National Exams December 2015

09-Mmp-B1, Applied Rock Mechanics

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. FIVE (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. Most questions require an answer in essay format. Clarity and organization of the answer are important.

Question 1

A long tunnel of circular cross section is located 500 m below ground surface. In the plane perpendicular to the tunnel axis, the field principal stresses are vertical and horizontal. The vertical stress p is equal to the depth stress, and the horizontal stress is defined by 0.40 p. The unit weight of the rock mass is 28 kN/m^3, the compressive strength is defined by the Mohr Coulomb failure criterion with c = 15 MPa, $\phi = 28^0$, and the tensile strength σ_t = 0.1 MPa.

{10} (1.1) Showing all your calculations predict the response of the excavation peripheral rock to the given conditions.

{10} (1.2) Propose an alternative design for the excavation.

Question 2

{10} (2.1) List advantages and disadvantages associated with the Hoek and Brown, Mohr Coulomb and Barton-Bandis failure criteria when they are used to model the strength of (i) intact rock; (ii) joints and (iii) fractured rock masses.

{10} (2.2) A series of direct shear tests was undertaken at different normal stress values on natural joint samples. The normal and peak shear stress was recorded for each test. Determine the basic friction angle and the asperity angle. Propose an appropriate failure criterion for these data.

Normal stress (kPa)	Peak shear stress (kPa)
200	0
255	5
300	10
360	20
420	25

Question 3

The following triaxial test results were obtained on intact rock granite specimens.

σ_1 (MPa)	σ_3 (MPa)
200	0
255	5
300	10
360	20
420	25

{10} (3.1) Determine the Mohr-Coulomb criterion for these data. Comment on the applicability of the criterion.

{10} (3.2) Determine and comment on the applicability of the Hoek and Brown criterion for these data.

Question 4

A 30 m high rock slope has been excavated at a face angle of 62^0. The rock in which this cut has been made contains persistent bedding planes that dip at an angle of 35^0 into the excavation. A 9.9 m deep tension crack is visible 10 m behind the crest.

The strength parameters of the sliding surface are as follows: cohesion (c) = 100 kPa; angle of friction, $\varphi = 34^0$. The unit weight of the rock is 27 kN/m^3, and the unit weight of the water is 9.81kN/m^3.

{4} (4.1) Calculate the factor of safety of the slope if the tension crack is filled with water up to 4.1 m.

{4} (4.2) Calculate the factor of safety if the tension crack is completely filled with water due to run-off on the crest of the slope.

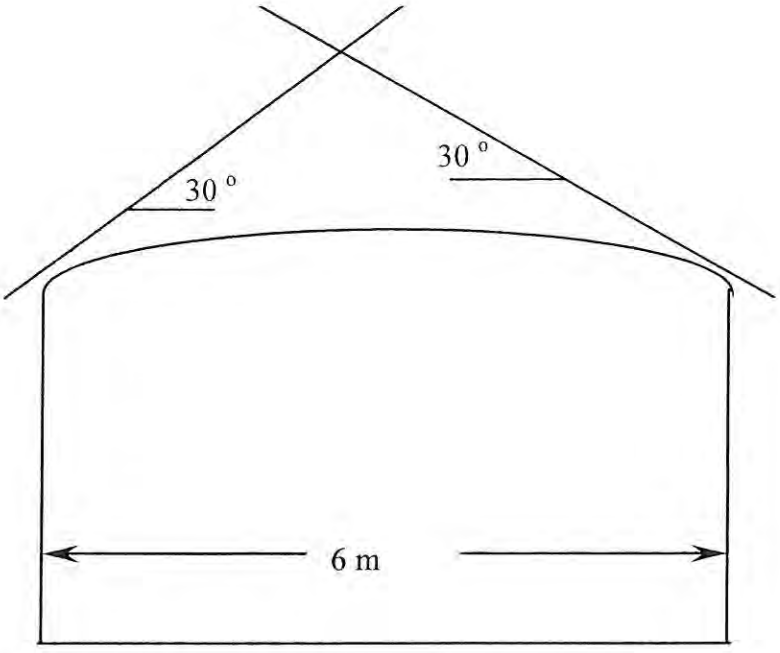
{4} (4.3) Determine the factor of safety if the slope is completely drained.

{4} (4.4) Determine the factor of safety if the cohesion were to be reduced to zero due to excessive vibrations from nearby blasting operations, assuming that the slope was still completely drained.

{4} (4.5) Demonstrate the sensitivity of the slope to the different scenarios in this question.

Question 5

{20} (5.1) You are responsible for planning the development of a permanent excavation 6 m wide at a depth of 450 m. Two dominant structures are observed along the length of the excavation. There are no data on the strength of any joints but the mine traditionally uses a cohesion of 22 kPa and $\varphi = 27^0$. The excavation is in a relatively good quality rock mass without any trace of water infiltration. Based on the available information propose an appropriate reinforcement strategy stating all assumptions.



Question 6

{10} (6.1) Provide a description for a type of expandable friction bolt. Discuss any perceived advantages and limitations.

{10} (6.2) Provide an example of a yielding ground support system for a seismically active underground hard rock mine.

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Marking Scheme

1.	20 marks total	a) 10 marks b) 10 marks
2.	20 marks total	a) 10 marks b) 10 marks
3.	20 marks total	a) 10 marks b) 10 marks
4.	20 marks total	a) 4 b) 4marks c) 4 marks d) 4 marks e) 4 marks
5.	20 marks total	20 marks
6.	20 marks total	a) 10 marks b) 10 marks