THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF MINING ENGINEERING

2020 FIRST SEMESTER EXAMINATION

Third Year Mining Engineering

MN313 –GEOMECHANICS - 1

DATE: **Friday 19th June 2020**

TIME: **12:50 P.M.**

TIME ALLOWED: **3 HOURS**

INFORMATION FOR CANDIDATE:

1. You have ten minutes to read this question paper. You **SHOULD NOT** begin writing during this period.

2. There are **SIX QUESTIONS** all together. You **MUST ALL (5) QUESTIONS**

3. Marks for each question is as indicated after question. **Total of 100 marks**

4. ALL answers must be written on the answer booklet provided. No other written materials will be accepted.

5. Write your **NAME** and **STUDENT NUMBER** clearly on the **ANSWER BOOK. DO THIS NOW.**

6. You **MUST NOT LEAVE** the room in the first hour.

7. All **MOBILE PHONES, AUDIO PLAYERS, MP3, MP 4 etc.. MUST BE**
8. **SWITCHED OFF.**

Question 1 (20 marks)

(a) With aid of sketches, graph, equation etc.. where necessary define the following:

i) Isotropic and anisotropic rock mass
ii) Heterogeneous and homogeneous rock mass
iii) Micro and macro crack propagation in a UCS test
iv) Elastic plastic deformation and brittle failure
v) Elastic plastic deformation and perfectly elastic deformation

..... **10 marks**

(b) Draw a complete stress strain curve for a rock specimen with load cycles in the elastic and plastic regions and explain elastic, strength, plastic, pore closure, strain softening and other behavior of rock deformation

..... **5 marks**

(c) A rock specimen was compressed in a rock testing machine having strain measuring device. The tangent modulus of elasticity of the rock was read as 15.5 GPa at a stress level of 10.4 MPa. Calculate the change in strain if the stress level is increased by 9.5 %.

..... **5 marks**

Question 2 (20 marks)

(a) In a uniaxial compression test of a rock sample the following strains were observed using electric strain gauges.

Load	**Average strain**	
(kN)	**(Instrument reading in micro strain)**	
	Longitudinal (Axial, Y)	Transverse (Lateral, X)
0	0	0
15	140	427
25	340	467
35	546	510

If the specimen is cylindrical with 50 mm diameter, and one microstrain is 0.000001 strain unit, then plot the given results an estimate the Young's modulus, Poison's ratio and Modulus of rigidity.

..... **10 marks**

(b) Discuss how you would obtain the volumetric strain for a given stress level. Convert the sets of result above (a) into volumetric strain and plot the results of stress versus volumetric strain on the same graph as (a).

..... **5 marks**

(c) With the help of stress versus volumetric and axial strain curve discuss the mechanical deformation process of a rock in terms of micro and macro crack growth and the ratio of axial contraction to lateral expansion during the transition stage from elastic to plastic deformation.

..... **5 marks**

Question 3 **(20 marks)**

a) Sample disturbance as a function of depth, showing the change in material response in uniaxial compression is shown below (**Figure 1**). Discuss the stress and deformation experienced by the rock at each depth and sketch the stress-strain curve that will represent each three conditions. ..... *5 Marks*

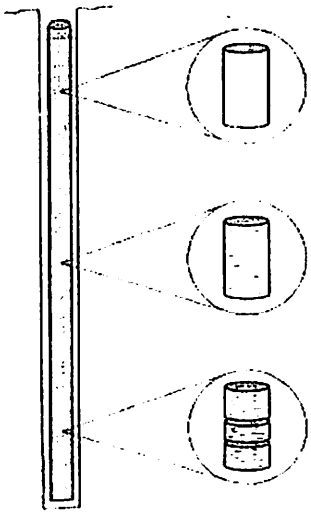


Figure 1

Question 3 continues ....

b) Rock deformation and mechanical properties and their relationship are given in **equation 1, 2, and 3** below with the mechanical properties and stress conditions.

$$\varepsilon_x = \frac{1-\nu^2}{E}\left(\sigma_x - \left(\frac{\nu}{1-\nu}\right)\sigma_y\right) \ldots\ldots Eqn\ 1$$

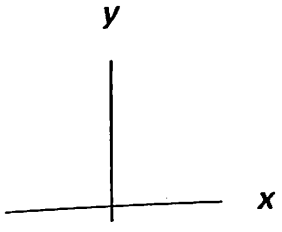
$$\varepsilon_y = \frac{1-\nu^2}{E}\left(\sigma_y - \left(\frac{\nu}{1-\nu}\right)\sigma_x\right) \ldots\ldots Eqn\ 2$$

$$\varepsilon_{xy} = \frac{(1+\nu)}{E}\tau_{xy} \ldots\ldots\ldots Eqn\ 3$$

Mechanical properties	
Youngs Moludus (E)	40 GPa
Poissons Ratio (ν)	0.421

Stress condition 1	
σ_x	0 MPa
σ_y	97.2 MPa

Stress condition 2	
σ_x	48 MPa
σ_y	228 MPa



The rock is investigated for its deformation at two stress condition. **Stress condition 1**, is near to the surface and stress **condition 2** is at greater depths. At principle stress the **shear stress (τ_{xy}) is equal to zero (0)** for both conditions.

