NAME	MUHAMMAD FURQAN
ID	7802
SECTION:	"A"
SUBJECT:	SOIL MECHANICS
INSTRUCTOR:	Engr. LIAQAT ALI
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QUESTION : 01

PART: a

a) **Hydraulic Gradient:** Hydraulic gradient is a vector gradient between two or more hydraulic head measurement over length of flow path. (or)
Hydraulic Gradient is a line joining point of highest elevation of water in a series of vertical open pipes rising from a pipeline in which water flows under pressure

b) **Coefficient of Permeability:** The co-efficient of permeability of soil is described as "how easily a liquid will move through soil. It's also commonly referred to as hydraulic conductivity of soil.

(c) **Liquidity Index:** The liquidity index is used for scaling natural water content of soil sample to limits. Liquidity Index can be calculated as "ratio of difference between natural water content, plastic limit and liquid limit.

$$LI = (W-PL)\ /\ (LL-PL)$$

4) **Porosity:-** Porosity or void fraction is the measure of void spaces in a material. It is fraction of volume of voids over total volume. It can range b/w 0 & 1 or in percentage 0 - 100%.

$$\eta = \frac{\text{vol. of voids}}{\text{Total vol. of Soil Mass}} = \frac{V_v}{V}$$

5) **Degree of Saturation:** It is defined as "ratio of humidity ratio of moist air to humidity ratio of saturated moist air at same temperature and pressure.

Degree of saturation is calculated as

$$S = \frac{\text{volume of water}}{\text{volume of voids}} = \frac{V_w}{V_v}$$

QUESTION: 01

PART: (b)

Given Data:

Total Weight of soil = 32 Kg

Volume = V = 0.0192 m^2

Weight of Dry Sample = 28.5

Required Data:-

Bulk density = ?

w_c = ?

γ_B = ?

Saturated Density = ?

Void Ratio = ?

Solution:-

⇒ Bulk Density = W/V

$$\gamma_B = \frac{32}{0.0192}$$

$$= 1666.67 \text{ kg/m}^3$$

⇒ Now finding Water Content:-

w_c = weight of water − weight of soil

= 32 − 28.5

= 0.12 = 12%

⇒ Now finding Dry Density

$$= \frac{W_{solid\ soil}}{\text{Total Volume}}$$ (puting values)

$$= \frac{28.5}{0.0192}$$

$$= 1484.37 \text{ Kg/m}^3$$

⇒ Now finding Saturated Density:

$$W/V$$

$$= 32/0.0192$$

$$\gamma_B = 1666.67 \text{ Kg/m}^3$$

$$\Rightarrow \gamma_d = W_s/V$$

putting values

$$\gamma_d = \frac{28.5}{0.0192}$$

$$1484.37 \text{ Kg/m}^3$$

⇒ Now finding void Ratio

$$\gamma_d = \frac{(G_s + e)\gamma_w}{1 + e}$$

$$\Rightarrow e = \frac{G_s \times \gamma_w}{\gamma_d} - 1$$

$$\Rightarrow e = \frac{2.65 \times 1000}{1484.37}$$

$$\Rightarrow e = 0.785.$$

QUESTION: 02

PART: (a)

Given:

To prove $e = \dfrac{G_s \times \gamma_w (1 + w_c)}{\gamma_B} - 1$

Solution:

As we know

$$\gamma_B = W / V$$

$$\gamma_B = \frac{w_s + w_w}{V_s + V_v}$$

$$\Rightarrow \gamma_B = \frac{w_s/w_s \ (\because w_s + w_w)}{V_s/V_s \ (V_s + V_v)}$$

$$= \frac{w_s \left(\dfrac{w_s + w_w}{w_s} \right)}{V_s \left(\dfrac{V_s + V_v}{V_s} \right)}$$

$$= \frac{w_s \left(\dfrac{w_s}{w_s} + \dfrac{w_w}{w_s} \right)}{V_s \left(V_s/V_s + V_v/V_s \right)}$$

$$= \frac{w_s \left(1 + w_w/w_s \right)}{V_s \left(1 + V_v/V_s \right)}$$

$$= \frac{w_s (1 + w_c)}{V_s (1 + e)}$$

$$= \gamma_s \frac{(1 + w_c)}{1 + e} \qquad \therefore G_s = \frac{\gamma_s}{\gamma_w}$$

