THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

SCHOOL OF ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

SECOND SEMESTER EXAMINATION

SUBJECT: SOIL MECHANICS AND GEOLOGY

SUBJECT CODE: CE221

SEMESTER: TWO

YEAR: 2023

DATE AND TIME OF EXAMINATION: 23 OCTOBER 2023 AT 8:20 AM

VENUE: SLT

INSTRUCTION:

1. **NO MOBILE PHONES AND NO NOTES IN THE EXAMINATION ROOM**
2. **FILL IN THE ATTENDANCE SLIP NOW**
3. **ANYONE CAUGTH CHEATING WILL BE REMOVED FROM THE EXAMINATION ROOM.**
4. **ATTEMPT FIVE QUESTIONS ONLY. DO ANY FIVE QUESTIONS ONLY**

QUESTION 1 - GEOLOGY

(a) What is plate tectonic? Please explain how plates interact with each other.

(b) There are three types of rocks, name each type and explain the processes by which they are formed? (

(c) Define the following terms;

(i) Geologic process

(ii) Oceanic process

(iii) Geotectonic

(d) State five importance of geology in civil engineering

(e) List five physical characteristics of a mineral and briefly explain them.

QUESTION 2 – SOIL CLASSIFICATION

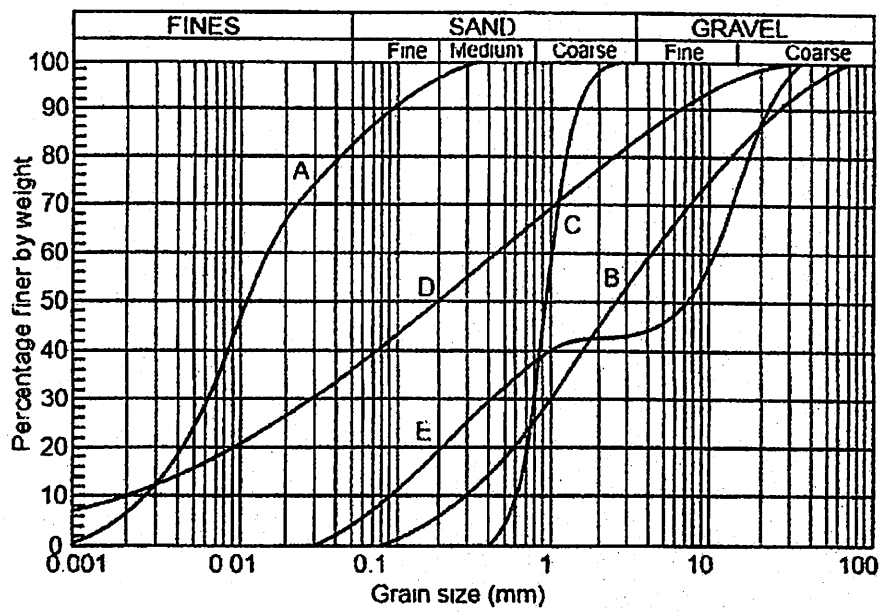
(a) Describe potential assumptions made and associated uncertainties that a geotechnical engineer might face in trying to classify soils. (2 marks)

(b) Briefly discuss how you would identify clay soils from silt on field. (3 marks)

(c) From the graphs below, indicate which curve represents the following;

i) Fine-grained soil
ii) Coarse-grained soil
iii) Poorly graded soil
iv) Well-graded soil
v) Gap-graded soil

(5 Marks)



Particle size distribution curve

(d) Determine the liquid limit, plastic limit and the plasticity index of the soil after conducting the Atterberg (Plasticity) Limits Test on a clay soil sample. The results are indicated in the table below;

Cone penetration (mm)	16.1	17.6	19.3	21.3	22.6
Water content (%)	50.0	52.1	54.1	57.0	58.2

Plastic limit test

Test No.	Mass of tin (g)	Mass of wet soil + tin (g)	Mass of dry soil + tin (g)
1	8.1	20.7	18.7
2	8.4	19.6	17.8

