

KATHMANDU UNIVERSITY
End Semester Examination
March/April, 2017

Marks Scored:

Level : B. E.

Year : IV

Course : CIEG 408

Semester : I

Exam Roll No. :

Time: 30 mins.

F. M. : 10

Registration No. :

Date **APR 13 2017**

SECTION "A"

[20 Q. × 0.5 = 10 marks]

1. For very poor rock mass the Q values lies between
a. 4-10 b. 0.1-1 c. 10-40 d. 40-100
2. In Q-system, RQD/J_n is expressed as
a. Joint blocks b. Strength of the block surfaces
c. Structure of rock mass d. Stress free factor
3. A shear zone is a zone in which
a. Rock mass is crushed b. Rock mass is very strong and tough
c. Tunnel is more stable d. Q-value is higher
4. Vertical rock stress
a. Linearly increases with depth b. Is constant to depth of tunnel
c. Is always equal to the horizontal stress d. Varies with tectonic stress
5. Hydraulic conductivity of a rock mass is largely governed by
a. The degree of jointing b. Strength of intact rock
c. Strength of rock mass d. Types of rock mass
6. The common dimension of blast hole for tunneling is
a. 25-30 mm b. 45-50 mm c. 50-75 mm d. 75-100 mm
7. The appropriate drilling rate for hard rock is
a. 50 cm /minute b. 100 cm/ minute c. 200 cm/minute d. 500 cm/ minute
8. In drill and blast method of tunneling cut holes are
a. always loaded b. unloaded
c. large diameter hole d. deep holes
9. Tunnel boring machine excavates the entire cross section
a. In two operations without explosives
b. In two operations with explosives
c. In one single operation with drill and blast method
d. In one single operation
10. Scaling is referring to
a. Add support to the tunnel after excavation
b. Remove the dust particles after blasting
c. Adding shotcrete immediately after excavation to make smooth surface
d. Remove loose rock after each blast

11. Spot bolting is carried out
 - a. For unstable blocks
 - b. For very loose rock mass
 - c. In every round of blasting
 - d. Very hard rock excavation
12. Tension rock bolts are used for
 - a. Long term support
 - b. Very hard rock mass
 - c. Immediate rock support
 - d. Blasting of weak rock mass
13. In dry mix
 - a. Cement and sand are dry mixed and water is added at the nozzle
 - b. Cement, sand and water are mixed
 - c. Sand and water are mixed and cement is added at the nozzle
 - d. Cement and water are mixed and sand is added at the nozzle
14. Spiling bolts are used
 - a. To support the roof of excavation
 - b. As a total support in difficult ground conditions
 - c. For very hard rocks
 - d. Immediately after excavation
15. Shotcrete is primarily used in
 - a. Only in invert of tunnel
 - b. Only in crown of tunnel
 - c. Very hard rock mass after excavation
 - d. In heavily jointed rock masses as immediate support
16. In Electrical Resistivity Tomography
 - a. An electric current is injected to ground
 - b. Radar waves are used for investigation
 - c. Seismic waves are used
 - d. Boring holes are drilled for geological investigation
17. The purpose of the Lugeon test is to
 - a. Identify the compressive rock strength
 - b. Assess water leakage
 - c. Identify triaxial stress
 - d. Find drill rate index
18. Which of the following items will normally be the most costly?
 - a. Surveying
 - b. Scaling
 - c. Drilling
 - d. Ventilation
19. Concrete lining is
 - a. Used as grouting
 - b. Normally used in all sections
 - c. Used instead of shotcrete
 - d. For stabilization is used in exceptionally poor rock mass section
20. The uncertainty level of geotechnical study at feasibility study is
 - a. High
 - b. Exactly determined
 - c. Low
 - d. Not known

