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METHOD FOR THE QUANTITATIVE DESCRIPTIONS OF DISCONTINUITIES IN ROCK MASSES

PART 10 BLOCK SIZE

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METHOD FOR THE QUANTITATIVE DESCRIPTIONS OF DISCONTINUITIES IN ROCK MASSES

PART 10 BLOCK SIZE

0. FOREWORD

0.1 This Indian Standard (Part 10) 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 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 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 expensive *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, weak 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, each part covering one parameter. This part covers size. The other parts covering other parameters are also being formulated.

0.5 Block size describes rock block dimensions resulting from the mutual orientation of intersecting discontinuity sets, and resulting from the spacing of the individual sets. Individual discontinuities may further influence the block size and shape.

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 10) covers the method for the quantitative description of size and shape of block resulting from the intersecting 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 Block size is an extremely important indicator of rock mass behaviour. Block dimensions are determined by discontinuity spacing, number of sets, and persistance of the discontinuities delineating potential blocks.

3.2 The number of sets and the orientation determine the shape of the resulting blocks, which can take the approximate form of cubes, rhomobohedrons, tetrahedrons, sheets, etc. However, regular geometric shapes are the exception rather than the rule since the joints in any one set are seldom consistently parallel. Jointing in sedimentary rocks usually produces the most regular block shapes.

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

†Glossary of terms and symbols relating to rock mechanics.

3.3 The combined properties of block size and interblocks shear strength determine the mechanical behavionr of the rock mass under given stress conditions. Rock masses composed of large blocks tend to be less deformable, and in the case of underground construction, develop favourable arching and interlocking. In the case of slopes, a small block size may cause the potential mode of failure to resemble that of soil (that is circular/ rotational) instead of the translational or toppling modes of failure usually associated with discontinuous rock masses. In exceptional cases 'block' size may be so small that flow occurs, as with a 'sugar-cube' shear zone in quartzite.

3.4 Rock quarrying and blasting efficiency are likely to be largely a function of the natural *in situ* block size. It may be helpful to think in terms of a block size distribution for the rock mass, in much the same way that soils are categorized by a distribution of particle size.

3.5 Block size can be described either by means of the average dimension of typical blocks (block size index I_b) or by the total number of joints intersecting a unit volume of the rock mass (volumetric joint count J_v).

3.6 Block size describes the shape and dimensions of rock block resulting from mutual orientation of intersecting sets of discontinuities (joints, cleavage, bedding, etc). The size is measured by a tape of at least 3 m length, calibrated in mm divisions.

4. PROCEDURE

4.1 *Block Size Index* (I_b) is estimated by selecting by eye several typical block sizes and taking their average dimensions. Since the index may range from millimetres to several metres, a measuring accuracy of 10% should be sufficient.

NOTE 1 — The purpose of the block size index is to represent the average dimensions of typical rock blocks. The average value of individual modal spacings (S_1, S_2, etc,) may not give a realistic value of I_b if there are more than three sets, since the fourth set, if widely spaced will artificially increase I_b, but may have little influence on actual block sizes as observed in the field.

NOTE 2 — In the case of sedimentary rocks, two mutually perpendicular sets of cross joints plus bedding constitute an extremely common cubic or prismatic block shape. In such cases, I_b is correctly described by:

$$I_b = \frac{S_1 + S_2 + S_3}{3}$$

4.1.1 Each domain should be characterized by a modal I_b together with the range, that is, typical largest and smallest block size indices.

4.1.2 The number of sets should always be recorded in parallel with I_b since if there are only one or two sets, any subsequent attempt to convert I_b to typical block volumes may be unrealistic.

4.2 Volumetric joint count (J_v) is defined as the sum of the number of joints per metre for each joint set present. Random discontinuities can be included, but will generally have little effect on the results.

NOTE 1 — Field mapping can be performed very rapidly as a measuring tape can be dispensed with when individual joint spacings are not of interest. 5 or 10 m can be paced out or estimated with reasonable accuracy by most observers (that is, to within $\pm 10\%$ of the correct length). The observer should face in the direction of strike for each joint set that is to be counted and count perpendicular to the strike, thereby removing the angular correction factor.

It should be noted that

$$J_V \text{ is not equal to } \frac{1}{S_1} + \frac{1}{S_2} + \dots \frac{1}{S_n}$$

NOTE 2 — The calculation of J_V is based on the mean spacings, not modal spacing. Generally the results will be similar, but spacing tends to be log-normally distributed.

NOTE 3 — The occasional random discontinuities will not noticeably effect the value of J_V unless the spacing of the systematic joints is wide or very wide (that is 1 – 10 m). In such cases they should be included with appropriately wide spacing, for example, 10 m.

4.2.1 The number of joints of each set should be counted along the relevant joint set perpendicular. A sampling length of 5 or 10 m is suggested. Each joint count will then be divided by 5 or 10 to express the results as number of joints per metre.

