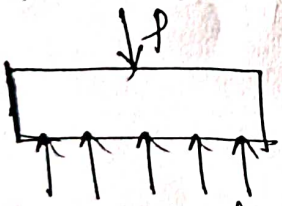
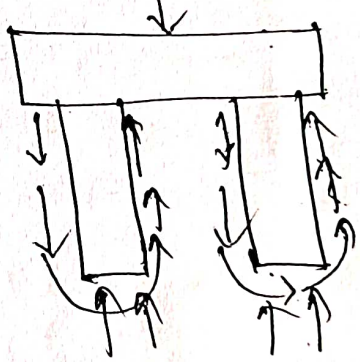
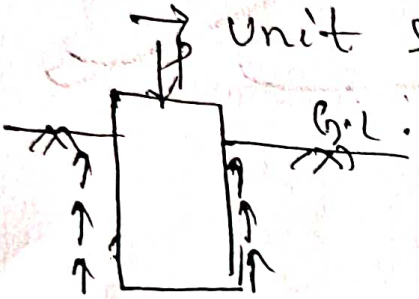
Q:- Difference between Deep & Shallow foundation:-

Shallow Foundation	Deep Foundation
1/ $D_f \leq B$. Where, D_f = Depth of foundation, B = width of found^n	1/ $D_f > B$
2/ vertical compressive load by bearing capacity q_f of foundation soil. 	2/ vertical compressive load by bearing capacity & ~~screen~~ skin friction. 
3/ Horizontal load by friction develop at the soil foundation interface.	3/ Horizontal load by lateral earth pressure develop at the soil foundation interface.
4/ Moments by redistribut^n of bearing pressure.	4/ By converting them to axial compaction & uplift pressure.

Q:- Explain friction pile.

(i) Friction Pile :-

→ The friction pile transfer the entire load to the surrounding soil. The sorrounding soil supports the load due to the skin friction develop between the soil & pile surface.



→ Unit skin friction = $\frac{\text{skin friction}}{\text{unit area of pile surface}}$

= Shear strength of soil.

Unit skin friction is denoted as 'τ_f'.

→ Load taken by friction pile = $\pi d L \tau_f$

$$\boxed{\tau_f = \alpha \cdot C_u}$$

→ Frictional piles are used to transfer loads to the soil sorrounding pile length.

→ The ultimate load bearing capacity

$$\boxed{Q_{up} = A_s \times \tau_f}$$

where, A_s = Surface area of pile.

α = Adhesion factor.

Q:- A group of 9 piles with 3 piles in a row was driven into soft clay extending from ground level to a great depth. The diameter & length of piles were 30 cm & 10 m respectively. The ~~unconfined~~ compressive strength of clay is 70 kN/m² unit cohesion. If the piles were spaced at 90 cm c/c. compute the allowable load on the pile group on the basis of shear failure criteria for a f.o.s of 2.5. Neglect bearing at the tip of pile. Take m = 0.6 for shear mobilization around its soil.

Date – 25/02/2020

Soln

$n = 9$

$d = 30 cm$

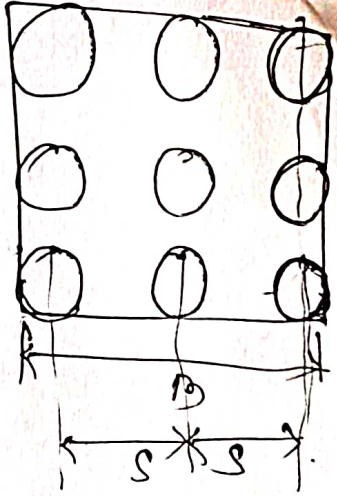
$L = 10 m$

$C_u = 70 kN/m^2$

$s = 90 cm$

F.O.S = 2.5

$\alpha_{cum} = 0.6$



$B = 2S + d$

$= 2 \times 90 + 30$

$= 210\ cm$.

