Negative skin friction

Negative skin friction is a downward drag acting on a pile due to the downward movement of the surrounding compressible soil relative to the pile.

This happens when the surrounding compressible soil has been recently filled are formed.

As the soil consolidates, the earth fill moves down ward, developing friction forces on the perimeter of the pile which tends to carry the pile farther in to the ground.

The negative skin friction may also be develop by the lowering of the ground water, the increase in effective stress causing consolidation of the soil, with the resultant settlement and friction force being developed on the pile.

For individual piles, the magnitude of negative friction Q_{nf} may be taken as follows.

(i) for cohesive soils. $Q_{nf} = P \cdot C \cdot L_f$

(ii) for granular soils. $Q_{nf} = \frac{1}{2} L_f^2 \gamma K \cdot f$

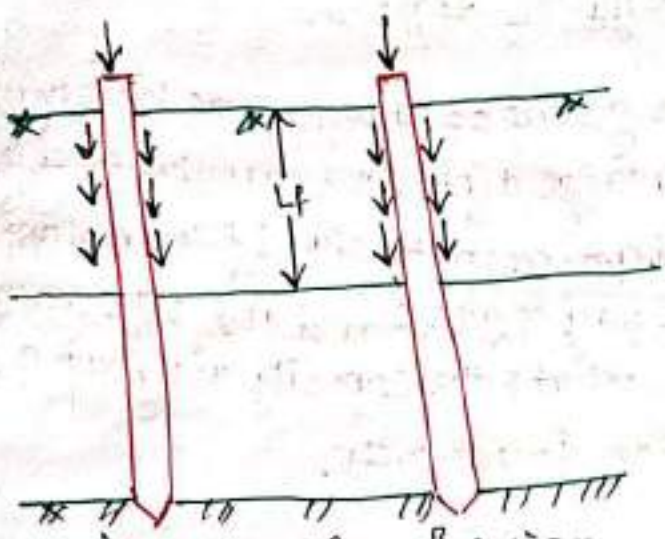
Where P = perimeter of the pile.

L_f = depth of fill or soil which is moving down ward.

C = Cohesion of soil in zone of L_f.

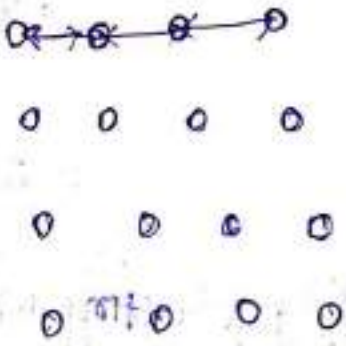
K = earth Pressure coefficient ($K_a < K_o < K_p$)

γ = unit weight of soil. f = Coefficient of friction $= \tan\phi$



Example 26.2

In a 16 pile group, the pile diameter is 45cm and centre to centre spacing of the square group is 1.5m. If $c = 50 kN/m^2$, determine whether the failure would occur with the pile acting individually or as a group? Neglect bearing at the tip of the pile. All pile are 10m long. Take $\eta = 0.7$ for shear mobilisation around each pile.



Solution.

$n = 16$; $d = 45cm$; $L = 10m$.

Width of group $B = (1.5 \times 3) + 0.45$

$= 4.95m$

(i) For the group

$Q_{ug} = PL\alpha f + A_p q_p = 4BLC = 50 \times 10 \times 4 \times 0.495$

$= 990 kN$.

(ii) For the pile acting individually

$Q_{ug} = nQ_{up} = n\{A_s C f + A_p q_p\} = n\{A_s \times c \times m\}$

$A_s = \pi dL = \pi \times 0.45 \times 10$

$Q_{ug} = 16 \times 0.7 \times 50 \times \pi \times 0.45 \times 10 = 791.7 kN$

which is less than the load carried by the group action, hence the foundation will fail by the piles acting individually, and

the load at failure would be 7917 kN.

Example 26.14. A square group of 9 piles was driven into soft clay extending to a large depth. The diameter and length of piles were 30cm and 9m. respectively. If the unconfined compression strength of clay is 9 t/m² and the pile spacing is 100 cm centre to centre. what is the capacity the group? Assume f.o.s of 2.5 and adhesion factor 0.75.

