Improvement Test Solutions – May 2017

Geotechnical Engineering-II

Q1.(a) Distinguish between active and passive pressures.

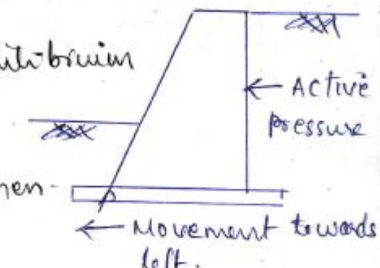
Ans:-

② Active Earth Pressure:

→ Soil mass yields such that it tends to stretch horizontally.

→ This is in a state of plastic equilibrium as soil is on the verge of failure.

→ Develops on the right hand side when the wall moves towards the left.



→ caused when there is an increase in the weight of the retained soil causing a substantial increase in the horizontal reaction.

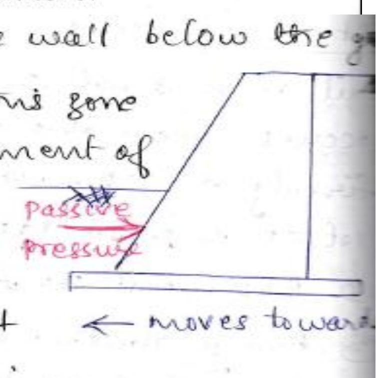
③ Passive Pressure

→ Occurs when the wall movement tend to compress the soil horizontally.

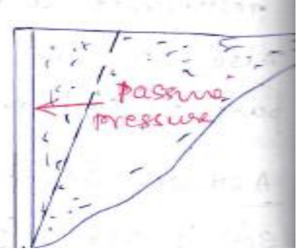
→ It is a condition of limiting equilibrium.

→ Develops on the left side of the wall below the g[round] level because the soil in this zone is compressed when the movement of the wall is towards left.

→ Develops on the right side of the wall when the movement of the wall is towards right.



Eg. Pressure acting on anchor block.

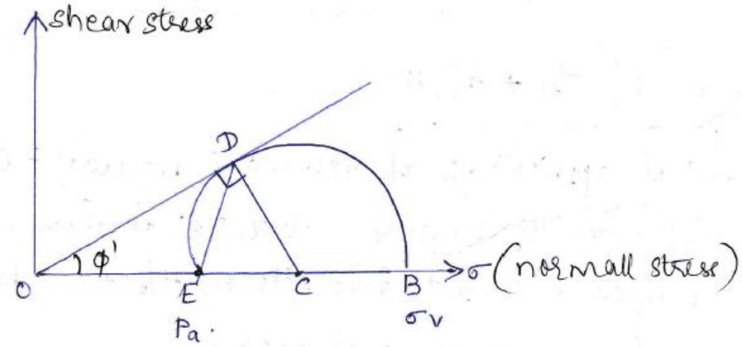


Q1(b). Derive equations for the earth pressure coefficients Ka and Kp by considering backfill with horizontal surface. Use Rankine's theory.

Ans:-

Active Earth Pressure

At failure the Mohr circle will touch the failure



$p_a = OE = OC - CE$.

from Δ^{le} ODC, $CD = OC \sin\phi' = CE$ (radius)

$\therefore \; p_a = OC - OC \sin\phi'$

$= OC(1 - \sin\phi')$

$\sigma_v = OC + CB$

$= OC + OC\sin\phi' = OC(1+\sin\phi')$

$\therefore \; \dfrac{p_a}{\sigma_v} = \dfrac{1-\sin\phi'}{1+\sin\phi'} \left(\dfrac{p_a}{\sigma_v} \right)$

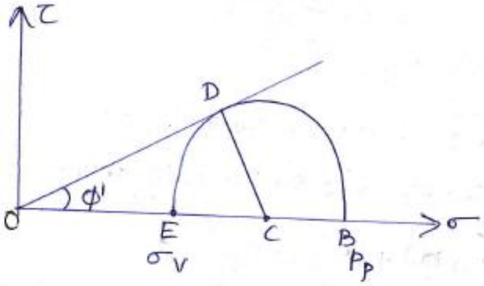
or $\; \sigma_h = K_a \times \sigma_v$

where K_a = coefficient of active earth pressure.

$$K_a = \frac{1-\sin\phi'}{1+\sin\phi'}$$

& ϕ' = angle of shearing resistance.

