Published in Tunnels and Underground Space Technology, Vol. 24, 2009, pp.491 - 492

Technical note

COMBINING THE RMR, Q, AND RMi CLASSIFICATION SYSTEMS

by Arild Palmström, Ph.D. RockMass as, Oslo, Norway

The main rockmass classification systems make use of similar rockmass parameters. Therefore, the input parameters in three of the systems can be combined into a set of common parameter tables. This enables the ground quality to be found directly in these systems from characterization of only one set of observations. Thus, the estimated rock support found in one system can be easily be compared with and checked in the other systems.

Three of the rockmass classification systems apply similar input parameters

The main classification systems for rock support estimates, the Q and the RMR (Rock Mass Rating) systems, use the most important ground features or parameters influencing on stability as input. Each of these parameters is classified and each class given a value or rating to express its influence on tunnel stability. All three classification systems estimate rock support for tunnel excavation by drilling and blasting.

Also the RMi classification system applies quantitative estimation of the rock mass quality linked with empirical design rules to estimate adequate rock support measures. Table 1 presents an overview of the input parameters used in the three systems.

Table 1. Overview of the input parameters used in the three systems (revised from Palmstrom, 1995)

INPUT PARAMETERS			The symbols used in:			
PARAMETER	**CLASSIFICATION**		**RMR1989**	**Q**	**RMi**	
A. ROCK(S)	A1. Uniaxial compressive strength of intact rock		A1	1)	σ_c	
B. DEGREE OF JOINTING	B1. RQD		A2	RQD	-	
	B2. Block volume		-	-	Vb	
	B3. Joint spacing		A3	-	-	
C. JOINTING PATTERN	C1. Number of joint sets (at the actual location)		-	Jn	Nj	
	C2. Orientation of main joint set		B	-	Co	
D. JOINT CHARACTERISTICS	D1. Joint smoothness	Joint roughness 2)	A4c	Jr 2)	js	jR 2)
	D2. Joint waviness		-		jw	
	D3. Joint alteration (weathering and filling)		A4e	Ja	jA	
	D4. Joint size (length)		A4a	-	jL	
E. ROCKMASS INTERLOCKING 3)	E1. Joint separation (aperture)		A4b	-	-	
	E2. Compactness of rockmass structure		-	-	IL	
F. GROUND WATER	F1. Water inflow or water pressure		A5	Jw	GW	
G. ROCK STRESSES (around tunnel)	G1. Stress level		-	SRF	SL	
	G2. Overstressing (rock burst or squeezing ground)		-		CF	
H. WEAKNESS ZONE (fault etc.)	H1. Type of weakness zone		-		-	
	H2. Size (thickness) of the zone		-	-	Tz	
	H3. Orientation of the zone		-	-	Coz	

1) Compressive strength of rock is included in the revised $Qc = Q \times \sigma_c / 100$; 2) $Jr = jR = js \times jw$;
3) The effect of interlocking of the rockmass structure is included in the RMi.

Some special rockmass or ground conditions, like swelling, squeezing, and ravelling ground are not covered well in any of the three classification systems. For such conditions, the rock support should be evaluated separately using other rock engineering tools.

Weakness zones are applied differently in the three systems. The Q system applies the SRF (stress reduction factor) values for some specified types of weakness zones, but does not have an input for the size of the zone. RMi applies the thickness (size) of the zone, while RMR has no special parameter for weakness zones. As advised by Bieniawski (1984), each weakness zone should be specially evaluated.

A combination of the input parameters

Bieniawski (1984, 1989) also advises the use of at least two classification systems when applying these empirical tools. However, many users are practising this recommendation by finding the value (or quality) in one classification system from a value in another using some sort of transition equation(s). The most known of these transitions is between Q and RMR as presented in Figure 1. However, this correlation is a very crude approximation, involving an inaccuracy of ± 50% or more.

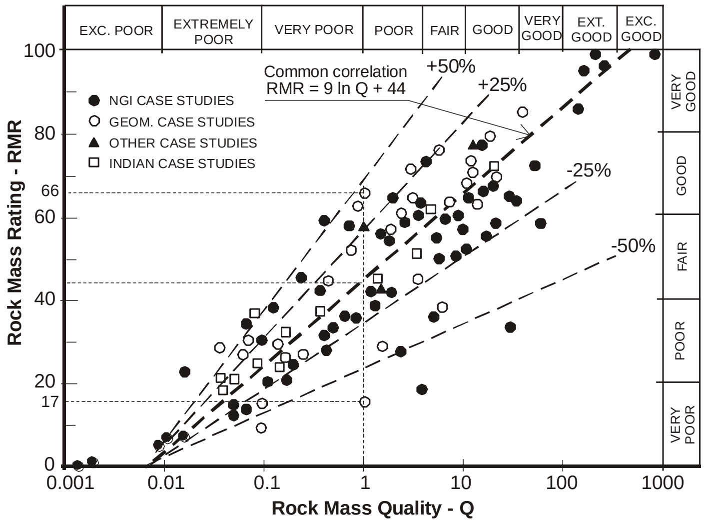

Figure 1. A commonly used correlation between the RMR and the Q-index where deviations from the common correlation are shown (revised after Jethwa et al., 1982). As seen, for Q = 1, RMR varies from less than 20 to more than 60. Note that the Q system applies logarithmic scale while RMR has a linear scale.

