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METHOD FOR THE QUANTITATIVE DESCRIPTIONS OF DISCONTINUITIES IN ROCK MASSES

PART 6 APERTURE

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METHOD FOR THE QUANTITATIVE DESCRIPTIONS OF DISCONTINUITIES IN ROCK MASSES

PART 6 APERTURE

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METHOD FOR THE QUANTITATIVE DESCRIPTIONS OF DISCONTINUITIES IN ROCK MASSES

PART 6 APERTURE

0. FOREWORD

0.1 This Indian Standard (Part 6) 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 advencement in the Field of Rock Mechanics, a number of methods for assessing the 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 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, 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 parametres to describe discontinuities in rock masses is being formulated in various parts with each part covering one parameter. This part covers aperture.

0.5 Aperture describes the perpendicular distance between adjacent rock walls of a discontinuity, in which the intervening space is air or water filled.

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*.

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1. SCOPE

1.1 This standard (Part 6) covers the method for quantitative description of aperture indicating the perpendicular distance between adjacent rocks wall of a discontinuity.

2. TERMINOLOGY

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

3. GENERAL

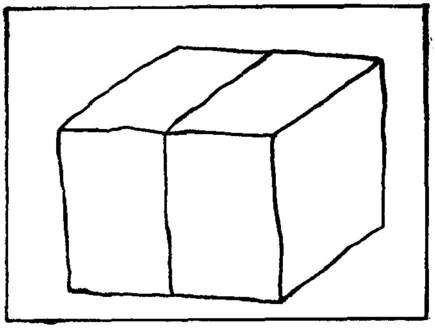
3.1 Aperture is the perpendicular distance separating the adjacent rock walls of an open discontinuity, in which the intervening space is air or water filled. Aperture is thereby distinguished from the width of a filled discontinuity (Fig. 1). Discontinuities that have been filled (that is with clay) also come under this category if filling material has been washed out locally.

3.2 Large aperture can result from shear displacement of discontinuities having appreciable roughness and waviness, from tensile opening, from outwash, and from solution. Steep or vertical discontinuities that have opened in tension as a result of a valley erosion or glacial retreat may have very large apertures.

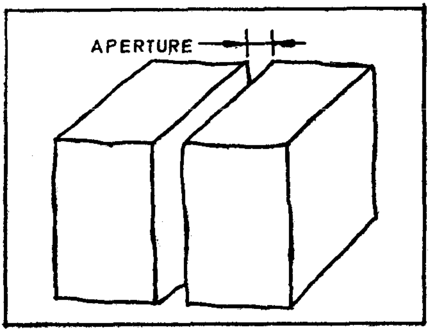
3.3 In most sub-surface rock masses apertures are small and will probably be less than half a millimetre, compared to the tens, hundreds, or even thousands of millimetres width of some of the outwash or extension varieties. Unless discontinuities are exceptionally smooth and planar it will not be of great significance to the shear strength that a 'closed' feature is 0·1 mm wide or 1 mm wide. However, indirectly as

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

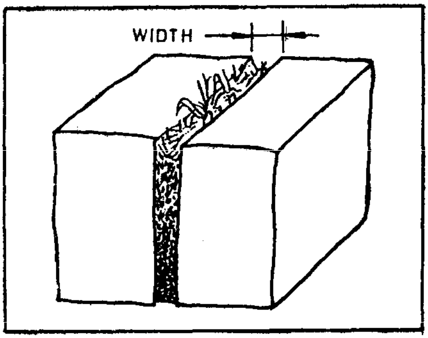
†Glossary of terms and symbols relating to rock mechanics.



1A CLOSED DISCONTINUITY



1B OPEN DISCONTINUITY



1C FILLED DISCONTINUITY

FIG. 1 DIAGRAMS SHOWING THE SUGGESTED DEFINITIONS OF THE APERTURE OF OPEN DISCONTINUITIES AND THE WIDTH OF FILLED DISCONTINUITIES a result of hydraulic conductivity, even the finest may be significant in changing the effective normal stress and therefore also the shear strength.

