13030 : 1991	Method of test for laboratory determination of water content, porosity, density and related properties of rock material

3 TERMINOLOGY

For the purpose of this standard, the definition of terms given in IS 11358 shall apply.

4 APPARATUS

Figures 1 and 2 show a typical design. However alternative suitable design may also be used.

4.1 Loading Frame

4.1.1 The frame shall be sufficiently rigid and shall be so designed that the load application is in plumb.

4.1.2 The distance between the top and the bottom bearing plates of this frame shall accommodate a hydraulic jack, two loading platens and platen to platen clearance for testing of rock specimens in the range of 15-100 mm. The platens should be of hard materials such as tungsten carbide or hardened steel so that they remain undamaged during frequent testing.

4.1.3 This frame shall have adequate adjustment to align perfectly the loading axis passing through the centre of the bearing plates and loading platens at all the positions of the ram of the hydraulic jack.

4.1.4 The diaphragm bolt shown in Fig. 2 should be used to check the alignment of the loading axis.

4.1.5 The point load tester shall be portable.

4.2 Hydraulic Jack and Accessories

4.2.1 The loading capacity of hydraulic jack should be of sufficient capacity to break the largest and strongest specimen to be tested.

4.2.2 There shall not be any play between the ram and the jack.

4.2.3 The ram shall have low friction seals. The friction between the ram and the jack shall be less than 50 N (5 kgf).

4.2.4 The system is to be resistant to hydraulic shock and vibration so that accuracy of readings is not adversely affected by repeated testing.

4.2.5 If quick-retracting ram is used to reduce the delay between tests, either the ram return spring force and ram friction should together be less than about 5 percent of the smallest load to be measured during testing, or an independent load cell rather than an oil pressure gauge should be used for load determination. These force can be significant when testing weaker and smaller specimens.