(10 Marks)

QUESTION 3 – PERMEABILITY & PROPERTIES OF SOIL

(a) Soil 1 with a cross-sectional area of 1.0×10-2 m2 is set up in the permeameter in which the specimen is supported by a mesh at the bottom. A constant-head difference across the specimen is maintained as shown in Figure 1. After a constant flow rate is established, the flow rate reaches 2.4×10-5 m3/min. Determine the hydraulic conductivity (coefficient of permeability) of Soil 1. Assume that the specimen is fully saturated with water once the constant flow rate is established.

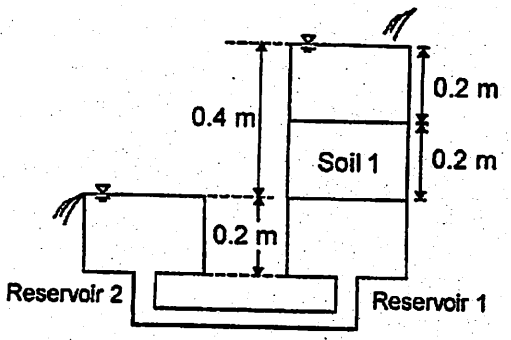


Figure 1

(10 marks)

(b) An embankment is constructed from the soil excavated from an excavation site. After completion, the total volume of this embankment is 20,000 m^3. The soil from the excavation site is investigated in its natural conditions and the following results are obtained:

Bulk density: 1.80 t/m3
Water content: 16.0%
Specific gravity of soil grains: 2.70

In addition, from the results of compaction tests conducted for the excavated soil, the optimum water content is found to be equal to 19.0%, at which the maximum dry density is equal to 1.80 t/m^3. During the construction of the embankment, water is sprayed and the optimum water content condition is reached. At this optimum water content condition, the maximum dry density of the embankment is 90.0% of the maximum dry density obtained during the compaction test (i.e., degree of compaction = 90.0%).

Considering the density of water as 1.00 t/m^3, calculate the void ratio, porosity, degree of saturation and dry density of the soil at the excavation site in the natural condition.

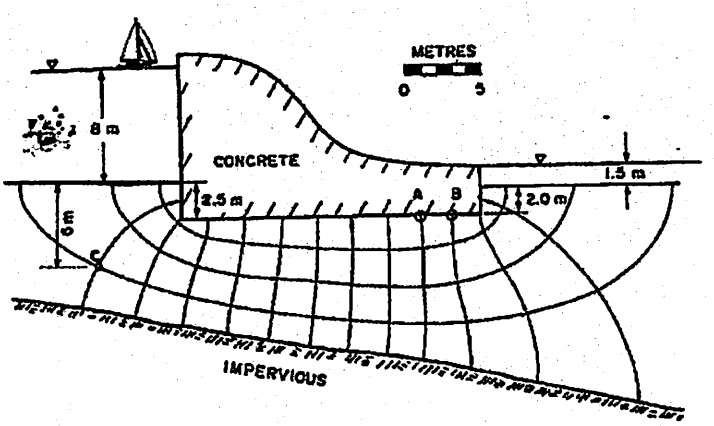
(10 marks)

QUESTION 4 – FLOW NETS

(a) The flow net shown below is constructed for an isotropic sand which supports a concrete weir and having the following soil properties; permeability $1x10^{-3}$ cm/sec, an average void ratio of 0.6 and $G_s = 2.65$. Determine the following:

i) The seepage loss in cubic meters per day per meter width of the dam perpendicular to the section shown.

ii) What is the effective stress at Point C if γ_{sat}=20 kN/m^3? Use γ_w = 10 kN/m3



