**TECHNICAL UNIVERSITY OF MOMBASA**

SCHOOL OF ENGINEERING AND TECHNOLOGY
Department of BUILDING & Civil engineering
**UNIVERSITY EXAMINATION FOR:**

BACHELOR OF SCIENCE IN CIVIL ENGINEERING
**TCV 4212: SOIL MECHANICS I**

SPECIAL/SUPPLEMENTARY EXAMINATION
**SERIES: MARCH 2025**
**TIME:** 2 HOURS

**Instructions to the candidate:**

1. You should have the following for this examination:
   - **Answer booklet.**
   - **Mathematical Table/Pocket Calculator.**
2. This paper consists of **FOUR** questions.
3. Answer question **ONE (Compulsory)** and any other **TWO** questions.
4. This paper consists of **FIVE** printed pages.
5. **Do not write on the question paper.**

**Question ONE (compulsory): Soil physics**

(a) The expression below is used in calculations of unit weights of soils:

$$\gamma_b = \left\{ \frac{G_s + e S_r}{1+e} \right\} \gamma_w$$

Where $\gamma_b$ = bulk unit weight, $\gamma_w$ = unit weight of water, $G_s$ = specific gravity of the soil grains and e = void ratio. Derive the expression from the basic principles.

**(10 marks)**

(b) A soil sample in its natural state has a mass of 183.5 kg and a volume of 0.1 $m^3$. In an oven dried state, the dry mass of the sample is 145.64 kg and the specific gravity $G_s$ of the solids is 2.71.
Determine:
(i) The bulk density,

(ii) The bulk unit weight,
(iii) Water content,
(iv) The dry unit weight,
(v) Void ratio,
(vi) Saturated unit weight,
(vii) Sub-merged unit weight,
(viii) Porosity,
(ix) Degree of saturation,
(x) Air voids ratio.

**(20 marks)**

**Question TWO: Soil classification**

The results of a sieve analysis, on a soil sample are presented in Table 2.1.

Table 2.1: Sieve analysis results

| Sieve size (mm) | Mass retained (g) |
|---|---|
| 50 | 0 |
| 37.5 | 15.5 |
| 20 | 17 |
| 14 | 10 |
| 10 | 11 |
| 6.3 | 33 |
| 3.35 | 114.5 |
| 1.18 | 63.3 |
| 0.6 | 18.2 |
| 0.15 | 17 |
| 0.063 | 10.5 |
| Mass passing 0.063 | 1 |

For the soil tested, determine:

(i) Effective size,

(ii) Uniformity coefficient,

(iii) Coefficient of curvature.

**(20 marks)**

**Question THREE: Soil Compaction**

The results of a compaction test are set out below

Table 3.1

| Moisture content (%) | 9.0 | 10.2 | 12.5 | 13.4 | 14.8 | 16.0 |
|---|---|---|---|---|---|---|
| Bulk density $\rho_b$ (kg/m$^3$) | 1923 | 2051 | 2220 | 2220 | 2179 | 2096 |

Specific gravity of solids Gs = 2.68

(a) (i) Plot the curve of dry density against moisture content and determine the values of maximum dry density and optimum moisture content,

(ii)On your graph plot the saturation line and 5% air voids line,

(b) Calculate the air voids percentage at maximum dry density.

**Hint:**

| Moisture content | % | 9 | 10.2 | 12.5 | 13.4 | 14.8 | 16.0 |
|---|---|---|---|---|---|---|---|
| | Decimal (w) | | | | | | |
| Bulk density $\rho_b = \frac{mass\ of\ soil}{vol.\ of\ mould}$ (kg/m$^3$) | | 1923 | 2051 | 2220 | 2220 | 2179 | 2096 |
| Dry density (kg/m$^3$) $\rho_d = \frac{\rho_b}{1+w}$ | | | | | | | |
| $\rho_d = \frac{G_s(1-A_r)}{1+wG_s}\rho_w$ | For saturation line, $A_r = 0$ | | | | | | |
| | For 5% air voids, $A_r = 0.05$ | | | | | | |

**(20 marks)**

**Question FOUR:** Principle of effective stress

Figure 4.1 shows a layout of soil strata.

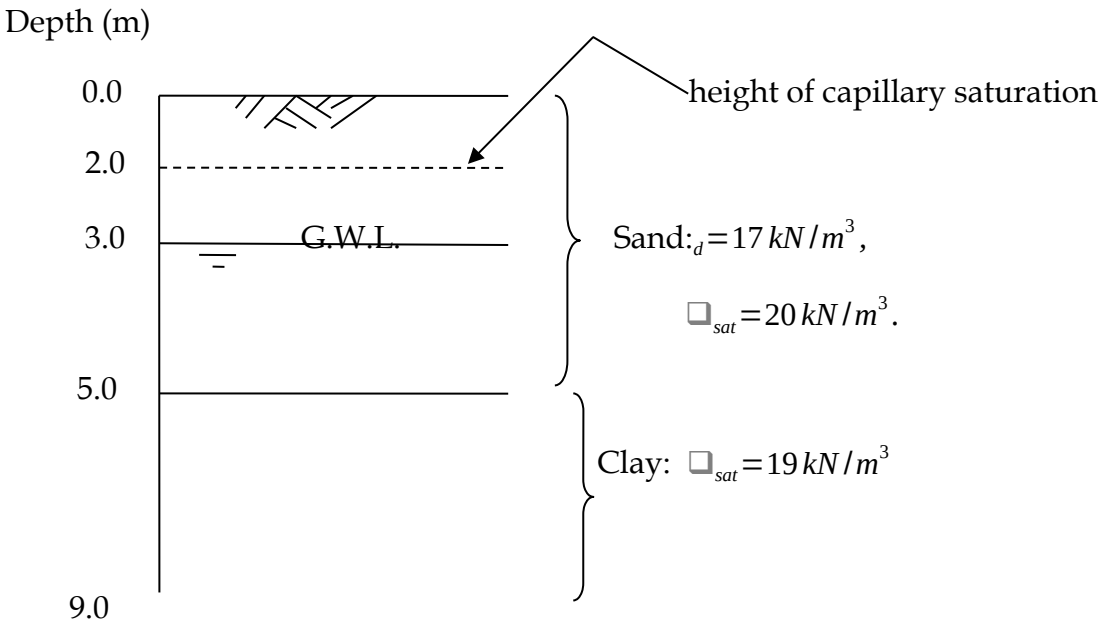


Figure 4.1: Details of a borehole log

Draw graphs showing the variation with depth, of total vertical stress, pore pressure and effective vertical stress.

**(20 marks)**