IMPROVEMENT TEST SOLUTION

APPLED GEOTECHNICAL ENGINEERING (15CV53)

1 (a) Briefly explain the necessity of pile foundation.

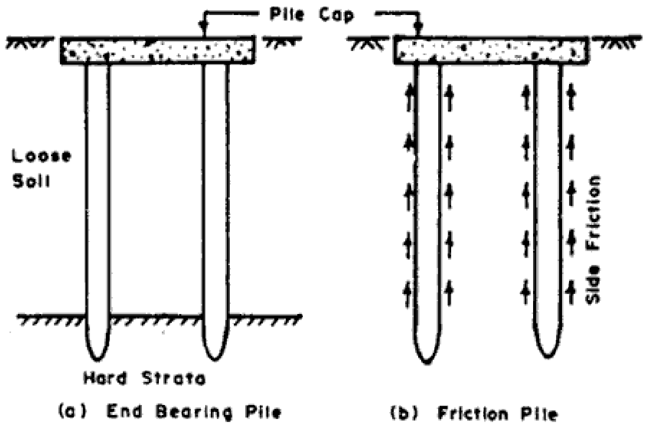
Ans:- Pile foundations are used in the following conditions:
1. When the strata at or just beneath the ground surface is greatly compressible and very weak or loose for carrying the load transferred from the structure above.
2. When the plan of the structure is irregular relative to its outline and load distribution. This may lead to the unpleasant non-uniform settlement when the shallow foundation is constructed.
3. For the transmission of different structural loading/forces via deep water to the firm stratum below.
4. To withstand the horizontal forces as well as the vertical forces/loads in the earth retaining structures and tall structure that are subjected to horizontal forces of wind and earthquake.
5. When the soil conditions are in very loose/weak conditions that a washout, erosion and scour of soil underneath leads to the collapse of shallow foundations.
6. For the foundations of some structures, such as transmission towers, off-shore platforms, which are subjected to uplift.
7. In expansive soils like black cotton soil, that swells or shrinks when the water content varies, the piles are used to transfer the load below the active zone.

1 (b) Write a note on classification of piles.

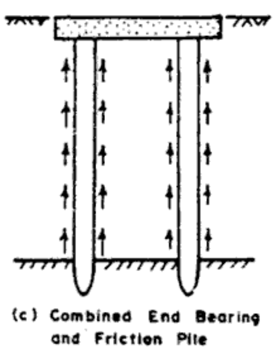
Ans:- Classification based on materials or composition:
1. *Timber piles:* Timber piles are made from tree trunks and are well seasoned, straight and free from all defects. Timber piles are used where good bearing stratum is available at a relatively shallow depth.
2. *Concrete piles:* Concrete piles 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. 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.

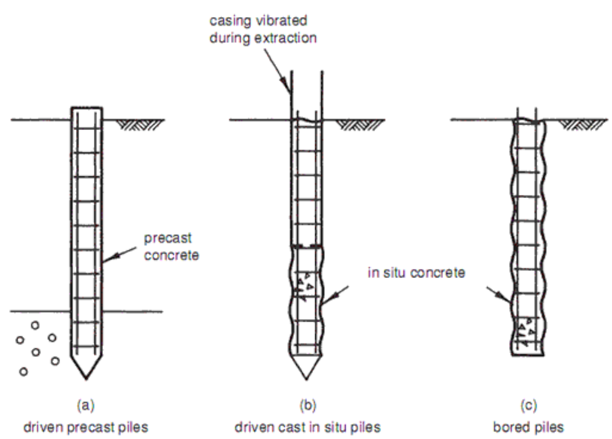
4. *Composite piles:* A pile made up of two different materials like concrete and timber or concrete and steel is called composite pile. Composite piles are mainly used where a part of the pile is permanently under water.

Classification based on the function:
1. *End bearing piles*: Piles which transfer structural load to a hard and relatively incompressible stratum such as rock or dense sand are known as end bearing piles. These piles derive the required bearing capacity from end bearing at tip of the pile.