Piles acting individually,

$Q_{ug} = Q_{un} = n \times Q_{up}$

$Q_{up} = A_s \tau_f + \cancel{A_p \tau_p}^{\,0}$

$Q_{up} = A_s \tau_f$

$= (\pi d L) \times \alpha \cdot c_u$

$Q_{ug} = Q_{un} = n \times Q_{up}$

$= 9 \times (\pi d L) \times \alpha \cdot c_u$

$= 9 \times (\pi \times 0.3 \times 10 \times 0.6 \times 70)$

$= 3562.57\ kN$ —— (1)

Pile acting as a group,

$Q_{ug} = A_s \tau_f + \cancel{A_p \tau_p}^{\,0}$

$= P \cdot L \cdot \tau_f$

$= 4 \cdot B \cdot L \cdot \tau_f$

$= 4 \times 2.10 \times 10 \times 0.6 \times 70$

For grouping action adhesion factor, $\alpha = 1$,

Then $M_f = \alpha \times C_u = C_u$.

$$Q_{ug} = 4 \times 2.10 \times 10 \times 70 = 5880 \quad \text{—— (2)}$$

Lesser of (1) & (2) i.e. 3562.6 KN.

Allowable load,

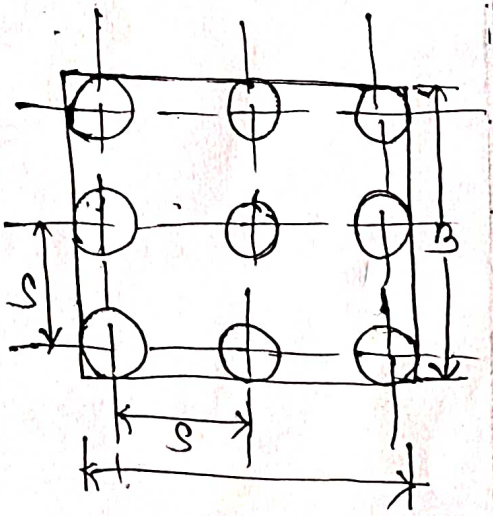
For safe load, Q_a or $Q_s = \dfrac{3562.6}{F}$

$$= \frac{3562.6}{2.5}$$

$$= 1425.04 \text{ KN}.$$

Q:- A square group of 9 piles was driven into soft clay extending to a large depth. The diameter & length of the piles were 30 cm & 9 m respectively. If the unconfined compression strength of clay is $9 t/m^2$ & is 100 cm c/c. What is the pile spacing of the group. Assume the capacity F.O.S 2.5 & adhesion factor 0.75.

Soln



$n = 9$

$d = 30 cm = 0.3 m$

$L = 9 m$

$q_u = 9 t/m^2$

$S = 100 cm$

$F = 2.5$

$\alpha = 0.75$

~~B = 2 × 100~~

$B = 2 \times 100 + 30$

$= 230\,cm$

$= 2.3\,m$

$C_u = \frac{q_u}{2} = \frac{9}{2}$

$= 4.5\ t/m^2$

Pile acting as individually,

$Q_{ug} = Q_{un} = n \times Q_{up}$

$= n \times \{A_s \cdot r_f + A_p \cdot r_p\}$

$= n \times \{(\pi d L) \times (\alpha \cdot C_u) + (\frac{\pi}{4} \times d^2) \times N_c \cdot C\}$

$= 9 \times \{\pi \times 0.3 \times 9 \times 0.75 \times 4.5 + \frac{\pi}{4} \times 0.3^2 \times 9 \times 4.5\}$

$= 283.4$ tonne —— (1)

Pile acting as a group,

$Q_{ug} = A_{sg} r_f + A_{pg} r_p$

$= 4 \cdot B \cdot L \cdot C + B^2 \times (N_c \times C)$

$= 4 \times 2.3 \times 9 \times 4.5 + 2.3^2 \times 9 \times 4.5$

$= 586.8$ tonne —— (2)

Lesser of (1) & (2) i.e. 283.4 tonne

$Q_s = \frac{283.4}{2.5}$

$= 113.36\ t$

Detailed site investigation :-

It consists of conducting test borings, collecting disturbed & undisturbed sample for lab test.

→ The field test may be conducted for determining the in-situ values of density, bearing, shear strength, permeability & ~~Pore~~ pore pressure.

Method of site exploration :-

1/ Direct method
2/ Indirect method.

1/ Direct method :-

Test pits & Trenches

2/ Indirect method :-

(i) Sounding test
(ii) Penetration test
(iii) Geophysical method.

Open Excavation :-

→ Test pit & trenches can be used for all type of soils.

5/ To obtain distributed & undistributed soil sample from different depth from visual observation & lab test.

6/ To conduct in-situ test such as vain-shear test.