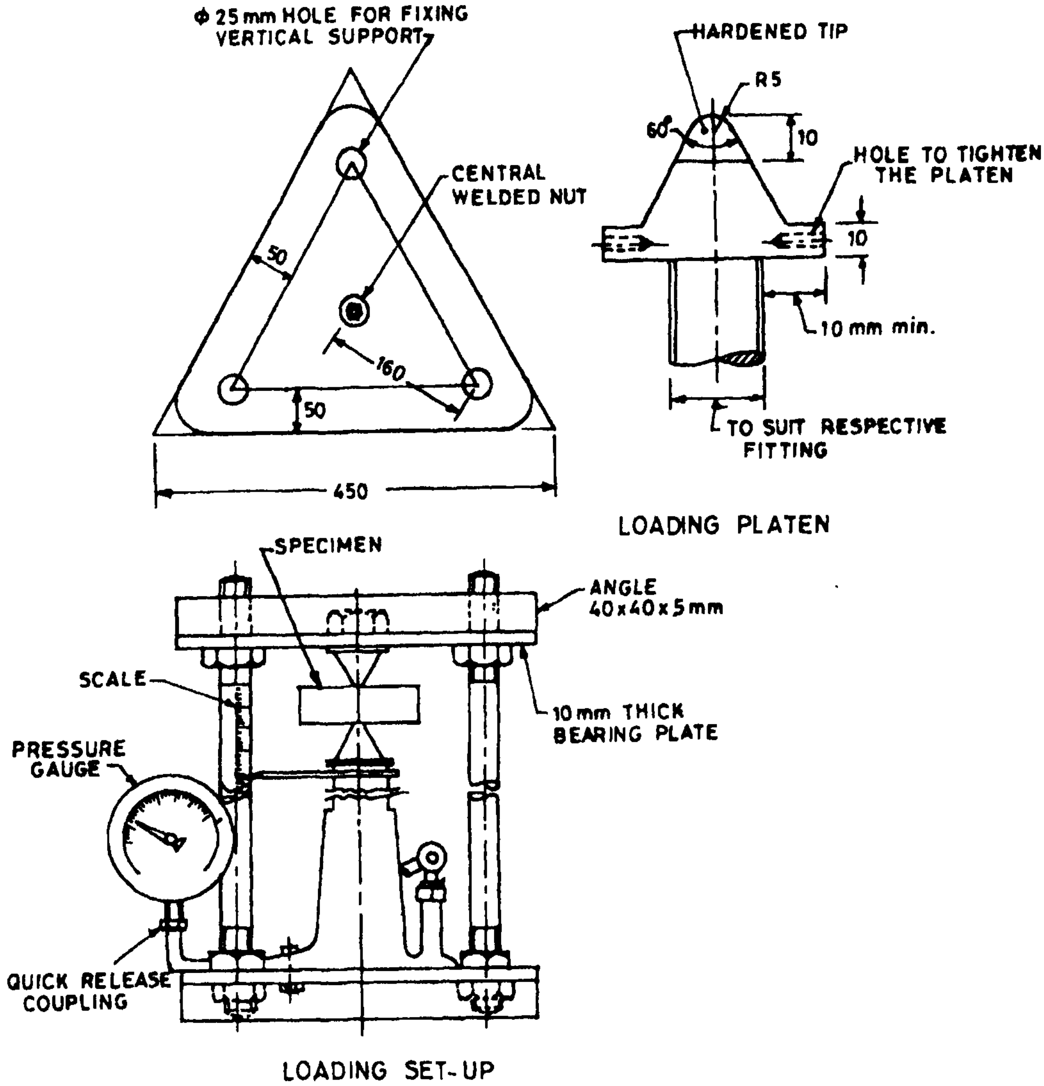
4.3 Pressure Gauges

4.3.1 Bourden type pressure gauges of 200 mm diameter shall be equipped with maximum reading indicator.

4.3.2 The gauges shall be fitted with a hydraulic 'snubber' of orifice type to protect the gauges against sudden decompression.

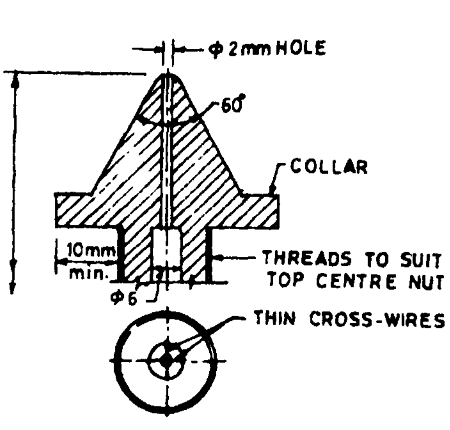
4.3.3 These gauges shall have the following ranges:

a) *Gauge No.* 1 — Maximum loading capacity of 25 kN (2 500 kgf) to read up to 0.25 kN (25 kgf).



All dimensions in millimetres.

FIG. 1 A TYPICAL ILLUSTRATION OF POINT LOAD TESTING SYSTEM AND LOADING PLATEN



All dimensions in millimetres.

FIG. 2 DIAPHRAGM BOLT FOR CHECKING ALIGNMENT OF BOTTOM PLATEN

b) *Gauge No.* 2 — Maximum loading capacity of 100 kN (10 000 kgf) to read up to 0.50 kN (50 kgf).

The gauges shall have an accuracy of ±2 percent.

4.3.4 The gauges shall be fitted with quick release couplings for interchanging them to suit the strength of a core or block and shall be provided with automatic cut-off valve to isolate the lower capacity gauge when its limit is exceeded.

4.3.5 A calibration chart shall be prepared for each gauge with the help of a proving ring.

4.3.6 Loads of up to 50 kN are commonly required for the larger hard rock specimens. The maximum specimen size that can be tested by a given machine is determined by the machine's load and distance measuring sensitivity. Tests on specimens smaller than D = 25 mm require particular precautions to ensure that the measuring sensitivity is sufficient. The range of required test load should be estimated before testing, from approximate assumed strength values, to ensure that the load capacity and sensitivity of the equipment are adequate. It may be necessary to change the load measuring gauge or load cell, or to test smaller or larger specimens to conform with the capacity of available equipment or with the accuracy specifications for this test.

