

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI
I SEMESTER 2023-24
COMPREHENSIVE EXAMINATION
CE F325 FUNDAMENTALS OF ROCK MECHANICS (CLOSE BOOK)

Duration: 180 Mins

Max Marks: 35

1. A 15 m high rock slope is proposed to be excavated with a slope face angle of 60° . A failure surface (joint) passes through toe at an angle of 35° with horizontal. Properties of the rock mass are [7M]

Cohesion of joint = 30 kPa
Friction angle of joint = 32°
Unit weight = 27 kN/m^3
Calculate the factor of safety for the case with no earthquake.
What should be the angle of slope in case the FOS is proposed to be maintained as 1.35 for the case with seismic coefficient of 0.15. Consider the height to be 15 m and same rock mass properties.
2. Seismic reflection test was conducted at a site comprising of two layers to determine the depth of the first layer. [3M]
The distance between the source and geophone was 40m. Disturbance at geophone were recorded at 30 ms and 250 ms after excitation at the source. What is the depth of first layer?
3. Investigations at a site for construction revealed the following data. What will be RMR basic for this case. [2M]

UCS of rock = 22 MPa
RQD = 26%
Joint spacing = 0.07-0.15 m
Condition of joints = undulating, highly weathered, joint separation about 3-5 mm with clay
Groundwater = rock mass observed to be damp
4. What are the limitations of RQD. Explain with the help of an example. How does the RMR system overcome the limitations? [2M]
5. Explain the seismic cross hole test and its uses. [2M]
6. Derive the equation for the trajectory of a rock block falling out from a mountain side. Determine the maximum height of rise based on the derived equation. [3M]
7. Briefly explain the DRESS and P5 techniques of tunneling in difficult ground. [3M]
8. How are rock cores extracted from the site? What are the common tests performed on extracted rock cores? [2M]
9. With the help of a neat sketch, define the terms bench height, burden, spacing and stemming. [2M]
10. What are squeezing ground? Explain the five level of squeezing with the help of a diagram. What factors influences squeezing potential? [3M]
11. Why TBMs are not favored in mixed geological conditions? [1M]
12. Explain the conditions in which top down and bottom up construction techniques are favorable. [2M]
13. A tunnel is to be analysed at a depth of 750 m. Diameter of the tunnel is 12 m. Considering that rock mass is classified as class III as per RMR system, evaluate the critical pressure, maximum radius of plastic zone and largest possible plastic deformation. All assumptions are to be made logically considering the information given and it should be clearly stated. Consider Poisson's ratio as 0.25 and unit weight as 27 kN/m^3 . [3M]

$$p_{cr} = \frac{2p_0 - \sigma_{cm}}{1 + k_p}$$

$$k_p = \frac{1 + \sin \phi}{1 - \sin \phi}, \quad \sigma_{cm} = \frac{2c \cos \phi}{1 - \sin \phi}$$

$$u_r^e = \frac{R(p_0 - p_i)}{2G_{rm}}$$

$$G_{rm} = \frac{E_{rm}}{2(1 + \nu)}$$

$$R_{pl} = R \left[\frac{2(p_0(k_p - 1) + \sigma_{cm})}{(k_p + 1)((k_p - 1)p_i + \sigma_{cm})} \right]^{1/(k_p - 1)}$$

$$u_r^{pl} = \frac{R}{2G_{rm}} \left[2(1 - \nu)(p_0 - p_{cr}) \left(\frac{R_{pl}}{R} \right)^2 - (1 - 2\nu)(p_0 - p_i) \right]$$

1. Strength of intact rock Rating	Point load index (MPa) UCS (MPa)	> 10 > 250 15	4-10 100-250 12	2-4 50-100 7	1-2 25-50 4	5-25 2	1-5 1	< 1 0
2. RQD (%) Rating	90-100 20	75-90 17	50-75 13	25-50 8	< 25 3			
3. Joint spacing (m) Rating	> 2 20	0.6-2 15	0.2-0.6 10	0.06-0.2 8	< 0.06 5			
4. Condition of joints Rating	Not continuous, very rough surfaces, unweathered, no separation 30	Slightly rough surfaces, slightly weathered, separation < 1 mm 25	Slightly rough surfaces, highly weathered, separation < 1 mm 20	Continuous, slickensided surfaces, or gouge < 5 mm thick, or separation 1-5 mm 10	Continuous, joints, soft gouge > 5 mm thick, or separation > 5 mm 0			
5. Ground water Rating	Inflow per 10 m tunnel length (L/min) Joint water pressure/major in situ stress General conditions at excavation surfaces		None 0 Dry 15	< 10 0-0.1 Damp 10	10-25 0.1-0.2 Wet 7	25-125 0.2-0.5 Dripping 4	> 125 > 0.5 Flowing 0	

Class No.	I	II	III	IV	V
RMR	100-81	80-61	60-41	40-21	< 20
Description	Very Good	Good	Fair	Poor	Very poor
Average stand-up time	20 years for 15 m span	1 year for 10 m span	1 week for 5 m span	10 h for 2.5 m span	30 min for 1 m span
Cohesion of rock mass (MPa)	> 0.4	0.3-0.4	0.2-0.3	0.1-0.2	< 0.1
Internal friction angle of rock mass (°)	> 45	35-45	25-35	15-25	< 15
Deformation modulus (GPa) ^a	> 56	56-18	18-5.6	5.6-1.8	< 1.8