National Exams - May 2010

98-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. Any non-communicating calculator is permitted.

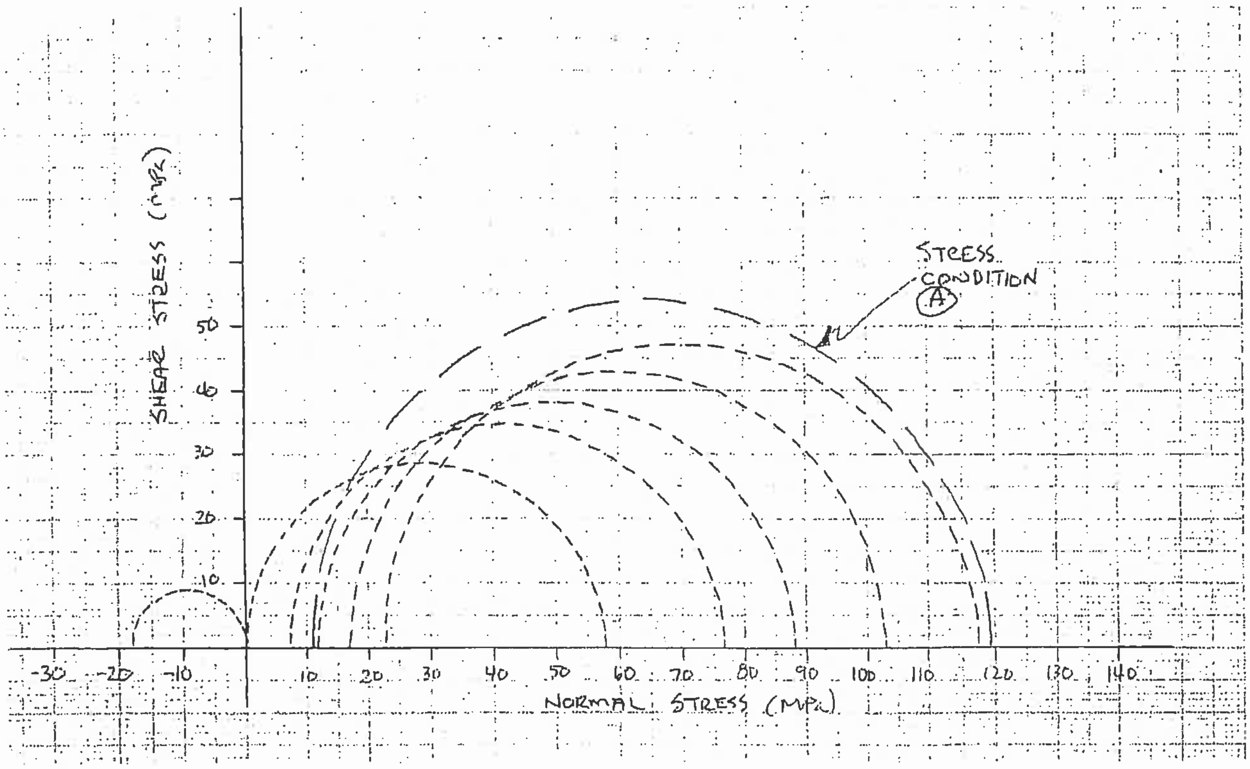
3. This is an Open Book exam. Any non-communicating calculator is permitted.

4. Any five questions constitute a complete exam paper. Only the first five questions as they appear in your answer book will be marked.

5. All questions are of equal value.

QUESTION 1

{10} (1.1) Using the attached Mohr-Coulomb plot of triaxial failure test data obtained from confined compression tests on six core specimens of a single rock type, determine the principal Mohr-Coulomb failure parameters for this rock material. Do not use the stress circle that is shown as Stress Condition (A) for your analysis. Indicate directly on this plot the Mohr-Coulomb strength failure locus and measurable parameters.



{4} (1.2) Using the information displayed in part 1(a), plot on this graph paper the Hoek-Brown failure locus for these same tests and indicate the strength parameters that can be determined from the Hoek-Brown plot.

{4} (1.3) If a potential excavation site underground is known to be acted upon by stress conditions indicated by Stress Condition (A) (as indicated in the attached plot), what minimum level of confining or support stress (σ_3) would need to be exerted to just prevent failure of a sample of this rock?

