DETAILS EXPLANATIONS

[PART : A]

1. Viod-Ratio is the ratio of volume of voids to the volume of solids in any soil.

2. Specific gravity of soil solids is the ratio of solid-density and density of water.

3. These are water-content, consistancy-linrits, insity density, particle size distribution, sensitivity, activity.

4. Water content

$$w = \left[\left(\frac{w_2 - w_1}{w_3 - w_4}\right)\left(\frac{G-1}{G}\right) - 1\right] \times 100\%$$

5.
- Meniscus-correction (always positive)
- Disperging agent correction (always negative)
- Temperature correction (positive or negative)

6. These are as follows :
- Shrinkage limit
- Plastic limit
- Liquid limit

7. Thixotropy is the property of soil by virtue of which soil regains it's strength lost due to remoulding.

8. The minerals found in clay are kaolinite, Illute and Montmorrilonite.

9. Seepage-pressure is exerted by the water on the soil due to friction drag. This drag force always acts in the direction of flow.

10.
$$\frac{k_p}{k_a} = \frac{(1+\sin\phi)/(1-\sin\phi)}{(1-\sin\phi)/(1+\sin\phi)}$$

$$= \frac{(1+\sin\phi)^2}{(1-\sin\phi)^2} = \left(\frac{1+\sin 30^o}{1-\sin 30^o}\right)^2 = 9$$

11. ***Ideal Fluid :*** A fluid is said to be ideal if it is assumed to be both incompressible and non viscous, it's balk modulous is infinite.

12. These are :
- Dilatent fluids
- Bingham plastic
- Psuedoplastic
- Thixotropic fluid
- Rheoplastic fluid

13. Vertical component of force is equal to the weight of the liquid block lying above the curved surface upto free surface.

14. When a body is submerged eith fully of partially then it is acted upon by a force of buoyancy vertically up which is equal to weight of liquid displaced by the body.

15. When a dye is injected in a liquid or smoke in a gas so as to trace the subsequent motion of fluid particles passing through a fixed point, the path followed by dye is streakline.

16. Bernoulli's equation

$$\frac{p}{\rho g}+\frac{v^1}{2g}+z = \text{constant}$$

17. It is the ratio of momentum/sec based on actual velocity to the momentum/sec based on average velocity.

18. (i) Gradual closure of valve.

(ii) Sudden closure of valve and pipe is rigid.

(iii) Sudden closure of valve and pipe is elastic.

19. It is the region in the immediate vicinity of the boundary surface in which the velocity of flowing fluid increases gradually from zero to the main velocity.

20. A whirling mass of fluid is called vortex-flow in this the velocity approaches to infinity at singular point.

[PART : B]

21. Relative Density (I_D)

$$I_D = \frac{e_{max} - e}{e_{max - e_{min}}} \times 100\%$$

where, e_{max} = Maximum void-ratio = 91% = 0.91

e_{min} = Minimum void-ratio = 35% = 0.35

e = Natural void ratio

When the soil is in loosest state

$e = e_{min} \rightarrow$ Cubical - Array.

When soil is in Densert state

$e = e_{max} \rightarrow$ Prismoidal-Array

22. Sensitivity(S_t) of a soil indicates its weakening due to remoulding. It is defined as the ratio of the undisturbed strength to the remoulded strength at the same water content.

$$S_t = \frac{(q_u)_{undisturbed}}{(q_u)_{remoulded}} \quad \text{where,}$$

$(q_u)_{undisturbed}$ = Unconfined compressive strength of undisturbed clay.
$(q_u)_{remoulded}$ = Unconfined compressive strength of remoulded clay.
Extra-Sensitive and quick soil for which sensitivity is (8 - 15) and >15 respectively are not suitable soils.

23. ***Specific-Yield :***

The specific yield of an unconfined aquifer is the ratio of volume of water which will flow under saturated condition due to gravity effect to the total volume (v).

Specific-Retention :

The specific retention of an unconfined aquifer is the ratio of volume of water retained against gravity effect to the total volume of aquifer.

24. Time factor is the factor which is used to determine the consolidation and amount of consolidation.

$$T_V = \frac{\pi}{4}(U)^2 \text{ if } \qquad U \le 0.6$$

$$T_V = -0.9332 \log_{10}(1 - U) - 0.0851$$

If u > 0.6

Where, U = Degree of consolidation
C_v = Cofficient of consolidation
t = Time
d = Length of drainage path

$$T_V = \frac{C_V t}{d^2}$$

25. ***Gross Pressure Intensity :***

It is the total pressure at the base of the footing due to the weight of the super structure, self weight of the foooting and weight of the earth fill.