$$\gamma_s = G_s \gamma_w$$

$$\Rightarrow \quad G_s = \frac{\gamma_s}{\gamma_w}$$

By rearranging, we get

$$\gamma_s = G_s \gamma_w$$

Now we have

$$\gamma_B = \frac{G_s \gamma_w (1 + w_c)}{1 + e}$$

Now by rearranging we get

$$1 + e = \frac{G_s \gamma_w (1 + w_c)}{\gamma_B}$$

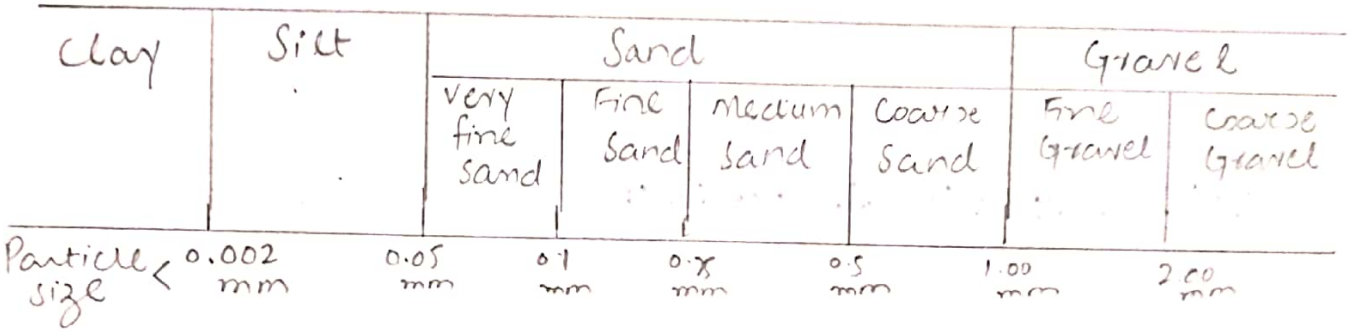
$$e = \frac{G_s \gamma_w (1 + w_c)}{\gamma_B} - 1$$

Hence proved.

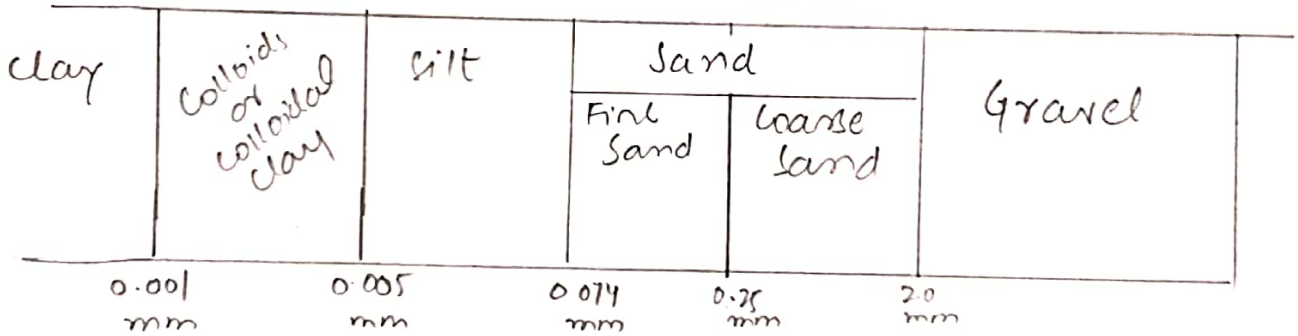
QUESTION: 02

PART: (b) The grain size classification is done based on three criteria or through three systems.

