BALASORE SCHOOL OF ENGGINEERING

GEOTECHNICAL ENGINEERING

THEORY-02

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SEMESTER-3RD

CHAPTER – 1

Q.1. What do you mean by Geo-tech Engineering ? [2016, 1-a]

Ans: It is the branch of civil Engg. Concerned with the engineering behavior of earth materials.

CHAPTER – 2

Q.1. What is a block diagram ? [2014 , 1-a]

Ans: A soil mass consists of solid particles, water and air. The three constituents are blended together to form a complex material. All the solid particles are segregated and placed in a lower layer of the three-phase diagram. The three phase diagram is known as Block diagram.

Q.2. What is Air content ? [2014, 1-l]

Ans: Air content is defined as the ratio of the volume of air to the volume of voids. It is denoted by 'a_c'

$$a_c = \frac{V_a}{V_v}$$

Air content is usually expressed as a percentage. Both air content and the percentage air voids are zero when the soil is saturated ($V_v = 0$).

Q.3. Write down the relationship between void ratio, water content, specific gravity and degree of saturation [2014, 1-b]

Ans: The relationship between void ratio, water content, specific gravity and degree of saturation .

e = WG/Sr

e = void ratio

w = water content

G = specific gravity

S = Degree of saturation

Q.4. Define Degree of Saturation. [2015 , 1-a]

Ans: Degree of saturation, S_r is defined as the ratio of volume of water (V_w) present n a soil mass to the volume of voids, V_v.

→ It is generally expressed as a percentage and is also referred to as present saturation.

→ Mathematically, $S_r = \frac{V_w}{V_v} \times 100\%$

→ The degree of saturation ranges from 0 for dry soil mass to 100 % for fully saturated soil mass.

Q.5. Define specific gravity. [2016 3-a,2019 1 b]

Ans: It is defined as the ratio of the weight of a given temp. to the weight of an equal volume of distilled water.

$G = \frac{\gamma s}{\gamma w}$ or $\frac{\rho s}{\rho w}$

Q.6.How bulk density is differ from unit weight?2019 1-a

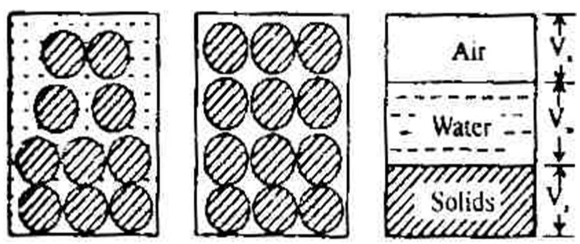
Ans-Bulk density is mass per unit volume but unit weight is weight per volume.

$\gamma = \rho \times 9.81$

CHAPTER-2 (Medium Types)

Q.1. Explain soil as a three phase system and state when it becomes a two phase system with the help of diagram. [2013, 2-b]

Ans: Soil as a three phase system : A soil mass is a three phase system consisting of solid particles (called soil grains)m water and air.



Soils as Two phase system :

Figure (a) if we take perfectly saturated soil, the voids are filled completely with water.Figure

(b) if we take a dry soil mass, the voids are filled with air only.

Q.2. Where the terms carry their usual meanings [2013, 7-b]

Prove that , $S = \frac{w}{\frac{\gamma_w}{\gamma}(1+w) - \frac{1}{G}}$

$$S = \frac{V_w}{V_v} = \frac{e_w}{e}$$

$$e_w = eS$$

$$w = \frac{W_w}{W_d} = \frac{e_w \gamma_w}{\gamma_s - 1}$$

$$G = \frac{\gamma_s}{\gamma_w} \text{or} \gamma_s = G\gamma_w$$

$$w = \frac{e_w \gamma_w}{G\gamma_w} = \frac{e_w}{G}$$

$$e_w = WG$$

$$e = \frac{G\gamma_w}{\gamma_d} = -1$$

$$\gamma = \frac{W}{V} = \frac{\gamma_s V_s + \gamma_s V_w}{V}$$

illustrating a partially saturated sample, we have

$V_s = 1$, $V_w = e_w$ and $V = (1 + e)$

$$\gamma = \frac{\gamma_s .1 + \gamma_w . e_w}{1 + e} \text{But } \gamma_s = G\gamma_w \ \ \& \ e_w = eS$$

$$\therefore \gamma = \frac{G\gamma_w + \gamma_w .eS}{1 + e}$$

$$\Rightarrow S = \frac{\gamma .(1 + e) - G\gamma_w}{\gamma_w - e} = \frac{\gamma(1 + e)}{\gamma_w .e} - G\gamma_w \text{..................(1)}$$

Put $e = \frac{WG}{S}$ in equation (1)

$$\therefore S = \frac{W}{\gamma_w (1 + W) - \frac{1}{G}}$$

where, W = Water content

S = Degree of saturation

G = Specific gravity

γ_w = Saturated unit weight

γ = ...coil weight

Q.3. A fully saturated soil sample has a mass of 130 gm and has a volume of 64 cm^3. After oven draying the mass of soil sample is 105 gm. Assuming that the volume does not change during draying condition, determine the following : [2014, 2-a,2019 1-c]

(i) Specific gravity of soil

(ii) Void ratio

(iii) Porosity

(iv) dry density

Ans: Fully saturated soil mass $= 130$gm.

For fully saturats, $S = 1$

After oven drying the mass $M_d = 105\text{gm}\ M_a$

Mass of water, $M_w = 130 - 105 = 25\text{gm}$

Watr content, $\omega = \frac{25}{105} = \frac{M_w}{M_s} = 0.238 = 23.809\ \%.$

Wet mass density ,

$\rho = \frac{130}{64} = 2.03\text{gm}/\text{cm}^3 = \frac{M}{V}$

dry density , $\rho_d = \frac{105}{64} = 1.64\text{gm}/\text{cm}^3 = \frac{M_s}{V}$

we know that $G_w = Se$ or $G \times 0.238 = 1 \times e$

or $e = 0.238\ G$

Again, $P = \frac{P_w(G + S_e)}{(1+e)}$ or $.2.03 = \frac{P_w(G + 1 \times e)}{(1+e)}$

or, $2.03 + 2.03e = G + e$

or $2.03 + 1.03e = G$...................(2)

Putting the value of e in (2), $2.03 + 1.03 \times 0.238G = G.$

or $2.03 + 0.245\ G = G$

or $2.03 = 0.7555\ G$ or $G = 2.689.$

$\therefore e = 0.238 \times 2.689 = 0.64$

$n = \frac{e}{1+e} = \frac{0.64}{1+0.64} = 0.39.$

Q.4. Establish a relationship between e, G, w & Sr[2015, 1-b,2019 1b]

Ans: Relation between e, G, w and S

$$s = \frac{v_w}{v_v} = \frac{e_w}{e}$$

$$e_w = es$$

$$w = \frac{w_w}{w_d} \Rightarrow \frac{e_w \gamma_w}{\gamma_s.1}$$

$$G = \frac{\gamma_s}{\gamma_w} \Rightarrow \gamma_s = G\gamma_w$$

$$w = \frac{ew\gamma_w}{G\gamma_w} = \frac{e_w}{G}$$

$$e_w = wG$$

$$e = \frac{wG}{s}$$

for saturated soil, $s = 1$ and $w = w_{sat}$

$$e = w_{sat}G$$

Q.5. Derive the relationship between e & w (void ratio and water content) with phase Dig. [2016(s) 1-b]

As: The symbol e_w used for volume of water is referred to as water void ratio

$$S_r = \frac{v_w}{v_v} = \frac{e_w}{e}$$

$$e_w = e.s_r$$

$$w = \frac{w_w}{w_s} = \frac{v_w \gamma_w}{v_s \gamma_s} \begin{bmatrix} \gamma_w = \dfrac{W_w}{V_w} \\ \gamma_s = \dfrac{w_s}{v_s} \end{bmatrix}$$

$$w = \frac{e_w \gamma_w}{1.\gamma_s}$$

$$\Rightarrow w = \frac{e.s_r \, \gamma_w}{G.\gamma_w} \left[\therefore G = \frac{\gamma_s}{\gamma_w}, e_w = e.s_r \right]$$

$$\Rightarrow w = \frac{e.s_r}{G}$$

$$es_r = wG$$

8 MARKS

Q.1 A soil sample has porosity of 50 5. The specific gravity of solids is 2.73. Calculate (i) Void Ratio (ii) Dry Density (iii) Unit weight, if the coil is 45 % saturated and (iv) unit weight if, the soil completely saturated. [2015 , 1-c]

