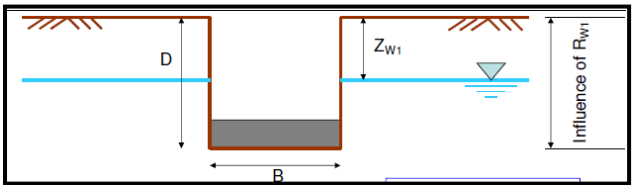
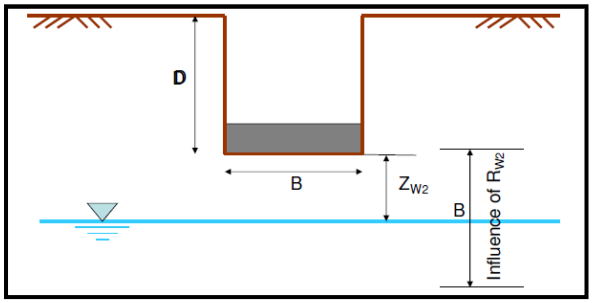
APPLIED GEOTECHNICAL ENGINEERING (17CV53)
SOLUTION – IAT2

1 (a) With the help of neat sketch, explain the effect of water table on bearing capacity.

Ans:-

The position of ground water has a significant effect on the bearing capacity of soil. Presence of water table at a depth less than the width of the foundation from the foundation bottom will reduce the bearing capacity of the soil. If the ground water is located close to the footing, some changes have to be incorporated in the wedge and surcharge terms of bearing capacity equation. These changes are in the form of water table correction factors R_{w1} & R_{w2}.





Ultimate bearing capacity with the effect of water table is given by,

$$q_f = cN_c + \gamma DN_q R_{w1} + 0.5\gamma BN_\gamma R_{w2}$$

Here, $R_{w1} = \frac{1}{2}\left[1 + \frac{Z_{w1}}{D}\right]$

where Z_{W1} is the depth of water table from ground level.

1. $0.5 < R_{w1} < 1$
2. When water table is at the ground level ($Z_{w1} = 0$), $R_{w1} = 0.5$
3. When water table is at the base of foundation ($Z_{w1} = D$), $R_{w1} = 1$
4. At any other intermediate level, R_{w1} lies between 0.5 and 1

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

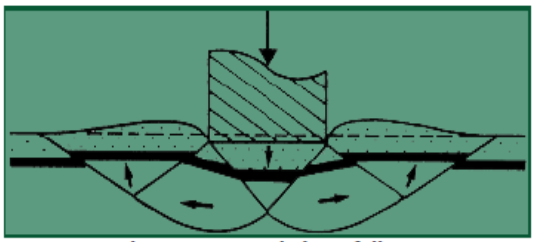
where Z_{W2} is the depth of water table from foundation level.

1. $0.5 < R_{w2} < 1$
2. When water table is at the base of foundation ($Z_{w2} = 0$), $R_{w2} = 0.5$
3. When water table is at a depth B and beyond from the base of foundation ($Z_{w2} >= B$), $R_{w2} = 1$
4. At any other intermediate level, R_{w2} lies between 0.5 and 1

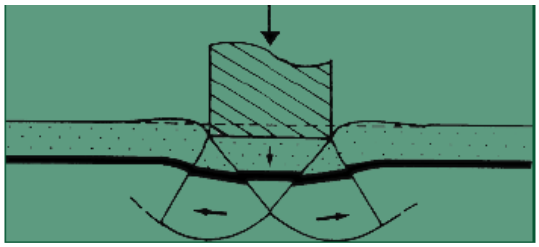
1 (b) Distinguish general shear failure from local shear failure.

Ans:-

General Shear Failure	*Local Shear Failure*
Occurs in dense/stiff soil $\Phi > 36^o$, N>30, I_D>70%, C_u>100 kPa	Occurs in loose/soft soil $\Phi < 28^o$, N<5, I_D<20%, C_u<50 kPa
Results in small strain (<5%)	Results in large strain (>20%)
Failure pattern well defined & clear	Failure pattern not well defined
Well defined peak in P-Δ curve.	No peak in P-Δ curve
Bulging formed in the neighborhood of footing at the surface	No Bulging observed in the neighborhood of footing
Extent of horizontal spread of disturbance at the surface large	Extent of horizontal spread of disturbance at the surface very small
Observed in shallow foundations	Observed in deep foundations
Failure is sudden & catastrophic	Failure is gradual
Less settlement, but tilting failure observed	Considerable settlement of footing observed



General shear failure



Local shear failure

1 (c) A foundation 2 m square is installed 1.2m below the surface of a uniform sandy gravel having a density of 19.2 KN/m^3, above water table and a submerged density of 10.1 KN/m^3. The strength parameters wrt effective stress are C=0 and φ= 35°. Find ultimate bearing capacity if (a) WT rises to the level of foundation, and (b) WT rises to the ground level. N_c=0, N_q=22, N_γ=20.