Solution:-

$$B = 2 \times 100 + 30 = 230\,cm = 2.3\,m.$$

$$c_u = q_u/2 = 9/2 = 4.5\ t/m^2$$

(a) Pile acting individually

$$Q_{uv} = n\{A_s \pi f + A_p r_p\}$$

$$= 9\{8.4823 \times 3.375 + 0.07069 \times 40.5\}$$

$$= 283.4\ t$$

$$A_s = \pi d L = \pi \times 0.3 \times 9 = 8.4823\ m^2$$

$$A_p = \pi/4 (0.3)^2 = 0.07069\ m^2$$

$$r_p = c_p N_c = 9 \times 4.5 = 40.5\ t/m^2$$

$$r_f = \eta c_u = 0.75 \times 4.5 = 3.375\ t/m^2$$

(b) Pile acting in a group

$$Q_{ug} = A_s \cdot r_f + A_p r_p$$

$$= P.L. \times c_u + B^2 \times 9 c_p$$

$$= 4BXL \times c_u + B^2 \times 9 c_p$$

$$= 4 \times 2.3 \times 9 \times 4.5 + 5.29 \times 40.5$$

$$= 586.85\ t$$

lesser of the two = 283.4 t

load capacity = $\frac{283.4}{2.5} = 113.36$ t.

Well foundation

well foundation is a type of deep foundation which is generally provided below the water level for bridges.

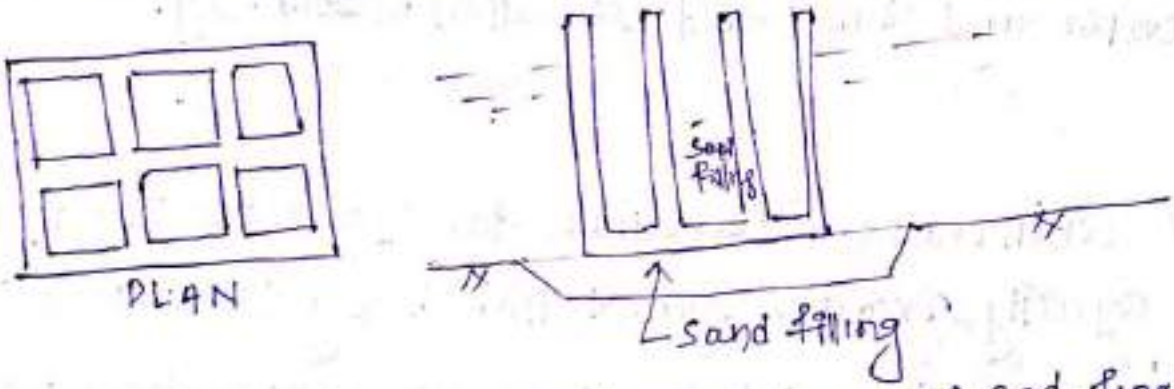
Caisson has come to mean a box like structure, round or rectangular, which is sunk from the surface of either land or water to some desire depth.

the caissons are of three types

(i) Box caissons
(ii) open caissons (wells)
(iii) Pneumatic caissons.

Box Caissons

A box caissons is open at top and closed at the bottom and is made of timber, reinforced concrete or steel.



This caisson is built on land, then launched and floated to pier site where it is sunk in position.

USED

→ @ the bearing stratum is available at shallow depth
→ Loads are not very heavy
→ It is also used for break waters and sea walls

Open caissons (wells)

An open caisson is a box of timber, metal, reinforce Concrete or masonary which is open both at the top and at the bottom, and is used for building and bridge foundations.

open caissons are called wells.

well foundations form the most common type of deep foundations for bridge in India.

Pneumatic caisson

Its lower end designed as a working chamber in which compressed air is forced to prevent the entry of water and thus permit excavation in dry.

→ Whenever consideration for scour or bearing capacity require foundation being taken to a depth of more than 5 to 7 meters, open excavation becomes costly and uneconomic as heavy timbering has to be provided.