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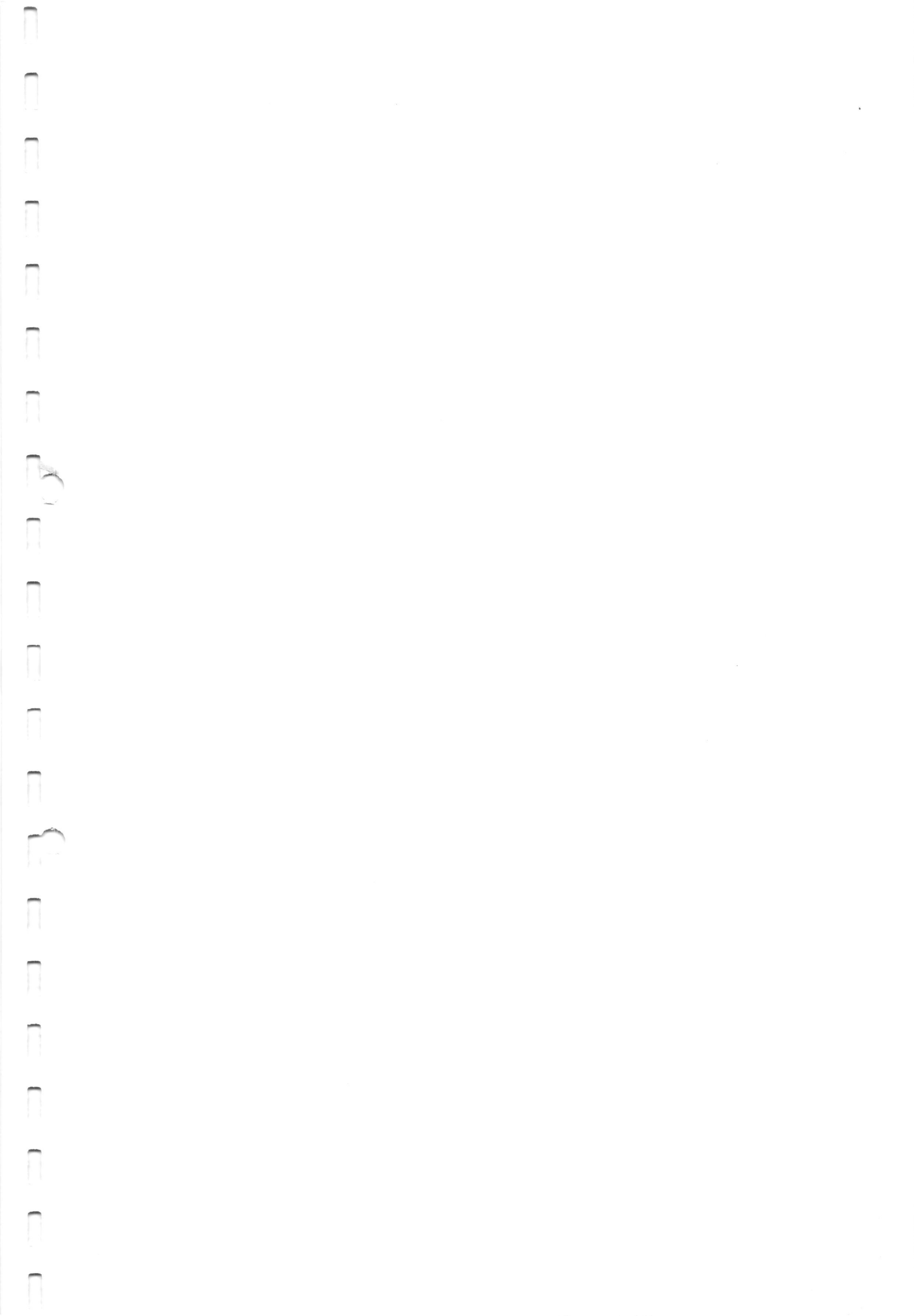
Level : B.E.
Year : IV
Time : 2hrs. 30 mins.