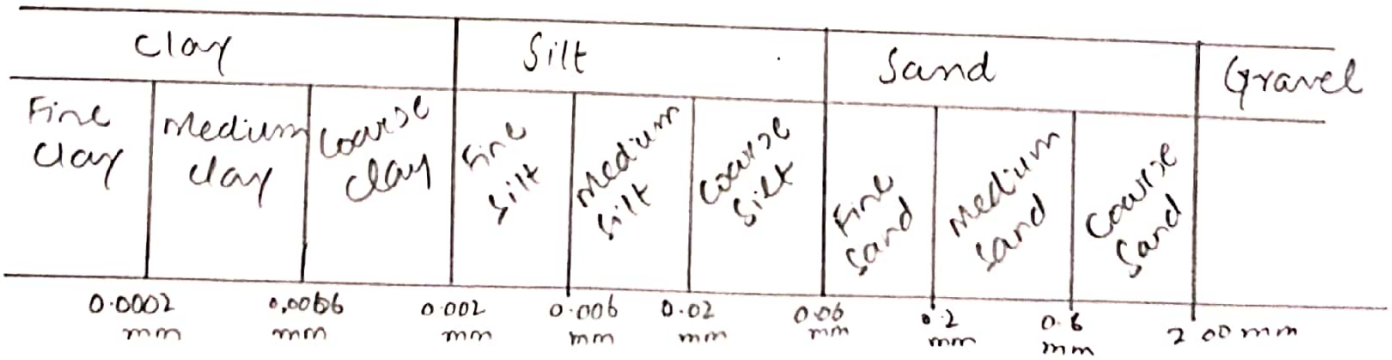
1. US Bureau of Soil Classification:-



(ii) AST M Soil Classification system:-



(iii) M.I.T Soil Classification system:-

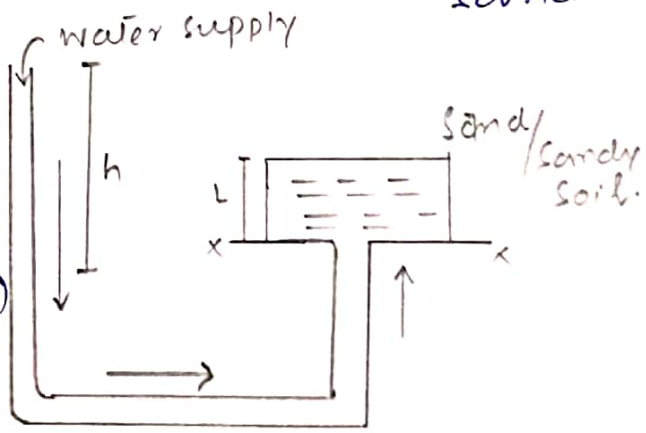


QUESTION: 03

PART: 1a)

Quick sand is defined as: When seepage pressure due to upward flow of water in solid / sandy soil balance the downward force of gravity (weight of material), a condition of unstability rises in sand. So the sand in two state is called "Quick sand".

Critical Hydraulic Gradient:



At bottom surface
i.e $x-x$

We know

upward force $= (h+L)\gamma_w \cdot A$ — ①

Downward force $= \dfrac{\gamma_w (G_s + e) V}{1+e}$

Since $\gamma_B = W/V \Rightarrow W = \dfrac{\gamma_w (G_s+e) V}{1+e}$ $\quad \therefore V = A \times L$

$$W = \frac{\gamma_w (G_s + e)}{(1+e)} \; A \times L$$

Now at Balance:

Upward force = Downward force

$$(h+L)\gamma_w A = \frac{\gamma_w (G+e)}{1+e} AL$$

$$\frac{h+L}{L} = \frac{G_s + e}{1+e} \quad L/L.$$

QUESTION: 03

PART: (b)

Given Data:-

V = Volume of soil = 65 ml = 0.000065 m^3 As 1 ml = 10^{-6} m^3

W = Weight of soil = 0.96 N

W_d = after Drying, Weight of soil = 0.785 N

G_s = Specific Gravity of soil = 2.65

Required:-

S = ?

Solution:-

As we know

$$\gamma_B = \frac{\gamma_w (G_s + e \times s)}{1 + e} \quad - (1)$$

$$\Rightarrow \gamma_B = \frac{W}{V} \quad \text{(puting values)}$$

$$\gamma_B = \frac{0.96}{0.000065} = 14769\ N/m^3$$

Now $\gamma_w = 9800\ N/m^3$

As $\gamma_s = \frac{W_s}{V_s}$

$$e = \frac{V_v}{V_s}$$

$$e = \frac{0.000035}{0.000030}$$

$$e = 1.167$$

$$V_s = \frac{W_s}{\gamma_s} \quad \text{(puting values)}$$

$$V_s = \frac{0.785}{25970}$$

$$V_s = 0.000030 m^3$$

Now we also know:

$$V = V_v + V_s$$

$$V_v = V - V_s$$

$$V_v = 0.000065 - 0.000030$$

$$V_v = 0.000035 \ m^3$$

But as we know by formula

$$G_s = \frac{\gamma_s}{\gamma_w}$$

$$\gamma_s = G_s \times \gamma_w \quad \text{(putting values)}$$

$$\gamma_s = 2.65 \times 9800$$

$$\gamma_s = 25970 \ N/m^3$$

Now by putting all calculated values in eq ①, we get the answer for S after solving it.

$$S = 0.527 \text{ or } 52.7\%$$