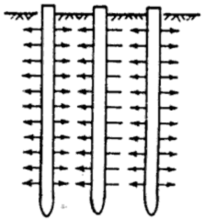


2. *Friction piles:* These are piles which derive carrying capacity from skin friction or adhesion between the pile surface and surrounding soil.
3. *Combined end bearing and friction piles*: These piles transfer loads by a combination of end bearing at the bottom of the pile and friction along the surface of the pile shaft.

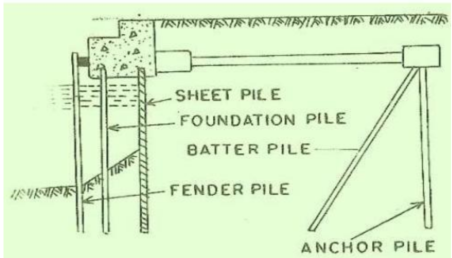




Classification based on method of installation:
1. *Bored piles*: Bored piles are constructed in pre-bored holes either using a casing or by circulating stabilizing agent like bentonite slurry. The borehole is filled with concrete after placing or lowering reinforcement.
2. *Driven piles*: Driven piles may be of concrete, steel or timber. These piles are driven into the soil strata by the impact of a hammer.
3. *Driven and Cast-in-Place Piles*: These piles are formed by driving a tube with a closed end into the soil strata, and then filling the tube with freshly prepared concrete. The tube may or may not be withdrawn afterwards.



(d) Compaction Pile



Classification based on use:

1. *Load bearing piles*: These piles are used to transfer the load of the superstructure to a suitable stratum by end bearing, by friction or by both.
2. *Compaction piles*: These piles are used to compact loose granular soil to increase its bearing capacity. Compaction piles do not carry load and hence they can be of weaker material. Sand piles can be used as compaction piles.
3. *Tension pile*: These piles are also called as uplift piles. Generally it can be used to anchor down the structures which are subjected to uplift pressure due to hydrostatic force.
4. *Sheet pile*: These piles form a continuous wall which is used for retaining earth or water.
5. *Fender piles*: Fender piles are used to protect water front structure from impact of any floating object or ships.
6. *Anchor piles*: These piles are used to provide anchorage for anchored sheet piles.

Classification based on displacement of soil:

1. *Displacement piles*: Soil gets displaced laterally when the pile is installed. Installation may also cause heaving of the surrounding ground.
2. *No-displacement piles*: As the soil is removed when the hole is bored, there is no displacement of the soil during installation.

