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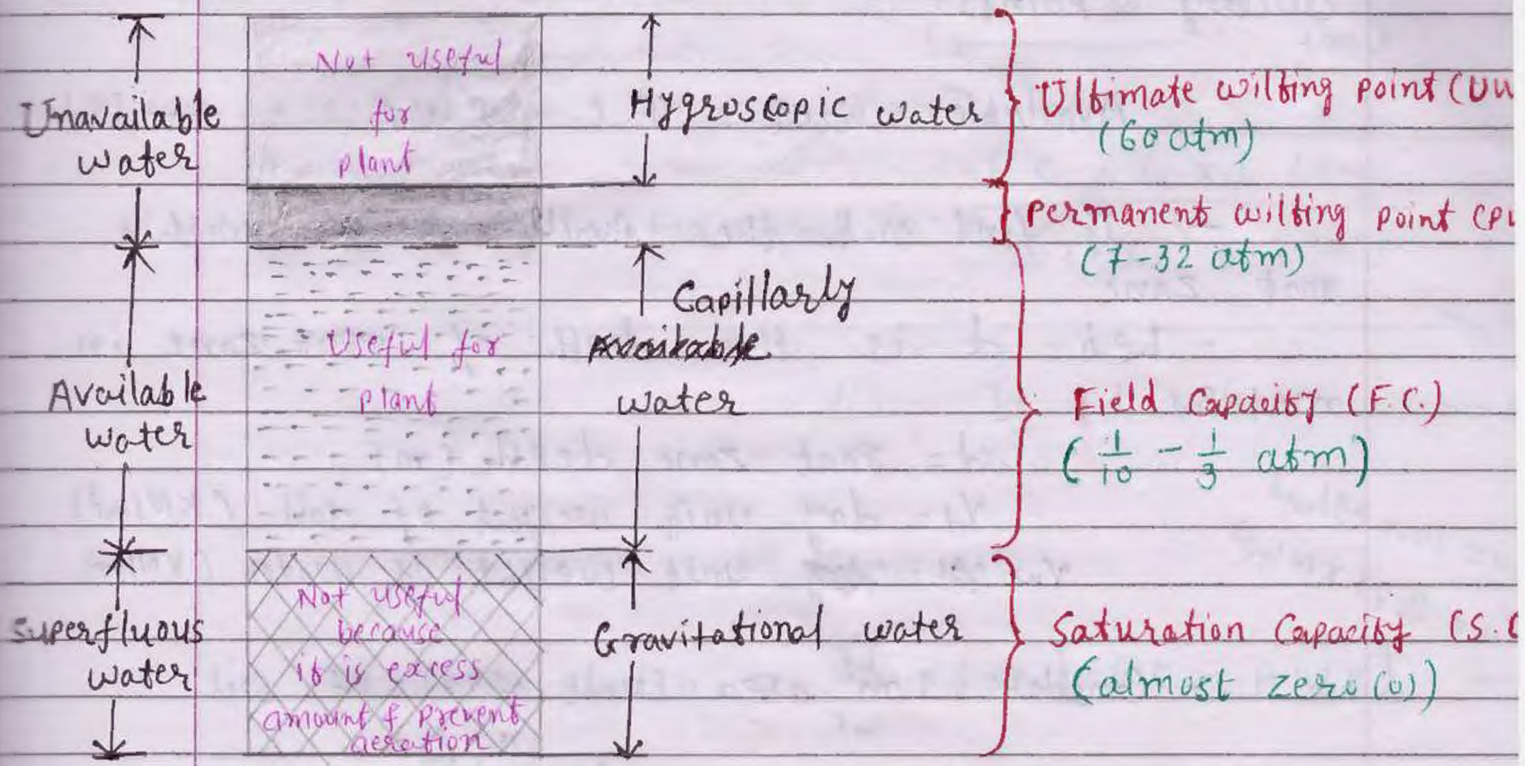
8.) Soil moisture deficiency

- It can be define as the requirement of water to bring (लाना) the soil moisture content of the soil to its field capacity. (F.C.)



* F.C., PWP & available water range for different soils

	F.C.	PWP	Available water
Fine Sand	3-5	1-3	2-4
Sandy loam	5-15	3-8	4-11
Silt loam	12-18	6-10	6-13
Clay loam	15-30	7-16	10-18
Clay	25-40	12-20	16-30

* How to calculate the available water stored in the root zone of plants?