4.4 Distance Measuring System

4.4.1 The distance measuring system, a direct reading scale is fitted to permit measurement of the distance '*D*' between specimen platen contact points. Measurements of '*D*' should be to an accuracy of ±2 percent of *D* or better irrespective of the size of specimen tested.

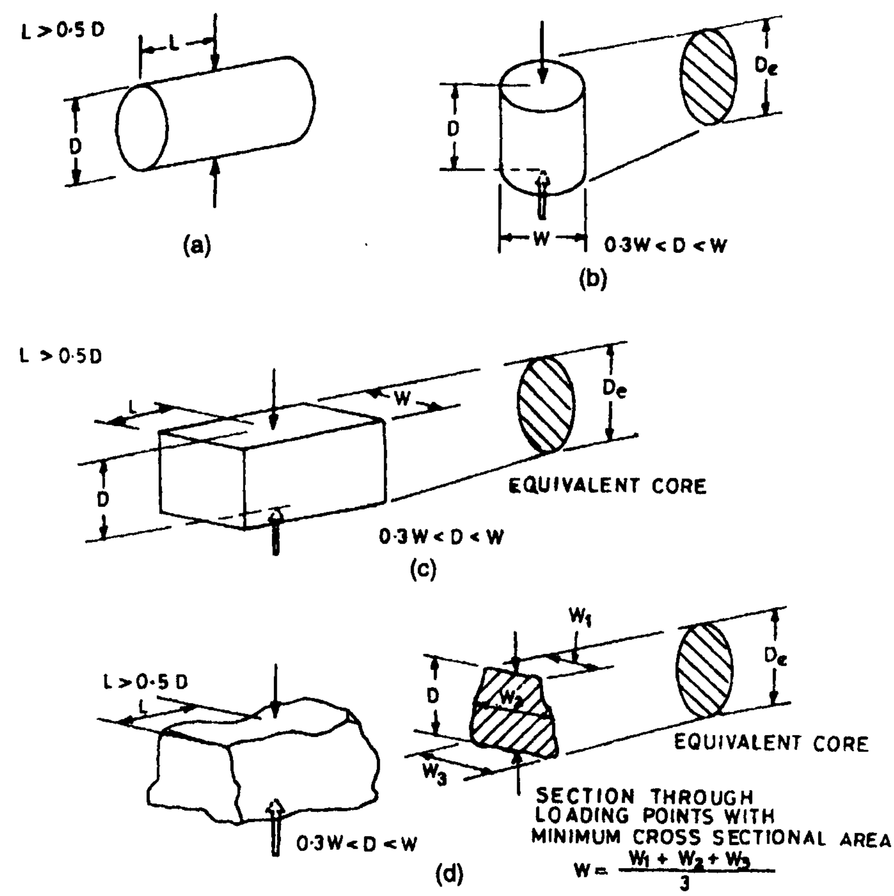
4.4.2 An instrument such as calipers or a steel rule is required to measure the width *W* of specimens for all but the diametrical test.

4.4.3 The measuring system should allow a check of the 'zero displacement' value when the two platens are in contact, and should preferably include a zero adjustment.

4.4.4 If significant platen penetration occurs, the dimension *D* to be used in calculating point load strength should be the value *D* measured at the instant of failure. The error in assuming *D* to be its initial value is negligible when the specimen is large or strong. The failure value may always be used as an alternative to the initial value and is preferred if the equipment allows it to be measured. Measurement of *W* or *D* made perpendicular to the line joining the platens are not affected and are retained at their original values. W_1, W_2 and W_3 are widths at three different locations of the actual fracture surface or minimum cross sectional area. Thus $W \times D$ represents the minimum cross sectional area through loading points [Fig. 3 (d)].

4.5 Loading Platens

4.5.1 Loading platens shall be conical with 60° angle and the radius of curvature of the cone truncation shall be 5 mm as shown in Fig. 1. The 60° cone and the 5 mm radius spherical truncation shall meet tangentially.



All dimensions in millimetres.