Passive earth Pressure



$P_p = OC + CB = OC + OC \sin\phi'$ $\left[\because CB = CD = OC \sin\phi \right]$

$\therefore P_p = OC(1+\sin\phi')$

$\sigma_v = OC - CE = OC - OC\sin\phi'$

$= OC(1-\sin\phi')$.

$\therefore \frac{P_p}{\sigma_v} = \frac{1+\sin\phi'}{1-\sin\phi'}$ or $P_p = k_p \times \sigma_v$

where $k_p = \frac{1+\sin\phi'}{1-\sin\phi'}$

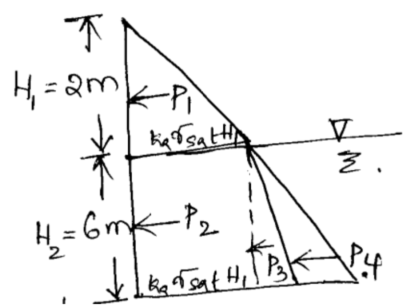
Q2.(a) A retaining wall 8m high supports sandy backfill with e=0.6, G=2.65 and Φ=30◦.Water table is at a depth of 2m from the ground surface. Draw active pressure diagram and find magnitude and point of application of total active pressure. Assume soil above water table has degree of saturation of 50%.

Ans:-

Ans: $\gamma_{sub} = \frac{(G-1)\gamma_w}{1+e} = \frac{(2.65-1)9.81}{1+0.6} = 10.11 \text{ kN/m}^3$

$\gamma_{sat} = \frac{(G+eS_r)\gamma_w}{1+e} = \frac{(2.65 + 0.6\times 0.5)9.81}{1+0.6} = 18.09 \text{ kN/m}^3$

$k_a = \frac{1-\sin 30^\circ}{1+\sin 30^\circ} = 0.33$



$P_1 = \frac{1}{2} \times K_a \times \gamma_{sat} \times H_1^2 = \frac{1}{2} \times \frac{1}{3} \times 18.09 \times 2^2$

$= 12.06 \text{ kN/m}$.

$P_2 = K_a \gamma_{sat} H_1 H_2 = \frac{1}{3} \times 18.09 \times 2 \times 6 = \underline{\underline{72.36}}$ kN/m

$P_3 = \frac{1}{2} \times K_a \gamma_{sub} H_2^2 = \frac{1}{2} \times \frac{1}{3} \times 10.11 \times 6^2 = \underline{\underline{60.66}}$ kN/m

$P_4 = \frac{1}{2} \times \gamma_w \times H_2^2 = \frac{1}{2} \times 9.81 \times 6^2 = \underline{\underline{176.58}}$ kN/m

$\therefore$ Total active pressure $P_a = P_1 + P_2 + P_3 + P_4 = \underline{\underline{321.66 \text{ kN/m}}}$

$$\bar{x} = \frac{12.06\left(6 + \frac{2}{3}\right) + (72.36 \times 3) + \left(60.66 \times \frac{6}{3}\right) + \left(176.58 \times \frac{6}{3}\right)}{321.66}$$

$= \underline{\underline{2.40 \text{ m}}}$ from base

Q2.(b) Write short notes on contact pressure distribution in sandy soil..
Ans:-

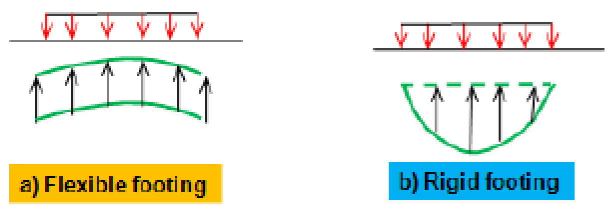
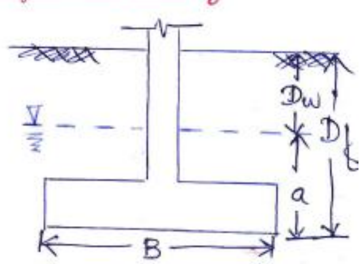


Figure above shows the qualitative contact pressure distribution under flexible and rigid footing resting on a sandy soil and subjected to a uniformly distributed load q. when the footing is flexible, the edges undergo a large settlement than at centre. The soil at centre is confined and therefore has a high modulus of elasticity and deflects less for the same contact pressure. The contact pressure is uniform. When the footing is rigid the settlement is uniform. The contact pressure is parabolic with zero intensity at the edge sand maximum at the centre.

Q3.(a) Explain the effect of ground water table on the bearing capacity of a soil deposit.
Ans:-

(I) WT located above the base of the footing



$q = \gamma D_w + a\gamma'$

But $a = D_f - D_w$.