Net pressure Intensity :

It is defined as excees of gross pressure to over burden pressure.

$$q_{net} = q_g - \bar{\sigma}$$

where, $\bar{\sigma}$ = Effective stress.

26. There are practically three types of shear test:

- ***Unconsolidated Undrained Test (UU-Test)***

  This test is suitable for construction of building over saturated clays.

- ***Consolidated Undrained Test (CU Test)***

  This test is suitable for stability of earthen dam.

- ***Consolidated Drained Test (CD Test)***

  This test is suitable for stability analysis of retaining wall having sandy fills.

27. ***Capillary Action :***

It is the property of a pipe of very thin/less diameter due to which fluid either moves vertically upward or downward.

This is due to both adhesion and colvsion height of water in capillary tube :

$$H = \frac{4\sigma\cos\theta}{\rho g d}$$

For capillary action diameter of tube should be less than 3 mm.

28. Atmospheric pressure is exerted by the atmosphere and it is assumed to be constant on earth-surface. The value of which is 1.01325×10^5 N/m^2.

Gauge pressure is measured above or below below atmospheric pressure. So,

Absolute pressure = Atmospheric pressure ± Gauge pressure

(+) → When gauge pressure is above atm pressure.

29. For stable equilibrium :

- In case of floating body, metacenter should be above center of gravity.
- In case of submerged body, center of buoyancy should be above center of gravity.
- Distance between metacenter and center of buoyancy.

$$BM = \frac{I_{min}}{V_{immerged}}$$ Where,

I_{min} = Moment of inertia of top view of flowating body about longitudinal axis.

V = Volume of body immersed in liquid.

30. General equation of continuity :

$$\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial x}(\rho u)+\frac{\partial}{\partial y}(\rho v)+\frac{\partial}{\partial z}(\rho w) = 0$$

Special-Case :

If flow is steady, then $\frac{\partial \rho}{\partial t} = 0$

Thus continuity equation will be

$$\frac{\partial}{\partial x}(\rho u)+\frac{\partial}{\partial y}(\rho v)+\frac{\partial}{\partial z}(\rho w) = 0$$

for steady, Incompressible flow; (ρ = constant)

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z} = 0$$

31. ***Assumptions in Bernoulli's equation :***

(i) Fluid is ideal.

(ii) Flow is steady.

(iii) Flow is containuous

(iv) Flow is incompressible

(v) Flow is non-viscous

(vi) Flow is ir-rotational

(vii) It is applicable along a stream-line.

(viii) It is obtained by integrading euler's equation.

32. ***Frction Loss :*** Darcy weisbach equation

$h_f = \frac{flV^1}{2gD}$ where,

h_f = Head loss due to friaction

f = Friction-cofficient

l = Length of pipe

V = Mean velocity of flow

D = Dia of pipe

For laminar flow : $f = \frac{64}{R_e}$; R_e = Reynold's Number.

For Turbulent flow : $f = \frac{0.316}{R_e^{1/4}}$

[PART : C]

33. Since $K = \dfrac{Ql}{Ath}$

$$A = \text{Area} = \pi\frac{D^2}{4} = \pi\times\frac{(7.5)^2}{4}$$

$$= 44.18 \text{ cm}^2$$

$$\therefore \quad K = \frac{626\times18}{44.18\times60\times24.7}$$

$$= 1.72 \times 10^{-1} \text{ cm/sec}$$

Discharge-Velocity

$$V = ki = 1.72 \times 10^{-1} \times \frac{24.7}{18}$$

$$= 2.36 \times 10^{-1} \text{ cm/sec}$$

Seepage velocity

$$V_s = \frac{V}{n} = \frac{2.36\times10^{-1}}{0.44}$$

$$= 5.36 \times 10^{-1} \text{ cm/sec}$$

For $n_1 = 44\%$

$$e_1 = 0.97$$

$$\frac{e_1^3}{1+e_1} = 0.275$$

For $n_2 = 39\%$

$$e_2 = 0.64$$

$$\frac{e_2^3}{1+e_2} = 0.16$$

At 25°C, Viscosity of water μ_1 = 8.95 mili-poise. At 20°, η_2 = 10.09 milipose.