FIG. 3 SPECIMEN SHAPE REQUIREMENT FOR (a) THE DIAMETRAL TEST, (b) THE AXIAL TEST, (c) THE BLOCK TEST, AND (d) THE IRREGULAR LUMP TEST

4.5.2 The tip portion of the platens to a height of up to 10 mm from the tip shall be of hard steel (high carbon-high chromium steel or tool steel).

4.5.3 The conical platen design is intended to give standardized penetration of softer specimens. When testing is confined to hard rocks and small (less than 2 mm) penetrations the conical design is unimportant provided that the tip radius remains at the standard 5 mm.

5 SAMPLING

5.1 A test sample is defined as a set of rock specimens of similar strength for which a single point load strength value is to be determined. The cores or lumps shall be selected so as to represent a true average of the rock type under consideration.

5.2 The total number of cores or lumps shall be such that at least ten tests specimen are possible per sample.

5.3 The test sample or rock with core or lumps is to contain sufficient specimen conforming the size and shape requirements for diametral, axial, block or irregular lump testing as specified in Fig. 3.

5.4 The diameter of cores shall be between 25 mm and 100 mm. The length of the core specimens between ends at their nearest points shall not be less than 1.5 times the diameter. However, the ends of core need not be finished.

5.5 In the field, these cores shall be from the same bore hole, from the same geological horizon and within the shortest possible difference in their elevation in the bore hole.

5.6 In the laboratory, these shall be from the same block of rock and drilled in the same direction.

5.7 Because this test is intended primarily as a simple and practical one for field classification of rock materials, the requirements relating to sample size, shape, numbers of tests, etc, can when necessary be relaxed to overcome practical limitations. Such modifications to procedure should however be clearly stated in the report. It is often better to obtain strength values of limited reliability than none at all. For example, rock is often too broken or slabby to provide specimens of the ideal sizes and shapes, or may be available in limited quantities such as when the test is used to log the strength of drill core. In core logging applications, the concept of a 'sample' has little meaning and tests are often conducted at an arbitrary depth interval, say one test every 1 m or 3 m depending on the apparent variability or uniformity of strength in the core and on the total length of core to be strength-logged.

5.8 As far as strength tests on rocks, point load strength varies with the water content of the specimens. The variations are particularly pronounced for water saturations below 25 percent. Oven dried specimens, for example, are usually very much stronger than moist ones. At water saturations above 50 percent the strength is less influenced by small changes in water content, so that tests in this water content range are recommended unless tests on dry rock are specifically required.

All specimens in a sample should be tested at a similar and well-defined water content, and one that is appropriate to the project for which the test data is required. Field testing of chisel-cut samples, not affected by drilling fluids, offers a method for testing at the *in-situ* water content. If possible, numerical values should be given for both water content and degree of saturation at the time of testing. The suggested method for water content determination given in IS 13030 should be employed. Whether or not water content measurements can be made, the sample storage conditions and delay between sampling and testing should be reported.

6 PROCEDURE

6.1 The equivalent diameter '*D*' shall be measured in mm.

6.2 The specimen core or fragment should be tested at the water content as obtained in the field and/or after soaking them for 7 days depending on requirement.

6.3 The specimen shall be held horizontal between the two loading platen.

6.3.1 The correct position of the specimen shall be checked first by giving longitudinal rotation to see the distance between loading points is minimum.

6.3.2 The correct position of the specimen shall also be checked by giving lateral movement to see that the distance between loading platens is maximum.

6.3.3 The platens shall have contact along a single plane of weakness or within the same material in the case of bedded rocks as shown in Fig. 4.

