



SECTION A

ANSWER ALL QUESTIONS ON THE ANSWER BOOKLET

1. There was no such engineering discipline known as “Rock Mechanics” until the year
 - a. 1960
 - b. 1877
 - c. 1964
 - d. 1977
2. A retrospective analysis is.....
 - a) A study to establish average values of rock parameters
 - b) A study to establish an appropriate model for the rock mass
 - c) A study to compare current rock parameters with initial values
 - d) A study to obtain mechanical properties of the rock
3. DIANE is an acronym describing the nature of a/an
 - a) Intact rock
 - b) Rock mass
 - c) Rock bolt
 - d) Concrete lining
4. Comparing the strengths of intact rock and the rock mass
 - a) The strength of the intact rock is higher than that of the rock mass
 - b) The strength of the rock mass is higher than that of the intact rock
 - c) The strength of the intact rock is the same as that of the rock mass
 - d) None of the above
5. When a slab of phyllite is to be used as a bridge over a gutter, what strength of the rock will you measure?
 - a) Uniaxial compressive strength
 - b) Shear strength
 - c) Tensile strength
 - d) Flexural strength
6. Why is the tensile strength of a rock mass always assumed to be equal to zero?
 - a) Because rock masses are discontinuous
 - b) Because rock masses are under no stresses
 - c) Because rock masses have no strength
 - d) None of the above

7. Which of these can be analysed as a plain strain problem?
- a) A mine pillar
 - b) A tunnel
 - c) A concrete block
 - d) A rock core
8. A 50mm diameter core of rock fails when an axial load of 80 kN is applied to it. What is its uniaxial compressive strength?
- a) 4000.00 MPa
 - b) 4.00 MPa
 - c) 160.85 MPa
 - d) 40.74 MPa
9. The boundary stresses of a circular excavation are
- a) Uniaxial
 - b) Biaxial
 - c) Triaxial
 - d) None of the above
10. The Poisson ratio is
- a) Ratio of axial stress to radial stress
 - b) Ratio of axial load to radial load
 - c) Ratio of axial strain to radial strain
 - d) Ratio of axial shear to radial shear
11. The RMR rock mass classification was developed by
- a) Barton
 - b) Terzaghi
 - c) Bieniawski
 - d) Hoek
12. The maximum RMR rock mass classification rating is
- a. 1000
 - b. 100
 - c. 500
 - d. 50
13. The unit weight of a rock mass is 27kN/m^3 . If the horizontal stress at 1500m below surface is 30MPa, what is the value of K o?
- a. 0.54 MPa
 - b. 0.84 MPa
 - c. 0.64 MPa
 - d. 0.74 MPa

14. Poisson ratio of a core of rock is
- a) Constant for the rock type
 - b) Increases with applied stresses
 - c) Decreases with applied stresses
 - d) None of the above
15. The more the difference between the major and minor principal stresses,
- a) The more stable the material becomes
 - b) The more unstable the material becomes
 - c) The harder the material becomes
 - d) The softer the material becomes
16. The Brazilian Test is used to determine the of rock indirectly
- a) Compressive strength
 - b) Flexural strength
 - c) Shear strength
 - d) Tensile strength
17. Which of the following does not represent a plastic material?
- a) It is typical of fractured rock
 - b) Strain realised may not be recoverable
 - c) The loading and unloading curves do not coincide
 - d) Stress/strain curve is linear
- 17 In a hydrostatic stress field, boundary stresses around a circular excavation are uniform
- a) True
 - b) False
- 18 The RMR rock mass classification system was developed by
- a) Bieniawski
 - b) Hoek and Brown
 - c) Hoek and Bray
 - d) The Norwegians
19. In a long circular horizontal excavation like a tunnel where the vertical stress is more than the horizontal stress, the redistributed stresses
- a) Are higher at the sidewalls and lower at the roof and floor
 - b) Are lower at the sidewalls and higher at the roof and floor
 - c) Are evenly distributed around the excavation boundary
 - d) Are equal at the sidewalls, roof and floor but different elsewhere
20. In the NGI rock mass classification system the term RQD/ J_n stands for

SECTION B

ANSWER ANY TWO QUESTIONS IN THIS SECTION

21. The Kirsch equations for estimating the redistributed stresses around single circular excavations are shown below,

$$\sigma_{rr} = \frac{p}{2} \left[(1 + K) \left(1 - \frac{a^2}{r^2} \right) - (1 - K) \left(1 - 4\frac{a^2}{r^2} + \frac{3a^4}{r^4} \right) \cos 2\theta \right]$$

$$\sigma_{\theta\theta} = \frac{p}{2} \left[(1 + K) \left(1 + \frac{a^2}{r^2} \right) + (1 - K) \left(1 + \frac{3a^4}{r^4} \right) \cos 2\theta \right]$$

$$\sigma_{r\theta} = \frac{p}{2} \left[(1 - K) \left(1 + \frac{2a^2}{r^2} - \frac{3a^4}{r^4} \right) \sin 2\theta \right]$$

where

p is the vertical stress,

K is the ratio of horizontal to vertical stress,

r , the distance of an element from the centre of the circular excavation,

a , the radius of the circular excavation

σ_{rr} , the radial stress

$\sigma_{\theta\theta}$, the circumferential stress and

$\sigma_{r\theta}$, the redistributed shear stress on the sides of the element

θ , the angular displacement of the element from the horizontal

- a. Show that at the boundaries of the excavation, only circumferential stresses exist.
- b. Deduce the expressions for the radial and circumferential stresses under hydrostatic conditions.
- c. Hence or otherwise, estimate the depth at which the boundary stresses begin to exceed the uniaxial compressive strength of the rock if a horizontal circular excavation is to be made in a rock mass under hydrostatic stress conditions, with unit weight of 0.027 MPa/m^3 and a uniaxial compressive strength of 80 MPa .

22. A horizontal tabular ore body at a depth of 200 m below ground surface is planned for extraction using 13 m room spans and 7.0 m square pillars with a square layout. The full thickness of 5 m is to be mined. The unit weight of the overburden rock is 27 kN/m^3 . Analysis of pillar failures in the orebody indicates that pillar strength is defined by

$$S_p = 110W^{0.46}H^{-0.66} \text{ MPa}$$

Where S_p is in MPa and pillar width (W) and pillar height (H) are in metres.

- a) Determine the factor of safety against compression failure in the pillars in the planned layout.
- b) Determine the extraction ratio.

- c) Find the room span in the strike direction, that will give you a factor of safety of 1.6, keeping the pillar width at 7m and a room span of 13m in the dip direction.
- d) Determine the extraction ratio at this new room span. (5 marks each)

23 The table below is data for a number of triaxial tests carried out on a rock material for which the Mohr-Coulomb criterion, shown below, is applicable

$$\sigma_1 = \frac{(1 + \sin\phi)}{(1 - \sin\phi)} \sigma_3 + \frac{2c \cos\phi}{(1 - \sin\phi)}$$

Test no	Cell pressure (MPa)	Peak stress at failure (MPa)
1	5	100
2	10	120
3	15	130
4	20	150
5	25	160
6	30	175
7	35	190
8	40	205
9	50	240

- a) Without drawing Mohr circles, graphically determine the shear strength parameters, c and ϕ
- b) Assuming the intact rock test sample is homogeneous and isotropic, what is the uniaxial compressive strength?
- c) If a peak stress of 150MPa were recorded, what would have been the cell pressure?

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