Ans:- $q_u = 1.3*C*N_c + 0.4*B*\gamma*N_\gamma + \gamma*D_f*N_q$

C= 0 kN/m^2, Φ= 35°, N_c= 0, N_q= 22, N_γ= 20 , D_f = 1.2 m, γ = 19.2 kN/m^3, γ_{sub} = 10.1 kN/m^3.

Case 1: $q_u = 0.4*B*\gamma_{sub}*N_\gamma\ W_\gamma + \gamma*D_f*N_q\ W_q$

$= 0.4*2*10.1*20*0.5 + 19.2*1.2*22*1 = 587.68$ kN/m^2

Case 2: $q_u = 0.4*B*\gamma_{sub}*N_\gamma\ W_\gamma + \gamma_{sub}*D_f*N_q\ W_q$

$= 0.4*2*10.1*20*0.5 + 10.1*1.2*22*0.5 = 214.12$ kN/m^2

2 (a) What is meant by efficiency of pile group? Explain Feld's rule.

Ans:-

Efficiency of pile group:- Piles are generally used in groups with a common pile cap. A group may consist of two or three, or as many as ten to twelve piles depending on the design requirement. IS 2911 (Part1) 1979 recommends a minimum spacing of

- 2.5D – point bearing piles
- 3D – friction piles
- 2D- loose sands or fill deposits.

Spacing of piles in a group depends on (a) length, size & shape of piles (b) soil characteristics (c) magnitude and type of loads.

Generally center to center spacing between piles in a group is kept between 2.5 d and 3.5d where d is the diameter of the pile.

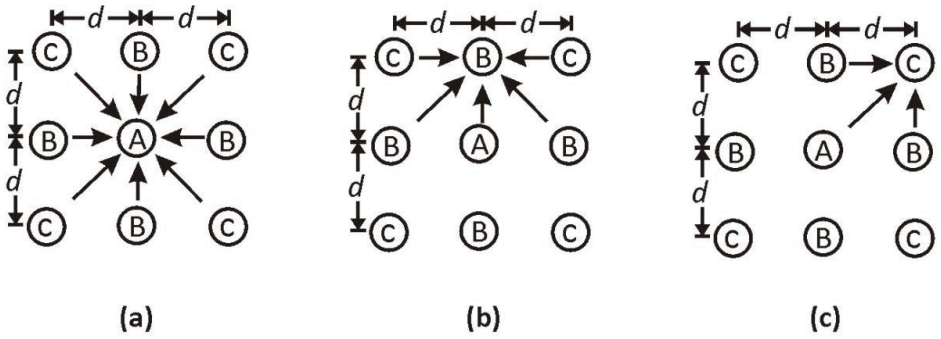
The efficiency of a pile group may be defined as $\eta_g = \frac{Q_{g(u)}}{NQ_u} \times 100$

$\eta = group\ efficiency$

$Q_{g(u)} = ultimate\ load - bearing\ capacity\ of\ the\ group\ pile$

$Q_u = ultimate\ load - bearing\ capacity\ of\ each\ pile\ without\ the\ group\ effect$

Feld's rule: According to Feld's rule, the ultimate capacity of a pile is reduced by one-sixteenth by each adjacent diagonal or row pile of which the particular pile is a member. This is demonstrated in the figure and tabular column given below.



2 (b) Write short notes on (a) settlement of piles (b) under reamed piles.

Ans:- ***Settlement of pile groups in clay:-*** The consolidation settlement in pile group may be obtained from the expression given below:

$$S_c = [\ C_c * H * \log (\sigma_o + \Delta\sigma\ )/\ \sigma_o\ ]/\ [\ 1+e_o]$$

Where, $C_c = 0.009(w_L - 10)$ for undisturbed soils & $= 0.007(w_L - 10)$ for remolded soils

e_o = initial void ratio, σ_o = initial overburden pressure at the middle of the clay strata

$\Delta\sigma = P/ [B + (2*0.5H*\tan 30)]^2$

Settlement of pile groups in sand:-

Skempton's settlement ratio:- $S_g/S_i = \{[4B + 2.7]/ [B + 3.6]\}^2$

Where, B = width of pile group in meters, S_i = settlement of a single pile obtained from pile load test data.