Course : CIEG 408
Semester: I
F. M. : 40

SECTION "B"

Attempt *ALL* questions:

1. Describe the Drill and Blast Method of tunnel construction technique. Describe the Q-system of rock mass classification to design the tunnel support in the lesser Himalayan region of Nepal. [4+4=8]
2. Discuss the various types of rock support system used in the underground structures in the Himalayan region of Nepal. [4]
3. Describe the common laboratory testing for rock. Classify the rock stress and its importance to design the tunnels in weak rock mass. [4+4=8]
4. A 8.0 m wide, D-Shaped headrace tunnel of major hydroelectric project, located in the lesser Himalayan region passes through weak rock mass with several shear zones. The tunnel section is characterized by graphitic phyllite with three number of joint sets, rough or irregular and undulating joints. The site has slightly altered joint walls, clay-free disintegrated rock and multiple weakness zones containing clay or chemically disintegrated rock. It is found that the rock cover at the section is 620 m. Use the rock mass classification approach, Q-method, to identify the rock support. Consider the suitable assumptions where ever necessary for the design. The ratings of different rock mass conditions also given in attached table. [10]
5. Discuss the process of risk management for construction of hydropower tunnel. [4]
6. Describe the operating cycle of the tunnel boring machine. [6]



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Table

Table A-1. Description of ratings for input parameters of Q-system (based on Barton, 2002).

RQD (Rock quality designation, %)		J_n (Joint set number)	
Very poor	0 - 25	Massive, no or few joints	0.5 - 1
Poor	25 - 50	One joint set	2
Fair	50 - 75	One joint set + random joints	3
Good	75 - 90	Two joint sets	4
Excellent	90 - 100	Two joint sets + random	6
Notes:		Three joint sets	9
(i) where RQD is reported or measured as ≤ 10 (including 0), a nominal value of 10 is used to evaluate Q.		Three joint sets + random	12
(ii) RQD intervals of 5 i.e. 100, 95, 90 etc., are successfully accurate.		Four or more joint sets, heavily jointed, sugar cube etc	15
		Crushed rock, earthlike	20
		Note: For tunnel intersections, use $(3 \times J_n)$ and for portals use $(2 \times J_n)$	
J_r (Joint roughness number)			
(a) Rock wall contact		(b) Rock wall contact before 10 cm shear	
Discontinuous joints	4	Rough or irregular, undulating	1.5
Rough or irregular, undulating	3	Smooth, undulating	1
Smooth, undulating	2	Slickensided, undulating	0.5
Slickensided, undulating	1.5		
© No rock wall contact when sheared			
Zone containing clay minerals thick enough to prevent rock wall contact			1
Sandy, gravelly or crushed zone thick enough to prevent rock wall contact			1
Notes: (i) Description refers to small-scale features and intermediate scale features, in that order (ii) Add 1.0 if the mean spacing of the relevant joint set is greater than 3 m. (iii) $J_r = 0.5$ can be used for planner, slickenside joints having lineations, provided these are oriented for minimum strength. (iv) J_r and J_a classification is applied to the joint set that is least favorable for stability both from the point of view of orientation and shear resistance. $\tau \approx \sigma_n \cdot \tan^{-1}(J_r/J_a)$			
J_a (Joint alteration number)			
(a) Rock wall contact (no mineral fillings, only coatings)		σ_r (appr.)	J_a
Tightly healed, hard, non-softening, impermeable filling i.e., quartz/epidote		-	0.75
Unaltered joint walls, surface staining only		25 - 35	1
Slightly altered joint walls, non-softening mineral coatings, sandy particles, clay free disintegrated rock, etc.		25 - 30	2
Silty or sandy clay coatings, small clay fractions (non-softening)		20 - 25	3
Softening or low friction clay mineral coatings, i.e., kaolinite or mica. Also chlorite, talk, gypsum, graphite etc., and small quantities of swelling clay		8 - 16	4
(b) Rock wall contact before 10 cm shear (thin mineral fillings)			
Sandy particles, clay free disintegrated rock etc.		25 - 30	4
Strongly over-consolidated non-softening clay mineral fillings (continuous, but < 5mm thickness)		16 - 24	6

