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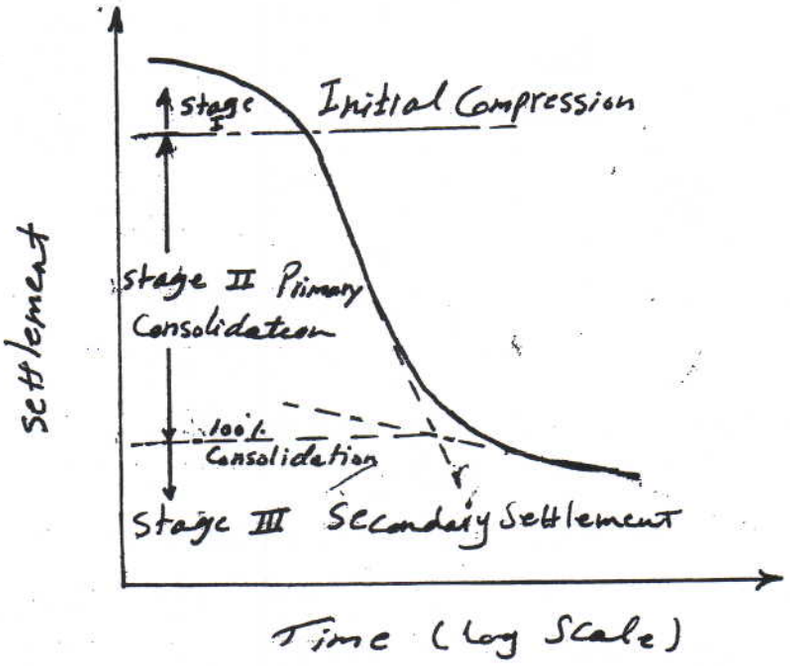
Settlements of Shallow Foundations :-

In general, The settlement caused in soil due to loadi may be divided into three categories. The shape of the plot of settlement (deformation) of the sample against time for a given load increment is shown in fig below.



From the plot, it can be observed that there are three stages, which is may described as below?

Stag I : Initial Compression: which is mostly take pla during or immediately after, the construction, of structure.

Stage II : Consolidation Settlement : It is time dependent an takes place as the result extrusion of the por water from the void spaces of the clayey soil.

Stage III : Secondary Consolidation, which is occurs after complete dissipation of excess pore water, when some deformation of the samples take place owing to plastic re-adjustment of soil fabric.

The total settlement is the sum of immediate or elastic Settlement, Consolidation Settlement and Seconda settlement.

1- Immediate or Elastic Settlement: (S_i)

which is due to elastic deformation of dry soils and of moist soils without any change in water content.

Immediate settlement calculation are generally based on eqs. drive from the theory of elasticity.

a- For Foundation on deep clay clayer immidate settle.i

$$S_i = f_i = \frac{q \cdot B\,(1-\nu^2)}{E_s} I_p$$

f_i = elastic settlement (m).

q = net pressure applied

B = width of Foundation

ν = poisson's ratio

E_s = modulus of elasticity of soil.

I_p = nondimensional influnce factor depend on the shape and stiffness of foundation.

Typical values of poissons rates (ν).

type of soil	ν
Saturated clay	0.4-0.5
Sandy clay	0.2-0.4
Sand of $\phi = 40^\circ$	0.2
$\phi = 25^\circ$	0.5

Values of undrained modulus of Elasticity E_s.

Type of soil	E_s kn/m²	Type of soil	E_s kn/m²
Soft clay	2000-5000	silty clay	7000-20000
Firm clay	4000-8000	Loose Sand	10000-2500
Hard clay	7000-20000	Dense Sand	50000-9000
Sandy clay	30000-40000	Dense gravel	100000-2000

b- Immediate settlement of a thin layer :-

IF the layer below the Foundation of a thikness less the twice the breadth, an over estimation will result, so for a lay of limited thickness, the following expression may be used t determine the average settlement under a Flexible Foundati

$$S_i = \frac{\mu_0 \mu_1 q B (1-\nu^2)}{E_s}$$

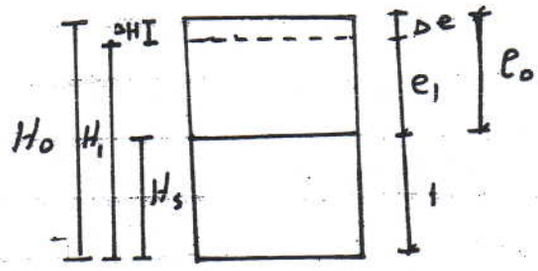
Values of $\mu_0 \mu_1$ are given in Fig.s and are dependent on the breadth and depth of Foundation and the thickness of layer below Foundation

2- Consolidation Settlement:-

Consolidation settlement occurs in saturated clayey soi when they are subjected to increased load caused by Founda Construction. The Final Consolidation Settlement can be Calculate using any of the following expressions:-

$$S_c = \Delta H = \frac{\Delta e}{1+e_0} \times H_0 \quad \text{---} (1)$$

$$S_c = m_v H_0 \Delta P \quad \text{---} (2)$$



when

$$m_v = \frac{1}{1+e_0} \cdot \frac{e_0 - e_1}{P_1 - P_0} \quad m^2/KN.$$

$$S_c = \frac{C_c}{1+e_0} H \log \frac{P_0' + \Delta P}{P_0'} \text{ --- (3) For normally Consolidation clay}$$

$$S_c = \frac{C_s}{1+e_0} H \log \frac{P_0' + \Delta P}{P_0'} \text{ --- (4) For Over Consolidation clay if } P_c > P_0' + \Delta P$$

$$S_c = \frac{C_s}{1+e_0} H \log \frac{P_c}{P_0'} + \frac{C_c}{1+e_0} H \log \frac{P_0' + \Delta P}{P_c} \text{ (5) For o.c.c.}$$

$$\text{IF } P_0' \leq P_c \leq P_0' + \Delta P$$

Where:-

Normally Consolidated clay N.c.c: whose present effective over burden pressure is equal that which the soil has been subjected in the past.

over Consolidated clay O.C.C.: whose present effective over burden pressure is less than that which the soil has exposed in the past. The max. past effective overburden pressure is called the preConsolidation pressure.

- Compression Index C_c: is the slope of linear porsion of e-log plot.

$$C_c = \frac{e_0 - e_1}{\log \frac{P_1'}{P_0'}}$$

Terzaghi suggested the following empirical expression for undist clay: $C_c = 0.009\,(L.L - 10)$. & for remolded clay $C_c = 0.007\,(L.L - 10)$.

- Swelling Index C_s: is the slope of a straight line for the expansive part of e-log p' part.

$$C_s \cong \frac{1}{5} - \frac{1}{10} C_c$$

- overConsolidation ratio O.C.R: it can be defined as

$$O.C.R = \frac{P_c}{P_0'}$$

- Pre-Consolidation P_c: It is max. pressure has the soil subjected in in the past. It is determined from e-logp plot