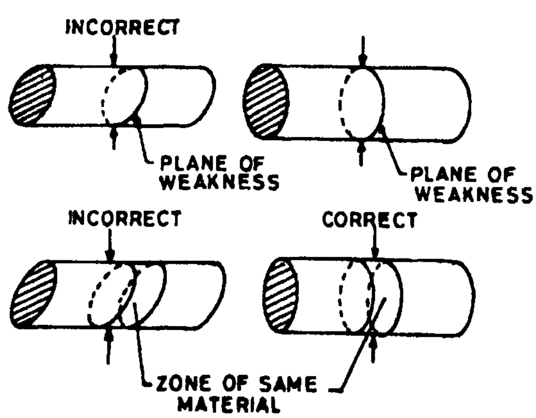


FIG. 4 RIGHT ORIENTATION OF TEST SPECIMEN FOR POINT LOAD TEST

6.4 The Diametral Test

6.4.1 Core specimens with length/diameter ratio greater than 1.5 are suitable for diametral testing.

6.4.2 There should preferably be at least 10 test specimen per sample and even more, if the sample is heterogeneous or anisotropic.

6.4.3 The specimen is inserted in the test machine and the platens closed to make contact along a core diameter, ensuring the distance L between contact point and the nearest free end is at least 0.75 times the core diameter.

NOTE — If the ends of the specimens are uneven, the length 'L' shall be measured as the shortest horizontal distance from any point at the nearest uneven end to the loading point.

6.4.4 The distance D between platen contact points is recorded to ±2 percent. The specimen length 'L' is recorded to ±5 percent.

6.4.5 The load shall then be applied to the core specimen such that failure occurs within 10-60 s. and the failure load 'P' is recorded. The test shall be rejected as invalid if the fracture surface passes through only one loading point [Fig. 5 (d)].

6.4.6 Of the four alternative forms of this test, the diametral test and the axial test with saw-cut faces are the most accurate if performed near the standard 50 mm size, and are preferred for strength classification when core is available. Axial test specimens with saw-cut faces can easily be obtained from large block samples by coring in the laboratory. Specimens in this form are particularly suitable when the rock is anisotropic and the direction of weakness planes must be noted.

6.5 Axial Test

6.5.1 Core specimens with length/diameter ratio of 0.3 to 1.0 are suitable for axial testing. Long pieces of core can be tested diametrally to produce suitable length for subsequent axial testing, alternatively, suitable specimen can be obtained by saw cutting or chisel splitting.

6.5.2 There should preferably be at least 10 test specimen per sample and even more, if the sample is heterogeneous or anisotropic.

