THE PAPUA NEW GUINES UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF MINING ENGINEERING

2021 FIRST SEMESTER EXAMINATION

Third Year Mining Engineering

MN313 – GEOMECHANICS & ENGINEERING GEOLOGY

DATE: **FRIDAY 18th 2021**

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 **2 (Two) Sections** in this Paper. **Section 1: Engineering Geology. Section 2: Geomechanics**. You are to Read instructions for each section before attempting questions in each section.

3. **Sections 1 (50%)**: Engineering Geology has two parts (50%)

   Part A – 10 Multiple Choice Questions (10 marks)
   Part B – 5 Short Answers Questions (40 marks)

4. **Sections 2 (50%):** Geo-mechanics has 4 Short Answer Questions. Marks for each question is as indicated. **ALL** questions carry a maximum of 100 marks.

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

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

7. You MUST NOT LEAVE the room in the first hour.

8. All MOBILE PHONES, AUDIO PLAYERS, MP3, ETC...MUST BE SWITCHED OFF.

SECTION 1: Engineering Geology – Part A Multiple choice. Each question has a value of 1mark .. (10 marks)

1. Joints can be healed through
   (A) leaching
   (B) dissolution
   (C) cementation
   (D) precipitation
   (E) infillings

2. Slope failure is a natural process, however the rate of failure can be affected by:
   (A).Climate change
   (B) Vegetation
   (C) Human activity
   (D) Only (A) and (C)
   (E) All of the above.

3. A transfer fault is a:

   (A) High angle reverse fault
   (B) Low angle normal fault
   (C) Low angle reverse fault
   (D) dip slip thrust fault
   (E) None of the above

4. Dip direction is always:
   (A) Parallel to strike
   (B) Horizontal to dip angle
   (C) Perpendicular to strike
   (D) Right angle to dip angle
   (E) Only (C) and (D)

5. Polished surface of fault plane are called:
   (A) Groves
   (B) Gouge
   (C) Pug
   (D) Slicken slides
   (E) None of the above

6. Which of the following reduce slope stability:
   (A) Water
   (B) Cohesion
   (C) Friction angle
   (D) Rock bolts
   (E) None of the above

7. Soil study for agronomical purposes is based on?
   (A) Bacteriology and mechanics
   (B) Chemistry and Bacteriology
   (C) Physics and Bacteriology
   (D) All the above
   (E) Only B and C

8. Host and graben is formed when principle stress acting on the plate is:
   (A) Compressional
   (B) Transitional
   (C) Extensional
   (D) Shear
   (E) Transformation

9. The character of discontinuities can be described in terms of:
   (A) Spacing
   (B) Roughness
   (C) Type of filling
   (D) All the above
   (E) Only (A) and (B)

10. Which one of the following is a mass movement?
   (A) Debris avalanches
   (B) Lahars
   (C) Snow avalanches
   (D) All of the above
   (E) A and C only

SECTION 1: Engineering Geology – Part B SHORT ANSWERS.

The marks for each question are indicated... (40 marks)

1. Name the Phase of the Star formation cycle that produces Ore forming Elements and name at least 4 of these Elements. (5marks)

2. Name the Phase of the Star formation cycle that produces Rock forming Elements and name at least 4 of these Elements. (5marks)

3. Define the words listed below with diagrams; (7x 2 = 14marks)
   (a) Shear Zone
   (b) Fold
   (c) Fault
   (d) Joint
   (e) Thrust fault
   (f) Detachment fault
   (g) Factor of safety

4. When soft rocks are compressed, they turn to form folds. Draw the basic geometry of fold and label all parts correctly including stress directions. (10mks)

5. Draw diagram showing the rock cycle and briefly describe the processes in your own words. (6marks)

END OF SECTION 1- Engineering Geology

SECTION 2. GEOMECHANICS

INFORMATION FOR CANDIDATE:

1. There are **4 (Four) Questions** altogether. You are to answer **ALL 4 (Four)** questions

2. Marks for each question is as indicated. **ALL** questions carry a maximum of **25 marks**.

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

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

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Question 1 *(25 marks)*

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

i) Micro and macro crack propagation in a UCS test
ii) Elastic plastic deformation and brittle failure
iii) Elastic plastic deformation and perfectly elastic deformation
iv) Average Youngs Modulus and Secant Youngs Modulus
v) Rock failure Mode

..... **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

..... **10 marks**

(c) A rock specimen was compressed in a rock testing machine having strain measuring device. The average modulus of elasticity of the rock was read as 21.5 GPa at a stress level of 12.8 MPa. Calculate the change in strain if the stress level is increased by 10.5 %.

..... **5 marks**

Question 2 *(25 marks)*

(a) In a uniaxial compression test of a rock sample the following strains were observed using dial gauge.

Load (force) (N)	Axial Def (Y) ($\times 10^{-2}$ mm)	Lat Def (X) ($\times 10^{-2}$ mm)
0	58	73
5000	87	75
10000	102	76
15000	114	78
20000	128	82
25000	139	84
30000	153	88
35000	168	94
40000	181	98
45000	199	108
50000	269	151

If the specimen is cylindrical with 5 cm diameter, length of 10.4 cm (and one microstrain is 0.000001 strain unit), then plot the given stress strain results and estimate the Average Young's modulus, and Poison's ratio.