$\therefore q = \gamma D_w + \gamma' D_f - \gamma' D_w$

$= D_w(\gamma - \gamma') + \gamma' D_f$

$\therefore q_u = c'N_c + 0.5B\gamma' N_\gamma + \left[(\gamma - \gamma')D_w + \gamma' D_f\right] N_q$.

If $D_w = 0$ i.e. $a = D_f$

$$q_u = c'N_c + 0.5B\gamma' N_\gamma + \gamma' D_f N_q .$$

If $a = 0$ i.e. $D_w = D_f$.

$$q_u = c'N_c + 0.5B\gamma' N_\gamma + \gamma D_f N_q$$

II) WT located at a depth b below the base

$$\bar{\gamma} = \gamma' + \frac{b}{B}(\gamma - \gamma')$$ (i.e. surcharge term not affected. only unit weight term is modified)

$$\therefore q_u = c'N_c + 0.5B\left[\gamma' + \frac{b}{B}\ \gamma - \gamma'\right]N_\gamma + \gamma D_f N_q .$$

General Expression

i.e. $\gamma' = 0.5\gamma_{sat}$

Taking submerged unit wt as roughly one-half of the bulk unit wt, the ultimate BC eqn becomes

$$q_u = c'N_c + 0.5B\gamma N_\gamma W_\gamma + \gamma D_f N_q W_q .$$

where W_q = WT correction factor for the 3^{rd} term.

$$= \frac{1}{2}\left[1 + \frac{Z_{w1}}{D_f}\right]$$

where Z_{w1} = depth of WT from ground level

① $0.5 < W_q < 1$

② If $Z_{w1} = 0$; $W_q = 0.5$

③ If $Z_{w1} = D_f$; $W_q = 1$

④ at any other intermediate level, W_q lies b/w 0.5 &

W_γ = WT correction for 2^{nd} term

$$= \frac{1}{2}\left[1 + \frac{Z_{w2}}{B}\right]$$

where Z_{w2} = depth of WT from foundation level.

① $0.5 < W_\gamma < 1$

② If $Z_{w2} = 0$; $W_\gamma = 0.5$

③ If $Z_{w2} \geq B$; $W_\gamma = 1.0$

④ at any other intermediate level, W_γ lies b/w 0.5 &

Q3.(b) Plate load test were conducted in a C-Φ soil, on plates of different sizes and following results were obtained. Find the size of square footing to carry a load of load of 800 kN at the same specified settlement of 25mm.

Load, KN	Plate size	Settlement,mm
40	0.3 m*0.3m	25
100	0.6m*0.6m	25

Ans:-

For C-φ soils, Housel's eqn $Q = Aq + Ps$

1st case → $40 = (0.3\times0.3)q + (4\times0.3)s$

$40 = 0.09q + 1.2s$ —— ①

2nd case → $100 = 0.36q + 2.4s$ —— ②

Solving ① & ②, ①×2

$80 = 0.18q + 2.4s$ — ③

$100 = 0.36q + 2.4s$ — ④

④ − ③ ⇒ $20 = 0.18q \Rightarrow q = 111.11\ \text{KN/m}^2$

$s = 25\ \text{KN/m}^2$

Let B be the size of □re footing

$800 = (B\times B)\,111.111 + (4B)\times25$

$B^2 + 0.9B - 7.2 = 0$

$\Rightarrow B \simeq 2.27\ \text{m} \simeq 2.3\ \text{m}$

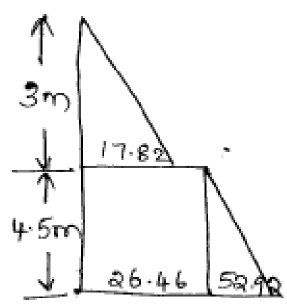
Q4.(a) A retaining wall retains a cohesionless backfill with a height of 7.5 m. The top 3m of the backfill has a unit weight of 18 kN/m^3 and Φ=30◦. Lower 4.5m of the backfill has a unit weight of 24 kN/m^3 and Φ=20◦. Obtain pressure distribution diagram and determine the total active pressure and its point of application.