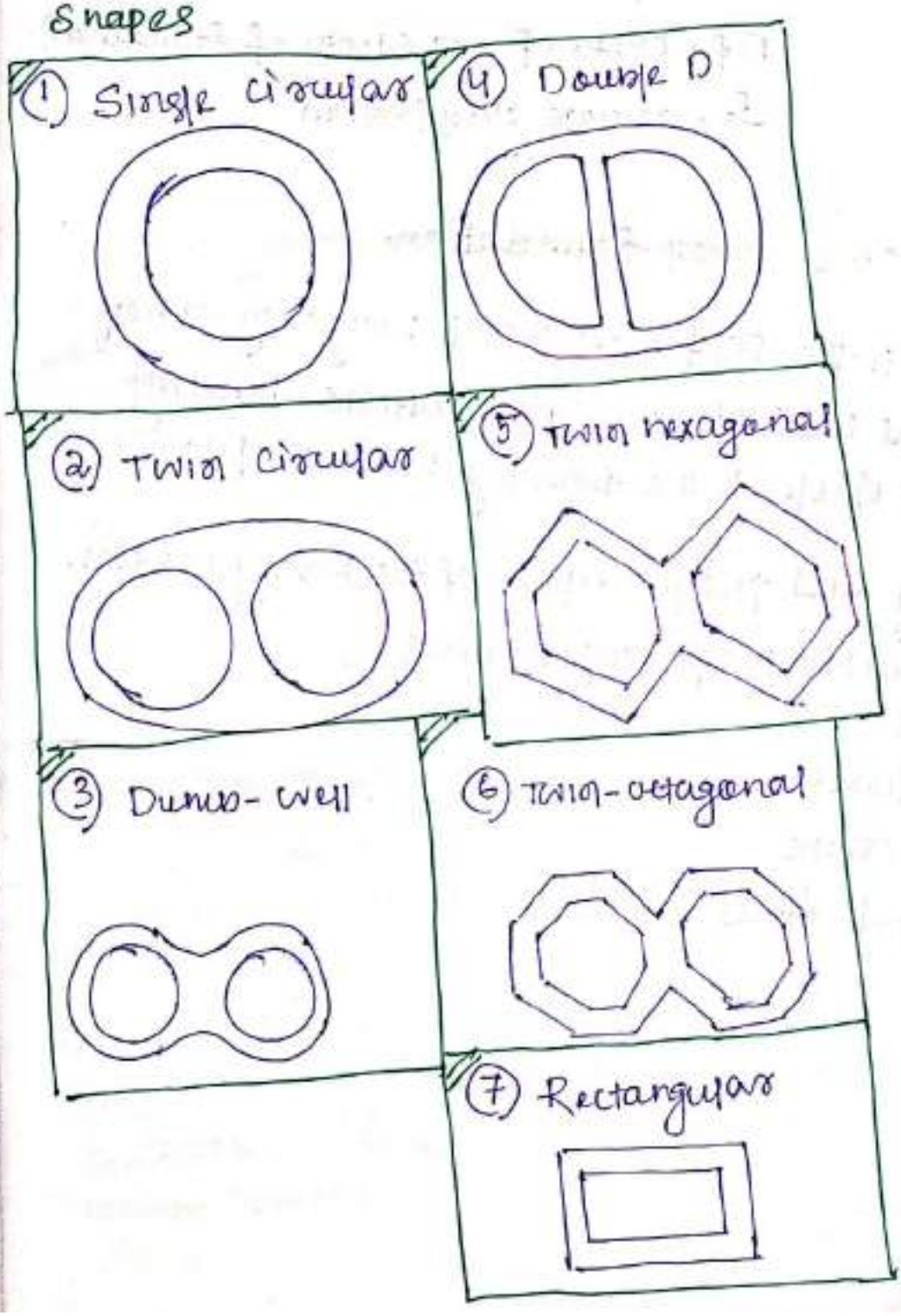
→ Because of the greater earth work involved due to a depth of more than 5 to 7 meters, side slopes, the progress of the work in open excavation will be very slow.

