AJAY KUMAR GARG ENGINEERING COLLEGE, GHAZIABAD

DEPARTMENT OF CIVIL ENGINEERING

SESSIONAL TEST –II SOLUTION

Course: B.Tech.
Session: 2017-18
Subject: Geotechnical Engineering
Max Marks: 50

Semester: V
Section: CE 1& CE 2
Subject code: NCE 501
Time: 2 hour

SECTION – A

1. Attempt all parts.

(a) Explain quick sand condition in soil.

Sol:- When flow occurs in upward direction, the seepage pressure also acts in upward direction and effective pressure is reduced. If seepage pressure becomes equal to pressure due to submerged weight of soil, the effective pressure is reduced to zero. In such case cohesionless soil loses all its shear strength & soil properties have tendency to move up in direction of flow. This phenomenon of lifting of soil is called quick condition.

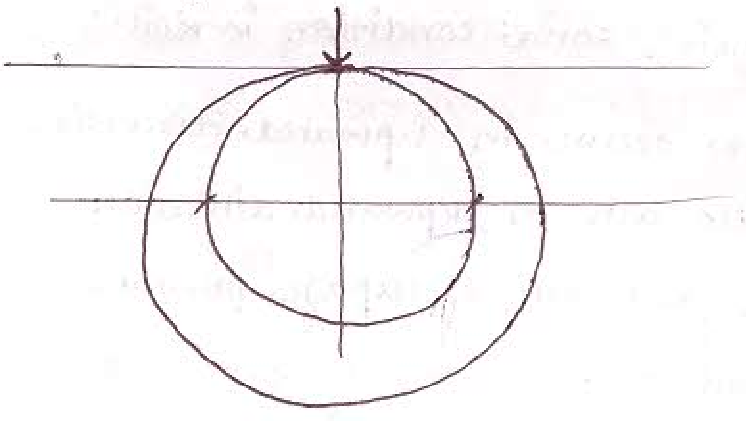
(b) What is the process of consolidation of soil? Distinguish between consolidation & compaction process.

Sol:- Consolidation :- is a process of decrease in water content of saturated soil without replacement of water by air is called process of consolidation.

<u>Compaction</u>:- It is a process of compression of soil due to expulsion of air voids.

(c) Explain in brief about stress isobar.

<u>Sol</u>:- Isobar is a curve or contour connecting all points below the ground surface of equal vertical pressure σ_z. It is curved surface of the shape of a bulb because the vertical pressure on a given horizontal plane is same in all directions at points located at equal radial distances around axis of loading.



d) Explain compression index & Recompression index of soil.

<u>Sol</u>:- <u>Compression index</u>:- slope of linear portion of pressure voids ratio curve:

$$\boxed{C_c = \frac{\Delta e}{\Delta \log_{10} \sigma'}}$$

<u>Recompression index</u>:- slope of variation of void ratio as a function of effective stress for unloading - reloading sequences.

(e) Define coefficient of permeability.

Sol: Coefficient of permeability is average velocity of flow that will occur through the total cross-sectional area of soil under unit hydraulic gradient.

SECTION - B.

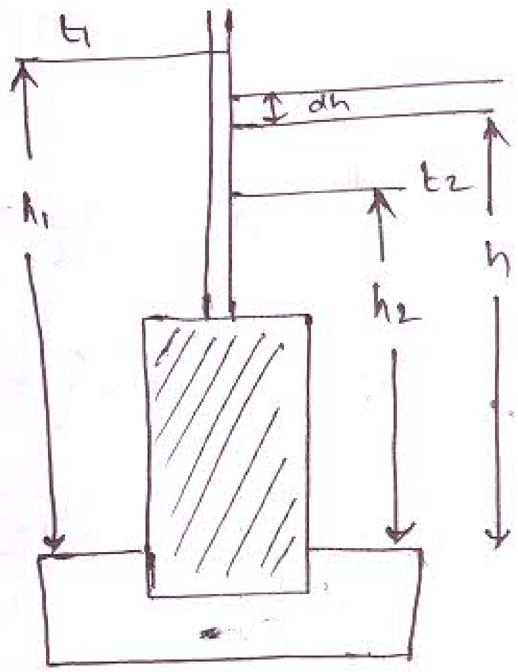
2. Attempt all parts.

(a) Derive the desired relationship of a falling head permeability test.

Sol: Let h_1 & h_2 be heads at time intervals t_1 & t_2.

Let h be the head at any intermediate time interval t &

$-dh$ change in head in smaller time dt.