Ans: Given data, η = 50 %,

(i) Void Ratio :

$\eta = e/1 + e$

$\Rightarrow 0.5 = e/1 + e$

$\Rightarrow (1+e)\,0.5 = e$

$\Rightarrow 0.5 + 0.5\,e = e$

$\Rightarrow 0.5\,e = 0.5$

$\Rightarrow e = 1$

(ii) density

$$r_d = \frac{Gr_w}{1+e}$$

$$= \frac{2.73}{1+1}\{\because G = 2.73(\text{given})\}$$

$$\Rightarrow r_d = 13.65\ kN / m^3$$

(iii) $$e = \frac{W_G}{S}$$

$$\Rightarrow w = \frac{Se}{G}$$

when $S = 45\%$

$$\Rightarrow W = \frac{0.45 \times 1}{2.73} = 0.164$$

$$\Rightarrow V = 15.89\frac{kN}{m^3}$$

(iv) When soil is comletely saturated

$S = 100\%$

$$\Rightarrow W = \frac{1}{2.73} = 0.367$$

$$\Rightarrow V = r_d(1 + w) = 13.65(1 + 0.367)$$

$$\Rightarrow V = 18.66\ \frac{kN}{m^3}$$

Q.2. The mass specific gravity of a fully saturated specimen of clay havig a water content of 39 % is 1.88 on oven drying, the mass specific gravity drops to 1.75. Calculate the specific gravity of clay and its shrinkage limit. [2015, 2-c]

Ans: Given data,

W = 39 % on oven draying

The specific gravity drops to 1.75

Required data :

Shrinkage limit

Specific gravity of clay

Solution : Assume mass specific gravity :

G_m sat = 1.90, e = $w_{sat.}$

w = 39 %

Gm dry = 1.75

For saturated soil.

$$G_m = \frac{r_{sat}}{r_w} \text{ or } r_{sat} = r_w \times G_m. \text{ Take}(r_w = 9.81)$$

$$= 1.9 \times 9.81 = 18.639\,kN / m^3$$

$$\text{Now },r_{sat} = \frac{(G+e)}{1+e}$$

$$(\text{where, } e = e_{sat} = w_{sat}, G = 0.39\,G)$$

$$\Rightarrow r_{sat} = 18.639 = \frac{G+0.39G}{1+0.39G}.r_w$$

$$= \frac{1.39}{1+0.39G} \times 9.81$$

$$G = 5.699$$

$$w_s = \frac{r_w}{r_d} - \frac{1}{G} = \frac{1}{1.75} - \frac{1}{5.699}$$

$$w_s = 0.396 = 39.6\%$$

$$\text{Alternativelym,}(e)\text{dry} = \frac{Gr_w}{r_d} - 1$$

$$e = \frac{5.699 \times 1}{1.75} - 1 = 2.256$$

$$w_s = \frac{e}{G} = \frac{2.256}{2.68} = 0.84 = 84\%$$

Q.3. A sample of soil was prepared by mixing a quantity of dry soil with 20 % by mass of water. Find the mass of this wet mixture required to produce a cylindrical compacted specimen of 25 cm diameter and 17.5 cm deep and having 9 % air content. Find also the void ratio and the dry density of the specimen, if G =2.69 [2015, 5-c]

Ans: Volume of the mould (V)

$$= \frac{\pi}{4} \times 25^2 \times 17.5 = 8590.29\text{cm}^3.$$

$$a_c = 0.09\{\because a_c = 9\%(\text{given})\}$$

$$\Rightarrow a_c = \frac{V_a}{V_v} = 0.09$$

$$\Rightarrow V_a = 0.09V_v$$

$$\Rightarrow V_w = 0.91 \quad V_v \Rightarrow V_v = V_w \times \frac{1}{0.91}$$

$$V_a = 0.09 \times \frac{V_w}{0.91} = 0.098V_w$$

$$V = V_s + V_w + V_a$$

$$\Rightarrow 8590.29 = V_s + V_w + 0.098\,V_w$$

$$\Rightarrow 8590.29 = \frac{M_s}{269 \times 1} + (1.098)\left(\frac{M_w}{1}\right)..............(1)$$

Mass of water = 20 % of mass of soil (given)

$$\Rightarrow M_w = 0.2 \times M_a$$

$$\Rightarrow 8590.29 = \frac{M_s}{2.69} + 1.098 \times 0.2 \times M_s$$

$$\Rightarrow 8590.29 = M_s\left\{\frac{1}{2.29} + (1.098 \times 0.2\right\}$$

$$M_s(0.591)$$

$$\Rightarrow M_s = \frac{8590.29}{0.591} = 14535.17\text{g}$$

$$\Rightarrow M_w = 0.2 \times 14535.17 = 2907.035 \text{ g}$$

$$\Rightarrow M = M_s + M_w = 2907.035 + 14535.17 = 17442.205 \text{ g}$$

$$\text{Bulk density} = \rho = \frac{M}{V} = \frac{17442.205}{8590.29} = 2.03 \text{ g} / c_c$$

$$\text{Dry density} = \rho_d = \frac{\rho}{1+w} = \frac{2.03}{1+0.2} = 1.69 \text{ g} / c_c$$

$$\text{Void ratio} = e = \frac{G\rho_w}{\rho_d} - 1 = \frac{2.69 \times 1}{1.69} - 1 = 0.59$$

$\rho_w \rightarrow$ Density of watr.

Q.4. In a plate bearing test on a pure clayey soil, failure occurred at a load of 125 kN. The size of the plate was 45 cm × 45 cm and the test was conducted at a depth of 1.5 m below ground leve. Find out the ultimate bearing capacity for a 1.2 m wise continuous wall footing with its base at a depth of 1.8 m below ground level. The unit weight of clay may be taken as 19 kN/m^3 and N_C = 5.7, N_q = 1 and N_r=0.

Ans: Given size of plate = 4.5 cm and 4.5 cm

For the plate load test on square plate

$q_r = 1.3\,C\,N_C + \bar{\sigma} N_q + 0.4\,B.\gamma.N_V$...............(1)

where $\bar{\sigma} = \gamma\,D$

$N_C = 5.7,\ N_q = 1$ and $N_v = 0$

also, $q_r = \dfrac{125}{0.45 \times 0.45} = 617.28\ KN/m^2$

substituting the values in equation (1)

$617.28 = 1.3 \times C \times 5.7 + 19 \times 1.8 \times 1 + 0$

$\Rightarrow C = 78.68\ kN/m^2$

forthe strip footing

$q_r = _C\ N_C + \bar{\sigma} N_q + 0.5 B\,\gamma N_\gamma$

$= (78.68 \times 5.7) + (19 \times 1.8 \times 1) + 0 = 482.67\ KN/m^2$

$q_{nf} = q_r - rD = 482.67 - (19 \times 1.8) = 448.47\ KN/m^2$

$\therefore q_s = \dfrac{q_{nf}}{F} + \gamma D$

$(\because \text{assuming factor of safety} = F = 3)$

$= \dfrac{448.47}{3} + (19 \times 1.8)$

$= 183.69\ KN/m^2$

Q.5. The following properties were determined for two types of soils A and B.

Property	**A**	**B**
Liquid	**60 %**	**35 %**
Plastic limit	**28 %**	**20 %**
Moisture content	**40 %**	**27 %**

Degree of saturation	**100 %**	**100 %**
Specific gravity of grains	**2.7**	**2.65**

Which of the two soils:

(i) Contains more clay fractions ?

(ii) has a greater dry density ?

(iii) has a greater void ratio ?

(iv) has a greater saturated unit weight ?

