Table B-1
Input Data Sheet for the Geomechanics (RMR) Classification System

CLASSIFICATION INPUT DATA WORKSHEET: GEOMECHANICS CLASSIFICATION OF ROCK MASSES

Name of project: _____
Site of survey: _____
Conducted by: _____
Date: _____

STRUCTURAL REGION

No. _____
Sta. _____
Sta. _____
Sta. _____
Sta. _____

ROCK TYPE AND ORIGIN

DRILL CORE QUALITY R.Q.D.

Excellent:	90-100%	.....
Good:	75- 90%	.....
Fair:	50- 75%	.....
Poor:	25- 50%	.....
Very poor:	< 25%	.....
Range %:		.....

WALL ROCK OF DISCONTINUITIES

Unweathered .....
Slightly weathered .....
Moderately weathered .....
Highly weathered .....
Completely weathered .....

GROUNDWATER

INFLOW per 1,000 ft of tunnel length gal/min .....
or
GENERAL CONDITIONS (completely dry, damp, wet, dripping or flowing under low, medium or high pressure):
.....

STRENGTH OF INTACT ROCK MATERIAL

	Uniaxial compressive strength, psi	
Very high:	Over 32,000	.....
High:	16,000 - 32,000	.....
Medium:	8,000 - 16,000	.....
Low:	4,000 - 8,000	.....
Very low:	150 - 4,000	.....

CONDITION OF DISCONTINUITIES

CONTINUITY		Set 1	Set 2	Set 3
Very low:	< 3 ft	.....	.....	.....
Low:	3-10 ft	.....	.....	.....
Medium:	10-30 ft	.....	.....	.....
High:	> 30 ft	.....	.....	.....
SEPARATION				
Tight joints:	< 0.01	.....	.....	.....
Moderately open joints:	0.01-0.1 in.	.....	.....	.....
Open joints:	0.1-0.5 in.	.....	.....	.....
Range in.:		.....	.....	.....
ROUGHNESS				
Very rough surfaces:		.....	.....	.....
Rough surfaces:		.....	.....	.....
Slightly rough surfaces:		.....	.....	.....
Smooth surfaces:		.....	.....	.....
Slickensided surfaces:		.....	.....	.....
FILLING (GOUGE)				
Type:		.....	.....	.....
Thickness:		.....	.....	.....
Consistency:		.....	.....	.....

SPACING OF DISCONTINUITIES

		Set 1	Set 2	Set 3
Very wide:	Over 10 ft	.....	.....	.....
Wide:	3-10 ft	.....	.....	.....
Moderate:	1-3 ft	.....	.....	.....
Close:	2 in. - 1 ft	.....	.....	.....
Very close:	< 2 in.	.....	.....	.....
Range:		.....	.....	.....

MAJOR FAULTS OR FOLDS

Describe major faults and folds specifying their locality, nature, and orientations.

STRIKE AND DIP ORIENTATIONS

				DIRECTION
Set 1	Strike:	(from ..... to .....)	Dip:	.....
Set 2	Strike:	(from ..... to .....)	Dip:	.....
Set 3	Strike:	(from ..... to .....)	Dip:	.....

GENERAL REMARKS AND ADDITIONAL DATA

The geologist should supply any further information which he considers relevant.

Table B-2
Geomechanics Classification of Jointed Rock Masses

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS

	PARAMETER		RANGES OF VALUES						
1	Strength of intact rock material	Point-load strength index	> 10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this low range – uniaxial compressive test is preferred		
		Uniaxial compressive strength	>250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5-25 MPa	1-5 MPa	< 1 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core quality RQD		90% - 100%	75% - 90%	50% - 75%	25% - 50%	< 25%		
	Rating		20	17	13	8	3		
3	Spacing of discontinuities		>2 m	0.6 - 2 m	200 - 600 mm	60 -200 mm	< 60 mm		
	Rating		20	15	10	8	5		
4	Condition of discontinuities		Very rough surfaces. Not continuous No separation Unweathered wall rock.	Slightly rough surfaces. Separation < 1 mm Slightly weathered walls	Slightly rough surfaces. Separation < 1 mm Highly weathered walls	Slickensided surfaces OR Gouge < 5 mm thick OR Separation 1-5 mm. Continuous	Soft gouge > 5 mm thick OR Separation > 5 mm. Continuous		
	Rating		30	25	20	10	0		
5	Ground water	Inflow per 10 m tunnel length	None	< 10 litres/min	10-25 litres/min	25 - 125 litres/min	> 125		
		Ratio $\frac{\text{joint water pressure}}{\text{major principal stress}}$	OR 0	OR 0.0-0.1	OR 0.1-0.2	OR 0.2-0.5	OR > 0.5		
		General conditions	OR Completely dry	OR Damp	OR Wet	OR Dripping	OR Flowing		
	Rating		15	10	7	4	0		