A/c darcy's law

$$q = -\frac{dh \cdot a}{dt} = kiA$$

$$k\frac{h}{L} \cdot A = -\frac{dh \cdot a}{dt} \Rightarrow \frac{AK}{aL}\int_{t_1}^{t_2} dt = -\int_{h_1}^{h_2} \frac{dh}{h} = \int_{h_2}^{h_1} \frac{dh}{h}$$

$$\frac{AK}{aL}(t_2 - t_1) = \log_e \frac{h_1}{h_2}$$

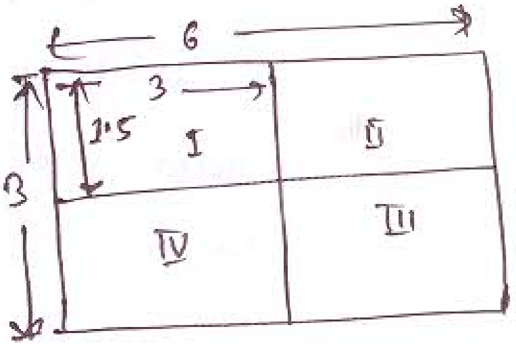
$$\frac{AK}{aL} \cdot (t_2 - t_1) = 2.303 \log_{10} \frac{h_1}{h_2}$$

$t_1 - t_2 = t$

$$\frac{AK}{aL} \cdot t = 2.3 \log \frac{h_1}{h_2}$$

$$\boxed{K = 2.3 \frac{aL}{At} \log \frac{h_1}{h_2}}$$

(b) A Rectangular footing 6m X 3m in size transmits a pressure of 16 KN/m² to the soil. Calculate the increase of vertical stress at a point 0.5 m below the centre of foundation. Use boussinesq equation.



sol: for Rect. I.

$$m = \frac{a}{z} = \frac{3}{0.5} = 6$$

$$n = \frac{b}{z} = \frac{1.5}{0.5} = 3$$

$$\sigma_z = \frac{q}{4\pi}\left[\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+1+m^2n^2} \times \frac{m^2+n^2+2}{m^2+n^2+1} + \tan^{-1}\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2-m^2n^2+1}\right]$$

$$= 1.78 \text{ KN/m}^2$$

$\therefore \sigma_z$ at centre $= 4 \times 1.78$

$$= \underline{7.12 \text{ KN/m}^2}$$

(c) A saturated soil stratum 6m thick lies above an impervious stratum & a pervious stratum. It has a compression index of 0.28 & coefficient of permeability of 3.5×10^{-4} cm/sec. Its void ratio at a stress of 150 KN/m^2 is 1.95. compute.

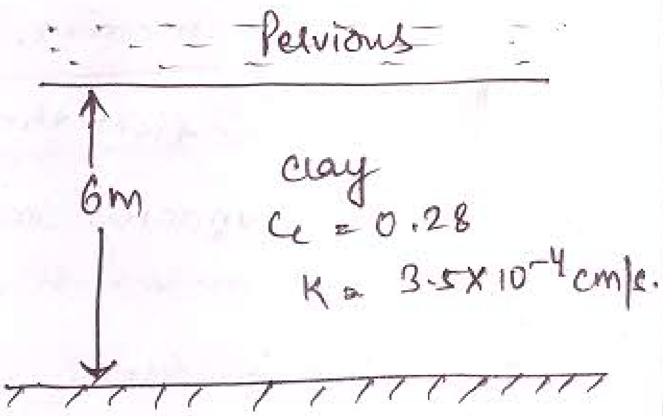
i) the change in void ratio due to an increase in stress to 210 KN/m^2

ii) settlement of the soil stratum due to above increase in stress

iii) time required for 50% consolidation as.

Assume $(T_v)_{50\%} = 0.20$.

Sol:- (i) $\Delta e = C_c \log \frac{\sigma_2}{\sigma_1}$



$= 0.28 \log \frac{210}{150}$

$= 0.0409.$

(ii) $\frac{\Delta H}{H_0} = \frac{\Delta e}{1+e_0}$

$= \frac{6 \times 0.0409}{1 + 1.95} = 0.0832$ m $= 8.32$ cm.

(iii) $t_{50} = \frac{T_v \cdot d^2}{C_v}$

$C_v = \frac{K}{m_v \cdot \gamma_w} = \frac{K(1+e_0)}{a_v \cdot \gamma_w} = \frac{K(1+e_0) \cdot \Delta\sigma}{\Delta e \cdot \gamma_w}$

$$= \frac{3.5\times10^{-6}\,(1+1.95)\,(210-150)}{0.0409\times9.81}$$

$$= 1.544\times10^{-3}\ m^2/sec.$$

$$t_{50} = \frac{0.2\,(6)^2}{1.544\times10^{-3}} = \underline{4663\ sec}.$$

$$= \underline{1\,hr\ 17.72\ min}.$$

(d) Derive the laplace's Equation of continuity with all assumptions.

