IS 11315-2 (1987): Method for the quantitative description of discontinuities in rock mass, Part 2: Spacing [CED 48: Rock Mechanics]

BLANK PAGE

IS : 11315 (Part 2) - 1987

(Reaffirmed 2001)

"पुनर्पुष्ट १९९६"

"RE-AFFIRMED 1996"

Indian Standard

METHODS FOR QUANTITATIVE DESCRIPTION OF DISCONTINUITIES IN ROCK MASS

PART 2 SPACING

UDC 624·121 : 550·347·4 : 620·191

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

September 1987

Indian Standard

METHODS FOR QUANTITATIVE DESCRIPTION OF DISCONTINUITIES IN ROCK MASS

PART 2 SPACING

Rock Mechanics Sectional Committee, BDC 73

Chairman	*Representing*
DR BHAWANI SINGH	University of Roorkee, Roorkee
Members	
ASSISTANT RESEARCH OFFICER (IRI)	Irrigation Department, Government of Uttar Pradesh, Roorkee
DIRECTOR (CW & PRS)	Central Water and Power Research Station, Pune
SHRI S. L. MOKHASHI (*Alternate*)	
DIRECTOR	Central Soil and Materials Research Station, New Delhi
DIRECTOR (CHIEF ENGINEER)	Karnataka Engineering Research Station, Krishnarajasagara
SHRI R. NARA SIMHA IYENGAR (*Alternate*)	
DR A. K. DUBE	Central Mining Research Station (CSIR), Dhanbad
SHRI P. S. GOSAL	Irrigation and Power Department, Government of Punjab, Amritsar
DR UDAY V. KULKARNI	Hindustan Construction Co Ltd, Bombay
DR G. S. MEHROTRA	Central Building Research Institute (CSIR), Roorkee
SHRI A. GHOSH (*Alternate*)	
SHRI M. D. NAIR	Associated Instrument Manufacturers (India) Pvt Ltd, New Delhi
PROF T. S. NAGARAJ (*Alternate*)	
SHRI P. L. NARULA	Geological Survey of India, Calcutta
SHRI T. K. NATARAJAN	Central Road Research Institute (CSIR), New Delhi
SHRI P. J. RAO (*Alternate*)	
PROF T. RAMAMURTHY	Indian Institute of Technology, New Delhi
DR G. V. RAO (*Alternate*)	
DR Y. V. RAMANA	National Geophysical Research Institute (CSIR), Hyderabad
DR G. V. RAO	Indian Geotechnical Society, Delhi

(*Continued on page* 2)

(*Continued from page* 1)

Members	*Representing*
RESEARCH OFFICER (MERI)	Irrigation Department, Government of Maharashtra Nasik
SECRETARY	Central Board of Irrigation & Power, New Delhi
DIRECTOR (C) (*Alternate*)	
SHRI C. D. THATTE	Irrigation Department, Government of Gujarat, Ahmadabad
SHRI G. RAMAN, Director (Civ Engg)	Director General, BIS (*Ex-officio Member*)

Secretary

SHRI K. M. MATHUR
Joint Director (Civ Engg), BIS

Rock Slope Engineering, Foundation on Rock and Rock Mass Improvement Subcommittee, BDC 73 : 4

Convener	
PROF L. S. SRIVASTAVA	University of Roorkee, Roorkee
Members	
DR R. K. BHANDARI	Central Building Research Institute (CSIR), Roorkee
SHRI A. GHOSH (*Alternate*)	
SHRI B. D. BALIGA	Central Mining Research Institute (CSIR), Dhanbad
SHRI A. P. BANERJEE	Cemindia Company Limited, Bombay
SHRI D. J. KETKAR (*Alternate*)	
SHRI D. G. KADKADE	Jaiprakash Associates Pvt Ltd, New Delhi
SHRI R. K. JAIN (*Alternate*)	
SHRI T. K. NATARAJAN	Central Road Research Institute (CSIR), New Delhi
SHRI P. J. RAO (*Alternate*)	
DR T. RAMAMURTHY	Indian Institute of Technology, New Delhi
DR K. G. SHARMA (*Alternate*)	
DR YUDHBIR	Indian Institute of Technology, Kanpur

