Determination of *in situ* RQD

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Abstract

For quick evaluation of Rock quality designation (RQD) directly from outcrops and underground excavations in rocks for use in modern rock mass classification systems-RMR and Q-systems, ad very simple procedure is proposed based on the original definition of RQD. In the proposed method, measurements are taken along an imaginary line roughly perpendicular to the dominating joint-set to reduce the effect of direction on RQD. The existing relationships / methods to determine in-situ RQD from volumetric joint count (Jv) and mean discontinuity spacing are theoretical, require enough field work and may not give correct values in all cases. Some other methods of determining RQD are also discussed.

Introduction

Rock quality designation (RQD) is widely used for geotechnical evaluation of rock masses, directly or indirectly, at almost every engineering project involving rock. This quantitative index of Deere (1964) is based on the modified core recovery procedure, which takes into account core pieces of more than 10cm only. For many years, RQD was used for the assessment of rock quality independently and the selection of tunnel supports (Deere *et al.*, 1970). Limitations of the RQD index were indicated in areas containing clay filled/weathered joints, shear zones, etc. by Merritt (1972). Although RQD is recognized as one of the parameters for assessment of rock mass quality, it is not suitable for providing the complete description of rock mass.

With the development of modern rock mass classification systems, Geomechanics Classification (RMR) of Bianiawski (1973) and Q-System of Barton *et al.* (1974), RQD index formed one of the basic parameters of these classification systems despite some demerits (RQD vary greatly on the angle of intersection of a borehole with the dominating joint set; 9cm pieces give 0 % RQD while 11cm pieces give 100% RQD). Since both the classification systems are applied for empirical design of supports in tunnels and underground caverns in rock, *in situ* determination of RQD is inevitable as it is not practical to drill boreholes in all rock zones, areas, or locations.

Methods / Relationships for *in situ* RQD Determination

There are two theoretical relationships between RQD and other parameters of degree of jointing - volumetric joint count (Jv) and mean discontinuity spacing..

Volumetric Joint Count (Jv)

The number of joints intersecting a unit rock mass is defined as the volumetric joint count (Jv). Procedure for calculating Jv is well described by Palmstrom (1982) and following relationship is used for determining RQD.

$RQD = 115 - 3.3\ Jv$

where $Jv = (1/S_1) + (1/S_2) + (1/S_3)$ for three joint sets, S_1, S_2, S_3 are joint spacings.

Author has used this relationship in field at river valley projects and found that it involves enough fieldwork and hence time if locations are not available in different planes, which is usually the case. Also when a dominating joint

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set is closely spaced, RQD calculated by this relationship give very high values if compared with the original definition of Deere (1964) by assuming a drill hole at the same location.

Mean Discontinuity Spacing

A graphical relationship between mean discontinuity spacing and RQD was proposed by Priest and Hudson (1976). Although this relationship is not very well known or popular, it requires calculation of 'mean discontinuity spacing' by taking spacing measurements of joint sets. Moreover, the relationship shows large deviation in minimum and maximum percentage of RQD from the average values, particularly for mean discontinuity spacing up to 15cm, as can be clearly observed from the relationship.

Other Methods

In the manual of rock mechanics (CBIP, 1988), a method recommended involves study of joints for 5m along a line perpendicular to joint orientation. Another method has been proposed by Shome *et al.* (1989) for rocks not amenable to good core recovery, which requires preparation of a template of $1m^2$, mapping of all discontinuities in $1m^2$ area on 1:10 scale, and keeping a photographic record of the same on same scale for cross checking and permanent documentation. RQD is calculated as per Deere's definition.

All methods discussed above are time consuming and involve sufficient fieldwork. Moreover, accuracy of results is not guaranteed in many cases except of course the method suggested by Shome *et al.* (*op cit*). But this method cannot be used single handedly as it requires carrying of a template of $1m^2$ besides fieldwork involved in mapping of the area within the template.

Field Practice

Due to the tedious field work involved in all methods of *in situ* evaluation of RQD, many engineering geologists or geotechnical engineers use their judgment and visually estimate the RQD for quick evaluation of Q and RMR values. The author has seen this practice being followed by beginners as well as experienced engineering geologists including some pioneer workers of Q-system. Such practice may be accepted at the preliminary stage of a project but not at detailed and construction stage for the design and selection of supports in an underground structure.

Proposed Method

Considering the aforementioned problems of *in situ* RQD evaluation, the author proposes that RQD can be determined by imagining a hole in some preferred direction at the location of study keeping in view the original definition of RQD by Deere (*op cit*). The hole should be imagined, as far as possible, in a direction roughly normal to the orientation of dominating joint set to avoid directional ambiguity. A measuring tape may be used to mark the line along the assumed direction of hole for a length easily measurable at site, which should be at least 1m (length of 2m or 3m would be better). The RQD can be determined in the same way as defined by Deere, i.e. by adding up the lengths of intact rock blocks having more than 10cm linear length (not intersected by any discontinuity) along the marked line (in centimeters) and dividing the sum by the length of the line. In this way RQD% can be directly obtained as given below.

$$RQD\% = \frac{\text{Sum of lengths of intact rock blocks of >10cm (in centimeters)}}{\text{Total length of line (in meters)}} = \frac{\Sigma l_i}{L}$$

where l_i = lengths of intact rock blocks of >10cm long (in centimeters)
L = Total length of line (in meters)

Preferably, three such observations should be made by shifting the line to appropriate nearby locations. The procedure is very simple, easy and quick to use in field for evaluation of RQD from outcrops as well as underground excavations in rock. The procedure can be repeated at some regular interval to record variations. The procedure has been applied at Nathpa-Jhakri tunnels and Rampur Project for detailed investigation and found useful. For recording of RQD data and classification of rock mass, use of data sheet developed by either NGI (for evaluation of Q-values only) or Kumar (1996) (for realistic assessment of Q, RMR, and GSI), may be made.

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