Your answer should be supported by necessary computations. Also classify these soils as per plasticity chart of I.S. classification system.

Ans: Given data

Property	**A**	**B**
Liquid limit	60 %	35 %
Plastic limit	28 %	20 %
Moisture content	40 %	27 %
Degree of saturation	100 %	100 %
Specific gravity of grains	2.7	2.65

$$\text{Voidratio}(e) = \frac{\omega G}{s}$$

$$\text{For soil A}, e = \frac{40 \times 2.7}{1 \times 100} = 1.08$$

$$\text{For soil B}, e = \frac{27 \times 2.65}{1 \times 100} = 0.71$$

Soil A has a greater void ratio

$$\text{Dry density } (\gamma_d) = \frac{G\gamma_w}{1 + e}$$

$$\text{For soil A}, \gamma_d = \frac{2.7 \times 1}{1 + 1.08} = 1.29$$

$$\text{For soil B}, \gamma_d = \frac{2.65 \times}{1 + 0.71} = 1.54$$

Soil B has greater dry density

$$\text{Saturated unit weigh } \gamma_{sat} = \frac{(G + e)\gamma_w}{1 + e}$$

$$\text{For soil A}, \gamma_{sat} = \frac{(2.65 \times 0.71) \times 1}{1 + 1.08} = 1.81$$

$$\text{For soil B}, \gamma_{sat} = \frac{(2.65 \times 0.71) \times 1}{1 + 0.71} = 1.06$$

∴ Soil B has a greater saturated unit weight.

Plastic Index (I_P) = $W_L - W_p$

For soil A, I_p = 60 – 28 = 32 %

For soil B, I_p = 35 – 20 = 15 %

∴ Soil A is much more plastic than soil B.

Plotting the point for I_p = 32 % and W_L = 35 %, the plastic chart, group symbol for the soil B will be CL.

Hence, the soil B contains more clay fractions.

Q.6. Tests on a fill reveal that one cubic meter of soil ion the fill weights 16.24 kN and after being dried 14 kN. If the specific gravity of soil solids is 2.65, determine the water content, void ratio porosity and degree of saturation of the soil mass in moist state. Also draw the phase diagram of the soil indicating thereon the magnitude of all the volume as well as mass/weight components. [2013, 5-c]

Ans: $M_w = 16.25 - 14 = 2.24KN$

$$V_w = \frac{2.24 \times 100}{1000} = 0.224 \text{ m}^3$$

$$M_s = M_d = 14 \text{ KN}$$

$$V_s = \frac{M_d}{G f_w} = \frac{1400 \times 1000}{2.65 \times 1} = 0.5283 \text{ m}^3$$

$$V_a = 1 - V_w - V_s = 1 - 0.024 - 0.5283 = 0.247 \text{ m}^3$$

$$V_v = V_a + V_w = 0.247 + 0.2240 = 0.471 \text{ m}^3$$

$$\therefore \text{Moisutre content} = w = \frac{M_w}{M_d}$$

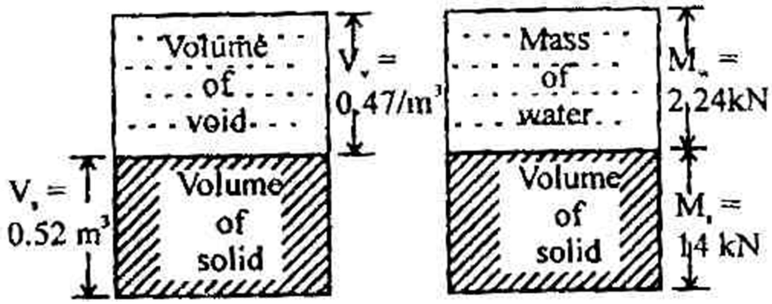
$$= \frac{2.24}{14} = 0.16 = 16\%$$

$$\therefore \text{Void ratio} = e = \frac{V_V}{V_S} = \frac{0.471}{0.0052} = 0.893$$

$$\therefore \text{Degree of saturation(s)}$$

$$= \frac{G.W}{e} = \frac{2.65 \times 0.16}{0.893} = 47.49\%$$

$$\therefore \quad \text{Porosity } \eta = \frac{e}{1+e} = \frac{0.893}{1+0.893} = 0.472$$



Q.7. A soil specimen has a water content of 15 % and wet unit weight of 25 KN/m^3. If the specific gravity is 2.95, determine the dry unit weight, void ratio and the degree of saturation. Take γ_w = 10 KN/m^3.

Ans: Given data

Specific gravity, G = 2.95

Water content , ω = 15 %

Wet unit weight or Bulk unit weight γ = 25 KN/m^3

Unit weight of water V_w = 10 KN/m^3

Dry unit weight (γ_d)

$$\gamma_d = \frac{\gamma}{1+\omega} = \frac{25}{1+15\%} = \frac{25}{1+0.15} = 21.74\,KN/m^3$$

Void ratio (e)

$$e = \frac{G\gamma_w}{\gamma_d} = \frac{2.95\times10}{21.74} = 1.36$$

Degree of saturation (sr)

$$S_r = \frac{wG}{e}$$

$$= \frac{0.15\times2.95}{1.36}$$

$$= 0.3254 = 32.54\%$$

CHAPTER:3

Q.1. What do you mean by piping ? [2013, 2-a]

Ans: Piping is the erosion of the sub-soil by the high velocities of flow of water through it when such velocities exceed a certain limit. But this concept of undermining is incomplete. Water has a certain residual force at each point along its flow through the sub-soil which acts in the direction of flow and is proportional to the pressure gradient at the point.

Q.2. What do you mean index property of soil [2013, 3-a,2019 1c]

Ans: The methods of determining those properties of soils which are used in their identification and classification. These include the determination of water content, specific gravity, particle size distribution, consistency limits, in-situ density and density index. These properties are known as index properties.

Q.3. Define Atterberg limits. [2014, 1-F]

Ans: The water contents at which are soil changes from one state to the other are known as Atterberg's limits. In 199, a Swedish agricultural engineer Atterberg mentioned that a fine-grained soil can exist in four states, namely liquid, plastic, semi-solid or solid state.

Q.4. Define co-efficient of curvature. [2014, 1-i]

Ans: The general shape of the particle size distribution curve is described by another co-efficient known as the co-efficient of curvature (C_c)

$$C_C = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

Where, D_{30} is the particle size corresponding to 30 % finer.

For a well graded soil the value of the co-efficient of curvature lies between 1 and 3.

Q.5. Define shrinkage limit. [2015, 3-a]

Ans: Shrinkage Limit :

→ It is defined as maximum water content at which reduction in water content doesn't cause an appreciable decrease in volume in soil mass.

→ At shrinkage limit on further reduction in water is starts to enter voids of soil and keeps the volume of the void constant.

MEDIUM TYPE

Q.1. A soil has liquid limit of 25 % and a flow index of 12.5 %. If the plastic limit is 17 %, determine the plasticity index and toughness index. If the water content of soil in its natural condition in the field is 20 %, find the liquidity index and consistency index. [2014, 6-b]

Ans: Data give $I_p = W_1 - W_p$

$$= 25 - 17 = 8\%$$

$$I_t = \frac{I_p}{I_f} = \frac{8}{12.5} = 0.64(64\%)$$

$$I_t = \frac{W - W_P}{I_p} \times 100$$

$$= \frac{0.2 - 0.17}{0.08} \times 100$$

$$= \frac{0.03}{0.08} \times 100 = 37.5\%$$

$$I_c = \frac{W_l - W}{I_p} \times 100$$

$$= \frac{0.25 - 0.2}{0.08} \times 100$$

$$= \frac{0.05}{0.08} \times 100 = 62.5\%$$

8 MARKS

Q.1. What are the Atterberg's limits explain the test being carried out for the limits ? [2016, 3-c]

Ans: Liquid limit and plasticity index are used to classify fine grained soils. For inorganic clays liquid limit valves are usually never greater than 100 %. But values greater than 100 % are possible in the case of highly organic clays &

clays of volcanic origin. In the case of bentonite, liquid limit is found in the range of 400 % to 600 %. Based on plasticity index, soils have been classified buy Atterberg as indicated below.