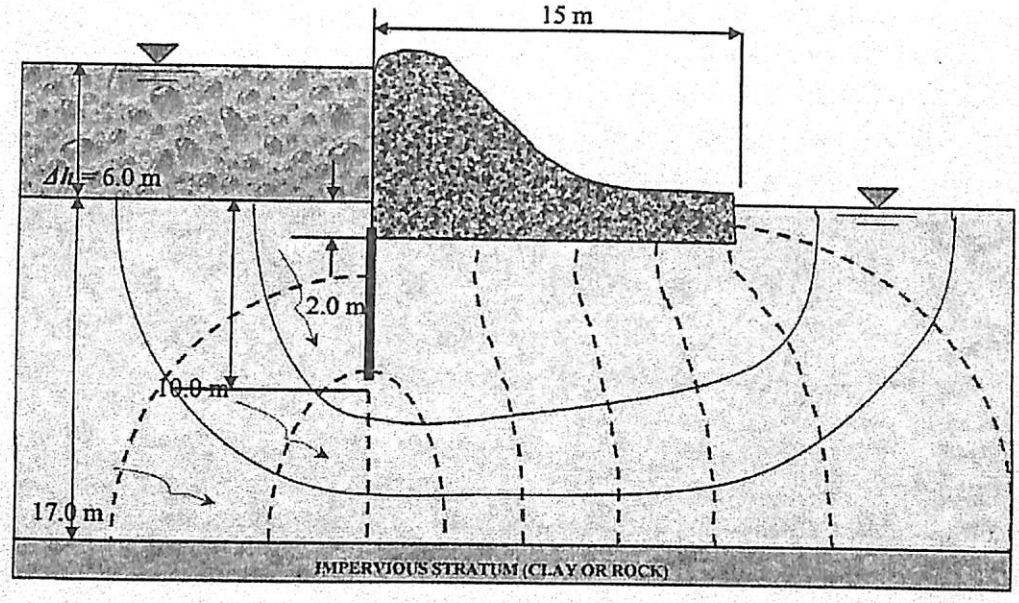
(10 marks)

(b) The dam was designed and constructed as shown below. The width of the dam was 500 m (shore to shore). The soil above impervious stratum of clay and rock consisted of silty sand which has k = 3.5 x 10^{-4} cm/s. A complete flow net of the dam is shown which includes a steel sheet-pile cut-off wall located at the head-water side of the dam in order to reduce the seepage loss.

Determine;

(a) Total seepage loss under the dam in litres per year, and

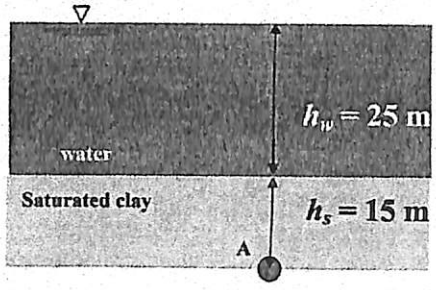
(b) State whether the dam would be more stable or not if the cut-off wall was placed under its tail-water side?



(10 marks)

QUESTION 5 - STRESSES IN SOIL

(a) A soil sample was obtained at 15 m below the ground surface (Point A) in the submerged clay layer as shown below. The moisture content of the sample was, w = 54% and a $G_s = 2.78$. Determine the effective vertical stress at A.



(10 Marks)

(b) A maximum stress of 14.6 kN/m^3 is subjected to a soil particle, and a minimum stress of - 4.18 kN/m^3. Calculate the σ and τ on the plane of $\theta = 50°$ with respect to the major principal stresses and also determine τ_{max}.

Show (a) graphical solution as well as (b) calculate / analytical solution.

(10 marks)

QUESTION 6 – APPLICATION OF GEOSYNTHETICS IN SOIL

(a) Briefly describe the following geosynthetics that are used in civil engineering projects:

i. Geotextile
ii. Geogrids
iii. Geonets
iv. Geomembranes
v. GCL

(5 marks)

(b) Describe the generic design process that applies to the different geosynthetic functions according to Koerner, 2005.

(5 marks)

(c) What is the specific function(s) of the different geosynthetic(s)?

(10 marks)