Considering that,

$$k_1 : k_2 = \frac{r_{w1}}{\eta_1} : \frac{r_{w2}}{\eta_2}; \text{ Neglecting effect on } r_w.$$

$$k_1 : k_2 = \frac{1}{\eta_1} : \frac{1}{\eta_2}$$

$$k_{20^\circ C} = 1.72 \times 10^{-1} \times \frac{8.95}{10.09}$$

$$= 1.526 \times 10^{-1} \text{ cm/sec}$$

At $e = 0.79$

Now considering that,

$$k_1 : k_2 = \frac{e_1^3}{1+e_1} : \frac{e_2^3}{1+e_2}$$

$k_{20^\circ C}$ at $e = 0.64$ is equal to

$$1.526 \times 10 \times \frac{0.16}{0.275} = 8.88 \times 10^{-2} \text{ cm/sec}$$

34. For the layer of 5 m thickness, U = 50%, t = 1 year and $S_{ct} = 80$

Since $S_{ct} = u_t S_F$

$$S_f = \frac{8}{0.5} = 16 \text{ cm}$$

Hence for 25 m thick layer

$$S_f = 16 \times \frac{25}{5} = 80 \text{ cm} \qquad (\because S_f \propto H_0)$$

From equation

$$T_V = \frac{C_v.t}{d^2}$$

$$T_V = \left.\frac{C_v t}{H^2}\right| d = H$$

$$\frac{t_1}{t_2} = \frac{H_1^2}{H_2^2}$$

For 5 m thick layer $t_{50} = 1$ year

Hence for 25 m thick layer,

$$t_{50} = 1 \times \left(\frac{25}{5}\right)^2 = 25 \text{ years}$$

For 25 m thick layer,

$$\frac{(T_V)_1}{(T_V)_2} = \frac{t_1}{t_2}$$

Also, Since

$$T_V = \frac{\pi}{4}U^2 \text{ for } U < 60\%$$

$$\frac{U_1^2}{U_2^2} = \frac{(T_V)_1}{(T_V)_2} = \frac{t_1}{t_2}$$

$$U_1 = 50\% \text{ for } t_1 = 25 \text{ year}$$

For $t_2 = 1$ year

$$U_2^2 = U_1^2 \times \frac{t_2}{t_1} = 0.5^2 \times \frac{1}{25} = 0.01$$

$$U_2 = 0.1$$

$$S_{Ct} = US_F$$

$$S_{Ct} = 0.1 \times 80 = 8 \text{ cm}$$

$$t_2 = 4 \text{ years}$$

$$U_2^2 = U_1^2 \frac{t_2}{t_1} = 0.5^2 \times \frac{4}{25} = 0.04$$

$\because$ $U_2 = 0.2$

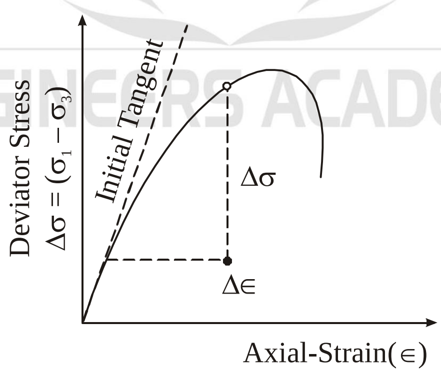
$\therefore$ $S_{Ct} = 0.2 \times 80 = 16$ cm

35. Elastic Properties of Soil

Modulus of Elasticity : *(Elastic Modulus)*

The Elastic modulus of soil is obtained from the deviator stress-strain curve. The undrained modulus, E_u is obtained from the undrained triaxial test data while the drained modulus, E_d is obtained from the drained test conditions.

Deviator stress-strain curve for triaxial shear-test.



Since the curve is non-linear one. So for such a curve, two types of modulus can be defined namely tangent modulus and secant modulus.

Tangent modulus = $\frac{d(\sigma_1 - \sigma_3)}{d \in_E}$

Secant modulus = $\frac{\Delta(\sigma_1 - \sigma_3)}{\Delta \in_E}$

If 'S_u' is the undrained strength of soil. Then.

(i) For a normally consolidated sensitive clay

E_u = (200 to 500)S_u

(ii) For a normally over consolidated clay

E_u = (750 to 1200)S_u

(iii) For a heavily consolidated clay

E_u = (1500 to 2000)S_u

Possion's Ratio

It is defined as the ratio of lateral strain to axial strain in triaxial compression test.

$$\mu = \frac{\in_3}{\in_1}$$

Possion's Ratio is not a constant for a soil but is dependent on the stress and strain levels.