Plastiity index (%)	Plastiity
0	Non-plastic
< 7	Low plastic
7 – 17	Medium plastic
> 17	Highly plastic

Q.2. The following observations were made in a standard proctor test on a soil. [2013, 6-c]

Mass of wet soil (kg)	1.70	1.89	2.03	1.99	1.96	1.92
Water content (%)	7.7	11.5	14.6	17.5	19.7	21.2

Volume of the mould = 945 cc, specific gravity of soil G = 2.68. Determine maximum dry density and optimum moisture content. Also plot zero air voids line. Also calculate the degree of saturation and percentage air voids at maximum dry density.

Ans: Given that,

Mass of wet soil (kg)	1.70	1.89	2.03	1.99	1.96	1.92
Water content (%)	7.7	11.5	14.6	17.5	19.7	21.2

Volume of mould = 945 CC

Specific gravity of soil, G = 2.68

The zero air voids line, corresponding to S = 1 is plotted by the equation

$$\left(\rho_d\right)_0 = \frac{G\rho_w}{1+WG} = \frac{2.68\times 1}{1+2.68w} = \frac{2.68}{1+2.68w} g/cm^3$$

$$\text{also, } \rho_d = \frac{\rho}{1+w} = \frac{M}{V}\times\frac{1}{1+w} = \frac{M}{1000(1+w)} g/cm^3$$

The computations are arranged in a tubular form below :

Sl. No.	Water content w	Mass of solid (m)kg	$\rho_d = \frac{M}{1000(1+w)}$ g/cm^3	$\left(\rho_d\right)_0 = \frac{2.68}{2+2.68w}$ g/cm^3
1	0.077	1.70	1.57	2.23
2	0.115	1.89	1.69	2.06
3	0.146	2.03	1.77	1.92
4	0.175	1.99	1.69	1.82
5	0.197	1.96	1.63	1.75
6	0.212	1.92	1.58	1.70

$$\therefore \rho_d = 1.77 = \frac{G\rho_w}{1+\frac{WG}{S}} = \frac{2.68\times 1}{1+\frac{0.146\times 2.68}{S}}$$

$$\Rightarrow \frac{0.146\times 2.68}{S} = \frac{268}{1.77} - 1 = 0.51$$

$$\therefore \quad S = \frac{0.146\times 2.68}{0.51} = 0.767 = 76.7\%$$

CH-4 (5 MARKS)

Q.1. Write short note on wet mechanical analysis of soil. [2013, 7-a]

Ans: In the wet mechanical analysis for sedimentation analysis, the soil fraction, finer than 75 micron size f kept in suspension in a liquid (usually water) medium. The analysis is based on Stoke's law, according to which the velocity at which grains settle out of suspension, all other gators being equal is dependent upon the shape, weight and size of the grain.

Q.2. State and explain the significance of particle size distribution curve. Discuss salient features of plot and shape parameters of the curve.

Ans: Particle Size Distribution Curve:

The result of the mechanical analysis are plotted to get a particle size distribution curve with the percentage finer N as the ordinate and the particle diameter as the abscissa, the diameter being plotted on logarithmic scale. A particle size distribution curve us an idea about the type and gradiation of soil. A curve situated higher up or to the left represents a relatively find grained soil while a curve situated to the light represents a coarse grained soil.

A soil sample may be either well graded or poorly graded. A soil is said to be well graded when it has good representation of particles of all sizes. On the other hand, to soil is said to be poorly graded if it has an excess of certain particles and deficiency of other, or if it has most of the particles of about the same size, in the better case it is known as a uniformly graded soil.

For coarse grained soil, certain particle sizes such as D_{10}, D_{30} and D_{60} are important.

The shape of the particles size curve is represented by the co-efficient of the curvature C_C given by

$$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

Q.3. How the soil are classified and explain briefly the particle size classification of soil. [2013 2-b,2017 7(c)]

Ans: Soil classification is the arrangement of soils into different groups such that the soils in a particle group have similar behavior.

Particle Size Classification:

The size of individual particles has an important influence on the behavior of soils. To classify the soils into four broad groups, namely, gravel, sand, slit size

(1) MIT System: MIT system of classification of soils was developed by Prof. G. Gilboy. In this system, the soil is divided into four groups:

(i) Gravel, particle size greater than 2 mm.

(ii) Sand, particle size between 0.06 mm to 2.0 mm

(iii) Slit size, particle size between 0.002 mm to 0.06 mm.

(iv) Clay size, particle size smaller than 0.002 mm.

(2) International Classification System:

The International classification system was proposed for general use at the International soils congress. The classification system was :

Clay (size)	Slit(size)			Sand			Gravel
	F	M	C	F	M	C	
Limit (mm)	0.002 (2μ)	0.006	0.02	0.06	0.2	0.6	2.0 mm

F = Fine, C = coarse, M = Legent medium.

(a) MIT System

Ultra Clay	Clay		Slit		M_0		Sand				Cravel
	F	C	F	C	F	C	F	M	C	VC	
Limit	(2μ)	0.64	(2μ)	0.006	0.02	0.05	0.1	0.2	0.5	1.0	2.0mm

VC= Very course

(b) International Classification System :

Clay (size)	Slit (size)	Sand				Fine Gravel	Gravel
		Very fine	Fine	Medium	Coarse		
Limit	0.005	0.05	0.10	0.25	0.5	1.0	2.0

(c) U.s. Bureau of Soils Classification :

(3) U.S. Bureau of Soils Classification

This is one of the earliest classification systems developed in 1895. In this system, the soils below the size 0.005 mm are classified as clay size in contract to 0.002 mm size in other systems. The soils between 0.0005 mm and 0.05 mm size are classified as list size

CHAPTER : 4(8 MARKS)

Q. Describe textural classification of soil with sketch. [2016, 2-c]

Ans: → The visual appearance of a soil is called its texture.

→ The texture depends upon the particle size, shape of particles and gradation of particles.

→ The triangular classification system suggested by S.S. Bureau of public roads is commonly known as textural classification system.

→ The term texture is used to express the percentage of the three constituents of soils namely sand, silt and clay.

→ According to the textural classification system, the percentages of sand size 0.05 to 2mm, silt size 0.005 to 0.05 mm and clay size less than 0.005 mm are plotted along three sides of an equilateral triangle. The equilateral triangle is divided into 10 zones, each zone indicates a type of soil. The soil can be classified by determining the zone in which it lies.

→ A key is given that indicates the direction in which lines are to be drawn to locate the point.

→ The textural classification system is useful for classifying soils of different constituents.

FIGURE

(c) Give a brief account of I.S. classification of soil.

Ans.

FIGURE

CHAPTER:5

Q.1. Define Quick sand. [2015, 2-a]

Ans: Quick sand is hydraulic condition. A cohesion less soil becomes quick when the effective stress is equal to zero. The critical gradient at which a cohesionless soil becomes quick is about unity. The discharge required to maintain a quick condition in a soil increases as the permeability of the soil increases.

Q.2. Define permeability of the soil. [2014, 1-b]

Ans: The property of a soil which permits flow of water or any other liquid through it is called the permeability of soil. A soil is highly previous when water can flow through it easily. In an impervious soil, the permeability is very low and water cannot easily flow through it.

Q.3. What do you mean by quick sand condition ? [2014, 1-e]

Ans: Quick sand is a hydraulic condition. A cohesion less soil becomes quick when the effective stress is equal to zero. The critical gradient at which a cohesionless soil becomes quick is about unity. The discharge required to maintain a quick condition in a soil increases as the permeability of the soil increases.

Q.4. Define critical hydraulic gradient line. [2014, 1-j]

Ans: The hydraulic gradient line at which the effective stress becomes zero is known as the critical hydraulic gradient line. It is denoted by 'i_c'. the effective stress becomes zero for the soil of 'G' and 'e' when the hydraulic gradient is unity i.e., the head causing flow is equal to the length of the specimen.

Q.5. What is critical hydraulic gradient ? [2018, 2-b]

Ans: For upward flow conditions in a saturated soil mass the hydraulic gradient at which the effective stress in soil mass becomes zero is known as critical hydraulic gradient.