4.2.2 A typical result for three joint sets and a random discontinuity counted along 5 to 10 m perpendicular sampling lines might appear as below:

$$J_v = 6/10 + 24/10 + 5/5 + 1/10$$
$$J_v = 0{\cdot}6 + 2{\cdot}4 + 1{\cdot}0 + 0{\cdot}1 = 4{\cdot}1/\text{m}^3 \text{ (medium-size blocks)}$$

4.3 The following descriptive terms give an impression of the corresponding block size:

Description	J_V (*joints*/m^3)
Very large blocks	< 1·0
Large blocks	1-3
Medium-sized blocks	3-10
Small blocks	10-30
Very small blocks	> 30

Values of $J_v > 60$ would represent crushed rock, typical of a clay-free crushed zone.

4.4 Rock masses can be described by the following adjectives, to give an impression of block size and shape (*see* Fig. 1):

i) massive = few joints or very wide spacing

ii) blocky = approximately equidimensional

iii) tabular = one dimension considerably smaller than the other two

iv) columnar = one dimension considerably larger than the other two

v) irregular = wide variations of block size and shape

vi) crushed = heavily jointed to 'sugar cube'

4.5 Orientation data provide additional descriptive data for a clearer expression of the form of an anisotropic block structure if present, that is, '*steeply dipping* sheets, slabs, beds', etc, or '*vertical* columnar blocks', etc. When block dimensions are reasonably isotropic only the block shape need be described, that is, cubic, rhombohedral, prismatic, tetrahedral, irregular, etc, as appropriate.

5. REPRESENTATION

5.1 Record the modal block size index (I_b), and I_b values typical for the largest and smallest block sizes for the domain or domains of interest. (Also record the *number of sets* and describe the *persistance.*)

5.2 Record and *volumetric joint count* (J_v) for the domain or domains of interest. (Also record the *number of sets* and describe the *persistance.*)

5.3 Describe the rock mass and its 'blockiness' in general terms as: massive, blocky, tabular, columnar, crushed or as appropriate.

5.4 Where possible, block size and shape should also be communicated by means of photographs and/or field sketches of typical exposures (Fig. 1).

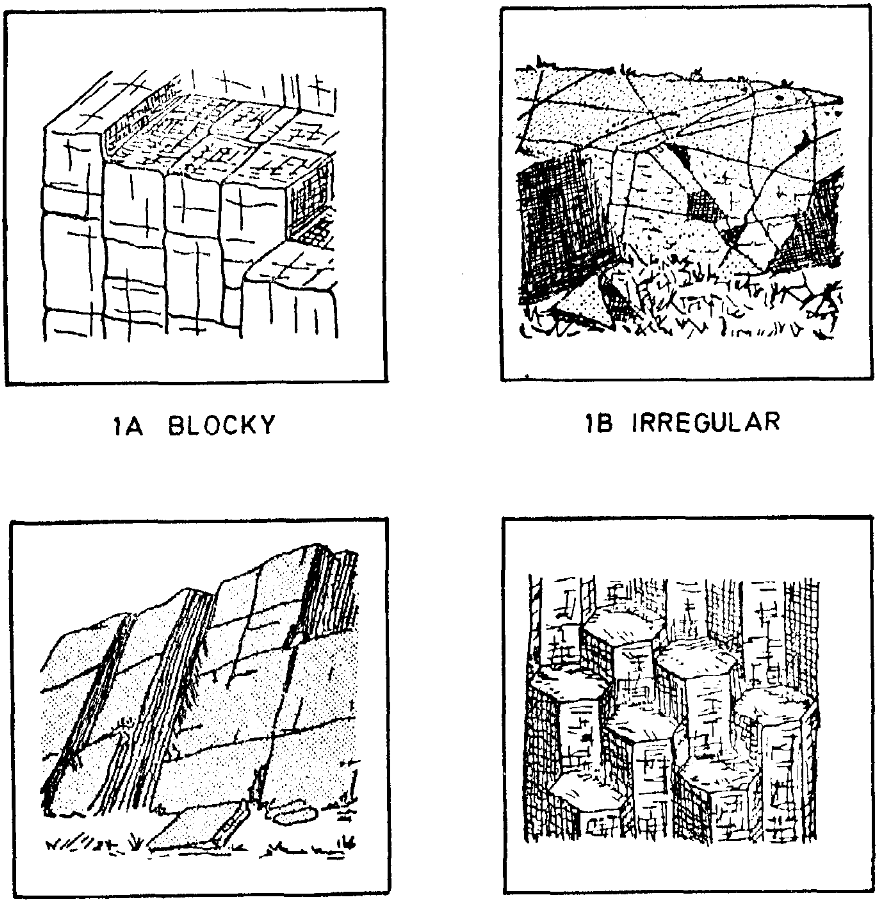

FIG. 1 SKETCHES OF ROCK MASSES