

## CLASSIFICATION OF VARIOUS ROCK AND ROCK MASS FEATURES

PARAMETER		SYMBOL	UNIT	CLASSIFICATION					REFERENCE
				very low or small	low or small	medium // moderate	high or large	very high or large	
ROCKS	Density	$\rho$	t/m <sup>3</sup>	< 2.4	2.4 - 2.6	2.6 - 2.8	2.8 - 3.0	> 3.0	NBG 1985
	Unit weight	$\gamma$	kN/m <sup>3</sup> ×10						
	Uniaxial compressive strength	$\sigma_c$	MPa	1 - 5	5 - 15	15 - 50	50 - 120	> 120	ISRM
	Point load strength	$I_s$	MPa	< 0.1	0.1 - 0.3	0.3 - 1	1 - 3	> 3	ISRM
	E-modulus	E	GPa	< 10	10 - 30	30 - 70	70 - 100	> 100	ISRM
	Modulus ratio ( $E_{stat}/\sigma_c$ )	-	-		< 200	200 - 500	> 500		NBG, 1985
	Flakiness value	f	-		< 1.3	1.3 - 1.45	> 1.45		NBG, 1985
	Brittleness value	S <sub>20</sub>	-		< 45	45 - 65	> 65		NBG, 1985
	Drilling rate index	DRI	-	< 32	32 - 43	43 - 57	57 - 75	> 75	Blindheim, 1982
	Bit wear index	BWI	-	< 18	18 - 28	28 - 38	38 - 48	> 48	Blindheim, 1982
CLAY GOUGE	Porosity	n	%	< 0.5	0.5 - 2	2 - 5	5 - 20	> 20	NBG, 1985
	Foliation anisotropy	fA	-	1 - 1.2	1.2 - 1.5	1.5 - 2	2 - 2.5	> 2.5	Palmström, 1995
	Permeability coefficient	k	m/s × 10 <sup>-7</sup>	< 0.001	0.001 - 0.1	0.1 - 10	10 - 100	> 100	NBG, 1985
	Weathering of rock	-	%		< 10	10 - 35	35 - 75	> 75	ISRM
	Slaking (two cycles)	I <sub>d2</sub>	%	< 30	30 - 60	60 - 90	90 - 98	98 - 100	ISRM
	Mineral size	-	mm	< 0.02	0.02 - 0.6	0.6 - 6	6 - 20	> 20	NBG, 1985
	Free swelling (of swelling clay)	S <sub>s</sub>	% <sup>*)</sup>		< 100	100 - 140	140 - 200	> 200	NBG, 1985
Hygroscopic moisture	-	% <sup>*)</sup>		< 8	8 - 15	15 - 25	> 25	NBG, 1985	
Swelling pressure	$\sigma_s$	MPa		< 0.1	0.1 - 0.3	0.3 - 0.75	> 0.75	NBG, 1985	
GROUND WATER	Capacity of drilled well	q <sub>w</sub>	l/h	< 3.6	3.6 - 36	36 - 360	360 - 3600	> 3600	NBG, 1985
	Leakage into tunnels // caverns	q <sub>l</sub>	l/min/m	< 0.05	0.05 - 0.3	0.3 - 2	2 - 10	> 10	NBG, 1985
	Water leakage test in bore hole	L	Lugeon	< 0.1	0.1 - 1	1 - 10	10 - 100	> 100	NBG, 1985
JOINTING	Joint spacing	S	m	< 0.06	0.06 - 0.2	0.2 - 0.6	0.6 - 2	> 2	ISRM
	Joint persistence (length)	l	m	< 1	1 - 3	3 - 10	10 - 20	> 20	Bieniawski, 1984
	Joint separation	d	mm	< 0.1	0.1 - 0.5	0.5 - 2.5	2.5 - 10	> 10	Bieniawski, 1984
	Angle of friction for joint surfaces	$\phi$	degree	< 15°	15 - 25°	25 - 35°	35 - 45°	> 45°	ISRM
	Volumetric joint count	J <sub>v</sub>	joints/m <sup>3</sup>	< 1	1 - 3	3 - 10	10 - 30	> 30	Palmström, 1982
	Block volume	V <sub>b</sub>	m <sup>3</sup>	< 0.001	0.001-0.03	0.03 - 1	1 - 30	> 30	Palmström, 1996
RQD-value	RQD	%	< 25	25 - 50	50 - 75	75 - 90	90 - 100	ISRM	
Block shape factor	$\beta$	-	27 - 32	32 - 50	50 - 100	100 - 500	> 500	Palmström, 1995	
ROCK MASSES	Weakness zone thickness	T <sub>z</sub>	m	< 1	1 - 3	3 - 10	10 - 30	> 30	NBG, 1985
	Rock mass strength (approx.)	RM <sub>i</sub>	MPa	< 0.01	0.01 - 0.1	0.1 - 1	1 - 10	> 10	Palmström, 1995
	Rock mass quality	Q	-	< 0.1	0.1 - 1	1 - 10	10 - 40	> 40	Barton et al, 1974
		RMR	-	< 25	25 - 50	50 - 70	70 - 90	90 - 100	Bieniawski, 1974
	Stand-up time in tunnels	-	day year	1/24 - 1	1 - 30	30 - 360 1/12 - 1	1 - 10	> 10	NBG, 1985
	Cost for rock support in tunnels	-	% <sup>**)</sup>	< 5	5 - 15	15 - 50	50 - 200	> 200	NBG, 1985
	Blastability index	RBFI	-		< 1	1 - 2.5	2.5 - 4	> 4	Selmer-Olsen, 1980
Rock stress ratio	$\sigma_c/\sigma_1$	-	< 5	5 - 10	10 - 20	20 - 200	> 200	NBG, 1985	
Seismic velocity in rock masses	v	km/s	< 2.5	2.5 - 3.5	3.5 - 5	5 - 7	> 7	NBG, 1985	

<sup>\*)</sup> % of dry material; <sup>\*\*)</sup> % of excavation (drill, blast, mucking) cost

### References

NBG 1985:

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Handbook in engineering geology - rock. (in Norwegian)  
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Bieniawski 1974:

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