UNIVERSITY OF ZAMBIA EXAMINATIONS

SCHOOL OF MINES

GEOLOGY DEPARTMENT

NOVEMBER, 2021

GGY 3051 – ENGINEERING GEOLOGY

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS
TOTAL MARKS: 100
TIME ALLOWED: 3 HOURS

NB. The marks allocated are an indication of the amount of detail expected. Show your working clearly.

Question 1

a) In soils engineering, what do the following terms mean? (8 marks)
   i. Angle of internal friction
   ii. Cohesion
   iii. Compressibility
   iv. Shear strength

b) What is the difference between consolidation and compaction? (2 marks)

c) A slightly moist sand sample is subjected to a normal force $\sigma' = 25KN$ in a direct shear test like the one shown below (Figure 1). If the strength parameters of the sand are $c =$ 1KPa and $\varphi = 28^{\circ}$, **calculate** the shear stress at failure if the soil sample is 12 cm × 12 cm in plane and 3cm in height. (5 marks)

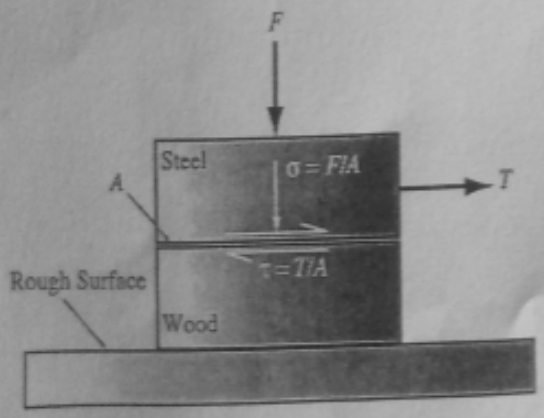


Figure 1: Diagram showing a direct shear box test

d) Despite being a very low strength material compared to other materials used to build structures, give three reasons why soil is widely used as building material (3 marks)

e) What laboratory tests would you use to determine the tensile and/or compressive strength of soils? (2 marks)

Question 2

In Engineering Geology, it is important to make an assessment of the ground response to loading, in line with Newton's third law of motion. The role of an Engineering Geologist is to determine the Nature of reaction as well as the behaviour of the completed works.

i) Explain the ***different methods*** you would employ to determine the ground properties of a site that is to be used as a mine tailings dump. (5 marks)

ii) What ***Geotechnical parameters*** and ***hydrogeological factors*** of the subsurface would you take into account? (5 marks)

iii) What are some ***possible impacts*** that the tailings dam would pose in the same and surrounding environment? (5 marks)

iv) What are some possible ***Mitigation measures*** you would employ? (5 marks)

Question 3

a) What is the difference between an intact rock and a rockmass? (2 marks)

b) As an engineering geologist, what physical properties of rocks would be of value to you before you advise the structural engineer on any construction works? (3 marks)

c) What factors of discontinuities influence the strength and deformability of rockmasses in construction works? (3 marks)

d) As an engineering geologist/geotechnical engineer, would you recommend design of structures based on intact rock properties? Give a reason for your answer (2 marks)

e) Geological structures are usually points/planes of weakness in rocks. Describe (with sketches where possible) the following structures:

i) Faults (2 marks)

ii) Folds (2 marks)

iii) Bedding (2 marks)

f) i) What is weathering? List and explain the three commonly known types of weathering (3 marks)

ii) Why is it important to consider the effect of weathering when designing buildings? (1 mark)

Question 4

a) List and briefly describe the three major layers of the earth (3 marks)

b) i) List the three main rock types and explain how they are formed (3 marks)
ii) Give an example of a rock name for each rock type (3 marks)

c) What are some of the physical properties of aggregate that make it a good construction material? (3 marks) Would you recommend the use of vitreous material on a road surface? Give a reason for your answer (2 marks)

d) What are some engineering uses of asphalt? (2 marks)

e) What are some important characteristics of industrial minerals in construction? (4 marks)

Question 5

a) As an engineering Geologist, you have been tasked with carrying out site investigations for a proposed dam construction project on a river portion that is 85m wide.

i) What lithological/geological and structural geology information needs to be considered/gathered as you do your site investigations? (5 marks)

ii) What vital geotechnical data/information should be obtained/collected before constructing any dam and how can you obtain such data? (5 marks)

b) The following are the results of seismic tests that were done by Mipishi Chibale & Sons on behalf of their clients Kunda Kawishe Plc before deciding to construct a 12 storey building in Kazungula District, Zambia. It was necessary to carry out a site investigation to determine the properties of the sub-surface geology to establish the ground's bearing capacity. A 3KG sledge hammer, adequate for 20m penetration, was used to generate the seismic vibrations.