Q: Planning for subsoil exploration at a site for construction of a structure:—

The planning is done in four stages:

1/ Information regarding the proposed structure:

(a) Load at footing.
(b) Load due to wall at foundation level.
(c) Type of structure.
(d) Requirement as per relevant code for bridge project span length, load on abutment & pier.

2/ Existing information ~~and~~ subsoil:—

(a) Geological map of India.
(b) Soil map of India
(c) Sub soil exploration report of nearby structure.

3/ Reconnaisance of the site:—

An inspection of the site & study of topographical features is obtained helpfull in getting usefull information about the soil & ground water condition & deciding the future programme of exploration.

Q:- What are the forces acting on well foundation?

Forces acting on well foundation:—

(I) Vertical load or forces:—

1/ Self weight of well & buoyancy
2/ Live load, dead load & super structure
3/ Dead load of pier.

(II) Horizontal forces on load:—

1/ Braking & tracking import of the moving vehicle.
2/ Force due to resistance of bearing
3/ Water current force.
4/ wind force
5/ Earthquake force
6/ Earth pressure
7/ Centrifugal force.

All the horizontal forces can be replaced by two horizontal forces P & Q & single vertical force 'W'.

Where, P = Resultant of all horizontal forces along the piers.

Dead Loads :-

The dead load carried by well include the weight of superstructure & self weight.

Live Load :-

The design of live loads on railway bridges are taken according to Indian railway bridges.

Impact Loads :-

Impact effect due to live load is considered only in the design of ~~pier~~ pier cap & bridge seat on the abutment.

Wind Loads :-

The wind loads act on the exposed area in elevation & thus it acts laterally on the bridge.

Water Pressure :-

Water pressure due to water current acts on the part of substructure which lies between the water level & maximum scour level. The intensity of water pressure is given by, $s = kv^2$

where, k = A constant depending upon the shape of well

V = velocity of current

s = Intensity of pressure.

Longitudinal Forces :-

Longitudinal forces occur due to ~~static &~~ tracking & breaking force. These forces depend upon the type of vehicles & bearing.

e → co-efficient of restitution

Q:- A reinforced concrete pile weighing 30kN (inclusive of helmet & dolly) is driven by a drop hammer weighing 40kN & having an effective fall of 0.8m. The average set per blow is 1.4cm. The total temporary elastic compression is 1.8cm. Assuming the co-efficient of restitution as 0.25. A factor of safety of 2. Determine the ultimate bearing capacity & allowable load for pile.

Soln)

$W = 40kN$.

$P = 30kN$.

$\eta_h \cdot H = 0.8m = 80cm$

$s = 1.4cm$

$c = 1.8cm$.

$e = 0.25$

$F = 2$.

$e \cdot P = 0.25 \times 30 = 7.5$

so, $W > e \cdot P$

$$\eta_b = \frac{W + e^2 P}{W + P} = \frac{40 + (0.25)^2 \times 30}{40 + 30}$$

$$= 0.598$$

$$Q_f = \frac{(\eta_h \cdot H) W \eta_b}{s + c/2} = \frac{80 \times 40 \times 0.598}{1.4 + 1.8/2}$$

$$= 832 \text{ kN}$$

$$Q_a = \frac{Q_f}{F}$$

$$= \frac{832}{2}$$

$$= 416\ kN.$$

Q:- In a 16 pile group the pile diameter is 45 cm & c/c spacing of the square group is 1.5 m is $c = 50\ kN/m^2$. Determine whether the failure would occur with the pile acting individually or as a group. Neglect bearing at the tip of the pile. All piles are 10 m long. Take $m = 0.7$ for shear mobilization around each pile.

Sol^n)

$n = 16$

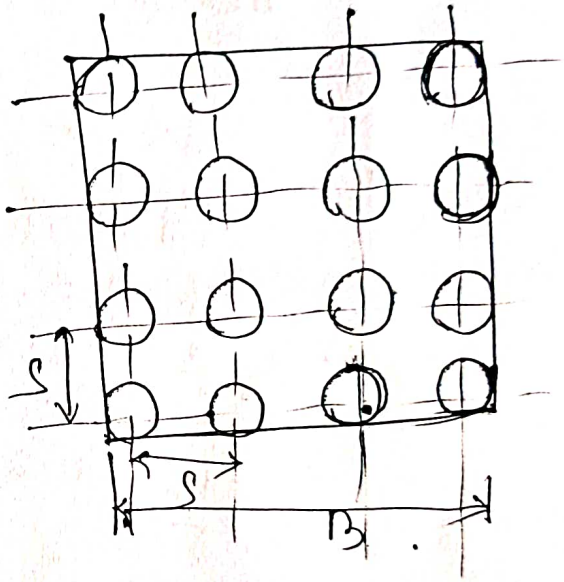
$S = 1.5\ m$

$d = 45\ cm = 0.45\ m$.