B. RATING ADJUSTMENT FOR JOINT ORIENTATIONS

Strike and dip orientations of joints		Very favourable	Favourable	Fair	Unfavourable	Very unfavourable
Ratings	Tunnels	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	-60

C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS

Rating	100←81	80←61	60←41	40←21	< 20
Class No	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

D. MEANING OF ROCK MASS CLASSES

Class No	I	II	III	IV	V
Average stand-up time	10 years for 15 m span	6 months for 8 m span	1 week for 5 m span	10 hours for 2.5 m span	30 minutes for 1 m span
Cohesion of the rock mass	> 400 kPa	300 - 400 kPa	200 - 300 kPa	100 - 200 kPa	< 100 kPa
Friction angle of the rock mass	> 45°	35° - 45°	25° - 35°	15° - 25°	< 15°

Table B-3
Summary of Joint Orientation Adjustments for Dam Foundations and Tunnels

A. Assessment of joint orientation favourability upon stability of dam foundations

Dip 0° - 10°	Dip 10° - 30°		Dip 30° - 60°	Dip 60° - 90°
	Dip direction			
	Upstream	Downstream		
Very favourable	Unfavourable	Fair	Favourable	Very unfavourable

B. The effect of joint strike and dip orientations in tunneling

Strike Perpendicular to Tunnel Axis			
Drive with Dip		Drive against Dip	
Dip 45°-90°	Dip 20°-45°	Dip 45°-90°	Dip 20°-45°
Very favorable	Favorable	Fair	Unfavorable

Strike Parallel to Tunnel Axis		Dip 0°-20° Irrespective of Strike
Dip 45°-90°	Dip 20°-45°	
Very unfavorable	Fair	Fair

Table B-4
Q-System: Description and Ratings for the RQD, J_n, J_r, J_a, and J_w Parameters (from Barton, Lien and Lunde 1974)

Rock Quality Designation (RQD)		
Very poor.....	0-25	Note:
Poor.....	25-50	(i) Where RQD is reported or measured as ≤ 10 (including 0) a nominal value of 10 is used to evaluate Q in Eq. (1).
Fair.....	50-75	
Good.....	75-90	
Excellent.....	90-100	(ii) RQD intervals of 5, i.e. 100, 95, 90 etc. are sufficiently accurate.

Joint Set Number (J_n)		
Massive, no or few joints	0.5-1.0	Note:
One joint set.....	2	(i) For intersections use ($3.0 \times J_n$)
One joint set plus random	3	
Two joint sets.....	4	(ii) For portals use ($2.0 \times J_n$)
Two joint sets plus random.....	6	
Three joint sets.....	9	
Three joint sets plus random.....	12	
Four or more joint sets, random, heavily jointed, "sugar cube", etc.....	15	
Crushed rock, earthlike..	20	

Joint Roughness Number (J_r)		
(a) Rock wall contact and (b) Rock wall contact before 10 cms shear		Note:
Discontinuous joints.....	4	(i) Add 1.0 if the mean spacing of the relevant joint set is greater than 3 m.
Rough or irregular, undulating.....	3	
Smooth, undulating.....	2	Note:
Slickensided, undulating	1.5	(ii) J_r = 0.5 can be used for planar slickensided joints having lineation, provided the lineations are favorably orientated.
Rough or irregular, planar.....	1.5	
Smooth, planar.....	1.0	
Slickensided, planar.....	0.5	(iii) Descriptions B to G refer to small scale features and intermediate scale features, in that order.
(c) No rock wall contact when sheared		
Zone containing clay minerals thick enough to prevent rock wall contact	1.0 (nominal)	
Sandy, gravelly or crushed zone thick enough to prevent rock wall contact.....	1.0 (nominal)	

(Continued)

Table B-4. (Continued)