	Geophone 1	Geophone 2	Geophone 3	Geophone 4
Distance from vibration source (meters)	10	20	30	40
Direct wave arrival time (milli seconds)	12.5	25	37.5	50
Refracted wave arrival time (milli seconds)	17	21	25	29

Calculate:

i) The wave velocities V1 and V2 (4 marks) The critical distance (D) (2 marks)

ii) The thickness of the drift (4 marks)

Question 6

a) Minerals are the building blocks of rocks. Mention any 3 ***definitive*** properties of minerals (3 marks)

b) i) Mention any four ***diagnostic*** properties of minerals (4 marks)
ii) Describe any two of the above diagnostic properties (2 marks)

c) Define the following terms:
i) An aquifer (2 marks)
ii) Porosity (2 marks)
iii) permeability (2 marks)

d) A cylindrical sample of partly saturated clay with an original length of 210mm and diameter of 95mm is subjected to a normal load of 185kN. This leads to an increase in the sample's radius by 2mm. If the soil's Poisson's ratio is 0.38, what is the final length of the sample? (5 marks)

END OF EXAM

Appendix

$$\rho_i = \frac{p * B\,(1 - \mu^2) * I_p}{E}$$

Wherein:

p ≡ uniform contact pressure;

B ≡ Width of foundation;

μ ≡ Poisson's ratio of the soil;

E ≡ Modulus of elasticity of the soil

Ip ≡ Influence factor depending upon dimensions of foundation, i.e. length (L) & width (B).

$$V_p = \sqrt{\frac{K + \frac{4}{3} * G}{\rho}}$$

Where:

Vp ≡seismic p-wave velocity

K≡bulk modulus;

$$\frac{V_p}{V_s} = \sqrt{\frac{2 * (1 - \mu)}{1 - (2 * \mu)}}$$

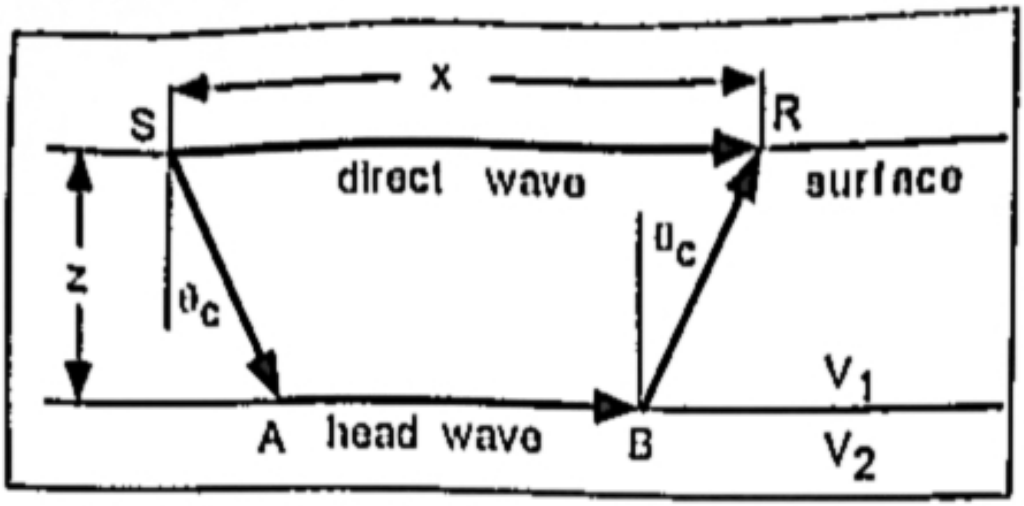
m transmitting w

$$E = k * \rho * V_s^2 \frac{\left(3 * V_p^2 - 4 * V_s^2\right)}{\left(V_p^2 - V_s^2\right)}$$

$$V_s = \sqrt{\frac{G}{\rho}}$$

$$\text{Poisson's Ratio, } \mu = \frac{V_p^2 - 2 * V_s^2}{2 * \left(V_p^2 - V_s^2\right)}$$

$$\text{Shear Modulus, } G = \rho * V_s^2$$



$$t = \frac{SA}{V_1} + \frac{AB}{V_2} + \frac{BR}{V_1}$$

$$X_c = 2z\sqrt{\frac{V_2 + V_1}{V_2 - V_1}}$$

$$Z = \frac{X_c}{2}\sqrt{\frac{V_2 - V_1}{V_2 + V_1}}$$

$$t_0 = \frac{2z * \sqrt{V_2^2 - V_1^2}}{V_1 * V_2}$$

$$Z = \frac{t_0}{2}\frac{V_1 V_2}{\sqrt{V_2^2 - V_1^2}}$$