Under reamed piles:- Under reamed piles are bored cast-in-situ concrete piles having one or more number of bulbs formed by enlarging the pile stem. These piles are best suited in soils where considerable ground movements occur due to seasonal variations, filled up grounds or in soft soil strata. They are suitable for loose and filled up sites, or where soils are weak or expansive like black cotton soil. The bulbs are located at depths where good bearing strata are available but they should not be placed too near the ground level. Bulb size is usually 2 to 3 times the pile stem diameter. The bulb provides a large bearing area, increasing the pile load capacity. They are also effective in resisting the downward drag due to the negative skin friction that arises in loose or expansive soils. Bulb spacing should not exceed 1.5 times the bulb diameter. Refer the figure below:

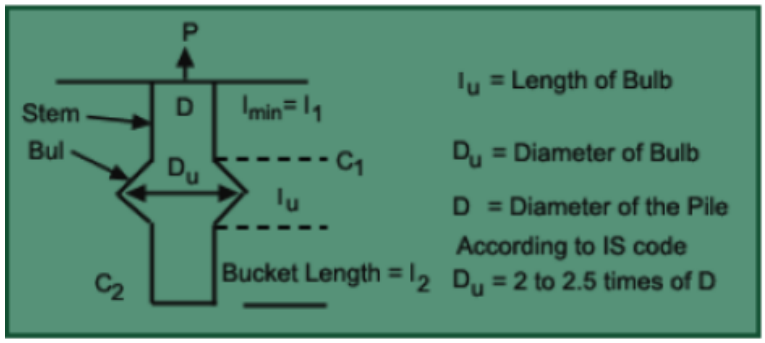
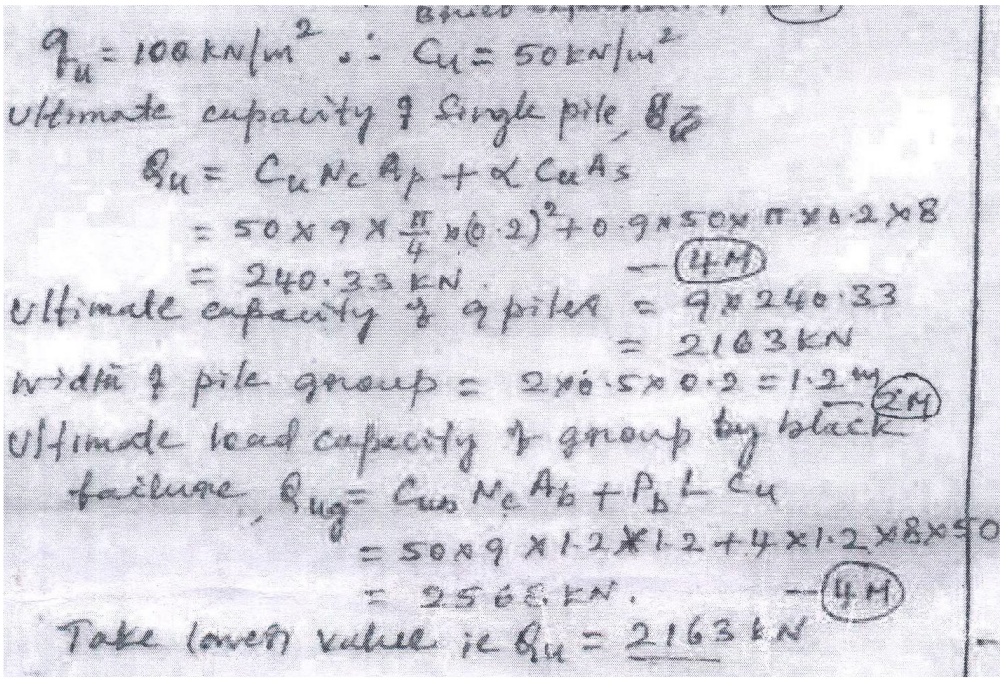


Fig 5.39 Single Under Reamed Pile

2(c) A 200mm dia, 8m long piles are used as foundation for a column in a uniform deposit of medium clay having unconfined compressive strength of 100 KN/m^2. The spacing between the piles is

500mm. There are 9 piles in the ground arranged in a square pattern. Calculate the ultimate load capacity of the group. Assume α=0.9.

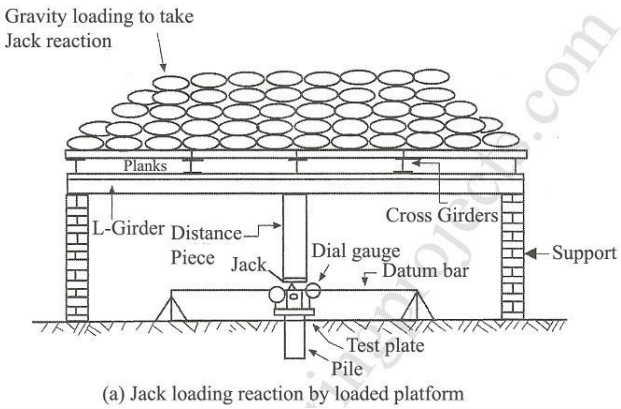
Ans:-



3 (a) Explain plate load test with a sketch.