In ordinary type of footing is that excavated material refilled around the structure is loose and hence easily scourable as compared to natural ground.

The above disadvantages are avoided in a well foundation which is a shell sunk by dredging inside of it and which finally becomes a part of the permanent structure.

Shapes of wells and components parts

Shapes



Bearing capacity of well foundation

$$Q_f = Q_p + 2\pi R f_s D_f$$

$$Q_p = \pi R^2 (1.2 c N_c + \gamma D_f N_q + 0.6 \gamma R N_\gamma)$$

where N_c, N_q & N_γ = Terzaghi's bearing capacity factors.

R = radius of well

D_f = depth of well (depth of foundation)

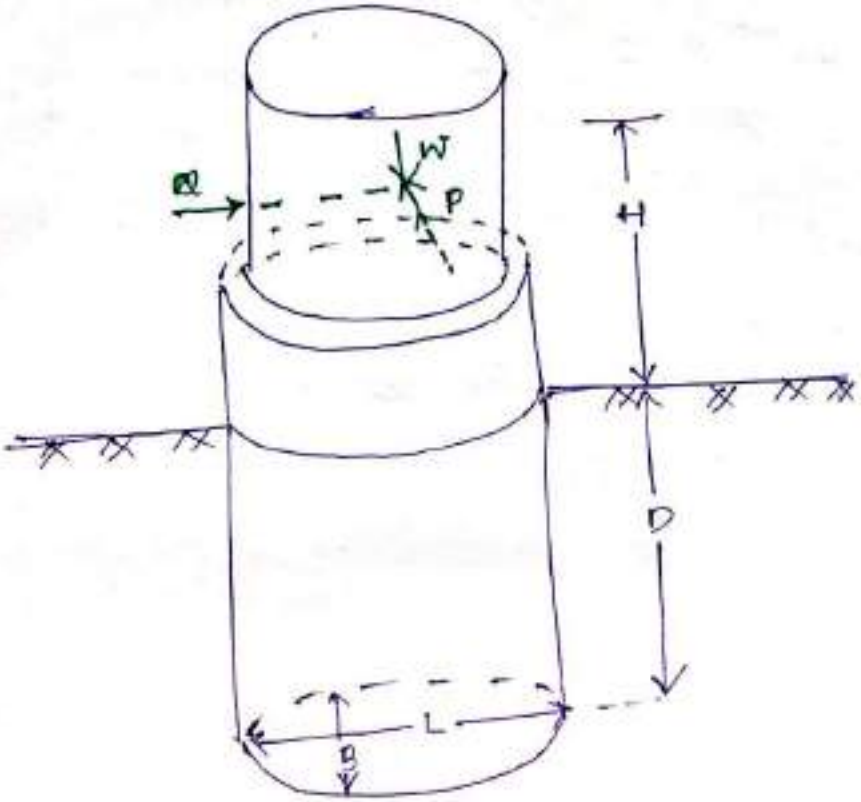
f_s = average skin friction

Forces acting on a well foundation

In addition to the self-weight and buoyancy, a well carries the dead load of the superstructure, bearing pier and is liable to the following horizontal forces

(i) braking and traction effect of the moving vehicles.
(ii) forces on account of water current
(iii) wind forces
(iv) seismic forces
(v) earth pressure
(vi) centrifugal forces

the magnitude, direction and point of application of the above forces can be found under most possible combinations and they can be replaced by two horizontal forces, P & Q and a single vertical force W



The analysis is done on the following assumptions (Banerjee and Gangopadhyay; 1960):

(i) The well is acted upon by an uni-directional horizontal forces P in a direction across the pier.

(ii) The well is founded in Sandy stratum.

(iii) The resultant unit pressure on a unit at any depth is simple proportional to horizontal displacement.

(iv) The ratio between contact pressure and corresponding displacement is independent of the pressure.

(v) The co-efficient of vertical subgrade reaction has the same value for every point of surface acted upon by contact pressure.

Analysis of well foundation

1. Horizontal soil reaction