Q.1. The following observations were made on a standard proctor test ona soil. [2013, 6-c]

Mass of wet Soil (kg)	1.70	1.89	2.03	1.99	1.96	1.92
Water content (%)	7.7	11.5	14.6	17.5	19.7	21.2

Volume of the mould = 945 cc, specific gravity of soil G = 2.68. Determine maximum dry density and optimum moisture content. Also plot zero air voids line. Also calculate the degree of saturation & % the air voids at maximum dry density.

Ans:-

Mass of wet Soil (kg)	1.70	1.89	2.03	1.99	1.96	1.92
Water content (%)	7.7	11.5	14.6	17.5	19.7	21.2

vol. of mould = 945 cc

sp. Gravity of soil g = 2.68

The zero air voids line corresponding to S = 1 is plotted by the equation.

$$(sd_0) = \frac{Gsw}{1+wG} = \frac{2.68\times 1}{1+2.88w} = \frac{2.68}{1+2.68w}\, g/cm^3$$

$$\text{and } sd = \frac{s}{1+w} = \frac{4}{v}\times\frac{1}{1+w} = \frac{4}{1000(1+w)}\, g/cm^3$$

$$s_d = 1.77 = \frac{Gsw}{1+\frac{WG}{S}} = \frac{2.68\times 1}{1+\frac{0.146\times 2.68}{S}}$$

$$\Rightarrow \quad S = 0.767 = 76.7\ \%$$

CH-5 (5 MARKS)

Q.1. What is flow-net ?State the properties of flow-net.[2014-2-f,2018 6(b)]

Ans: The flow-net is the graphical representation of the equipotential lines and stress lines.

Properties of Flow Rate :

- → The flow lines and equipotential lines meet at right angles to one another.
- → The fields are approximately squares, so that a circle can be drawn touching all the four sides of the square.
- → The quantity of water flowing through each flow channel is same.
- → Smaller the dimensions of the field, greater will be the hydraulic gradient and velocity of flow through it.
- → In a homogeneous soil, every transition in the shape of the curve is smooth, being either elliptical or parabolic in shape.

Q.2. A soil sample of height 8 cm are area of cross-section of 120 cm^2 was subjected to falling head permeability test. In a time interval of 5 minutes, the head dropped by a 20 cm. If the cross-sectional area of the stand pipe is 2 cm^2, calculate the co-efficient of permeability of the sample.

Ans: Given data,

A = 2 cm^2

L = 8 cm

A = 120 cm^2

T = 5 minute

(h_1/h_2) = 20 cm

$$h = \frac{aL}{At}\log_e(h_1 / h_2)$$

$$= \frac{2\times 8}{120\times 5}\log_e 20 = \frac{16}{600}\log_e 20$$

Q.2. What are the factors affecting permeability of soil[2019 4 b,2013 7-d]

Ans: The factors affecting permeability are :

- → Grains size
- → Properties of the pore fluid
- → Void ratio of the soil.
- → Structural arrangement of the soil particles.
- → Entrapped air and foreign matter.

→ Absorbed water in clavev soil.

Q.3. Hydrometer Analysis

Ans: This method first requires preparation of calibration chart which is used to find effective depth . He corresponding to any reading R_h of hydrometer. A hydrometer used in sedimentation analysis is usually graduated from 0.995 to 1.030. As indicated in this figure the effective depth H_e corresponding to a reading R_h. on the stem is given by :

$$H_e = h + \frac{H}{2} \text{(without immersion correction)}$$

$$H_e = h + \frac{H}{2} - \frac{V_H}{2AJ} \text{(with immersion correction)}$$

Where h = distance from reading R_h on stem to the neck, in cms.

H = height of bulb, in cms

V_H = volume of hydrometer, in cm^3.

A_J = area of c/s of jar used for sedimentation analysis in cm^2.

FIGURE.

Q.4. Describe briefly about the different factors affecting permeability of soil. [2014, 2-c,2019 -6a]

Ans: Factors Affecting Permeability of Soil

(i) Particle Size :

The co-efficient of permeability of soil is proportional to the square of the particle size (D). The permeability of coarse-grained soils is very large as compared to that of fine grained soils. The permeability of coarse sand may be more than the million times as much that of clay.

(ii) Structure of soil mass :

The co-efficient 'c' makes into account the shape of the flow passage. The age of the flow passage depends upon the structural tangement. For the same void ratio, the permeability more in the case of flocculated structure as compared to that in the dispersed structure. Stratified soil deposits have greater permeability parallel to the plane of artification that the perpendicular to this plane. The permeability of a natural soil deposit should be determined in undisturbed condition. The disturbance caused during sampling may destroy the original structure and affect the permeability. The effect of disturbance is more pronounced in the case of fine rained soils than in the case of coarse grained soils.

(iii) Shape of particles:

The permeability of soil depends upon the shape of particles. Angular particles have greater specific surface area as compared with the bounded particles. For the same void ratio, the soil with angular particles are less permeable than those with bounded particles is the permeability is inversely proportional to the specific surface. However in a natural deposit the void ratio for a soil with angular particles may be greater than that for rounded particle, and the soil with angular particle may be actually more permeable.

(iv) Void Ratio :

The co-efficient of permeability varies as $e^3/(1+e)$. For a given soil, the greater the void ratio, the higher is the value of the co-efficient of permeability. If the permeability of soil at a void ratio of 0.85 is known, its value at another void ratio of 'e' can be determined using the equation.

$K = 1.4\ k_{0.85}\ e^2$

$K_{0.85}$ = permeability at a void ratio of 0.85

K = permeability at a void ratio of 'e'

(v) Properties of water :

The co-efficient of permeability is directly proportional to the unit weight of water 'Y_ω' and is inversely proportional to the unit weight of water 'Y_w' and is inversely proportional to its viscosity μ. The unit weight of water does not vary much over the range of temperature. The co-efficient of permeability increases with an increase in temperature due to reduction in the viscosity.

The equation can be used for conversion of the permeability to 27°C.

$$k_{27} = k_t \frac{\mu}{\mu_{27}}$$

Where k_{27} = co-efficient of permeability at 27°C when viscosity is μ_{27}.

K_t = co-efficient of permeability at t°C when viscosity is μ_t.

So $k_{27} = C_t\, k_t$

Where C_t is the correction factor, equal to (μ_t/μ_{27})

(vi) Degree of saturation :

If the soil is not fully saturated, it contains air pockets formed due to entrapped air or due to air liberated from percolating water. The permeability is reduced due to presence of air which cause blockage of passage. Consequently, the permeability of a partially saturated soil is considerably smaller than that of a fully saturated soil.

(vii) Adsorbed water :

The fine-grained soil have a layer of adsorbed water strongly attached to their surface. This adsorbed water layer is not free to move under gravity. It causes an obstruction to flow of water in the pores and hence reduces the permeability of soils.

(viii) Impurities in water :

Any foreign matter in water has a tendency to plug the flow passage and reduce the effective voids and hence the permeability of soils.

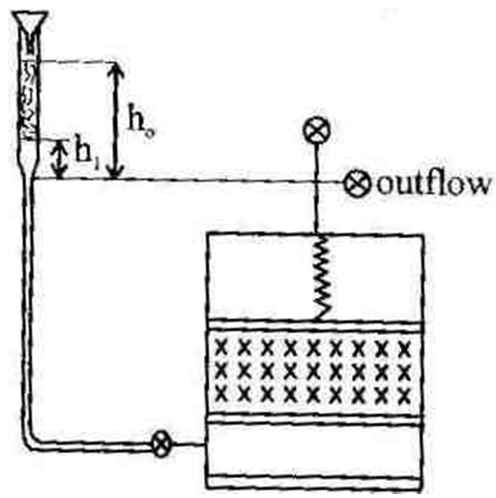
7 MARKS

Q.1. Define permeability and explain the falling head permeability test with neat sketches.

Ans: Permeability is a measure of the ease in which water can flow through a soil volume. It controls the strength and deformation behavior of soil.

