IS 11315-9 (1987): Method for the quantitative description of discontinuities in rock mass, Part 9: Number of sets [CED 48: Rock Mechanics]

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IS : 11315 (Part 9) - 1987

(Reaffirmed 2001)

"पुनर्पुष्टि १९९६"

"RE-AFFIRMED 1996"

Indian Standard

METHOD FOR THE QUANTITATIVE DESCRIPTIONS OF DISCONTINUITIES IN ROCK MASSES

PART 9 NUMBER OF SETS

UDC 624·121:550·347·4:620·191

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

Gr 2

May 1987

Indian Standard

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Indian Standard

METHOD FOR THE QUANTITATIVE DESCRIPTIONS OF DISCONTINUITIES IN ROCK MASSES

PART 9 NUMBER OF SETS

0. FOREWORD

0.1 This Indian Standard (Part 9) was adopted by the Indian Standards Institution on 30 January 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 assessingthe strength characteristics of the rocks 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 the 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 within 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, spacing, persistance, roughness, wall strength, aperture, filling, seepage, number of sets, and block size. These parameters are also evaluated from the 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 with each part covering one parameter. This part covers Number of Sets.

0.5 Number of sets describe the number of discontinuity sets comprising the intersecting discontinuity system. The rock mass may be further divided by individual discontinuities.

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 (Part 9) covers the method for the quantitative description of the number of sets of discontinuities 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 Both the mechanical behaviour and the appearance of a rock mass will be dominated by the number of sets of discontinuities that intersect one another. The mechanical behaviour is especially affected since the number of sets determines the extent to which the rock mass can deform without involving failure of the intact rock. The appearance of the rock mass is affected since the number of sets determines the degree of overbreak that tends to occur with excavation by blasting (*see* Fig. 1).

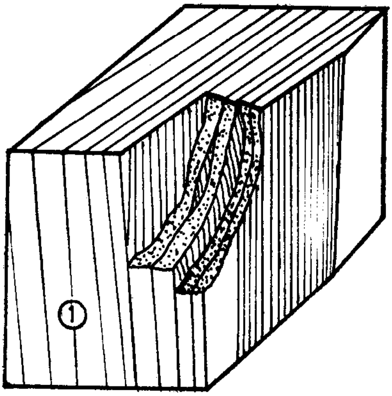
3.2 The number of sets of discontinuities may be a dominant feature of rock slope stability, though traditionally the orientation of discontinuities relative to the face is considered of primary importance. However, if sufficient sets exist the probability of instability may be reduced almost to zero. On the other hand a large number of sets having close spacing may change the potential mode of slope failure from translational or toppling to rotational/circular.

3.3 In the case of tunnel stability three or more sets will generally constitute a three-dimensional block structure having considerably more 'degree of freedom' for deformation than a rock mass with less than three sets. For example a strongly foliated phyllite with just one closely spaced joint set may give equally good tunnelling conditions as a massive

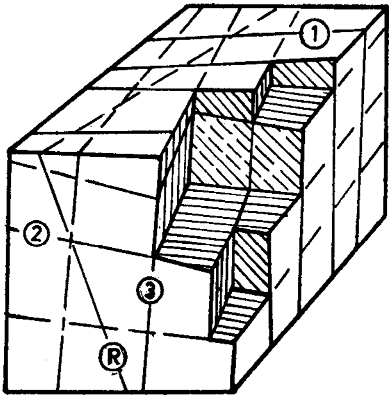
*Rules for ronnding off numerical values (*revised*).

†Glossary of terms and symbols relating to rock mechanics.

granite with three widely spaced joint sets. The amount of overbreak in a tunnel will usually be strongly dependent on the number of sets.



ONE JOINT SET



THREE JOINT SETS

FIG. 1 EXAMPLES THAT DEMONSTRATE THE EFFECT OF THE NUMBER OF JOINT SETS ON THE MECHANICAL BEHAVIOUR AND APPEARANCE OF A ROCK MASS

3.4 The number of sets forming an intersecting system of discontinuities divide the rock mass and describe the appearance and form of the rock mass. The information is obtained from visual recognition during rock mass survey and/or study of photographic recording or rock exposure.

4. PROCEDURE

4.1 The number of sets will often be a function of the size of the area mapped. In a preliminary investigation it is important to record all sets present. The recognition of individual sets will usually proceed simultaneously with the *orientation* measurements. Up to 150 discontinuity planes (joints) may need to be measured, and the number of sets can usually be determined by contouring discontinuity plane (joint) poles plotted on polar equal area nets.

NOTE 1 — Systematic discontinuity (joint) sets should be distinguished from systematic discontinuities (joints) when recording the number of sets. In general, systematic discontinuities (joints) will be persistent features, with individual discontinuities (joints) parallel or sub-parallel in plan, while non-systematic discontinuities (joints) display random rather than oriented patterns in plan and section. Problems of set identification when sets cannot readily be distinguished in the field may be reduced by utilizing statistical tests for identifying trends in the distribution of poles plotted on polar equal area nets.

NOTE 2 — Incipient discontinuities such as those that may develop parallel to bedding, or parallel to foliation or cleavage, should be included in the local estimate of the number of sets, if it is considered that the method of excavation employed will sufficiently disturb the rock mass to cause development of these features into equivalent bedding joints, foliation joints, etc.

NOTE 3 — The number of sets recorded will tend to be a function of the size of area mapped, and should be interpreted accordingly. The *spacing* of individual sets will play an important role in this interpretation. For example, four sets recognised following a 'conventional' survey of an area (using the pole contouring method) may include some sets with such wide spacing that these would be of little relevance to the stability of a short length of tunnel, though possibly of considerable importance to the stability of a major slope.

4.2 If orientations are consistent, careful sampling may reduce the number of discontinuities (joints) that have to be measured to define the number of sets.

4.3 In the detailed stages of field investigations, the number of sets present *locally* should be recorded as a supplement. The stability of a given section of tunnel or rock slope, or the deformability of a given foundation will be a function of the relevant number of sets found *locally*, rather than of the total number mapped in whole area.

4.4 Visual recognition of the number of sets should be accompanied by some system of numbering for identification purposes. For example the most systematic and persistent set can be labelled "set No. 1" and so on. (Fig. 1). Alternatively sets can be numbered in the order of their importance to stability.

5. PRESENTATION OF RESULTS

5.1 The number of joint sets present can be represented visually as part of the presentation of *orientation* data.

5.2 The number of joint sets occurring locally (for example, along the length of a tunnel) can be described according to the following scheme:

I massive, occasional random joints

II one joint set

III one joint set plus random

IV two joint sets

V two joint sets plus random

VI three joint sets

VII three joint sets plus random

VIII four or more joint sets

IX crushed rock, earth-like

Major individual discontinuities should be recorded on an individual basis.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.S
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s(s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2