Table 2. An example of a combined input table (for jointing pattern in Table 1)

C. JOINTING PATTERN	RMR	Q	RMi
C1. Number of joint sets (at the actual location)	-	Jn =	Nj =
a. No or few joints		0.75	6
b. 1 joint set		2	3
c. 1 joint set + random joints		3	2
d. 2 joint sets		4	1.5
e. 2 joint sets + random joints	*Not included*	6	1.2
f. 3 joint sets		9	1
g. 3 joint sets + random joints		12	0.85
h. 4 joint sets or more; heavily jointed		15	0.6
i. Crushed, earth-like		20	-
C2. Orientation of main joint set	B =	-	Co =
a. Very favourable	0		1
b. Favourable	-2		1
c. Fair	-5	*Not included*	1.5
d. Unfavourable	-10		2
e. Very unfavourable	-12		3

The example in Table 2 shows two of the input parameter combinations. By using the combined set of input parameters (shown in www.rockmass.net), it is sufficient with one characterization of each of the input parameters to find values or ratings in all three systems.

Comparison between the three RMR, Q, and RMI systems

With a computer spreadsheet the values in all the tree systems can easily be estimate from a single set of input parameters. By this, it is easy to calculate the corresponding ground qualities in the three classification systems. Comparisons between the systems can then be made, provided that the inputs of ground conditions are within the limits of all the three systems.

Figure 2 presents the results from comparison of the RMR and Q systems. It shows the same as Figure 1, that there may be large inaccuracies from the average correlation equation between the values found for

RMR and Q, often ± 30 - 50%. Similar comparisons have been performed also between the Q and the RMi systems as well as between the RMR and the RMi systems. These are presented in the www.rockmass.net web site.

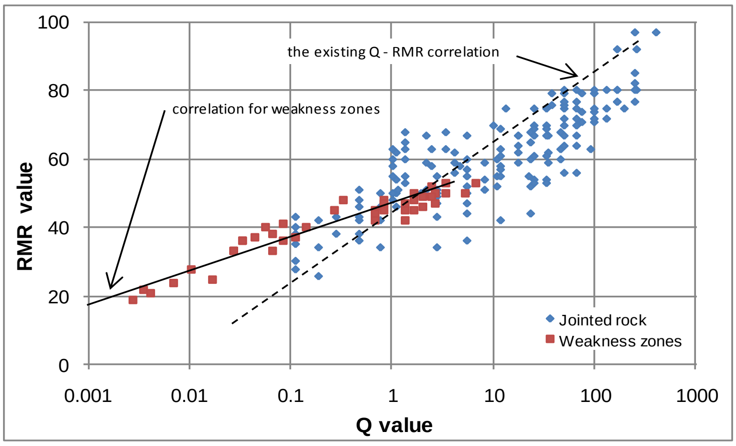

Figure 2. Comparison between the RMR and Q systems. Overstressing (rock burst and squeezing) is not included, because it is not covered in the RMR system.

By using the common input tables, significantly more reliable correlations between the RMR, Q and RMi can be found than the existing transition equations in use. This is because the quality value in each of the three systems can be found independently. With a spreadsheet this calculation can easily be done (an Excel spreadsheet can be downloaded from www.rockmass.net).

5. References

Bieniawski Z.T. (1989): Engineering rock mass classifications. John Wiley & Sons, New York, 251 pp.

Grimstad E. and Barton N. (1993): Updating the Q-system for NMT. Proc. Int. Symp. on Sprayed Concrete, Fagernes, Norway 1993, Norwegian Concrete Association, Oslo, 20 p.

Jethwa J.L., Dube A.K., Singh B., and Mithal R.S. (1982): Evaluation of methods for tunnel support design in squeezing rock conditions. Proc. 4th Int. Congr. Int. Assoc. Eng. Geol., New Delhi, 1982, Vol. 5 pp. 125-134

Palmström A. (1995): RMi - a rock mass characterization system for rock engineering purposes Ph.D. thesis Univ. of Oslo, 400 p (also available in www.rockmass.net)

Palmström A. (2000): Recent developments in rock support estimates by the RMi. Journal of Rock Mechanics and Tunnelling Technology, Vol. 6, No. 1 May 2000, pp. 1 – 19; also in www.rockmass.net

Palmström A. and Broch E. (2006): Use and misuse of rock mass classification systems with particular reference to the Q-system. Tunnels and Underground Space Technology, Vol. 21, pp. 575-593; also in www.rockmass.net