3.4 Visual observation of small apertures is inherently unreliable since, with the possible exception of drilled holes and bored tunnels, visible apertures are bound to be disturbed apertures, either due to disturbance by blasting, or due to surface weathering effects. The influence of apertures is best assessed by water permeability testing.

3.5 Apertures are recorded from the point of view of both their loosening and conducting capacity. Joint water pressure inflow of water and outlow of storage products (both liquid and gas) will all be affected by aperture.

3.6 The aperture giving the perpendicular distance separating the adjacent rock walls of an open discontinuity is described as *closed*, *gapped* and *open* based on the width of the aperture. Measuring tape of at least 3 m length calibrated in mm is used to determine the width of aperture over the sets of discontinuities. Feeler gauge is used for estimating width of fine aperture. White spray paint after washing the dirty rock exposure is used to make discontinuity sets more visible.

4. PROCEDURE

4.1 Dirty underground exposures should be washed clean. It is helpful to spray white paint along the desired lines of survey, so that the finest discontinuities are more easily visible. Good lighting is essential.

4.2 Fine apertures can be measured approximately with feeler gauges, while the larger apertures can be measured with a rule graduated in mm. The apertures of all discontinuities interesecting the survey line will be recorded. Alternatively the variation in aperture of a major discontinuity can be measured along the trace of the discontinuity.

NOTE 1 — The apertures visible in a rock exposure are inherently disturbed apertures, due either to localized surface weathering or to the mode of excavation. For those reasons measured apertures are likely to be larger than those existing within the rock mass. Tunnels that are machine bored (and bore hole walls) should give a much more reliable indication of the undisturbed apertures. Borehole walls can be surveyed by means of periscopes, borehole cameras, and TV equipment, and by means of pressure sensitive packers.

NOTE 2 — The borehole periscope is recommended when the depth from the surface does not exceed 30 metres. Greater depths result in distortion of the optical path which consists of a series of rigid tubes supporting a system of lenses and prisms. A millimetre calibrated scale, differently coloured from the rock, should be located on the outside of the periscope in such a position that the apparent apertures can be recorded. These readings must be corrected for orientation if the borehole does not intersect the discontinuities approximately at right angles.

NOTE 3 — The core recovery method known as the *integral sampling method* is recommended for obtaining aperture data in special circumstances. The method essentially consists of recovering a core sample which has previously been reinforced with a grouted bar. The reinforcing bar is coaxially overcovered with a larger diameter coring crown.

NOTE 4 — Even undisturbed apertures give a poor indication of their water conducting potential. The wall roughness may reduce the actual conductivity to a fraction of its theoretical smooth-wall equivalent as a result of friction and tortuousity effects. In addition, there is much evidence that flow in joints may be tube-like rather than sheet-like. *In situ* permeability testing will be much more reliable indicator of the influence of apertures than direct measurement.

NOTE 5 — Apertures measured across discontinuities that are displaced by previous sheering (for example, in an unstable slope) may vary widely from point to point. The 'dead areas' caused by asperity contact and undetected debris will again make aperture measurements rather unreliable as a basis for conductivity estimation.

5. PRESENTATION OF RESULTS

5.1 Apertures can be described by means of the terms given in Table 1.

TABLE 1 TERMS FOR APERTURE

Aperture	Description	
$<$ 0·25 mm	Tight	'Closed' features
0·25 – 0·5 mm	Partly open	
0·5 – 2·5 mm	Open	'Gapped' features
2·5 – 10 mm	Moderately wide	
$>$ 10 mm	Wide	
1 – 10 cm	Very wide	'Open' features
10 – 100 cm	Extremely wide	
$>$ 1 m	Cavernous	

5.2 Model (most common) apertures should be recorded for each discontinuity set.

5.3 Individual discontinuities having apertures noticably wider or larger than the modal value should be carefully described, together with location and orientation data.

5.4 Photographs of extremely wide (10 – 100 cm) and cavernous (1 m) apertures should be appended.

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