- We know that the available water is difference between field capacity & permanent wilting point

$$\text{Available water} = F.C. - P.W.P. \quad \text{---}($$

- To find out the available water within root zone
- Let d is the depth of root zone in meters

d = root zone depth (m)

$\gamma_w = 1000\ kg/m^3$, $\gamma_w = 9.81\ kN/m^3$

γ_d = dry unit weight of soil (kN/m^3)

γ_w = unit weight of water (kN/m^3)

- Consider $1\ m^2$ area (unit area) of soil

Now, (As per volume)

$$F.C. = \frac{\text{weight of water in } 1\ m^3 \text{ (unit volume)}}{\text{weight of soil in } 1\ m^3 \text{ (unit volume)}}$$

$$F.C. = \frac{\text{weight of water in } 1\ m^3 \text{ (unit vol)}}{1\,(m^2) \times d\,(m) \times \gamma_d\,(kN/m^3)}$$

So,
$$F.C. = \frac{\gamma_w \times d_w \times 1\ m^2 \text{ (unit area)}}{\gamma_d \times d \times 1\ m^2 \text{ (unit area)}} = \frac{\gamma_w}{\gamma_d} \times \frac{d_w}{d}$$

Volume = Area × depth
$V = A \times d$

$\gamma_w \times$ $$d_w = \frac{\gamma_d}{\gamma_w} \times d \times F.C.$$ — (

Now,

$$\text{Available water} = \frac{\gamma_d}{\gamma_w} \times d \times [F.C. - P.W.P.]$$ —

Kept in mind → $$A.W. = G \times d \times [F.C. - P.W.P.]$$ —

where,

G = Apparent spe. gravity = $\frac{\gamma_d}{\gamma_w}$

d = root zone depth (m)

F.C. = Field capacity (decimal)

P.W.P. = permanent wilting point (decir

Ex-3.2 Punamia (52)

The root zone of an irrigation soil has dry weight of 15 KN/m³ & a field capacity of 30%. The root zone depth of a certain crop, having permanent wilting percentage of 8%. is 0.8 m. Determine

a - Depth of moisture in the root zone at field capacity

b - Depth of moisture in the root zone at permanent wilting point

c - Depth of available water.

Solⁿ:

Given data;

γ_d = dry unit weight = 15 KN/m³

F.C. = 30% = 0.3

d = root zone depth = 0.8 m

P.W.P. = 8% = 0.08

Aw @ F.C. = ?

Aw @ P.W.P. = ?

Aw = ?

a.) Available water / depth of moisture in the root zone per metre depth @ field capacity

- we know that

$$Aw \text{ @ } F.C. = \frac{\gamma_d}{\gamma_w} \times d \times F.C.$$

$$= \frac{15}{9.81} \times \quad \times 0.3$$

= 0.459 m/m

= 459 mm/m

Ex-3.3 B.C. Punamia (52) The field capacity of a certain soil is 15% & the moisture content of the soil before irrigation is 8%. Determine the depth upto which the soil profile will be wetted with on application of 60mm of water. Take the dry unit weight soil as 15.3 KN/m^3

Solⁿ: Given data:

$F.C. = 15\% = 0.15$

m.c before irrigation $= 8\% = 0.08$

Depth of applied water $(d_w) = 60$ mm

$\gamma_d = 15.3\ KN/m^3$

$\gamma_w = 9.81\ KN/m^3$

$d = ?$

- we know that

Applied water $(d_w) = \frac{\gamma_d}{\gamma_w} \times d \times [F.C - PWP]$

$= \frac{15.3}{9.81} \times d \times [F.C. - \text{moisture content before irrigation}]$

$60 = \frac{15.3}{9.81} \times d \times [0.15 - 0.08]$

$d = \frac{60 \times 9.81}{15.3 \times 0.07}$

$= 549.57$ mm

≈ 550 mm

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Ex-3.4 The field capacity of a certain soil is 20%. its apparent specific gravity is 1.6. Before applying
Punamia (53) irrigation water, a wet sample of soil was tak & its mass was found as 150 gm. The same sample weighed as 136 gm after oven drying. Determine the depth of water that must be applied to irrigate the soil to a depth of 0.9 m

Sol^n: Given data:

$F.C. = 20\% = 0.2$

$G = 1.6 = \gamma_d/\gamma_w$

Mass of wet soil (M_w) = 150 gm

Mass of dry soil (M_d) = 136 gm

$d = 0.9$ m

- We know that

Available water (d_w) $= \frac{\gamma_d}{\gamma_w} \times d \times$ (F.C. − M.C. before irrigation

But =

$$\text{M.C. before irrigation} = \frac{\text{Wet soil} - \text{Dry soil}}{\text{Dry soil}} \times 100$$

$$= \frac{150 - 136}{136} \times 100$$

$$= 10.29\%$$

$$= 0.1029$$

$$\frac{\gamma_d}{\gamma_w} = \frac{\rho_d \cdot g}{\rho_w \cdot g} = \frac{\rho_d}{\rho_w} = \frac{\text{Density of soil (dry)}}{\text{Density of water}}$$