Value of 'μ' ranges from 0 to 0.5 for soils. For saturated soils, it is close to 0.5 and for dry soils, close to '0'.

Shear Modulus :

The shear modulus 'G' is defined as the ratio of shear-stress to shear strain and can be determined from the following relationship.

$$G = \frac{E}{2(1+\mu)}$$

The above discussion on elastic properties is relevant for static conditions. For dynamic conditions, the elastic properties are evaluated from cyclic load tests and other special tests.

36. For concrete piles,

$$\delta = \frac{3}{4}\phi' = \frac{3}{4} \times 40^o = 30^o$$

and k = 2.0 for dense sand.

For $\frac{L_{Cr}}{D}$ = 15, the critical length of the pile

= 15 × 0.3 = 4.5 m

Limiting vertical effective stress,

$\bar{\sigma}$ = 4.5 m = 18 × 4.5 = 81 kN/m^2

From 4.5 m to 12 m, unit point bearing resistance and skin fraction resistance remain constant $\bar{\sigma}$ = 81 kN/m^2.

The untimate pile load capcity Q_n is given by

$$Q_n = q_{pu} A_b + f_s A_s$$

$$q_{pu} = \bar{\sigma} N_q \text{ and } f_{S(av)} = \bar{\sigma}_{av} \ k \tan\delta$$

Skin friction resistance over length 4.5 m

$$\text{Average } \bar{\sigma} = \frac{81}{2} = 40.5 \text{ kN/m}^2$$

$$f_{s(av)} = \bar{\sigma}_{av} \times 2 \times \tan 30^o = 46.8 \text{ kN/m}^2$$

Skin friction Resistance

$$= 46.8 \times \pi \times 0.3 \times 0.5 = 198 \text{ kN}$$

Skin friction resistance over the remaining length 7.5 m

$$\bar{\sigma}_{av} = 81 \text{ kN/m}^2$$

$$f_{S(av)} = 81 \times 2 \tan 30^o = 93.5 \text{ kN/m}^2$$

Skin friction resistance

$$= 93.5 \times \pi \times 0.3 \times 7.5 = 661 \text{ kN}$$

$$Q_F = 198 + 661 = 859 \text{ kN}$$

$$\text{For} \quad \phi = 40^o \text{ and } \frac{L}{D} = \frac{12.0}{0.3} = 40$$

$$N_q = 137$$

$$q_{pu} = 81 \times 137 = 11097 \text{ kN/m}^2$$

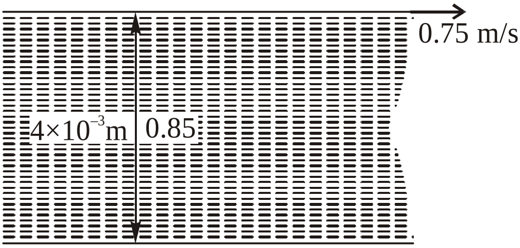
$$Q_{pu} = 11097 \times \frac{\pi \times 0.3^2}{4} = 784 \text{ kN}$$

$$Q_u = Q_{pu} + Q_f = 784 + 859 = 1643 \text{ kN}$$

$$Q_a = \frac{Q_u}{2.5} = \frac{1643}{2.5} = 651 \text{ kN}$$

37. F = 0.2 kgf = 0.2 × 9.81 = 1.962 N

A = 800 × 10^{-4} m^2



Velocity gradient

$$\frac{v}{y} = \frac{0.75}{4\times10^{-3}}$$

Velocity gradient = 187.5 $(\text{sec})^{-1}$

$$F = \frac{\mu AV}{y} = \frac{\mu\times800\times10^{-4}\times0.75}{4\times10^{-3}}$$

$$1.962 = \frac{\mu\times800\times10^{-4}\times0.75}{4\times10^{-3}}$$

$$\mu = \frac{1.962\times4\times10^{-3}}{800\times10^{-4}\times0.75} = 0.1308 \text{ Pa-sec}$$

μ = 1.308 Pose

Kinematic Viscosity

$$\frac{\mu}{\rho} = \frac{0.1308}{850} = 1.5388 \times 10^{-4} \text{ m}^2/\text{sec}$$