Medium or low over-consolidated non-softening clay mineral fillings (continuous, but < 5mm thickness)	12 - 16	8
Swelling clay fillings, i.e., montmorillonite (continuous, but < 5mm thick)	6 - 12	8 - 12
<i>(c) No rock wall contact when sheared (thick mineral fillings)</i>		
Zones or bands of disintegrated or crushed rock and clay	6 - 24	6, 8 - 12
Zones or bands of silty or sandy clay, small clay fraction (non-softening)	-	5
Thick, continuous zones or bands of clay	6 - 24	13 - 20
J_w (Joint water reduction factor)	<i>Approx. P (bars)</i>	J_w
Dry excavations or minor inflow, i.e., < 5 l/min locally	< 1	1
Medium inflow or pressure, occasional outwash of joint fillings	1 - 2.5	0.66
Large inflow or high pressure in competent rock with unfilled joints	2.5 - 10	0.5
Large inflow or high pressure, considerable outwash of joint fillings	2.5 - 10	0.33
Exceptionally high inflow or pressure at blasting, decaying with time	> 10	0.2 - 0.1
Exceptionally high inflow or pressure continuing without noticeable decay with time	> 10	0.2 - 0.1

Notes: (i) The last four factors are crude estimates. Increase J_w if drainage measures are installed. (ii) Special problems caused by ice formation are not considered. (iii) For general characterization of rock masses distance from excavation influences. The use of $J_w = 1, 0.66, 0.5, 0.33$, etc. as depth increases from say 0-5, 5-25, 25-250 to >250m is recommended, assuming that RQD/J_w is low enough (0.5-25) for good hydraulic connectivity.

SRF (Stress Reduction Factor)

