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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination – December, 2017

Program/course: B.Tech APE- upstream **Semester : V**

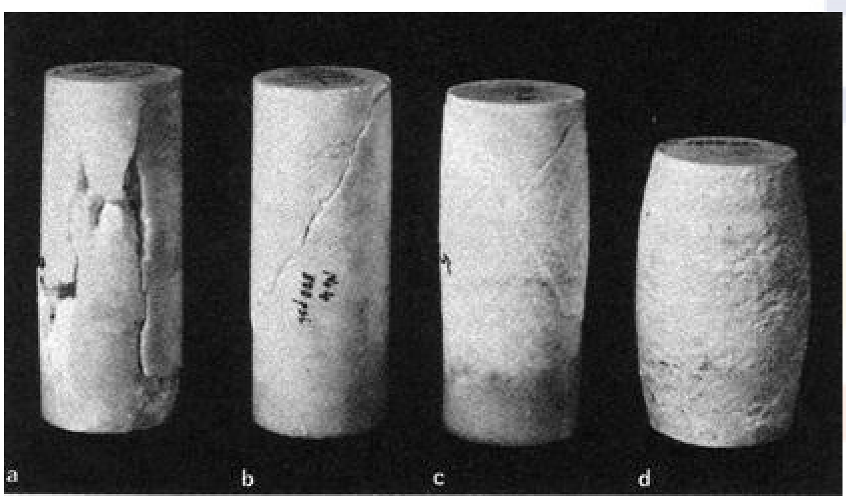
Subject: Geomechanics **Max. Marks : 100**
Code : GSEG 312 **Duration : 3 Hrs**
No. of page/s: 04

Instructions:

- Assume missing data if any.
- *Your answer should be precise & to the point.*

SECTION A: Answer all the questions. **(5*4=20Marks)**

1. Which type of fields to be taken up for the study under geomechanics ?
2. What are the intangible benefits of Geomechanical studies?
3. Assume a block of impermeable, zero porosity, quartz sandstone with a density of 2.6 gr/cm3 rests on a horizontal surface. What is the total normal stress and effective stress at the base of a 10.5 m tall block of quartz sandstone?
4. Describe the modes of failure you would expect to see in samples tested under uni-axial and tri-axial conditions. Utilise a stress-strain curve to indicate the impact of increasing confinement on failure mode.
5. Experimental results for rock fracturing in triaxial tests are shown as :



Correlate above figures a, b, c & d with the following confining pressures respectively.

(1) 35MPa (2) Ambient pressure (3) 100MPa (4) 3:5MPa

SECTION B: Answer all the questions. **(5*8=40Marks)**

1. For an oil field where a vertical well is drilled to a maximum depth of 10,200 ft, the average specific gravity and pore pressure gradient are given as 2.3 and 0.37 psi/ft, respectively. Assuming the Biot's constant and Poisson's ratio as 1 and 0.28, respectively, calculate the overburden and horizontal in-situ stresses for the surrounding rock formation at the bottom of the vertical well.

2. The most important equations used for the analysis of wellbore failure are the Kirsch Equations. Please write the set of equations (Kirsch Equations) for an anisotropic solution.
   Also write the general assumptions used while developing these equations.

3. What are the necessary steps applied to find the stresses at the wellbore wall. Show diagrammatically position of stresses around a wellbore in the rock formation, also represent principal in-situ stress state (point A), and stress states at the wellbore in Cartesian (point B) and cylindrical coordinate (point C) systems.

4. Several failure criteria are applied in rock engineering practice. Describe and explain the Mohr-Coulomb criterion by referring to (use sketches / equations to assist in the description).
   Prove, using the Mohr circle, that failure of an intact rock sample according to Mohr-Coulomb will create a shear plane that makes an angle of $(45° - \frac{\emptyset}{2})$, .

5. (a) Samples of a specific rock type has been subjected to the application of stresses in tri-axial tests as shown below. Plot the stress conditions in shear stress / normal stress space to determine the internal friction angle and cohesion of the rock material. **(4Marks)**

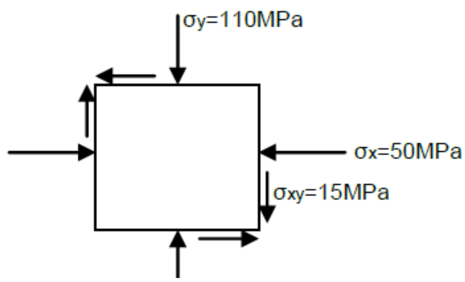
Major principal stress (MPa)	Confinement stress (MPa)
54	6
86	26
109	41

   (b) 50mm high, 32mm diameter rock sample taken from geological core is subjected to a 100kN force along the core axis. If the change in height due to the application of the force is 0.8mm and the increase in diameter 0.15mm, determine the following: **(4Marks)**

   a. Young's Modulus
   b. Poisson's ratio

SECTION C: Answer all the questions. **(2*20=40Marks)**

1. The figure below represents the state of stress at a point in the rock mass. If the internal friction angle of the material is 21° and its cohesion 10MPa, perform the required calculations to determine whether this material will fail according to the Mohr-Coulomb failure criterion.



Confirm your answer by representing the stress state on a Mohr circle together with the material properties in a shear stress / normal stress space presentation and indicating whether failure will occur or not.

2. **OIL FIELD CASE STUDY**

Field data from the first extended-reach horizontal well drilled was used for the evaluation of failure criteria. Rock mechanical properties were determined based on the triaxial and thick walled cylinder strength test results on core samples from three intervals. The extended-reach horizontal well was drilled successfully using the mud weight of 1.3 g/cc (0.57 psi/ft) for all the three intervals.

Formation	Rock Properties			Stress Data				Field MW (g/cc)
	ϕ (°)	c (MPa)	ν	σ_h (g/cc)	σ_H (g/cc)	σ_V (g/cc)	p_0 (g/cc)	
Middle Ness	39	9	0.2	1.66	1.66	2.3	1.24	1.3
Etive	30	7	0.1	1.66	1.66	2.3	1.24	1.3
Rannoch	36	25	0.25	1.66	1.66	2.3	1.24	1.3

Results of predicted minimum required mud weight by different criteria and difference with field mud weight for Middle Ness formation (60° Inclination)

Failure Criteria	Predicted Required Mud	Percentage Difference with

	Weight (g/cc)	Field Mud Weight (%)
Tresca	1.67	27.6
Griffith	1.48	13.1
Mohar-Coulomb	1.40	6.8

Results of predicted minimum required mud weight by different criteria and difference with field mud weight for Etive formation (70° Inclination)

Failure Criteria	Predicted Required Mud Weight (g/cc)	Percentage Difference with Field Mud Weight (%)
Tresca	2.27	73.4
Griffith	1.75	33.9
Mohar-Coulomb	1.65	25.9

- Discuss and analysis the predicted results of minimum mud weight (evaluated from different failure criteria) by field mud weight. **(08 marks)**
- Bar chart representation of the above results. **(06 marks**)
- Concluding remarks on the basis of rock mechanical properties & failure criterion.**(06 marks)**

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