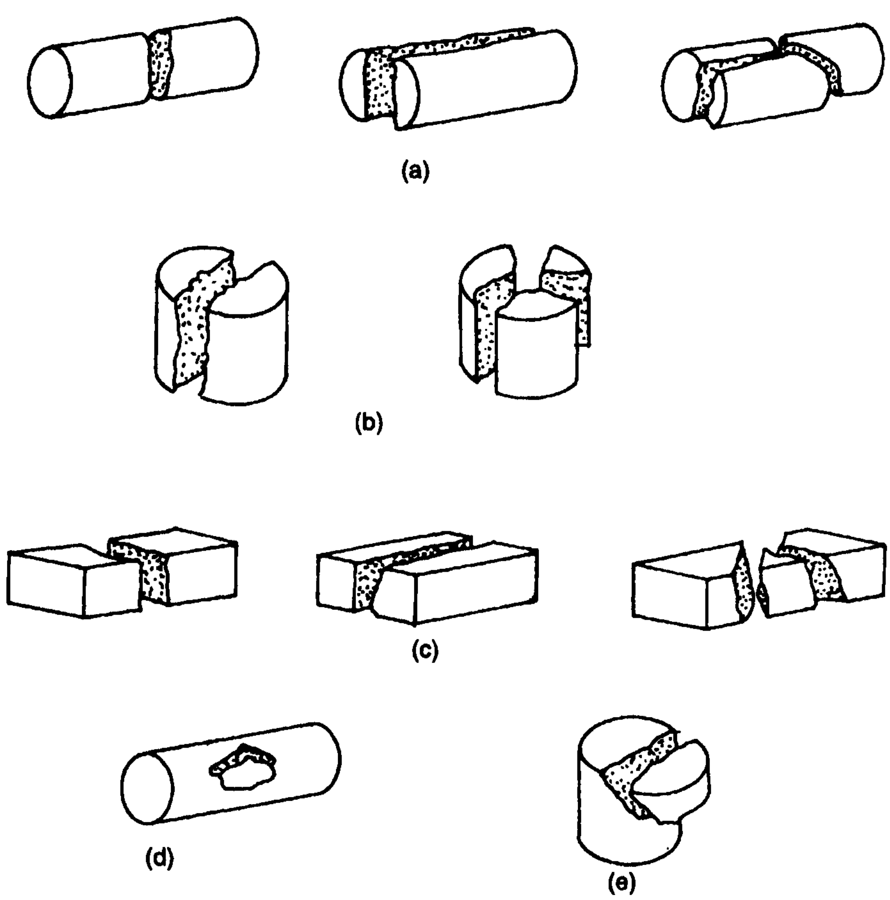


FIG. 5 TYPICAL MODES OF FAILURE FOR VALID AND INVALID TESTS (a) VALID DIAMETRAL TESTS, (b) VALID AXIAL TESTS, (c) VALID BLOCK TESTS, (d) INVALID CORE TEST, (e) INVALID AXIAL TEST

6.5.3 The specimen is inserted in the test machine and the platens closed to make contact along a line perpendicular to the core end faces.

6.5.4 The distance D between platen contact points is recorded to ±2 percent. The specimen width 'W' perpendicular to the loading direction is recorded to ±5 percent. In axial test W is equal to the diameter of axial core.

6.5.5 The load shall then be applied to the specimen such that failure occurs within 10-60 s and the failure load 'P' is recorded. The test should be rejected as invalid if the fracture surface passes through only one loading point [Fig. 5(e)].

6.6 The Block and Irregular Lump Tests

6.6.1 Rock blocks or lumps of size 50 ±35 mm and of shape shown in Fig. 3(c) and Fig. 3(d) are suitable for the block and irregular lump tests. The ratio of 'D/W' should be between 0.3 and 1.0, preferably close to 1.0. The distance 'L' should be at least 0.5 D.

6.6.2 There should preferably be at least 10 test specimen per sample and even more, if the sample is heterogeneous or anisotropic.

6.6.3 The specimen is inserted in the test machine and the platens closed to make contact with the smallest dimensions of the block or lump, away from the edges and corners.

6.6.4 The distance D between platen contact points is recorded to ±2 percent. The smallest specimen width 'W' perpendicular to the loading direction is recorded to ±5 percent. If the sides are not parallel, then 'W' is obtained from W_1, W_2 and W_3 as given in Fig. 3 and calculated as follows:

$$W = \frac{W_1 + W_2 + W_3}{3}$$

6.6.5 The load shall then be applied to the specimen such that failure occurs within 10-60 s and the failure load 'P' is recorded. The test should be rejected as invalid if the fracture surface passes through only one loading point [Fig. 5(d) or Fig. 5(e)].

7 CALCULATION AND SIZE CORRECTION

7.1 Calculation of Point Load Strength Index of Cores

7.1.1 The point load strength index I_s shall be calculated from the following formula:

$$I_s\,(50) = \frac{P}{\sqrt{D^{1.5}\,D^*}},\ \text{MN/m}^2$$

where

$I_s(50)$ = point load strength index (for the standard core size) in MN/m^2, (kgf/cm^2);

P = failure load in N (kgf);

D = core diameter in mm; and

D^* = standard core diameter = 50 mm.

7.1.2 The mean value of strength index shall be determined by systematically deleting two highest and lowest values from the ten or more valid tests and calculating the mean of the remaining values. If significantly fewer specimens are tested only the highest and lowest values are to be deleted and the mean calculated from those remaining. Invalid tests are shown in Fig. 5.

7.2 Uniaxial Compressive Strength

The uniaxial compressive strength of rock may be predicted from the following correlation:

$$q_c = 22\,I_s(50)$$

where

q_c = uniaxial compressive strength in MN/m^2 (kgf/cm^2), and

$I_s(50)$ = corrected point load strength.