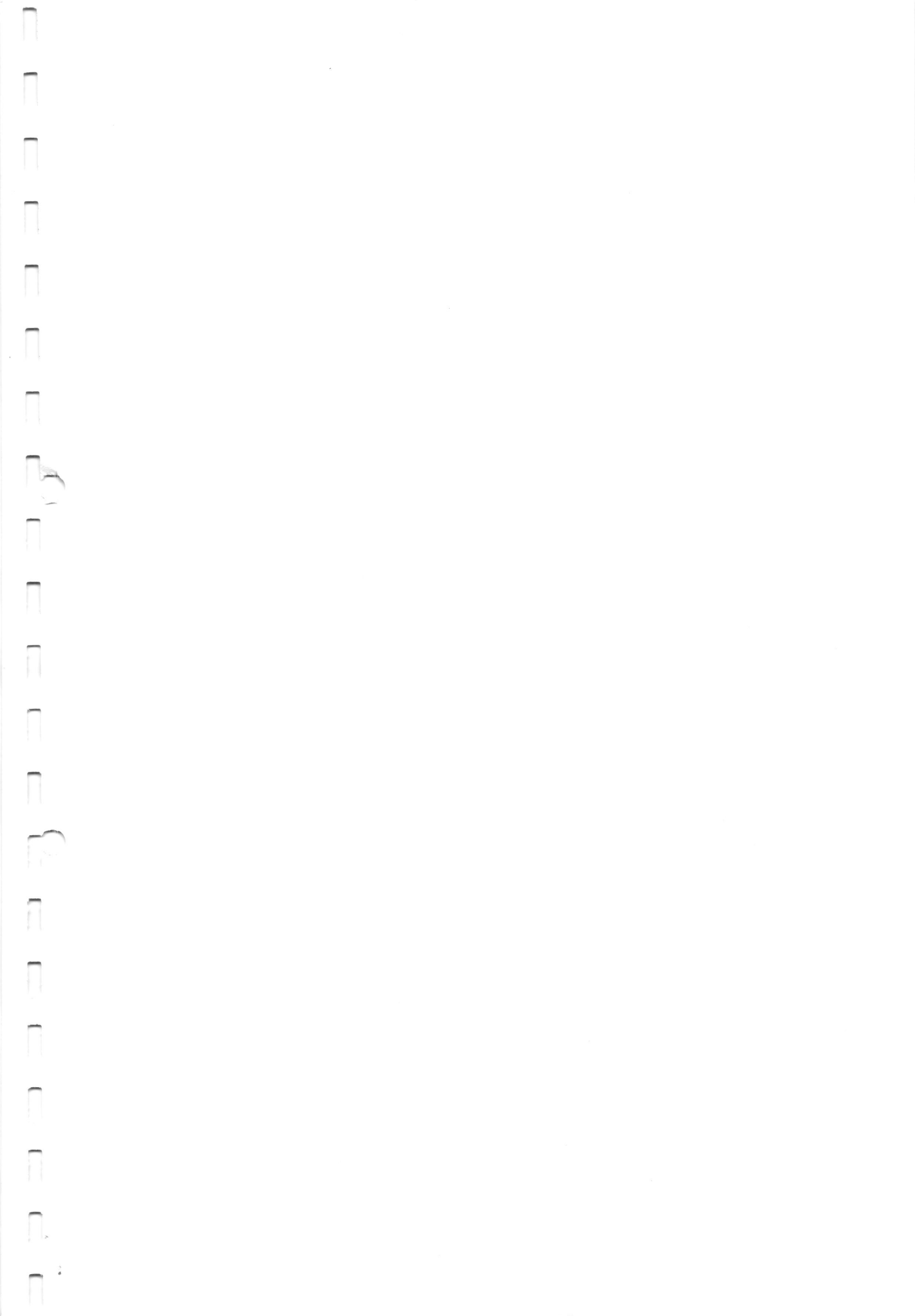
<i>(a) Weakness zones intersecting excavation, which may cause loosening of rock mass</i>	SRF	
Multiple occurrence of weakness zones containing clay or chemically disintegrated rock, very loose surrounding rock at any depth	10	
Single weakness zone containing clay or chemically disintegrated rock (depth ≤ 50m)	5	
Single weakness zone containing clay or chemically disintegrated rock (depth > 50m)	2.5	
Multiple shear zones in competent rocks (clay free), loose surrounding rock at any depth	7.5	
Single shear zone in competent rocks (clay free), (depth of excavation ≤ 50m)	5	
Single shear zone in competent rocks (clay free), (depth of excavation > 50m)	2.5	
Loose, open joints, heavily jointed or sugar cube etc. at any depth	5	