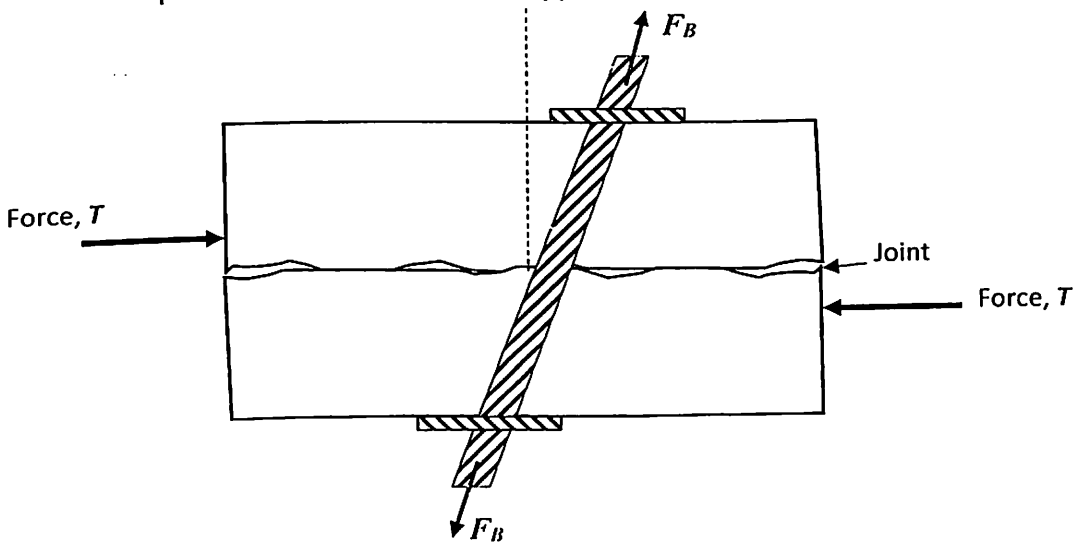
i) Calculate the axial (y) and lateral (x) deformation for stress condition 1 *(5 Marks)*

ii) Calculate the axial (y) and lateral (x) deformation for stress condition 2 *(5 Marks)*

iii) Make comments on the deformation of the rock at shallow depth and greater depths. *(.....5 Marks)*

Question 4 (20 marks)

(a) A jointed shear test specimen is drilled at angle α with the normal to the shear plane and a model rock bolt is installed and tensioned to force F_B as shown below. A pair of shear force, T is then applied until the joint slips.



What is the bolt tension at slip and just sufficient to prevent slip under the shear force T.

..... **5 marks**

(b) A rock specimen of 80 mm diameter and 160 mm height is uniaxially compressed to a force of 105 kilo newtons (KN) . It undergoes an axial deformation of 0.0525 mm and lateral diametrical deformation of 0.0085 mm.

i) Calculate the modulus of elasticity and Poisson's ratio of the rock.

..... 7 **marks**

ii) Incidentally an excavation is to be created in this rock, at a depth of 1800 m below the surface. If the overlaying rock is homogeneous and having a density (Unit weight) of 98 kN/m^3, **calculate** the pre-mining stresses, i.e **vertical stress and horizontal stress.**

..... **8 marks**

Question 5 (20 marks)

A Uniaxial Strength test was conducted on a porphyry rock and the details are given below.

Length 0.111 m
Dia 0.06 m

Load (N)	Axial (Strain)	Lateral (Strain)
0	0	0
2500	0.003468468	-0.001333333
5000	0.006171171	-0.001666667
7500	0.008153153	-0.001833333
10000	0.010225225	-0.002
12500	0.012117117	-0.002666667
15000	0.01481982	-0.004

a) Draw the Stress- Strain curve of the rock
   i) Axial Stress – Strain Curve
   ii) Lateral Stress-Strain curve
   iii) Volumetric Stress-Strain Curve

..... **10 Marks**

NOTE: Volumetric Strain = Axial Strain + (2 x Lateral Strain) ➔ (ε_x + (2 x ε_y) .... For raw test data for above table.

b) Evaluate the following;

   i) UCS strength of the rock
   ii) Average Younga modulus
   iii) Poisons ratio

..... **10 Marks**

THE END.....