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

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

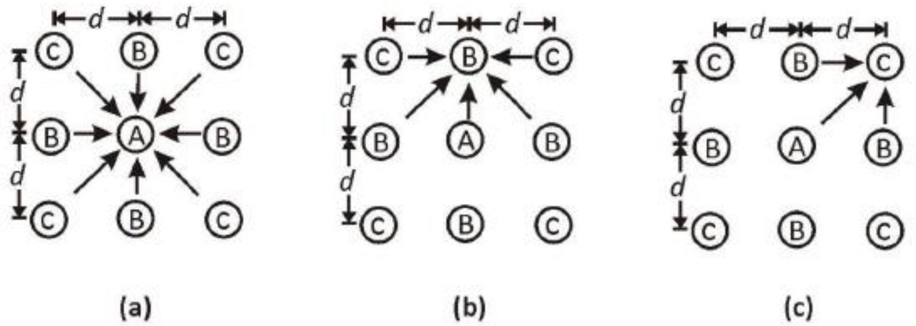
$\eta = group\ efficiency$

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

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

n = number of piles in the group

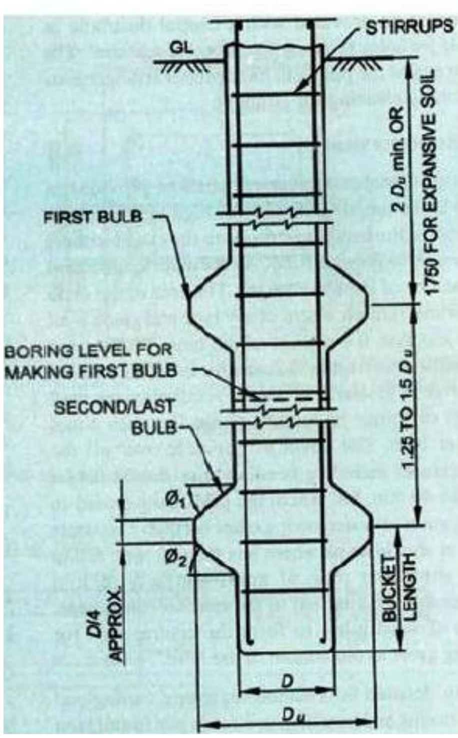
Feld's rule: According to Feld's rule, the ultimate capacity of a pile is reduced by one-sixteenth by each adjacent diagonal or row pile of which the particular pile is a member. This is demonstrated in the figure and tabular column given below.

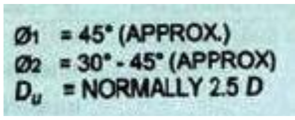


Pile type	No. of Piles	No. of adjacent piles/pile	Reduction factor for each pile	Ultimate capacity
A	1	8	$1-\frac{8}{16}$	$0.5Q_u$
B	4	5	$1-\frac{5}{16}$	$2.75Q_u$
C	4	3	$1-\frac{3}{16}$	$3.25Q_u$

2 (b) **Draw a typical arrangement of under reamed pile with proportion of diameter of pile, bulb and spacing.**

Ans:-





2 (c) **A group of nine piles with three piles in a row was driven into soft clay extending from ground level to a great depth. The diameter and length s of the piles were 30cm and 10m respectively. The cohesion C = 35kN/m^2. If the piles were spaced at 90cm c/c, compare the bearing load on the pile group on the basis of shear failure criterion for a factor of safety of 2.5. Take m=0.6 for shear mobilization around each pile.**

Ans:- The ultimate load carrying capacity for the pile group taken as a block is given by

$$Q_{ug} = (C_{ub}*N_c*A_b) + (P_b*L*C_u')$$

$$= (2.1*2.1*35*9) + (4*2.1*10*35) = 4329.15 \text{ Kn}$$

Q_{all} = 4329.15/2.5 = 1731.66 kN

The load carrying capacity of the pile group may also be evaluated as

$$Q_u = (C_p*N_c*A_p) + (\alpha*C*A_s)$$

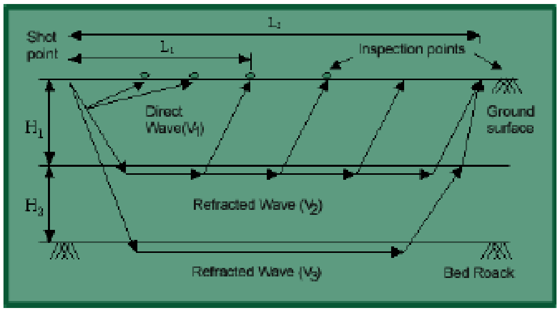
$$= [(35*9*0.3*0.3*\pi/4) + (0.6*35*\pi*0.3*10)]\ 9 = 1981.62 \text{ kN}$$

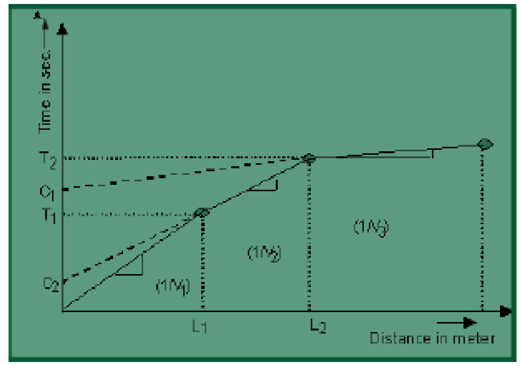
Q_{all} = 1981.62 /2.5 = 792.65 kN

Hence the individual pile governs the design and allowable load on the pile group = 792.65 Kn.