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

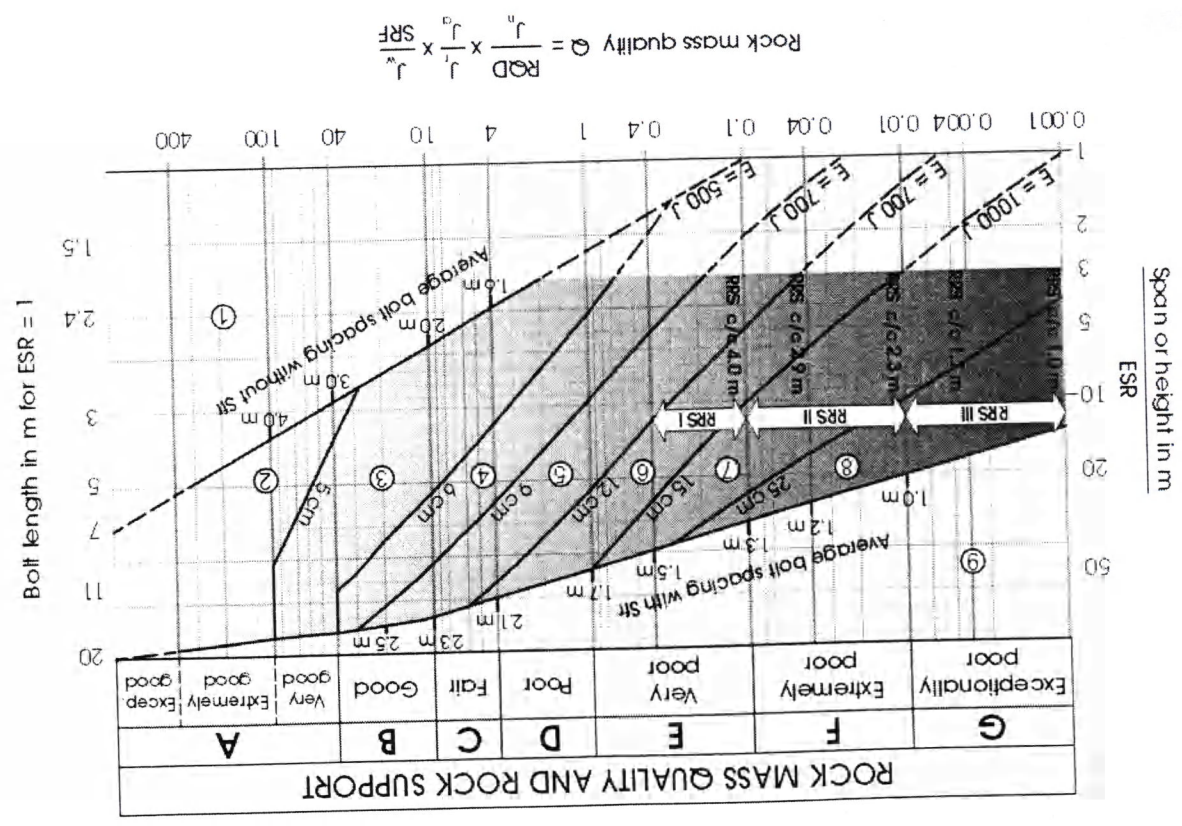
<i>(b) Competent rock, rock stress problems</i>	σ_c / σ_1	σ_1 / σ_c	SRF
Low stress, near surface, open joints	> 200	< 0.01	2.5
Medium stress, favorable stress condition	200 - 10	0.01 - 0.3	1
High stress, very tight structures. Usually favorable to stability, may be unfavorable for wall stability	10 - 5	0.3 - 0.4	0.5 - 2
Moderate slabbing after > 1 hour in massive rock	5 - 3	0.5 - 0.65	5 - 50
Slabbing and rock burst after a few minutes of excavation	3 - 2	0.65 - 1	50 - 200
Heavy rock burst and immediate dynamic deformations	< 2	> 1	200 - 400

Notes: (i) For strongly anisotropic virgin stress field (if measured): when $5 \leq \sigma_1 / \sigma_3 \leq 10$, reduce σ_c to $0.75 \sigma_c$ and when $\sigma_1 / \sigma_3 > 10$, reduce σ_c to $0.5 \sigma_c$. (ii) For general characterization of rock mass, overburden from excavation influences. The use of SRF 5, 2.5, 1 and 0.5 is recommended as depth increases from say 0-5, 5-25, 25-250 to > 250m respectively.

<i>(c) Squeezing rock: plastic flow of incompetent rock under the influence of high rock pressure</i>	σ_1 / σ_c	SRF
Mild squeezing rock pressure	1 - 5	5 - 10
Heavy squeezing rock pressure	> 5	10 - 20
<i>(d) Swelling rock: chemical swelling activity depending on pressure of water</i>	SRF	
Mild swelling rock pressure	5 - 10	
Heavy swelling rock pressure	10 - 15	



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$$\text{Rock mass quality } Q = \frac{RQD}{J_r} \times \frac{J_a}{J_w} \times \frac{J_s}{SRF}$$