Indian Standard

METHODS FOR QUANTITATIVE DESCRIPTION OF DISCONTINUITIES IN ROCK MASS

PART 2 SPACING

0. FOREWORD

0.1 This Indian Standard (Part 2) was adopted by the Bureau of Indian Standards on 4 May 1987, after the draft finalized by the Rock Mechanics Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 In view of the advancement in the field of rock mechanics, a number of methods for assessing the strength characteristics of the rock and rock masses are being formulated by Rock Slope Engineering and Foundation on Rock and Rock Mass Improvement Subcommittee of Rock Mechanics Sectional Committee. The majority of rock masses, in particular those within a few hundred metres from the surface, behave as discontinuous with the discontinuities largely determining the mechanical behaviour. It is, therefore, essential that structure of a rock mass and the nature of its discontinuities are carefully described and quantified to have a complete and unified description of rock masses and discontinuities, and it may be possible to design engineering structures in rock with a minimum of expense *in-situ* testing. Careful field descriptions will enhance the value of *in-situ* tests that are performed since the interpretation and extrapolation of results will be made more reliable.

0.3 Discontinuity is the general term for any mechanical discontinuity in a rock mass, along which the rock mass has zero or low tensile strength. It is the collective term for most types of joints, weak bedding planes, weak schistocity planes, weakness zones, shear zones and faults. The ten parameters selected for rock mass survey to describe discontinuities are orientation sapcing, persistance, roughness, wall strength, aperture, filling, seepage, number of sets and block size. These parameters are also evaluated from study of drill cores to obtain information on the discontinuities.

0.4 It is essential that both the structures of a rock mass and the nature of its discontinuities are carefully described for determining the mechanical behaviour. This Indian Standard covering various parameters to describe discontinuities in rock masses is being formulated in various parts each part covering one parameter. This part covers spacing.

0.5 Spacing describes the perpendicular distance between adjacent discontinuities and normally refers to the mean or modal spacing of a set of joints.

0.6 In reporting the result 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*.

1. SCOPE

1.1 This standard covers the method for quantitative description of spacing of discontinuity sets in rock mass.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions of terms given in IS : 11358-1986† shall apply.

3. GENERAL

3.1 The spacing of adjacent discontinuities largely controls the size of individual blocks of intact rock. Several closely spaced sets tend to give conditions of low mass cohesion whereas those that are widely spaced are much more likely to yield interlocking conditions. These effects depend upon the persistence of the individual discontinuities.

3.2 In exceptional cases a close spacing may change the mode of failure of a rock mass from translational to circular or even to flow (like a 'sugar cube' shear zone in quartzite). With exceptionally close spacing, the orientation is of little consequence as failure may occur through rotation or rolling of the small rock pieces.

3.3 The importance of spacing increases when other conditions for deformation are present, that is low shear strength and a sufficient number of discontinuities or joints sets for slip to occur.

---

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

†Glossary of terms applicable to rock mechanics.

3.4 The spacing of individual discontinuities and associated sets has a strong influence on the mass permeability and seepage characteristics. In general, the hydraulic conductivity of any given set will be inversely proportional to the spacing, if individual joint apertures are comparable.

3.5 Spacing describes the perpendicular distance between adjacent discontinuities measured with a measuring tape (at least 3 m length) calibrated in mm divisions. Compass and clinometer are used to measure the angle between the measuring tape and the observed discontinuity set.

4. PROCEDURE

4.1 The measuring tape is held along the exposure such that the surface tape trace of the discontinuity set being measured is approximately perpendicular to the tape (Fig. 1) and the distance adjacent discontinuities is recorded. If the tape is not perpendicular, directional bias corrections are required to obtain the true spacing.

4.2 All distances (*d*) between adjacent discontinuities are measured and recorded over a sampling length not less than 3 m (or the thickness of the rock unit being observed, if this is less than 3 m). The sampling length should preferably be greater than ten times the estimated spacing. The distances (*d*) should be measured to within 5 percent of their absolute values.

4.3 The smallest angle (α) between the measuring tape and the observed joint set is measured with a compass to the nearest 5°.