Procedure :

→ Compact the sample in the lower chamber section of the parameter, in layers approximately 1.5 cm deep to within about 2 cm of the lower chamber mm. Use an appropriate tamping device to compact the sample to the desired density.



→ Remove the upper section of the chamber tie rods and place the upper porous store on the specimen, securing the upper section of the chamber with spring to the unit.

→ Measure and record the length of the specimen.

→ Use the clamp to attach the falling head burettle to the support rod. Position the burette, so the height of water in the burette above the chamber outflow port may be read.

→ Saturate the specimen, following the steps outlined above.

→ Measure the heights of two levels from the outflow level.

→ Mathematically, $K = \frac{aL}{At} 1n \frac{h_0}{h_1}$

Where K = co-efficient of permeability.

a = Area of the burette

L = Length of soil column

A = Area of the soil column.

h_0 = Initial height of water

h_1 = Final height of water.

f = Time required to get head drop of Δh.

Q.2. The falling head permeability test was conducted on a soil sample of 4 cm dia. & 18 cm length. The head fell from 1m to 0.4 m in 20 min. If the cross-sectional area of the stand pipe was 1 cm^2, determine the co-efficient of permeability. [2015, 7-c,2019 3 b]

Ans: Given data

$h_1 = 1m$,

$h_2 = 0.4$ m,

$t = 20$ min.

$G_A = 1$ cm^2

Soil sample = 4cm dia and 18 cm length co-efficient of permeability.

$$k = 2.3\frac{aL}{At}\log_{10}\left(\frac{h_1}{h_2}\right)$$

$$A = \frac{\pi}{4}d^2 = \frac{\pi}{4}\times 4^2 = \frac{\pi}{4}\times 16 = 12.56 \text{ cm}^2$$

$$k = 2.3\frac{1\times 18}{12.56\times 20}\log_{10}\left(\frac{1}{0.4}\right)$$

$$k = 0.065$$

CHAPTER:6(2 MARKS)

Q.1.Write Terzaghi's bearing capacity equations for a square footing.

[2015, 4-a,2019 4 a]

Ans: $q_u = 1.3\, c\, N_c + r\, D_r\, N_1 + 0.4\, r\, B\, N_r$

Where q_u = Gross ultimate bearing capacity

C – Unit cohesion

N_c, N_q, N_r = Bearing capacity factor.

Q.2. What is zero air void line ? [2014, 1(g),2019 1 f]

Ans: The line indicating the theoretical maximum density can be plotted along with the compaction curve is known as zero air void lines. It is also called as 100 % saturation line. The compaction method cannot remove all the air voids, and therefore the soil never becomes fully saturated. So the theoretical maximum density is only hypothetical. It can be calculated for any value of 'w' if the value of 'G' is known.

Q.3. Define OMC. [2014, 1-x]

Ans: The water content corresponding to the maximum dry density is known as optimum moisture content (OMC). A compaction curve is plotted between the water content as abscissa and the corresponding dry density as ordinate. It s observed that the dry density initially increased with an increase in water control till the maximum density is attained.

Q.4. What is the significance of co-efficient of uniformity ? [2013, 1-a]

Ans: The co-efficient of uniformity (C_v) is a measure of particle size range and is given by the ratio of D_{60} sizes.

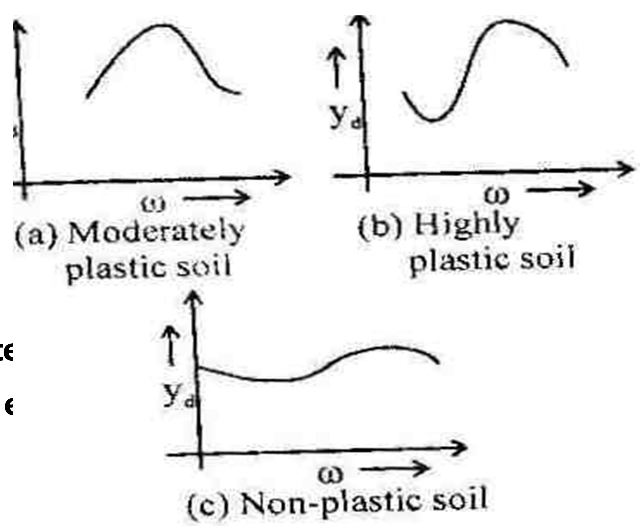
$$\text{i.e.,}\ C_V = \frac{D_{60}}{D_{10}}$$

For a uniformly graded soil, C_V is nearly unity.

Q.5. Define compaction curve. [2015, 5-a]

Ans: For a given compactive effort, the maximum dry density achieved depends to a large extent upon the soil type.

→ Well graded coarse-grained soils attain much higher maximum dry density at lower optimum moisture content when compared with fine grained soils.



Q.1. Write short note

Purpose of soil e

A soil exploration programme depends upon the type of the structure to be built and upon the variability of the strata at the propose site. The extent of sub-soil exploration is closely related to the relative cost of the investigations and that of the entire project for which it undertaken. In general, the more detailed the investigations are done, the more is known about the sub-surface conditions. The extent of investigations would also depend upon the location of the project. A small house in an already built-up area would not require much exploration. On the other hand, if the house is to be built in a newly developed area, detailed investigation would be required to ascertain the location of different soil strata and their physical characteristics. The exploration programme has to be changed as the investigation progress. As the variability of the soil.

Q.2. Differentiate between consolidation and compaction with examples.[2015, 5-b,2019 2 d,2018 3-b]

Ans: Compaction is a mechanical process by which soil particles in a soil mass are rearranged and packed together in order to decrease the voids in the soil and hence increase the dry density. By compaction mainly air voids are expelled out of the soil mass. Compaction is a dynamic process of short duration. The degree of compaction is measured in terms of its dry density. This is because the weight of the solids remain constant during compaction through the volume changes. Compactions depends upon the quantity of water added to the soil under compaction. Compaction is an artificial process of volume reduction.

Consolidation is a gradual process of volume reduction under sustained loading. The process involves expulsion of both air and water voids. In case of saturated soil, the decrease in volume is due to expulsion of pore water only. Consolidation depends upon the permeability of soil. This is an important factor in consolidation of clays. Consolidation is a natural process of volume reduction leading to the failure of structure over the soil mass.

Q.3. Briefly discuss the different field compaction methods and their suitability. [2013, 1-b]

Ans: Field Compaction Methods:

Various types of soils can be compacted in the field by three methods, rolling ramming (by impact) and vibration. Corresponding to these, the various compacting equipments can be grouped under three categories: rollers, rammers and vibrators. The rolling equipments are of five types (i) smooth wheel rollers, (ii) pneumatic tyred rollers, (iii) sheep fott rollers, (iv) lorries and pneumatic tyred construction plant, and (v) track laying vehicles. The ramming equipment consists of three types (i) dropping weight type (including piling equipment), (ii) internal combustion type and (iii) pneumatics type. Thee vibrating equipment, mounted on screeds, plates or rollers are of two types : (i) dropping weight type and (ii) pulsating hydraulic type.

The smooth wheel roller are of two types: (i) the conventional three-wheel type with two large smooth faced steel wheels in the reat and one smaller smooth faced drum in the front weighting from 20 to 150 kN. (ii) tandem rollers weighing from 10 to 140 kN, and (iii) the three axle tandem rollers weighting from 120 to 180 kN. Smooth wheel rollers are usually self propelled and are equipped with a cluth type- reversing gear so that they can be operated back and forth without turning.

The pneumatic type rollers range in size from the smaller wobble wheel rollers to the very heavy rollers. A common form of pneumatic roller consists of a box or platform mounted between two axles, the rear of which has one more wheel than the front, the wheel mounted on the front axle being arranged to track in between those mounted on the rear axle. The tyre pressures in the small.

The sheep foot rollers consist of hollow cylindrical steel drum on feet are mounted. The weight of the drum can be varied by filling it with water or sand and they are mounted either singly or in pairs on as is towed by either track-laying or pneumatic tyred tractors. The loaded weight from about 15 to 130 kN

Suitability of various compaction equipments: The performance of a corresponding upon the soil type, its particle size distribution, and its water co smooth wheel rollers are most suited to crushed rock, hard core, mechanic sand sands. They can also be used satisfactory.