η = 1.5388 stokes

38. Specific gravity of the lubricating oil = 0.85

Dynamic Viscosity = 0.01 × 9.81 = 0.0981

d = 3 cm

Now, pressure drop

= 0.15 kgf/cm^2

$$= \frac{0.15\times9.81\text{N}}{10^{-4}\text{m}^2}$$

Pressure Drop = 14715 N/m^2

$$\Rightarrow \quad \frac{\Delta P}{\Delta L} = \frac{32\mu V}{D^2} = \frac{32\times0.981\times V}{9\times10^{-4}}$$

$$V = \frac{14715\times9\times10^{-4}}{32\times0.0981}$$

V = 4.2187 m/s

Now, (i) Mass flow Rate = ρaV

= 850 × (0.7854 × 3^2 × 10^{-4}) × 4.2187

= 2.5334 kg/sec

Reynolds Number = $\dfrac{\rho vd}{\mu} = \dfrac{850 \times 4.2187 \times 3 \times 10^{-2}}{0.01 \times 9.81}$

$R_e = 1097$

Coffecient of Friction

$$4f^* = \frac{64}{R_e}$$

Fraction factor

$$f = \frac{64}{1097} = 0.058$$

Shear stress at the pipe wall

$$\tau = \mu \frac{v}{y}$$

$$\tau = 0.0981 \times \frac{4.2187}{(3/2) \times 10^{-2}} \text{ N/m}^2$$

$$t = 27.59 \text{ N/m}^2$$

Power Required

$$P = \rho Q g h_F$$

$$P = 2.53 \times 9.81 \times 70.56$$

$$P = 1751.24 \text{ Watt}$$

$$h_f = \frac{flV^2}{2gD} = \frac{0.058 \times 40 \times (4.2187)^2}{2 \times 9.81 \times 3 \times 10^{-2}}$$

$$h_f = 70.56 \text{ m}$$

39. Where some flow of fluid takes place through any pipe, the head provided is not achieved at the end the pipe. Because there are always some losses in head provided during the flow. These losses are broadly catagorised in two groups.

(i) Major-loss

(ii) Minor loss

Major Losses : During the flow, the loss which his quantitatively most influence is the friction loss. The friction loss depends both upon pipe material and fluid and can be determined by.

Darcy weisbach formula

$$h_f = \frac{flV^2}{2gD} \text{ or } h_f = \frac{4f^* lV^2}{2gD}$$

where, f = Fraction factor

l = Length of pipe

V = Velocity of fluid

D = Diameter of pipe

For laminar flow

Friction factor

$$f = \frac{64}{R_e}$$

For Turbulent flow

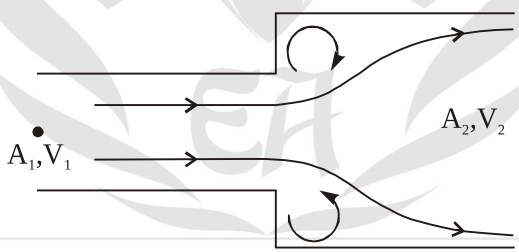
Friction factor

$$f = \frac{0.316}{R_e^{1/4}}$$

Minor Losses : These losses are dependent on the distribution network.

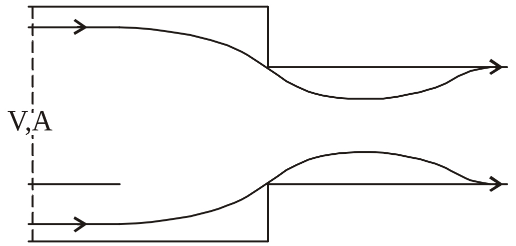
- Losses due to sudden expansion

$$h_{le} = \frac{(V_1 - V_2)^2}{2g}$$



- Losses due to sudden contraction

$$h_{lC} = \frac{(V_C - V_2)^2}{2g} = \frac{V_2^2}{2g}\left(\frac{1}{C_c} - 1\right)^2$$



Generally

$$h_{lC} = \frac{0.5V^2}{2g}$$

- Losses due to exit

$$h_e = \frac{V^2}{2g}$$

- Losses at entrance to pipe

$$h_f = \frac{0.5V^2}{2g}$$

- Losses due to Bend

$$h_{Lb} = \frac{kV^2}{2g}$$

k = Bend cofficient

k = 1.2 for 90^o bend

k = 0.4 for 45^o bend

- Losses due to gradual expansion

$$h_L = k_L \frac{(V_1 - V_2)^2}{2g}$$ Where,

k_L = Depends upon angle of expansion.

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