4.4 The most common (modal) spacing is calculated from the equation:

$$S = d_m \sin \alpha$$

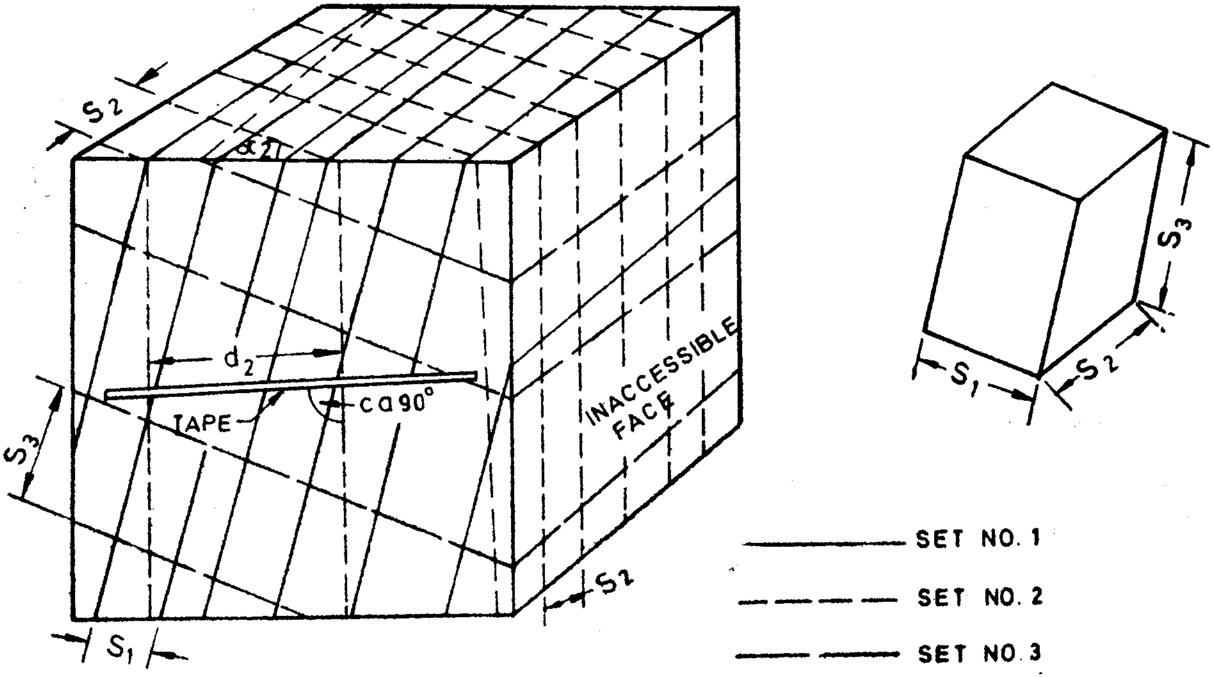
where d_m is the most common (modal) distance measured. It is helpful to present the variation in spacing by means of a histogram as illustrated in Fig. 2.

NOTE 1 — The use of a measuring tape and compass is strongly recommended, but it is not essential if the engineering geologist is experienced in taking these measurements using visual judgement. This will depend on the degree of precision required. It should be borne in mind that discontinuities such as joints may not be sufficiently parallel in a given set to justify great precision.

NOTE 2 — The average value of individual modal spacings (S_1, S_2, etc) represents the average dimension of typical rock block (Fig. 1), if persistence is assumed. Other methods of representing block size from observations of spacing are described in Part 10.

NOTE 3 — In any given discontinuity set, domains with recognizably similar spacing may be separated by more massive rock containing a few widely spaced discontinuities. Block diagrams (Fig. 1) or histograms (Fig. 2) can be used to indicate this type of variability.