Q.4. State the assumption made in Terzaghi's theory of consolidation.[2014, 2c, 2016, 7i]

Ans: Terzaghi gave the theory for the determination of the rate of consolidation of a saturated soil mass subjected to a static, steady load.

Assumption :

(i) The soil is homogeneous and isotropic

(ii) the soil is fully saturated.

(iii) The solid particles and water in the voids are incompressible. The consolidation occurs due to expulsion of water from the voids.

(iv) The co-efficient of permeability of the soil has the same value at all points, and it remains constant during the entire period of consolidation.

(v) Darcy's law is valid throughout the consolidation process.

(vi) Soil is laterally confined, and the consolidation takes place only in axial direction. Drainage of water also occurs only in the vertical direction.

(vii) The time lag in consolidation is entirely due to the low permeability of the soil.

(viii) There is a unique relationship between the void ratio and the effective stress, and this relationship remains constant during the load increment. In other words, the co-efficient of compressibility and the co-efficient of volume change and constant.

Q.5. Differentiate between primary consolidation and secondary consolidation. [2014, 6-a]

Ans: Primary Consolidation:

After initial consolidation further reduction in volume occurs due to expulsion of water from voids. When a saturated soil is subjected to a pressure, initially all the applied pressure is taken up by water as an excess pore water pressure as water is almost incompressible as compared with solid particles. A hydraulic gradient develops and the water starts flowing out and a decrease in volume occurs. The decrease depends upon the permeability of the soil and is, therefore time dependent. This reduction in volume is called primary consolidation.

Secondary Consolidation :

The reduction in volume continues at a very slow rate even after the excess hydrostatic pressure developed by the applied pressure is fully dissipated and the primary consolidation is complete. This additional reduction in the volume is called secondary consolidation. The causes for secondary consolidation are not fully established.

Q.6. Spring analogy for consolidation [2016, 7-c]

Ans: Terzaghi demonstrated the mechanics of consolidation by piston and spring analogy. A saturated soil mass taken in a container consists of soil particles forming the and selection of soil mass & voids filled with water. The compressive stress in caused by load applied on piston placed on top of the springs. An outlet with valve is provided to control drainage of water from out of the cylinder.

CHAPTER : 7

Q.1 Define shear strength of the soil [2014, 1-c,2019 1h]

Ans: the shear strength of soil in its maximum resistance to shear stresses just before the failure. The shear stresses develop when the soil in subjected to direct compression.

5 MARKS

Q.1. Write merits and demerits of direct shear test.[2018 4-c,2015 6-b]

Ans: Merits of direct shear test:

→ The direct shear test is a simple test compared to the tri axial compression test.

→ Since the thickness of the sample is small quick drainage and hence rapid dissipation of pure pressure is possible

Demerits of direct shear test :

- → The shear stress is not uniformly distributed being more at the edge that at the enter, because of this the entire shear strength is not mobilized simultaneously at all points on the failure plane and this leads to progressive failure of the specimen.
- → The failure plane is predetermined. Therefore, the specimen is not allowed to fail along its weakest plane.
- → Shear displacement causes reduction in area under shear corrected area should be used in computing normal and shear stresses.
- → The side walls of the shear box can cause lateral restraint on the edge of the specimen.
- → There is little control on drainage of pure water as compared with triaxial compression test.
- → Measurement of pure pressure is not possible.

Q.2. State and explain Mohrcoulomb failure theory ? [2019 2-c,2018 4-b]

Ans: Mohr-Coulomb Failure Theory of the many theories of failure that have been proposed, only that formulated by Mohr (1900) has been useful in case of soils. The following are essential points of Mohr's strength theory:

(i) Material fails essential by shear. The ritial shear stress causing failure depends upon the properties of the material as well as on normal stress on the failure plane.

(ii) the ultimate strength of the material is determined by the stress on the potential failure plane (or plane of shear).

(iii) When the material is subjected to three dimensional principal stress (i.e. σ_1, σ_2, σ_3) the intermediate principal stress does not have any influence on the strength of material. In other words, the failure criterion is independent of the intermediate principal stress.

The theory was first expressed by Coulomb (1776) and later generalization theory can be expressed

Q. CBR [2014, 5-b]

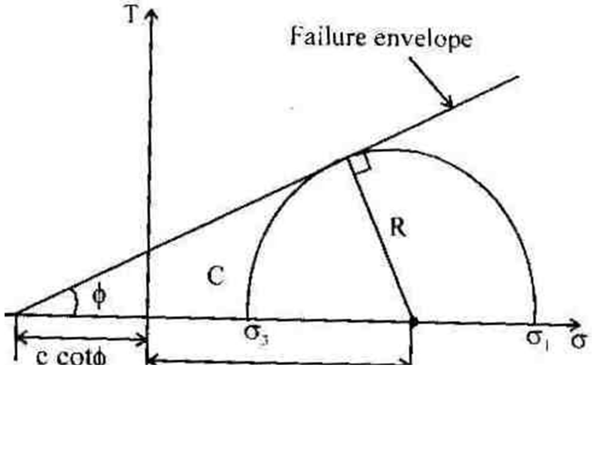
Ans: California bearing ratio (CBR) test is a type of test developed by the California division of highways. The test is used for evaluating the suitability of sub grade and the materials used in sub-base and base-coarse. The test results have been correlated with the thickness of the various materials required for flexible pavements. The test may be conducted on a prepared specimen in a mould or on the soil in – situ condition. The laboratory CBR apparatus consists of a mould 150 mm dia. and 175 mm high, having a separate base plate and a collar. The load is applied by a loading frame through a plunger of 50 mm diameter. Dial gauges are used for measurement of the expansion of the specimen on soaking and for measurement of penetration. It may be noted that with the displacer disc inside the mould, the effective height of the mould is only 125 mm.

7 MARKS

Q.1. Explain Mohr – Coulomb theory with sketches.[2013 , 5-E]

Ans: Of the many theories of failure that have been proposed only that formulated by Mohr has been useful in case of soil. The following are essential points of Mohr's strength theory.

- → Material fails essentially by shear. The critical shear causing failure depends upon the properties of the material as well as on normal stress on the failure plane.
- → the ultimate strength of the material is determined by the stress on the potential failure plane.
- → When the material is subjected to three dimensional principle stress the intermediate principal stress doesn't have any influence on the strength of material.



CHAPTER: 8

Q.1. What is passive earth pressure ? [2016]

Ans: It is important because it affects the consolidation behavior and strength of the soil and because it is considered in the design of geotechnical engg. Structures such as retaining walls, basements tunnels.

Q.2. Define Earth pressure at Rest. [2015, 7-a]

Ans: the earth pressure at rest is the horizontal pressure acting on the rigid structure.

→ When structures loaded by earth pressures are due to some technological reasons extremely good and do not allow deformation in the direction of load necessary to mobilize the active earth pressure.

→ Earth pressure at rest is given by $\sigma_t = \sigma_z \times k_r$

K_r → Jaky constant.

5 MARKS

Q.1. Write assumptions for Rankine's earth pressure theory. [2015, 7-b]

Ans: As originally proposed, Rankine's theory is applied to uniform cohesion less soil only. Later it was extended to include cohesive soil by Bell in 1915.

Assumptions of Rankine's Theory of Earth pressure

→ The backfill should be dry, homogeneous, cohesionless and semi-infinite.

→ The ground surface is considered to be plane which may be horizontal or inclined.

→ The backfill of the wall is vertical and smooth.

→ The wall is yields, yields about the base.

CHAPTER:9

Q. What do you mean by deep foundation [2013, 4-a]

Ans: Shallow foundation is a foundation in which the depth is smaller than or equal to width where as deep foundation is the foundation in which the depth is greater than its width.

Q. Define bearing capacity of soil [2015, 6-a]

Ans: Bearing capacity of soil is defined as the maximum average constant pressure between the foundation and the soil which should not produce shear failure in soil.