7.3 Point Load Lump Strength Index Test

This test shall be conducted on lump pieces of rock material. The depth of the specimen (D) between the points should be less than the width of the specimen, but should be more than one-third width of the specimen. Point load lump strength index (I_L) is calculated by the formula:

$$I_L\,(50) = \frac{P}{(DW)^{0.75}\sqrt{D^*}},\ \text{MN/m}^2$$

where

P = peak load in kgf at failure,

(DW) = cross-sectional area of the fractured surface in cm^2 or the minimum cross-sectional area,

$I_L(50)$ = point load lump strength index in kgf/cm^2,

D^* = standard size of lump = 50 mm (or 5 cm), and

Mean I_L = shall be calculated as per 7.1.2.

7.4 Uniaxial Compressive Strength *vs* Point Load Lump Strength Index

Uniaxial compressive strength q_c is related to point load lump strength index by:

$$q_c \approx 15 \times I_L(50)$$

This correlation is valid for unweathered rocks only.

8 ANISOTROPIC ROCK

a) When a rock sample is shaly, bedded, schistose or otherwise observably anisotropic, it should be tested in directions which give the greatest and least strength values, which are in general parallel and normal to the planes of anisotropy.

b) If the sample consists of core drilled through the weakness planes, a set of diametral tests may be completed first, spaced at intervals which will yield pieces which can then be tested axially.

c) Best results are obtained when the core axis is perpendicular to the planes of weakness, so that when possible the core should be drilled in this direction. The angle between the core axis and the normal to the weakness planes should preferably not exceed 30°

d) For measurement of the I_s value in the directions of least strength, care should be taken to ensure that load is applied along a single weakness plane. Similarly when testing for the I_s value in the direction of greatest strength, care should be taken to ensure that the load is applied perpendicularly to the weakness planes.

e) If the sample consists of blocks or irregular lumps, it should be tested as two sub-samples, with load applied firstly perpendicular to, then along the observable planes of weakness. Again, the required minimum strength value is obtained when the platens make contact along a single plane of weakness.

8.1 Point Load Strength Anisotropy Index

8.1.1 The strength anisotropy index $I_a(50)$ is defined as the ratio of mean $I_s(50)$ values measured perpendicular and parallel to planes of weakness that is the ratio of the greatest to the least point load strength indices. $I_a(50)$ assumes values close to 1 for quasi-isotropic rocks and higher values when the rock is anisotropic.

8.1.2 Commonly the shortest dimension of naturally occurring anisotropic rock lumps is perpendicular to the weakness planes.

9 REPORT OF THE TEST RESULTS

9.1 The corrected mean value of the point load strength index $I_s(50)$ or $I_L(50)$ shall be reported in MN/m^2 (kgf/cm^2).

9.2 Identification of the sample, location, depth and date of sampling and testing shall be reported.

9.3 Core or fragment size, length L and width W in mm shall be indicated.

9.4 The direction of loading shall be indicated with respect to bedding planes in foliated rocks.

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Rock Mechanics Sectional Committee, CED 48

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PROF BHAWANI SINGH	University of Roorkee, Roorkee
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SHRI U. S. RAJVANSHI	In personal capacity (*KC-38 Kavi Nagar, Ghaziabad*), UP
DR J. L. JETHWA	In personnal capacity (*Scientist Incharge, CMRI Station Unit, Nagpur*)
DR V. M. SHARMA	In personnal capacity (*ATES, New Delhi*)
SHRI VINOD KUMAR, Director (Civ Engg)	Director General, BIS (*Ex-officio Member*)

Member-Secretary
SHRI W. R. PAUL
Joint Director (Civ Engg), BIS

Rock Testing in Laboratory Subcommittee, CED 48 : 2

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SHRI B. K. SHARMA	National Hydroelectric Power Corporation Ltd, New Delhi
SHRI U. S. RAJVANSHI	In personal capacity (*KC-38, Kavi Nagar, Ghaziabad*), UP

This Indian Standard has been developed from Doc : No. CED 48 (5463).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Printed at Printograph, New Delhi, Ph : 5726847