3 (a) **Explain seismic refraction method of soil exploration with neat sketch.**

Ans:- This method is based on the fact that seismic waves have different velocities in different types of soils (or rock) and besides the wave refract when they cross boundaries between different types of soils. Shock waves are created into the soil by exploding small charges or by striking a plate on the soil with a hammer. These waves are classified as direct, reflected and refracted waves. Radiating shock waves are picked up by geophones, where the time of travel gets recorded. Either a number of geophones are arranged along a line or shock producing device is moved away from the geophone. The direct wave travel in approximately straight line from the source of impulse. The reflected and refracted wave undergoes a change in direction when they encounter a boundary separating media of different seismic velocities. Results are plotted as a graph shown in figure below. This method is suited for the shallow explorations for civil engineering purpose.





Seismic refraction method **Graph of Time vs Distance**

3 (b) Estimate the ground water level by Hvorslev's method using the data given. Depth up to which water is bailed out is 30m, rise in water level after first day is 2.2m, second day 1.8m and on third day it is 1.5m.

Ans:- $H_o = h_1^2/(h_1 - h_2) = 2.2^2 / (2.2 - 1.8) = 12.1$ m

$H_1 = h_2^2/(h_1 - h_2) = 1.8^2 / (2.2 - 1.8) = 8.1$ m

$H_2 = h_3^2/(h_2 - h_3) = 1.5^2 / (1.8 - 1.5) = 7.50$ m

1^{st} day $h_{w1} = H_w - H_o =$ <u>17.9 m</u>

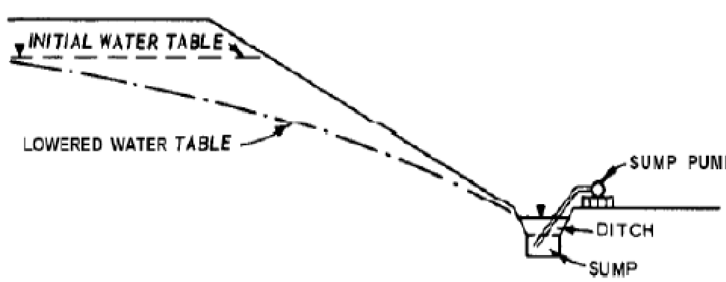
2^{nd} day $h_{w2} = H_w - (h_1 + h_2) - H_1 =$ <u>17.9 m</u>

3^{rd} day $h_{w3} = H_w - (h_1 + h_2 + h_3) - H_2 =$ <u>17 m</u>

$h_w = (h_{w1} + h_{w2} + h_{w3})/3 =$ <u>17.6 m</u>

3 (c) List out the methods of dewatering. Explain any two methods of dewatering with neat sketch.

Ans:- ***1. Open Excavation by Ditch and Sump***



Widely used method and economical method for installation and maintenance.

✓ Can be applied for most soil and rock conditions whose permeability > 10^{-3} cm/s.

✓ Shallow pits called sumps are dug along the periphery of the are-drainage ditches.

✓ Water from slopes or sides flows under gravity and is collected in the sumps from which it is pumped out.

2. Vacuum method

Fine-grained soils with permeability in the range of 0.1 –10 x 10 -3 mm/s can be dewatered satisfactorily by applying a vacuum to the piping system.

- ✓ A vacuum dewatering system requires that the well-point screens, and rise a pipe be surrounded with filter sand extending to within a few metres of the ground surface.
- ✓ A hole of 25 cm dia is created around the well point and the rise pipe by jetting of water under pressure.
- ✓ While the jetting is still flowing, medium to coarse sand is shoveled into the hole to fill about 0.75 to 1 m from the top.
- ✓ Top portion is then sealed using bentonite, soil-cement or clay.
- ✓ Vacuum pumps are used to create a vacuum in the sand filling.
- ✓ Although the quantity of water drawn out does not increase much, the unbalanced atmospheric pressure acting on the ground surface consolidates the sub-soil which makes the soil stiff for carrying out excavations.