$c = 50\ kN/m^2$.

$m = 0.7$.

$L = 10\ m$.



$$B = 3S + d$$

$$= 3 \times 1.5 + 0.45$$

$$= 4.95\ m$$

Pile acting as individually,

$$Q_{ug} = n \times Q_{up}$$

$$= n \times \{ A_s \tau_f + A_p \tau_p \}$$

$$= 16 \times \{ (\pi d L)\ \alpha . c_u \}$$

$$= 16 \times (\pi \times 0.45 \times 10 \times 0.7 \times 50)$$

$$= 7916.81\ kN \quad \text{—— (1)}$$

Pile acting as a group,

$$Q_{ug} = A_{sg} C_{sg} + \cancel{A_{pg} C_{pg}}^{\,0}$$

$$= 4B \cdot L \times c$$

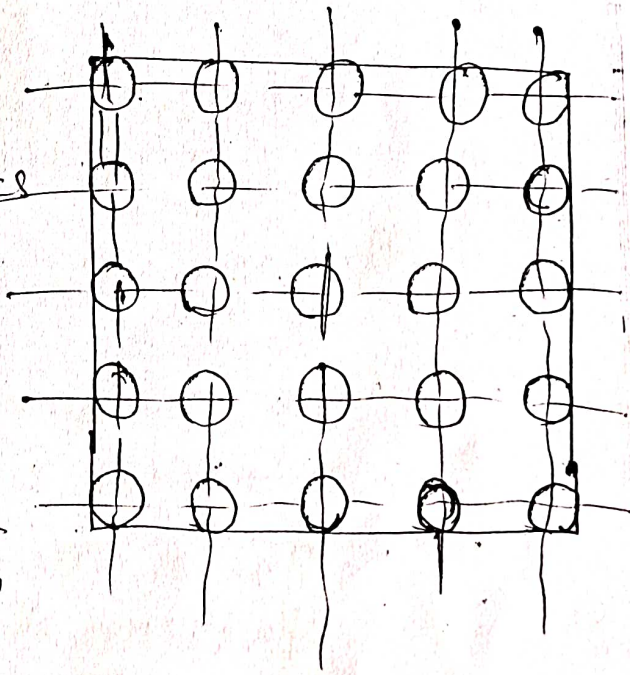
$$= 4 \times 4.95 \times 10 \times 50$$

$$= 9900 \text{ KN} \quad \text{——— (2)}$$

From Eq(1) & (2), Allowable load bearing capacity is 7916.81 KN.

Q:- An end pile group has to be proportion in uniform pattern in soft clay with equal spacing s in all direction. Assuming any value of c, determine the optimum value of spacing of piles in the group. Take n = 25 & m = 0.7. Neglect the end bearing effect. Assume that each pile is circular in section.

Sol:



Let c/c each spacing of pile = s

Diameter of each pile = d

Width of each pile = 4s + d

Length of pile = L

Load carried by pile acting individually,

$$Q_{un} = n \times Q_{up}$$

$$= n \times \{A_{sn} C_{sn} + \cancel{A_{pn} C_{pn}}^{\,0}\}$$

$$= 25 \{(\pi d L)(\alpha \cdot c)\}$$

$$= 25 \pi \times d \times L \times 0.7 \times c$$

$$= 55 L d c \quad \text{——— (1)}$$

Load carried by group action,

$$Q_{ug} = Q_{up}$$

$$= A_s f_s + \cancel{A_p f_p}^{\,0}$$

$$= 4BL \times C$$

$$= 4(4s+d)L \times C$$

$$= 4CL(4s+d) \quad \text{——— (2)}$$

Equating Eq^n (1) & (2)

$$4\cancel{C}\cancel{L}(4s+d) = 55\cancel{L}d\cancel{C}$$

$$\Rightarrow 4(4s+d) = 55d$$

$$\Rightarrow 16s + 4d = 55d$$

$$\Rightarrow s = \frac{55d - 4d}{16}$$

$$\Rightarrow s = 3.19d$$

Spacing should be equal to 3.19 times diameter of pile.