	Joint Alteration Number	(J_a)	ϕ_r (approx.)
	(a) Rock wall contact		
A.	Tightly healed, hard, nonsoftening, impermeable filling i.e. quartz or epidote.....	0.75	(-)
B.	Unaltered joint walls, surface staining only.....	1.0	(25°-35°)
C.	Slightly altered joint walls. Non-softening mineral coatings, sandy particles, clay-free disintegrated rock etc.....	2.0	(25°-30°)
D.	Silty-, or sandy-clay coatings, small clay-fraction (non-softening)	3.0	(20°-25°)
E.	Softening or low friction clay mineral coatings, i.e. kaclinite, mica. Also chlorite, talc, gypsum and graphite etc., and small quantities of swelling clays. (Discontinuous coatings, 1-2 mm or less in thickness).....	4.0	(8°-16°)
	(b) Rock wall contact before 10 cms shear		
F.	Sandy particles, clay-free disintegrated rock etc.....	4.0	(25°-30°)
G.	Strongly over-consolidated, non-softening clay mineral fillings (Continuous, <5 mm in thicknes)....	6.0	(16°-24°)
H.	Medium or low over-consolidation, softening, clay mineral fillings. (continuous, <5 mm in thickness)...	8.0	(12°-16°)
J.	Swelling clay fillings, i.e. montmorillonite (Continuous, <5 mm in thicknes). Value of J_a depends on percent of swelling clay-size particles, and access to water etc.....	8.0-12.0	(6°-12°)
	(c) No rock wall contact when sheared		
K., L., M.	Zones or bands of disintegrated or crushed rock and clay (see G., H., J. for description of clay condition).....	6.0, 8.0 or 8.0-12.0	(6°-24°)
N.	Zones or bands of silty- or sandy clay, small clay fraction (nonsoftening).....	5.0	
O., P., R.	Thick, continuous zones or bands of clay (see G., H., J. for description of clay condition).....	10.0, 13.0 or 13.0-20.0	(6°-24°)

Note:

(i) Values of $(\phi)_r$ are intended as an approximate guide to the mineralogical properties of the alteration products, if present.

(Continued)

Table B-4. (Concluded)

Stress Reduction Factor

		σ_c/σ_1	σ_t/σ_1	(SRF)
	(a) Weakness zones intersecting excavation, which may cause loosening of rock mass when tunnel is excavated.			
A.	Multiple occurrences of weakness zones containing clay or chemically disintegrated rock, very loose surrounding rock (any depth).....			10.0
B.	Single weakness zones containing clay, or chemically disintegrated rock (depth of excavation ≤50 m).....			5.0
C.	Single, weakness zones containing clay, or chemically disintegrated rock (depth of excavation >50 m).....			2.5
D.	Multiple shear zones in competent rock (clay free), loose surrounding rock (any depth).....			7.5
E.	Single shear zones in competent rock (clay free) (depth of excavation ≤50 m).....			5.0
F.	Single shear zones in competent rock (clay free) (depth of excavation >50 m).....			2.5
G.	Loose open joints, heavily jointed or "sugar cube" etc. (any depth).....			5.0
	(b) Competent rock, rock stress problems.			
H.	Low stress, near surface..	>200	>13	2.5
J.	Medium stress.....	200-10	13-0.66	1.0
K.	High stress, very tight structure (Usually favorable to stability, may be unfavorable to wall stability).....	10-5	0.66-0.33	0.5-2.0
L.	Mild rock burst (massive rock).....	5-2.5	0.33-0.16	5-10
M.	Heavy rock burst (massive rock).....	<2.5	<0.16	10-20
	(c) Squeezing rock; plastic flow of incompetent rock under the influence of high rock pressures.			
N.	Mild squeezing rock pressure.....			5-10
O.	Heavy squeezing rock pressure.....			10-20
	(d) Swelling rock; chemical swelling activity depending on presence of water			
P.	Mild swelling rock pressure.....			5-10
R.	Heavy swelling rock pressure.....			10-15

Note:

(i) Reduce these values of SRF by 25-50% if the relevant shear zones only influence but do not intersect the excavation.

(ii) For strongly anisotropic stress field (if measured): when $5 \leq \sigma_1/\sigma_3 \leq 10$, reduce σ_c and σ_t to 0.8 σ_c and 0.8 σ_t; when $\sigma_1/\sigma_3 > 10$, reduce σ_c and σ_t to 0.6 σ_c and 0.6 σ_t where: σ_c = unconfined compression strength, σ_t = tensile strength (point load), σ_1 and σ_3 = major and minor principal stresses.

(iii) Few case records available where depth of crown below surface is less than span width. Suggest SRF increase from 2.5 to 5 for such cases (see H).

Joint Water Reduction Factor

		(J_w)	Approx. water pressure (kg/cm^2)
A.	Dry excavations or minor inflow, i.e. 5 l/min. locally.....	1.0	<1
B.	Medium inflow or pressure occasional outwash of joint fillings.....	0.66	1.0-2.5
C.	Large inflow or high pressure in competent rock with unfilled joints.....	0.5	2.5-10.0
D.	Large inflow or high pressure, considerable outwash of joint fillings.....	0.33	2.5-10.0
E.	Exceptionally high inflow or water pressure at blasting, decaying with time.....	0.2-0.1	>10.0
F.	Exceptionally high inflow or water pressure continuing without noticeable decay.....	0.1-0.05	>10.0

Note:

(i) Factors C to F are crude estimates. Increase J_w if drainage measures are installed.

(ii) Special problems caused by ice formation are not considered.