Ans:-

- The pile load test can be performed either on a working pile which forms the foundation of a structure or on a test pile. A working pile is a driven or cast in situ pile along with other piles to carry the load from the superstructure. The test load on such piles = 1.5*safe load or load corresponding to 12 mm settlement.
- According to IS 2911 part4, 1979, the test shall be carried out by applying a series of vertical downwards loads on a RCC cap over the pile. Load shall be applied by a remote controlled hydraulic jack taking reaction against a loaded platform. Load shall be applied at increments of 20% of safe load.
- Settlements shall be recorded with 3 dial gauges with a sensitivity of 0.02mm, symmetrically arranged over the test plate. Each load increment is kept for sufficient time till the rate of settlement becomes less than 0.02mm per hour.
- Test load is increased to 2.5* estimated load or load corresponding to settlement = 0.1*pile dia. Results are plotted in the form of load vs settlement curve.
- Allowable load on a single pile shall be lesser of the following:
    a. Two-thirds of the final load which cause a settlement of 12mm
    b. One-half to two-third of the final load which cause a settlement of 0.1*pile dia, or
    c. Two-thirds of final load which causes a net settlement of 6mm.



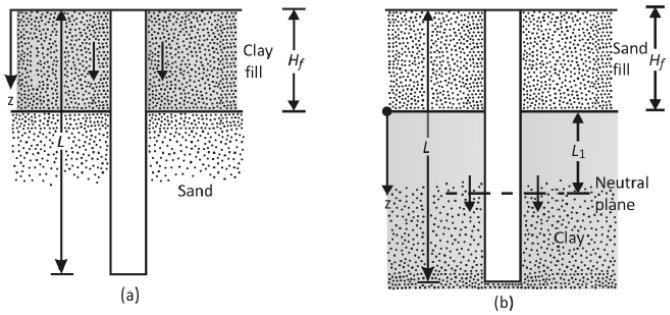
(a) Jack loading reaction by loaded platform

3 (b) Explain briefly (a) negative skin friction (b) classification of piles based on materials.

Ans:- Negative skin friction

Negative skin friction is a downward drag force exerted on the pile by the soil surrounding it. This action can occur under conditions such as the following:

1. If a fill of clay soil is placed over a granular soil layer into which a pile is driven, the fill will gradually consolidate. This consolidation process will exert a downward drag force on the pile (figure a) during the period of consolidation.
2. If a fill of granular soil is placed over a layer of soft clay, as shown in figure b, it will induce the process of consolidation in the clay layer and thus exert a downward drag on the pile.
3. Lowering of the water table will increase the vertical effective stress on the soil at any depth, which will induce consolidation settlement in clay. If a pile is located in the clay layer, it will be subjected to a downward drag force.



Classification based on materials:

1. *Timber piles:* Timber piles are made from tree trunks and are well seasoned, straight and free from all defects. Usually available length will be 4 to 6m. Timber piles are used where good bearing stratum is available at a relatively shallow depth.
2. *Concrete piles:* Concrete piles are either precast or cast in-situ. Precast piles are cast and cured at the casting yard and then transported to the site for installation. These piles are adequately reinforced to withstand handling stresses along with working stress. Precast piles are generally used for short lengths. Cast-in-situ piles are constructed by drilling hole in the ground and then filling that hole with freshly prepared concrete after placing the reinforcement.
3. *Steel Piles:* Steel piles are usually of rolled H-sections or thick pipe sections. These piles are used to withstand large impact stresses and where fewer disturbances from

driving is desired. These piles are also used to support open excavations and to provide seepage barrier.

4. *Composite piles:* A pile made up of two different materials like concrete and timber or concrete and steel is called composite pile. Composite piles are mainly used where a part of the pile is permanently under water. The part of the pile which will be under water can be made of untreated timber and the other part can be of concrete.

(c) Find the dimensions of a combined rectangular footing for 2 columns A & B spaced 3.4m center to center. Column A is 30 cm*30 cm in size and transmits a load of 500KN. Column B is 40 cm*40 cm in size and carries a load of 700 KN. The SBC of the soil is 150 KN/m^2.

Ans:-

Weight of the footing, W' = 10% of (W1 + W2) = 120 KN.

Area, A= W1 + W2 + W'/ q_s = 8.8 m^2.

Let B= 1.8m , L = 5 m.

x = W2*l/(W1 + W2) = 1.98m.

a_1 = (L/2) – x = 0.52m

a_2 = L – (l + a1) = 1.08m

p_0 = (W1 + W2)/ B*L = 133.33 KN/m^2.