Ans:-

Ans:

$K_{a_1} = \dfrac{1-\sin 30^\circ}{1+\sin 30^\circ} = 0.33$

$K_{a_2} = \dfrac{1-\sin 20^\circ}{1+\sin 20^\circ} = 0.49$



$p_1 = K_{a_1}\gamma_1 H_1 = 0.33\times18\times3 = 17.82\ \text{KN/m}^2$

$p_2 = K_{a_2}\gamma_1 H_1 = 0.49\times18\times3 = 26.46\ \text{KN/m}^2$

$p_3 = K_{a_2}\gamma_2 H_2 = 0.49\times24\times4.5 = 52.92\ \text{KN/m}^2$

$P_1' = \frac{1}{2}\times17.82\times3 = 26.73\ \text{KN/m}$

$P_2 = 26.46 \times 4.5 = 119.07$ kN/m

$P_3 = \frac{1}{2} \times 52.92 \times 4.5 = 119.07$ kN/m.

Total active pressure $= P_1 + P_2 + P_3 = \underline{264.87}$ kN/m

$$\bar{x} = \frac{26.73\left(4.5 + \frac{3}{3}\right) + \left(119.07 \times \frac{4.5}{2}\right) + \left(119.07 \times \frac{4.5}{3}\right)}{264.87}$$

$= \underline{2.24\text{m}}$ from base

Q4.(b) Explain earth pressure at rest.

Ans:-

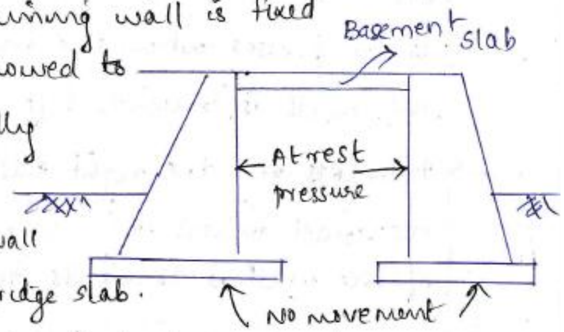
① At rest pressure

→ Soil mass is not subjected to any lateral movement

→ occurs when the retaining wall is fixed firmly on top & not allowed to rotate or move laterally

Eg ① Basement slab

② Bridge abutment wall restrained at top by bridge slab.



→ Also known as state of elastic equilibrium as no part of soil mass has failed & attained the plastic eq bm.

Q5.(a). Explain briefly the corrections applied to standard penetration test.

Ans:- The N-value observed during testing is not utilized directly in assessing soil properties. These values are corrected to account for

1. The overburden pressure
2. Dilatancy in saturated fine sands and silts

Correction for overburden pressure:- The penetration resistance of soil depends on the over burden pressure. At deeper depth in-situ soil will have higher overburden pressure hence its response to SPT test will be better when compared to the behavior of the same soil at shallow depth. Bazaraa (1967 Bowels, p99) proposed the following corrections to the actual count N, based on the over burden pressure

For p_0 <= 75 kPa

$$N' = \frac{4N}{(1 + 0.04 p_0)}$$

For $p_0 > 75$ kPa

$$N' = \frac{4N}{(3.25 + 0.01 p_0)}$$

Where N’ = corrected N value

N = observed N-value

P_0 = over burden pressure, (kPa) = γ x D

D = depth of testing (m)

γ = unit weight of soil at the time of testing

<u>Correction for dilatancy in saturated fine sands and silts:-</u>When dynamic loads are applied on silty and fine sandy soils in saturated state the pore pressure in such soil will not be in a position to get dissipated due to low permeability. Hence, during dynamic loading (i.e. application of blows) the pore water will offer a temporary resistance to dynamic loads. This leads to higher value of N-value which is unsafe. Therefore when SPT is performed in saturated silts and fine sands and if the observed N-value is more than 15, a correction has to be applied to reduce the observed values. This correction is applied on the N-value corrected for over burden pressure (N’). If the stratum (during testing) consists of fine sand & silt below water table, the corrected N-value (N’) has to be further corrected to get the final corrected value N”.

$$N'' = 15 + \frac{1}{2}(N' - 15)$$

Q5.(b). An 8 m thick clay layer with single drainage settles by 120 mm in 2 years. The coefficient of consolidation for this clay was found to be 0.6 mm^2/s. Calculate the likely ultimate consolidation settlement and find out how long will it take to undergo 90% of this settlement.