Q. Pile Foundation [2014, 5-iii]

Ans: When the soil at or near the ground surface is not capable of supporting a structure, deep foundations are required to transfer the loads to deeper strata. Deep foundations are therefore used when surface soil is unsuitable for shallow foundation and a firm stratum is so deep that is cannot be reached economically by shallow foundations. The most common types of deep foundations are piles. A pile is a slender structural member made of steel, concrete or wood. A pile is either driven into the soil or formed in – situ by excavating a hole and filling it with concrete. Apier is a vertical column of relatively larger cross-section than a pile. Pile foundations are used when the strata at or just below, the ground surface is highly compressible and very weak to support the load transmitted by the structure. When the plan of the structure is irregular relative to its outline and load distribution. It would cause non-uniform settlement if a shallow foundation is constructed. A pile foundation is required to reduce differential settlement.

Q. A strip footing 4m wide at its base is located at a depth of 0.95 m below the ground surface. The properties of the foundation soil are : $\gamma = 18\ kN/m^3$, $C = 30\ kN/m^2$ and $\phi = 30^o$. Determine the safe bearing capacity, using a factors of safety of 5. Use Terzaghi's analysis.

Assume that the soil fails by local shears N_c = 30.1, N_q = 18.4, N_r = 22.4. **[2015, 4-b]**

Ans: Given data

Wide = 4m, depth = 0.95 m below the ground surface.

R = 18 kN/m^3, C = 30 kN/m^3

$\phi = 30^o$, N_C = 30 %, N_2 = 18.4 N, N_r = 22.4

By Terzaghi Analysis,

$Q_v = C\ N_C + q_0\ N_0 + 0.5\ r\ B\ N_r$

$Q_0 = r\ D_F = 18 \times 0.95 = 17.1\ kN/m^3$

$Q_v = 30 \times 30.1 + 17.1 \times 18.4 + 0.5 \times 18 \times 4 \times 22.4$

$= 903 + 314.64 + 806.4 = 2024.64\ kB/m^2$.

Safe bearing capacity

$$= \frac{\text{Gross ultimate bearing capacity}}{\text{Factor as sagety}}$$

$$\Rightarrow \quad q_{safe} = \frac{q_v}{5} = \frac{2024.64}{5} = 404.8 kN / m^2$$

Q. Describe briefly the plate load test for bearing capacity of soils.

Ans: Plate load test for bearing capacity of soils : The allowable bearing pressure can be determined by conducting a plate load test at the site the conduct a plate load test, a pit of the size 5 B_p × 5 where B_p is the size of the plate, is excavated to a depth equal to the depth of foundation 'Df'. The size of the plate is usually 0.3 m square. It is made of steel and 25 mm thick. Sometimes circular plates are also used large size plates of 0.6 m square are used. A central hole of the size $B_p \times B_p$ is excavated in the pit. The depth of the central hole D_p is obtained with the relation.

$D_p/Bp = D_f/B_f$

$D_p = (B_p/B_f) \times D_f$

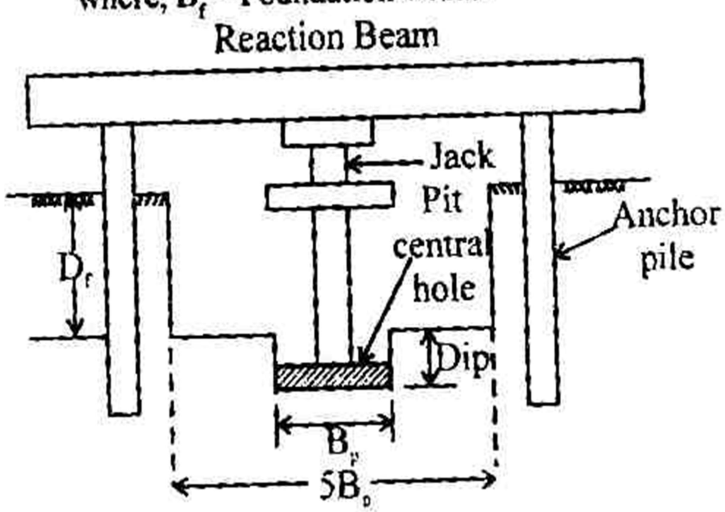
Where B_f is the width of the pit, and B_p is the edge of plate for conducting the plate load test, the plate placed in the central hole and the load is applied by means of hydraulic jack. The reaction of the jack is provided by means of a reaction beam. A seating load of N/m^2 is first applied in increments of about 20 % of estimated safe load or one-tenth of the ultimate load. The settlement is recorded after 1, 5 , 10. 20. 40. 60 minutes and further after an interval of one hour. These hourly observations are continued for clayey soils until the rate of settlement is less than 0.2 mm per hour. The test is conducted less than 0.2 mm per hour. The test is conducted until failure per hour. The test is conducted until failure or at least until the settlement of about 25 mm has occurred. The ultimate load for the plate q_v (P) is indicated by a break on the og-log plot between the load intensity 'q' and the settlement. If the break is not well-defined, the ultimate load is taken as that corresponding to a settlement of one-fourth of the plate width (B_p)

The ultimate bearing capacity of the proposed foundation q_v (f) can be obtained from the following relation.

(a) for clayey soils, $q_u(f) = q_u(p)$

(b) for sandy soils, $q_u(f) = q_u(P) \times \frac{B_f}{B_P}$

where, B_f = Foundation width.



Q. A strip footing is required to carry a net load of 900 kN at a depth of 1m. Taking a factor of safety of 3, determine the width of footing. Tke ϕ = 30°, r = 19 kN/m³, C = 20 kN/m², N_c = 37.2, N_q = 22.5, N_f = 19.7 (Assume general shear failure). [2014, no.3

Ans: Given data,

Strip footing , P = 900 kN, d = 1m, ϕ = 30°

Factor of safety = 3

γ = 19 kN/m^3 , C = 20 kN/m^2

N_C= 22.5, N_y = 19.7

Using IS code formula

Q_{nu} = ($C\ N_c\ S_c\ d_c\ i_c$) + q ($(N_q - 1)\ s_q\ d_q\ i_q$) + (0.5 Y B $N_y\ S_y\ d_y\ i_y$), where q = γI)

$$\left.\begin{aligned} S_c &= 1.0 \\ S_q &= 1.0 \\ S_y &= 1.0 \end{aligned}\right\} \quad \text{for strip footing}$$

$$dc = 1 + 0.1\left(\frac{D_f}{B}\right)\tan\left(45^o + \frac{\phi}{2}\right)$$

$$= 1 + 0.2\left(\frac{1}{B}\right)\tan\left(45^o + \frac{30}{2}\right) = 1 + \frac{0.346}{B}$$

$$d_q = d_y = 1 + 0.1\left(\frac{D_f}{B}\right)\tan\left(45^o + \frac{\phi}{2}\right)$$

$$= 1 + 0.1\left(\frac{1}{B}\right)\tan\left(45^o + \frac{\phi}{2}\right) = 1 + \frac{0.173}{B}$$

for vertical load, $i_{cv} = i_q = i_r = 1$

$$\therefore q_u = 20 \times 37.2 \times 1 \times \left(1 + \frac{0.346}{B}\right) \times 1 + 19 \times 1$$

$$\times\left(22.5^{-1}\right) \times 1 \times \left(1 + \frac{0.173}{B}\right) \times 1$$

$$+0.5 \times 19 \times B \times 19.7 \times 1 \times \left(1 + \frac{0.173}{B}\right) \times 1$$

$$q_s = \frac{q_{nu}}{F} + \gamma D$$

$$\text{or} \quad \frac{P}{B \times 1} = \frac{q_{nu}}{3} + 19 \times 1$$

$$\text{Here } q_{nu} = 744 + \frac{257.4}{B} + 408.5 + \frac{70.67}{B} + 187.15B + 25.64$$

$$= 1178.14 + \frac{328.07}{B} + 187.15B$$

$$\frac{900}{B} = 392.7 + \frac{109.36}{B} + 62.38B$$

$$\text{or, } 900 = 392.7B^2 = 109.36 + 62.38B^2$$