2.2CAPILLARY WATER:

It is held in the inter space of soil due to capillary forces. Capillary action (or) Capillarity is the phenomenon of movement of water is the interstices of a soil due to capillary forces. The minute pores of soil serve as capillary tubes through which the moisture rises above the ground water table.

The capillary force depends on surface tension of water, pressure in water and size of pores.

2.2.1 CAPILLARY RISE:

The capillary water is held in the intersices of soil due to capillary forces. Capillary action (or) Capillarity is the phenomenon of movement of water between the voids of the soil due to capillary forces.

The minute pores of soil serve as capillary tubes through which the moisture rises above the groundwater table.

The capillary force depends on surface tension of water, pressure in water and size of pores.

The rise of water in the capillary tube is due to the existence of surface tension is called as capillary rise.

Weight of water for the capillary rise height $W_w=\rho_w$ g X volume

$$= \rho_w g X \frac{\pi d^2}{4} X h_c - - - - - - - - (1)$$

Vertical component of surface tension=$T_s\cos\theta$

Surface tension force = surface tension X length

$= T_s\cos\theta$ X πd--------(2)

At equilibrium (1)&(2)

$$\rho_w g X \frac{\pi d^2}{4} X h_c = \text{Tscos}\theta \text{ x}\pi\text{d}$$

Height of capillary water,

$$h_c = \frac{4Ts}{\gamma_w d}$$

where, h_c = height of capillary rise

at 4°C, of water $h_{c\ max} = \frac{0.3084}{d}$ cm

at 20°C, of water $h_{c\ max} = \frac{0.2975}{d}$ cm

2.2.2 CAPILLARY TENSION (OR) CAPILLARY POTENTIAL:

It is to be noted that the water in the capillary tube,

- ⟶ Above the G.W.L., (or) free water surface will be in state of Tension.
- ⟶ Below the G.W.L., (or) free water surface will be in hydrostatic compression as usual.

At any height 'h' above the W.T.,

Stress , $u = -h\gamma_w$ (minus sign for tension)

Max, magnitude of the stress 'u' will depend on the radius 'R'of themeniscus.

The relationship between 'd' and 'R' is

$\underline{d} = R\cos\alpha 2$

$d = 2R\cos\alpha$

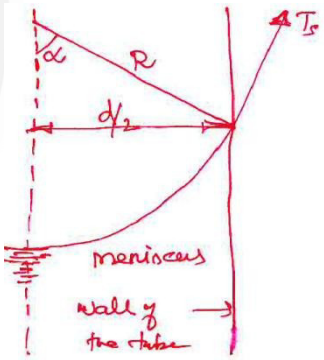

Fig 2.4 capillary tension

$$h_c = \frac{4T_s}{2R\gamma_w}$$

u_c = max., tension at the level of meniscus= $\gamma_w h_c$

$$= \frac{\gamma_w 4T_s}{\gamma_w 2R}$$

$$= \frac{4T_s}{2R}$$

$$u_{c(\max)} = \frac{2T_s}{R}$$

$$u_{c(\max)} = \frac{4T_s}{d}$$

The tensile stress caused in water is called the capillary tension (or) the capillary potential. It is the pressure deficiency (or) pressure reduction (or) negative pressure in the pore water (pressure below atmospheric) by which water is retained in a soil mass. It decreases linearly from a max., value of $\gamma_w h_c$ at the level of meniscus to zero value at the free water surface.

2.2.3 SOIL SUCTION:

The pressure deficiency in the held water is also termed as soil suction (or) suction pressure.

It is measured by the height 'h_c' in 'cm' to which a water column could be drawn by suction in a soil mass free from external stress. The common logarithm of this height (cm) or pressure (g/cm^2) is known as PF value.

$$PF = \log_{10}(h_c)$$

PF = 2, Soil suction = 100 cm of water.

Suction pressure=100 g/cm^2.

2.2.4 FACTORS AFFECTING SOIL SUCTION:

1) **Particle size of soil:**

Smaller the size of the particles, smaller will be the pore size with small radii of menisci, resultingin greater capillary rise and hence greater suction.

2) **Water content**:

Smaller the w/c, greater will be the soil suction. Soil suction will attain its maximum value whenthe soil is dry.

3) **Plasticity Index of soil:**

For a given w/c, soil suction will be greater in a soil which has greater plasticity index (Ip) than inthe one which has lower Ip.

4) **History of drying and wetting:**

For the same soil, suction is greater during drying cycle than during wetting cycle.

5) **Soil structure:**

The size of interstices in a soil depends on the structure of the soil. Change in the

structure of soil result in the change in the size of interstices and hence change in soil suction.

6) Temperature:

Rise in temperature results in decrease in Surface Tension (Ts) and hence decrease in soil suction. Similarly, fall in temperature results in increase of soil suction

7) Denseness of soil:

Increase in denseness of soil results in decrease in the size of the pores of the soil and hence increase in soil suction. At low density, the soil will be relatively loose, with the larger size pores resulting in decrease in soil suction.

8) Angle of contact:

The mineralogical composition of soil governs the angle of contact between the soil particles and water. Soil suction decreases with increase in the angle of contact (α). α = 0, soil suction is maximum depends on h_c.

9) Dissolved salts in pore water:

Impurities such as dissolved salts etc., increase the surface tension resulting in increase of soil suction.

Problem

1) Compute the maximum capillary tension for a tube be 0.05 mm in diameter.The maximum capillary height at 4 ^{0}C

$$(h_{cmax}) = \frac{0.3084}{d}$$

$$= \frac{0.3084}{0.005}$$

$$= 61.7cm = 0.617\ m$$

$$\text{capillary tension} = (h_{cmax})\gamma_w = 0.617x9.81$$

$$= 6.05\ KN/m^3$$

2) The internal diameter of a tube is 0.1mm what will be the maximum capillary rise when it held vertical with bottom end dipped in pure water taken in a trough? Also compute the maximum capillary tension if the temperature of water is 20^0C.

Given:

d=0.1mm=$0.1x10^{-3}$

For 20^0C, Ts=$72.8x10^{-6}$ KN/m

Pure water, θ=0

$$h_c = \frac{4T_s cos\theta}{d\gamma_w}$$

$$= \frac{4x72.8x10^{-6}cos0}{(0.1x10^{-3})x9.81} = 0.297m$$

Maximum capillary tension=$h_c\gamma_w$

=0.297x9.81

=2.91 KN/m^2