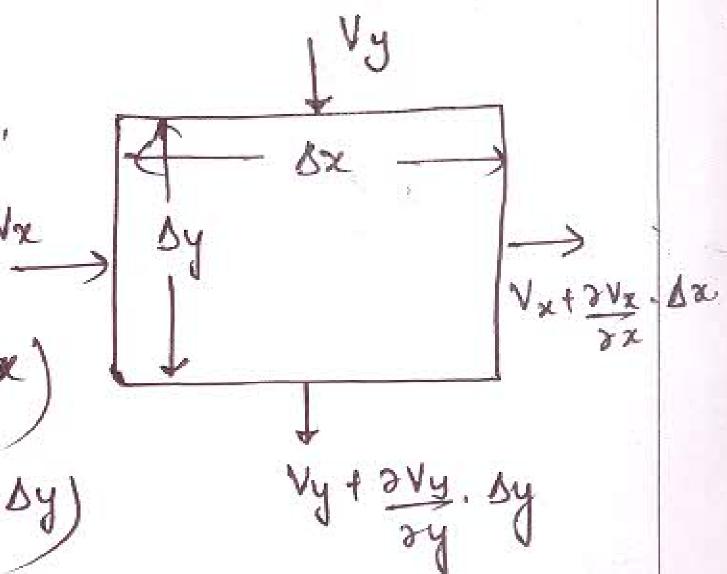
Sol:- Assumptions

i. Saturated porous medium is incompressible.

ii. Darcy's law for flow through medium is valid.

iii. Hydraulic boundary condition at entry & exit are known

iv. water is incompressible.



consider an element of soil Δx, Δy.

Velocities at entry ⇒ V_x, V_y.

Velocities at exit ⇒ $\left(V_x + \frac{\partial V_x}{\partial x}.\Delta x\right)$

$\left(V_y + \frac{\partial V_y}{\partial y}.\Delta y\right)$

Quantity of water entering is equal to leaving it.

$$V_x(\Delta y\cdot1) + V_y(\Delta x\cdot1) = \left(V_x + \frac{\partial V_x}{\partial x}.\Delta x\right)\Delta y + \left(V_y + \frac{\partial V_y}{\partial y}.\Delta y\right)\Delta x.$$

$$\frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} = 0$$

$$V_x = K_x \cdot i_x = K_x \frac{\partial h}{\partial x} \quad , V_y = K_y \frac{\partial h}{\partial y}$$

$K_x, K_y \Rightarrow$ permeability in x & y direction

$$\frac{\partial^2 (K_x \cdot h)}{\partial x^2} + \frac{\partial^2 (K_y \cdot h)}{\partial y^2} = 0.$$

$K_x = K_y = K$

$$\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2} = 0$$

$\phi = Kh \Rightarrow$

$$\boxed{\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0}$$

This is Laplace eqn of flow in two dimensions.

(e) What is piping in hydraulic structure? Suggest some remedial measure to check or prevent it.

Sol: Piping indicate the progressive erosion of downstream slope. When hydraulic gradient of the flowing water is high the water rises above the ground surface with a high velocity, due to this some of fine soil particles get removed near ground level. A cylindrical void extend from down stream side to the upstream side in the foundation soil below hydraulic structure. This is piping failure

Prevention :-

1) Increasing path of percolation
→ Increasing base width of dam
→ providing cut off walls
→ providing an impervious blanket on U/s slope.

2) By proving drainage filter.

3) By reducing seepage

SECTION - C

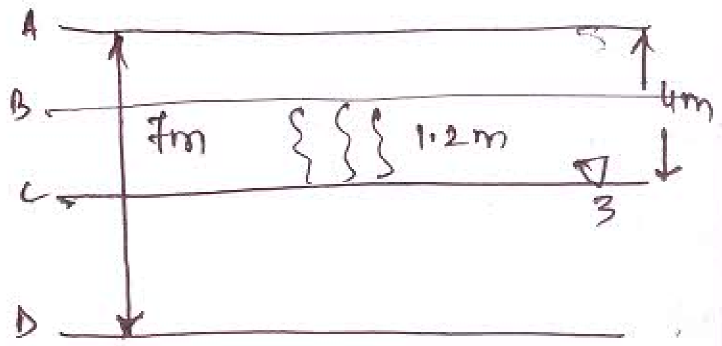
3. Attempt all parts.