NOTE 4 — In general, fractures cause by blast damage should be excluded from consideration when measuring the spacing of discontinuities.



$$S_2 = d_2 \sin \alpha$$

Fig. 1 Measurement of Joint Spacing from Observation of Rock Exposure

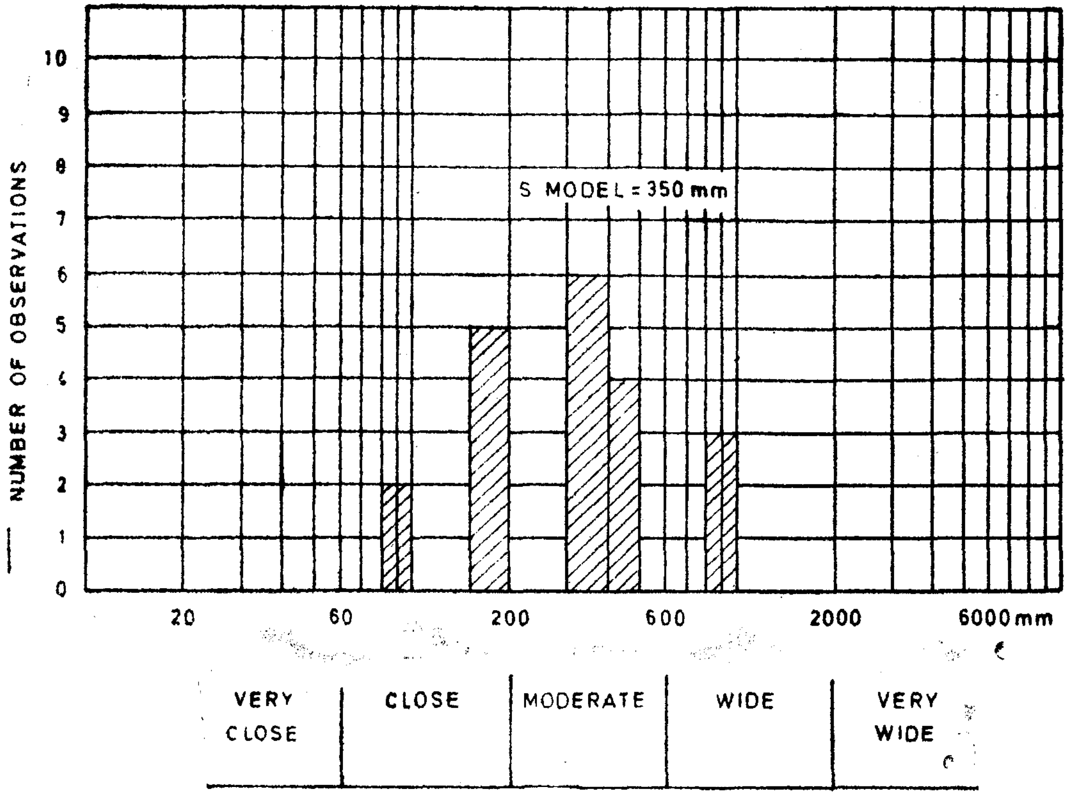


Fig. 2 Histogram Showing Modal, Minimum and Maximum Spacing Obtained from Observation of the Spacing of One Set. Suggested Descriptions Given at Base of Histogram

NOTE 5 — In cases where rock exposures are of limited extent or absent, seismic refraction techniques can be used to estimate spacing in the upper 20-30 m. Several investigators have found a fairly reliable relationship between frequency, that is, number of discontinuities per metre, and the longitudinal or compression (*P*) wave velocity V_p.

NOTE 6 — The spacing or frequency of discontinuities can also be determined from analysis of drill core and from borehole viewing techniques such as borehole television cameras, photographic cameras and borehole periscopes.

5. PRESENTATION OF RESULTS

5.1 The minimum, modal and maximum spacing, *S* (*Min*), *S* and *S* (*Max*) should be recorded for each discontinuity set. The distributions can conveniently be presented as histograms, one for each set (Fig. 2). The following terminology can be used:

Description	*Spacing*
Very close spacing	< 60 mm
Close spacing	60-200 mm
Moderate spacing	200-600 mm
Wide spacing	600-2 000 mm
Very wide spacing	> 2 000

5.2 A convenient method of presenting large number of spacing measurements, for which statistical treatment may be required is the use of histograms, one for each set of discontinuities. Frequency curves for each set can be drawn on the same diagram, giving an immediate impression of the respective modal values and dispersions (using mean in place of modal spacings may help to eliminate difficulties with samples having multiple, poorly-defined modes, and with samples with modes at very small spacing that is from negative exponential distributions).

5.3 Spacing may also be expressed as the inverse, that is, number of discontinuities per metre. This is termed frequency.