..... **20 marks**

(b) Discuss how you would obtain the volumetric strain for a given stress level. Convert the sets of result above Q2(a) into volumetric strain and plot the results of stress versus volumetric strain on the same graph as (a).

..... **5 marks**

Question 3 *(25 marks)*

(a) A rock specimen of 73 mm diameter and 152 mm height is uniaxially compressed. It undergoes an axial deformation of 0.0327 mm and lateral diametrical deformation of 0.0057 mm.

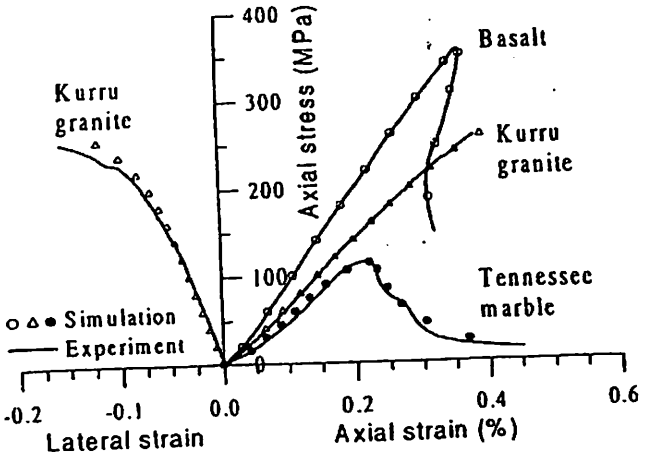
i) Calculate the Poisson's ratio of the rock and the Youngs Modulus of the rock at 114 MPa Stress level.

..... **5 marks**

ii) Incidentally an excavation is to be created in this rock, at a depth of 900 m below the surface. If the overlaying rock is homogeneous and having a density (Unit weight) of 50 kN/m^3, **calculate** the pre-mining stresses, i.e **vertical stress and horizontal stress.** (Assuming that horizontal stress is 1/3 of the vertical stress)

..... **5 marks**

Figure 1



b) From the above, (**figure 1**) stress strain curve of three (3) different rock types, discuss the following:

i) Estimate the strength of each rock (give values) ..... *((5 Marks)*

ii) Which rocks exhibit **elastic deformation** and which rocks exhibit **elastic- plastic deformation** and discuss why. ..... *(10 Marks)*

Question 4 *(25 marks)*

The original Hoek & Brown failure criterion has been modified since the original formulation was presented in 1980, and has been updated several times, but for intact rock, the formular is almost the same and is given in ***Eqn 1***:

$$\sigma_1 = \sigma_3 + \sigma_{ucs}\sqrt{m_i \frac{\sigma_3}{\sigma_{ucs}} + 1} \quad \text{..... } \textit{Eqn. 1}:$$

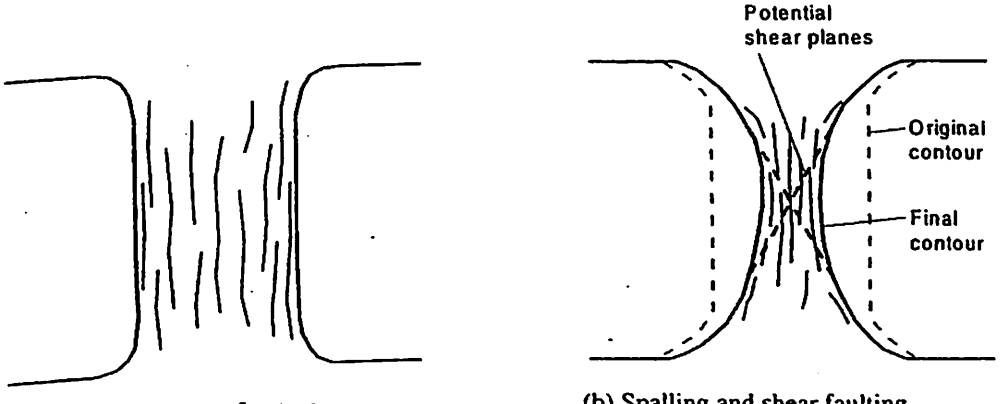
Where σ_1 and σ_3 are the major and minor principal stresses, respectively; σ_{ucs} is the **unconfined compressive strength (UCS);** and m_i is a material constant for the intact rock.

a) If you are involved in an open pit slope design project that requires a series of **uniaxial compressive test** and needed to determine the failure criteria of that particular rock using the above ***Eqn. 1.***, then simplify and re-define the above Hoek & Brown equation to suit your scope of work.

..... **10 marks**

b) You designed a pillar support in an underground mine. The change in rock response in the stressed pillar are shown in **Figure 2** below.

i) Discuss the failure mode/type experienced by the pillar..... **5 marks**
ii) Discuss which pillar is potentially dangerous and why. ..... **5 marks**
iii) Discuss your design approach to increase safety of the dangerous pillar
.....**5 Marks**



(a) Splitting fracture

(b) Spalling and shear faulting

Figure 2

END OF SECTION 2: Geomechanics