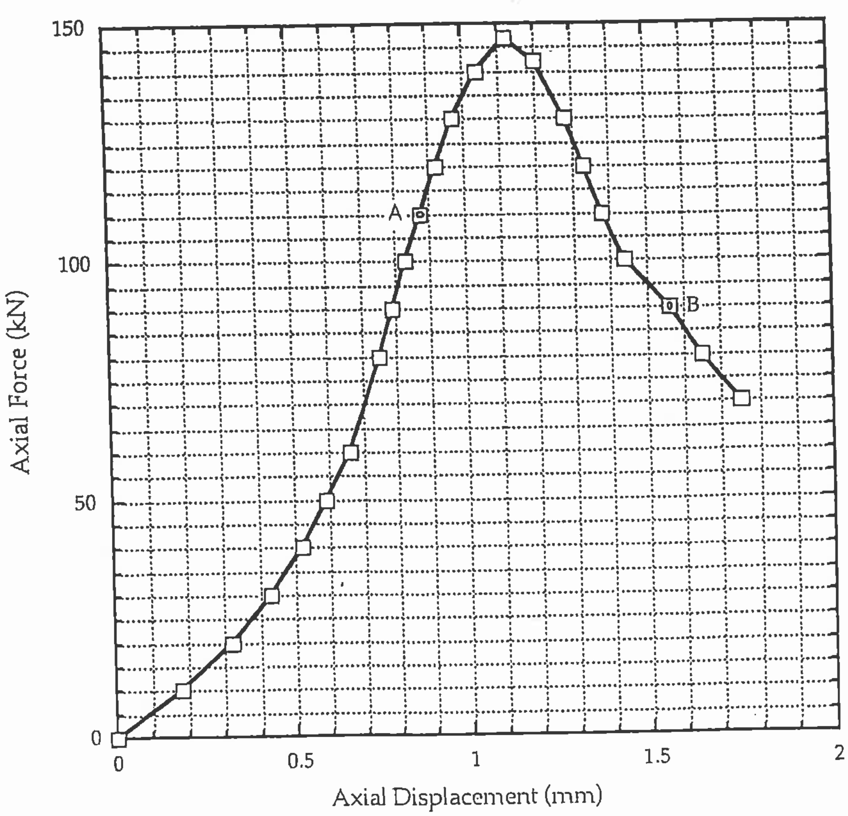
{2} (1.4) For triaxial confinement (σ_3) levels of 30 MPa and 50 MPa, at what expected levels of axial stress would samples of this rock material be expected to undergo shear failure?

QUESTION 2

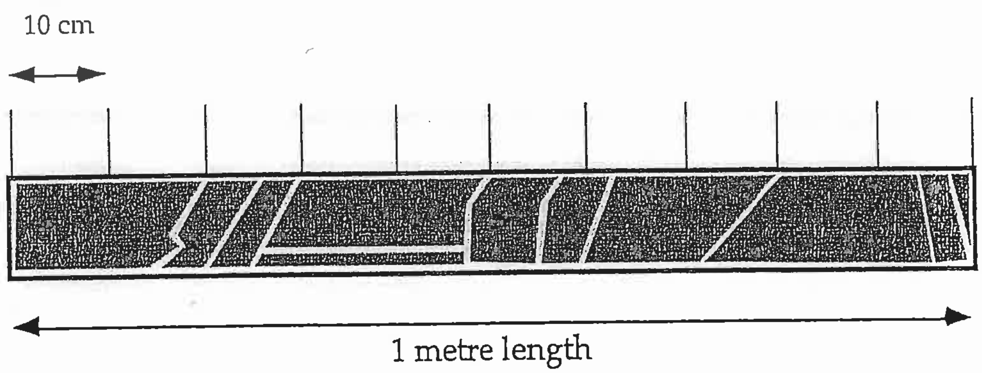
{10} (2.1) For a section of drill core, whose length and diameter was measured to be 9.8 and 4.6 cm respectively, the appended force-deformation curve was measured during unconfined compression testing in the laboratory. For this core material, determine the following parameters:

- -unconfined compressive strength (UCS)
- -Young's Modulus ($E_{50\%}$)
- -secant Young's Modulus (E_{secant}), and
- -the specimen stiffness conditions at points (A), in the pre-yield loading region, and (B), in the post-yield loading region

For the stiffness condition exhibited by this core specimen at point (B), and knowing that the measured loading frame stiffness approximates 750 kN/mm, explain why the loading system should theoretically be capable of generating controlled, non-violent post-yield failure of similar rock materials.