Ans:-

$H = 8\,m, \quad t = 2 \times 365 \times 24 \times 60 \times 60\ s$

$C_v = 6 \times 10^{-3}\ cm^2/s = 6 \times 10^{-3} \times 10^{-4}\ m^2/s.$

$\because C_v = \frac{T_v d^2}{t} \Rightarrow T_v = \frac{C_v t}{d^2}$

$= \frac{6 \times 10^{-7} \times 2 \times 365 \times 24 \times 60 \times 60}{(8)^2}$

$= 0.5913$

$T_v = 1.7813 - 0.9332 \log_{10}(100 - u\%).$

$\frac{-0.5913 + 1.7813}{0.9332} = \log_{10}(100 - u\%)$

$1.2751 = \log_{10}(100 - u\%).$

$u = 81.5\%$

$u > 60\%$, hence the use of above eqn is right

$(S_c)_t = u_t (S_c)_f$ → (Basic consolidation law)

$(S_c)_f = \frac{(S_c)_t}{u_t} = \frac{120}{0.815} = \underline{\underline{147 mm}}$.

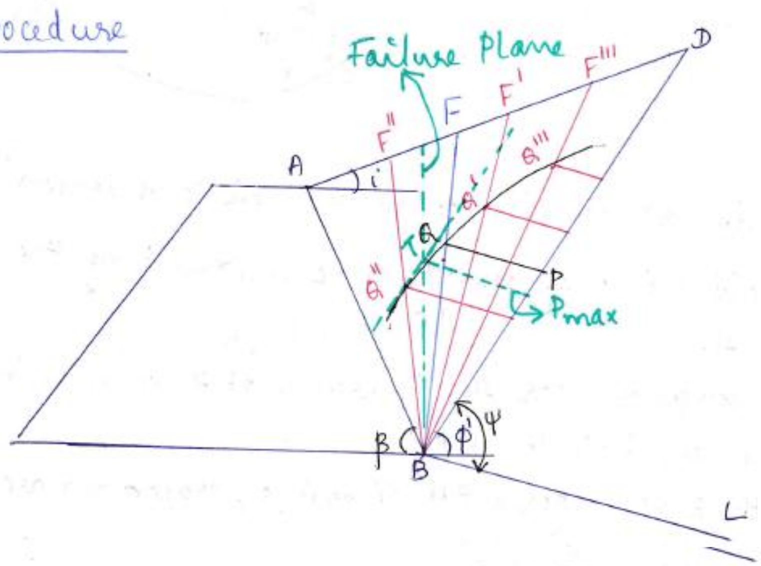
For $u = 90\%$, $T_v = 0.848$.

$\therefore t = \frac{T_v d^2}{c_v} = \frac{0.848 \times 64}{6 \times 10^{-7} \times 60 \times 60 \times 24 \times 365}$

$= \underline{\underline{2.87 yrs}}$.

Q6.(a). Explain Culmann's graphical method of active earth pressure determination.
Ans:-

Procedure



From B, a line BD is drawn at an angle φ' to the h…
As the weight of the wedge is plotted along this line, …
s also known as the weight line.
A line BL is drawn at an angle ψ with the line BD, …
hat $\psi = \beta - \delta$
A failure surface BF is assumed & the weight W of
the failure wedge ABF is computed.

(4) The weight (W) of the wedge is plotted along BD such that BP = W.

(5) From P, draw a line PQ parallel to BL to intersect the failure surface BF at Q.

(6) The line PQ represents the magnitude of P_a required to maintain equilibrium for the assumed failure plane.

(7) Similarly several other failure planes BF'', BF', BF''' etc are assumed & the procedure is repeated & thus the points Q'', Q', Q''' etc are located.

(8) A smooth curve is drawn joining the points Q'', Q, Q', Q'''. This curve is called culmann's line.

(9) A line (shown dotted) is drawn tangential to the culmann line & parallel to BD. Point T is the point of tangency.

(10) The magnitude of the largest value (P_{max}) of P_a is measured from the tangent point T to the line BD and parallel to BL. It is equal to Coulomb's active pressure (P_a).

(11) The actual failure plane passes through the point T.

Q6.(b) Determine the creep settlement in a sensitive clay of thickness 8m, given Cα = 0.01, when the laboratory sample 20 mm thick with double drainage experienced complete consolidation in 10 min. The life span of the structure is 100 years. Assume single drainage in the field.

Ans:-

Assuming single side drainage in field,

$$\frac{(20/2)^2}{10} = \frac{(6000)^2}{t_{field}} \Rightarrow t_{field} = \frac{36\times10^5}{60\times24\times365} = 6.849 \text{ yrs}$$

ie $t_{prim} = 6.849$ yrs

$$\therefore S_s = 0.01\times6\times\log_{10}\left(\frac{100-6.849}{6.849}\right) = 0.068\text{ m} = 68.01\text{ mm}.$$