(a) Granulate soil deposit is 7m deep over an impermeable layer - The ground water table is 4m below the ground surface. The deposit has a zone of capillary rise of 1.2m with a saturation of 50%. Plot the variation of total stress, pore water pressure & effective stress with the depth of deposit $e = 0.6$, $G_s = 2.65$

Sol :-

$e = 0.6$,

$G_s = 2.65$



$$\gamma_{sat} = \left(\frac{G + e}{1 + e}\right)\gamma_w$$

$$= 19.9 \text{ KN/m}^3$$

$$\gamma = \left(\frac{G + Se}{1 + e}\right)\gamma_w = 18.1 \text{ KN/m}^3, \quad \gamma_d = \frac{G\gamma_w}{1 + e} = 16.25 \text{ KN/m}^3$$

Total stress along ht. of deposit $A = 0$

$B = 2.8 \times \gamma_d = 2.8 \times 16.3 = 45.6\ KN/m^2$

$C = 2.8\ \gamma_d + 1.2\ \gamma_{sat} = 67.4\ KN/m^2$

$D = 127.1\ KN/m^2$.

Pore pressures :-

$A = 0$

$B = -1.2 \times \gamma_w = -11.8\ KN/m^2$

$C = 0$

$D = 3 \times \gamma_w = 29.4\ KN/m^2$.

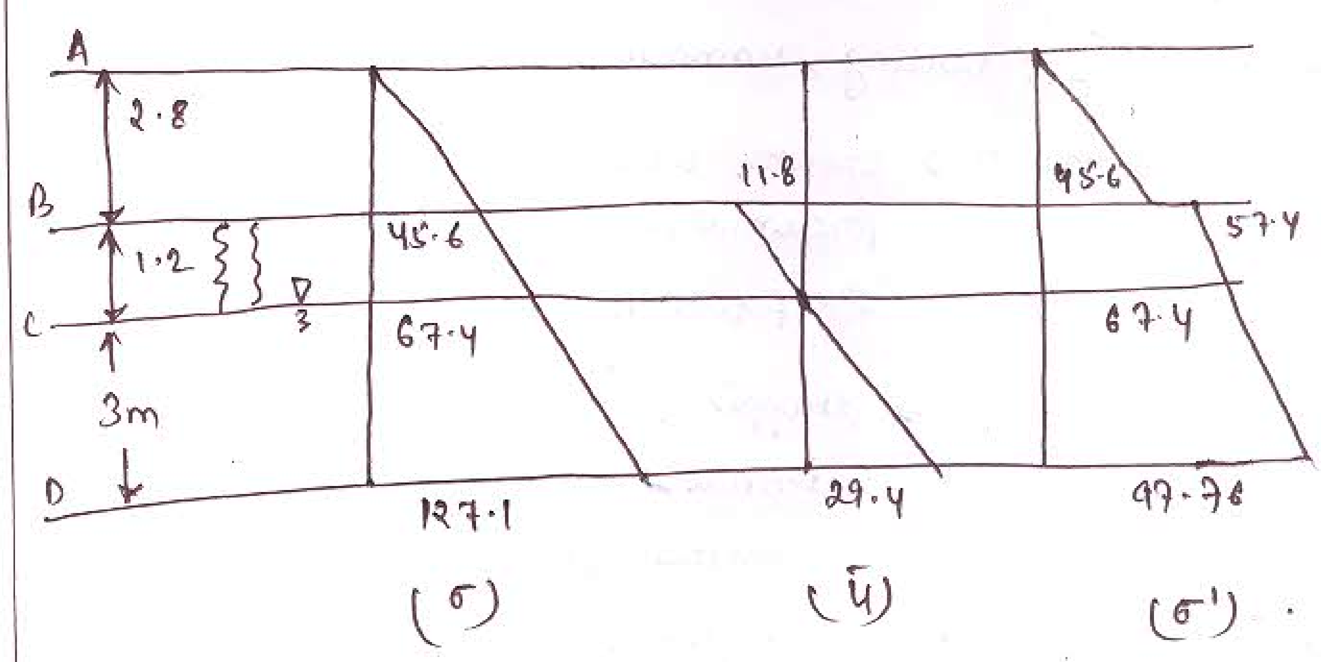
Effective pressure :-

$A = 0$

$B = 45.6\ KN/m^2 \quad . \quad 45.6 + 11.8 = 57.4\ KN/m^2$

$C = 67.4\ KN/m^2$

$D = 127.1 - 29.4 = 97.76\ KN/m^2$.



(b) Write short note:

i. Field compaction control:- consist of determination of water content at which soil has been compacted & dry density & hence degree of compaction.

- Dry density can be determined either by core cutter method or by sand replacement method.
- Rapid determination of water content can be done by two methods - calcium carbide method or by Proctor needle method.

The penetration resistance of compacted soil in the field is determined with the proctor needle & its water content is read off from calibration curve.

(ii) Field compaction methods:

Various type of soils can be compacted in the fields by three methods: rolling, ramming & vibration.

Rolling equipment → smooth wheel rollers,
pneumatic tyred rollers
sheep foot rollers.

Ramming equipment → dropping weight type
internal combustion type
pneumatic type

Vibrating equipment → dropping weight type
- pulsating hydraulic type