{10} (2.2) For the following sketch, showing a one meter long section of recovered drill core, what numerical estimate of Deere's RQD would you estimate for the core length and what rock quality quality would you associate with this rock? Provide a brief description of the RQD classification technique, explaining its applicability for assessing rock character in a "stand-alone" fashion and in combination with other commonly-used rock mass classification techniques.



QUESTION 3

Answer each of the following sections of this question by selecting the most appropriate multiple choice answer from the list provided. In order to obtain full marks, you must justify your answer by showing your calculations.

{10} (3.1) A room-and-pillar stope is to be developed at a depth below ground surface of 950 meters. The average bulk density of the hanging wall waste rock is 21.53 kN/m^3 (lying between the tabular ore body and surface), and it is known that the host ore exhibits an average unconfined compressive strength approximating 132.5 MPa.

It is planned that an array of square pillars will be left to support the stope roof and that a constant pillar centre-to-centre distance of 25 meters will be maintained between all pillars. Two design cases are to be implemented - one in which pillars are to be constructed at 10 meters width, the other in which pillar widths will be set at 14 meters. For these two cases of development, the differences in post-development pillar stress and extraction ratio conditions will be best reflected by:

(a) (45 MPa, 10%)
(b) (65 MPa, 10%)
(c) (45 MPa, 15%)
(d) (65 MPa, 15%)

{10} (3.2) Three lengths of rock core, of similar composition and at 54 mm diameter, have been subjected to point load testing failure. The failure forces applied for the three tests were found to be (23.5 kN), (27.6 kN) and (21.4 kN). The average Point Load Index (I_s) and calculated unconfined compressive strength (S_c) that can be inferred for the sum of tests conducted on this rock material are best expressed by:

(a) (I_s = 8.05 MPa, S_c = 161.1 MPa)
(b) (I_s = 8.05 MPa, S_c = 193.2 MPa)
(c) (I_s = 8.25 MPa, S_c = 198.0 MPa)
(d) (I_s = 8.55 MPa, S_c = 171.0 MPa)

QUESTION 4

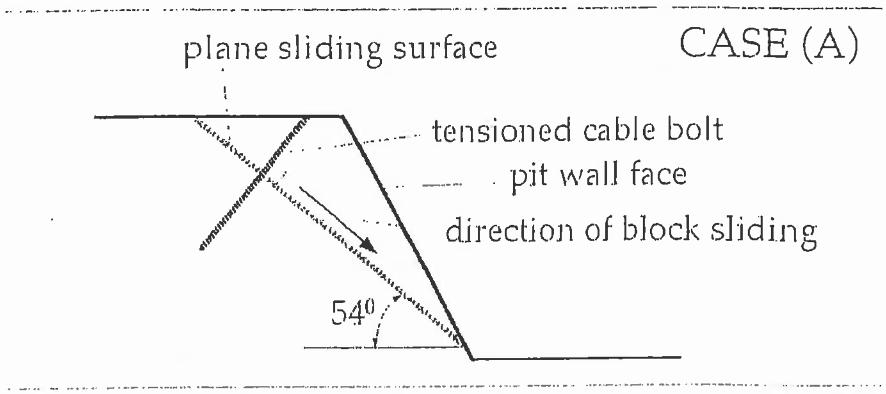
{20} (4) A sliding block failure condition exists in one wall of an open pit. Views of three proposed cable bolt reinforcement scenarios are shown in the following figure, and rock physical characteristics have been determined to be:

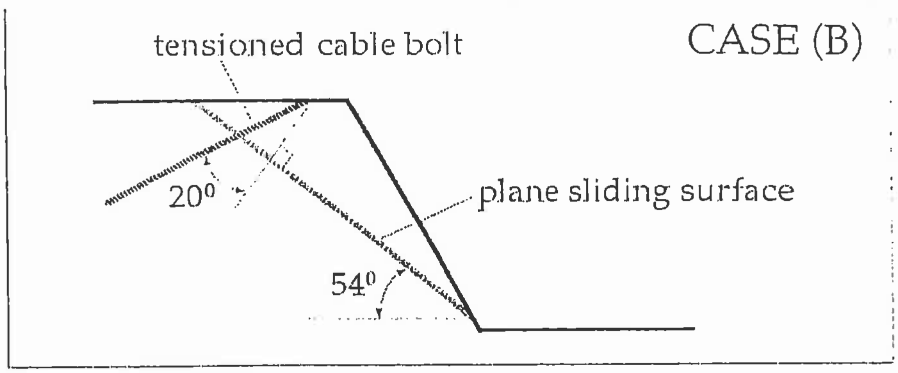
-contact area of block on plane of sliding = 2575 m^2
-cohesion resistance along sliding plane surface = 122.7 N/m^2
-internal friction angle mobilized along sliding plane (ϕ) = 35°
-dip of plane of sliding (as shown in the accompanying figure) = 54°
-net gravity block weight = 5.6 x 10^6 N

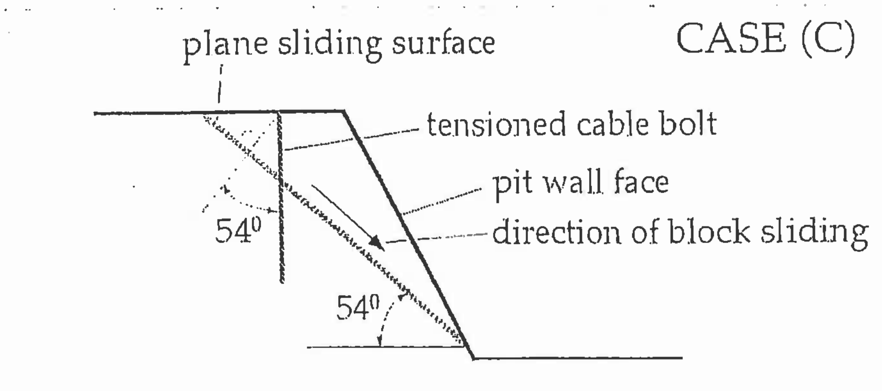
For case (B), holes will be drilled down from the pit crest and tensioned cable bolts will be installed in them (each exerting 55 kN of tension) to reinforce the block against planar sliding failure into the pit. The Factor of Safety conditions that will exist when (i) no bolts are installed and when (ii) 40 cable bolts are installed using only the Case (B) scenario, can be closest approximated by which of the following:

(a) (0.40, 1.05)
(b) (0.55, 1.05)
(c) (0.40, 1.15)
(d) (0.55, 1.25)

In order to get full marks you must show your calculations.







QUESTION 5

Briefly answer the following, using sketches to illustrate your answers:

{10} (5.1) Explain how the presence of water and ground acceleration, induced by either blasting or seismic events, can affect the stability of open pit walls structures. For each of the two influences (exposure to groundwater and ground vibration), present two different cases, and show by illustrative example, how wall stability can be (a) detrimentally affected and (b) beneficially affected (or remain unchanged).

{10} (5.2) Describe the major functions of ground support media used to reinforce underground mine excavations. Provide examples of typical reinforcement media, and differentiate between support methods that have been adopted to (a) reinforce the structural capabilities of near-excavation rock zones and (b) provide purely surface or areal support enhancement for underground excavations.

Explain and differentiate between the mechanisms of support that can be developed using passive and active rock dowel systems. In your response, provide descriptions of the methods of installation and an explanation of the processes whereby bolt or dowel tensions are developed for each system.

QUESTION 6

In point form responses only, briefly describe the following:

{5} (6.1) Two methods, and their procedures for installation and operation, by which rock mechanics or geotechnical staff can determine in-situ <u>uniaxially-directed</u> or <u>biaxially-directed</u> stress conditions from a single test

{5} (6.2) Some of the common problems that are associated with conducting overcore stress measurements in the field, and how these problems can be overcome.

{5} (6.3) Two types of instrumentation are commonly utilized by mining and geotechnical staff for the purpose of measuring both loading force and rock deformation conditions. Both types of instrumentation make use of strain gauge technology to provide such measurements. Relate the methods by which strain measurements are used by each type of instrument to provide output of force and deformation conditions.

{5} (6.4) Principal methods by which area support can be provided for underground mining excavations, with a statement for each which details the manner in which effective resistance to rock displacement is developed by them and significant variations in support capabilities offered by each.