So, γ (Unit wt) = ρ (Density) × g (acceleration)

Available water (dw) = 1.6 × 0.9 × (0.2 − 0.1029)

= 0.14 m

dw = 140 mm

Ex-3.5 Punamia (53) ✓

Find the field capacity of a soil for the following data

Root zone depth = 2 m
Existing water content = 5 %
Dry density of soil = 15 KN/m³
water applied to the soil = 500 m³
Water loss due to evaporation & deep perlolation = 10 %
Area of plot = 1000 m²

Solⁿ:- Given data

Note:- Short-method also given at last of this problem

d = 2 m
F.C = ?
Existing water content = 5 %
ρ_d = 15 KN/m³
Total water supplied = 500 m³
losses = 10 %
A = 1000 m²

– We are applying 500 m³ of water & from that 10 % is lost due to evaporation & deep percolation

$\rho_w = 1 \frac{gm}{cc} = 1 \frac{gm}{cm^3} = \frac{1\times10^{-3}}{1\times10^{-6}} \frac{kg}{m^3} = 10^3 \frac{kg}{m^3} = 1000\ kg/m^3 = 9.81\ kN/m^3$

- So, the total utilize water

Total water

$= 500\ (m^3) - loss$

$= 500\ (m^3) - \left(\frac{500\times10}{100}\right)$

$= 500\ (m^3) - 50$

Utilized water $= 450\ m^3$

- After adding water, the utilized water raised the m.c. is given by m.c. on dry basis

$= \frac{\text{wt. of water}}{\text{wt. of dry soil}} \times 100 = \frac{\text{Mass of water}}{\text{Mass of dry soil}}$

Newly raised moisture content $= \frac{M_w}{M_d} \times 100$ — (

density $= \frac{\text{Mass}}{\text{volume}}$

$\rho = \frac{M}{V}$

$M = \rho \times V$

But

wt. of water or Mass of ~~dry soil~~ water $(M_w) =$ Density of water (ρ) $\times$ volume (V) of utilized water

$M_w = \rho_w \times V$

$M_w = 9.81\ (kN/m^3) \times 450\ (m^3)$

$M_w = 4414.5\ kN$

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Mass of dry soil (M_d) = Density of dry soil (ρ_d) $\times$ Volume of soil (V_d)

Volume = Area x depth
$V = A \cdot d$

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Area depth
$M_d = 15\ (KN/m^3) \times 1000\ (m^2) \times 2\ (m)$

$M_d = 30{,}000\ KN$

From eq^n - (1)

$$\text{New water content} = \frac{4414.5}{30{,}000} \times 100$$

$= 14.72\ \%$

Therefore

Total water content or Field Capacity (F.C) = original + New water Content

$= 5\% + 14.72\%$

$= 19.72\%$

Short method

$$d_{actual} = \frac{\text{Actual applied volume}}{\text{Area}} = \frac{450}{1000} = 0.450\ m = d_w$$

As we derived

$$F.C. = \frac{\gamma_w \times d_w \times 1}{\gamma_d \times d \times 1} \Rightarrow d_w = \frac{\gamma_d}{\gamma_w} \times d \times F.C. \Rightarrow 0.45 = \frac{15}{9.81} \times 2 \times$$

So,

$$F.C. = \frac{0.45 \times 9.81}{15 \times 2} = 0.147 = 14.7\% =$$ water content after adding $450 m^3$ volume of water

So,

Field Capacity after adding the $450 m^3$ water = Existing + New = 5 + 14.7 = 19.72 %

Ex-3.6 Punamia (53) A loam soil has field capacity of 22% & wilting coefficient of 10%. The dry unit weight of soil is 15 KN/m³. If the root zone depth is 70 cm, determine the storage capacity of the soil. Irrigation water is applied when moisture content falls to 14%. If the water application efficiency is 75%, determine the water depth required to be applied in the field.

Solⁿ: Given data:

F.C. = 22% $\gamma_w = 9.81$ KN/m³

PWP = 10%

$\gamma_d = 15$ KN/m³

d = 70 cm = 0.7 m

Storage capacity (Available water) (dw) = ?

M.C. before irrigation = 14%

Efficiency (η) = 75% = 0.75

Required irrigation depth (dw) = ?

- we know that

$$\text{Available depth of water } (d_w) = \frac{\gamma_d}{\gamma_w} \times d \times (F.C - PWP)$$

$$= \frac{15}{9.81} \times 0.7 \times (0.22 - 0.10)$$

$$= 0.128 \text{ m}$$

$$= 128 \text{ mm}$$