RSSB-JE 2020

Rajasthan Staff Selection Board

Combined Junior Engineer Direct Recruitment Examination

Civil Engineering

Irrigation & Water Resources

Well Illustrated **Theory** *with*
Solved Examples and **Practice Questions**

MADE EASY Publications

Irrigation & Water Resources

Contents

❍❍❍❍

CHAPTER 4

Soil, Water, Plant Relationship

4.1 Introduction

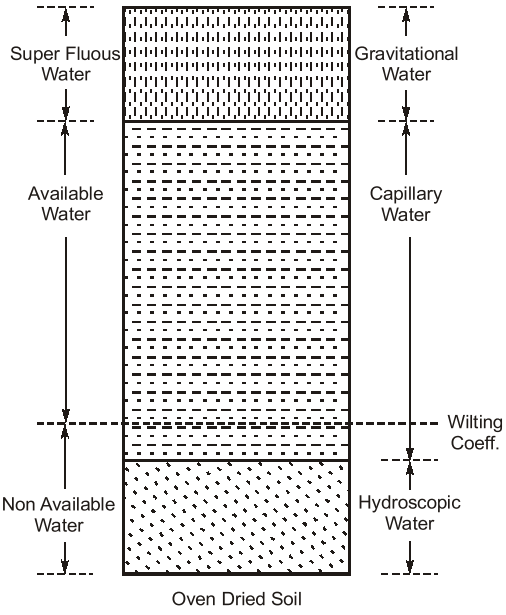
- Water which is added to the soil mass during irrigation is held in the pores of soil and is called as soil water (or soil moisture).
- Soil water causes the soil to appear wet or even damp based on amount of moisture held by soil mass.
- Factors responsible for growth of the crops are
  (a) Rate of entrance of water to the soil.
  (b) The water retained by soil.
  (c) Availability of water to plant roots.

4.2 Classes and availability of soil water

Water present in the soil may be classified under three heads:

1. Hygroscopic water 2. Capillary water
3. Gravitational water

- When an oven-dried sample is kept open in the atmosphere, it absorbs some amount of water from the atmosphere. This is known as hygroscopic water, and is not capable of moment by the force of gravity or capillary forces.
- Capillary water is that part in excess of hygroscopic water which exists in the pore space of the soil by molecular attraction.
- Gravitational water is that part in excess of hygroscopic and capillary water which will move out of the soil if favourable drainage is provided.

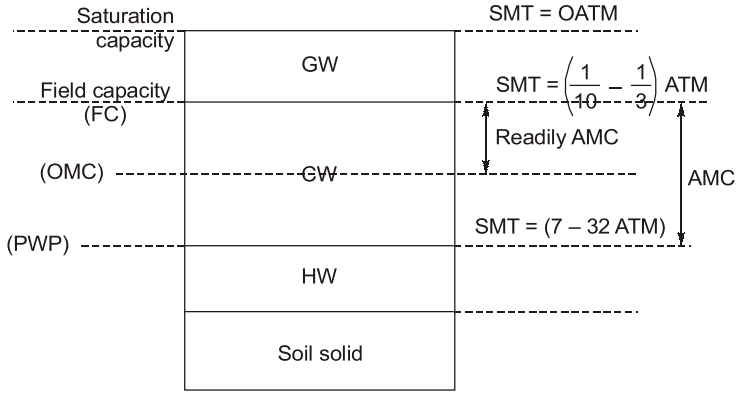


4.3 Soil Moisture Tension/Soil Moisture Stress

Soil moisture is defined as force per unit area that must be exerted in order to extract water from the soil.

- Soil moisture tension is usually expressed in terms of atmosphere.
- For a given soil, soil moisture tension is inversely proportion to water content.
- If we know SMT (Soil moisture tension) and various moisture content then we can determine how much water is available for plants and what amount of water must be added to the soil for the purpose of irrigation.
- Soil moisture stress in sum of SMT (Soil Moisture tension) and OP (Osmotic pressure).
- The force with which water moves across the cell membrane is called osmotic pressure.

4.4 Soil Moisture Constants



AMC → Available Moisture Content

RAMC → Readily available moisture content

(Saturation Capacity) — It is defined as total water content.

- At saturation capacity SMT is zero.

(Field Capacity) — Field capacity is the maximum water which can be held by the soil against gravity.

- It depends on porosity and capillarity.
- Moisture content at field capacity includes hygroscopic water and capillary water.

$$FC = \frac{\text{Weight of water retained in certain volume of soil}}{\text{Weight of same volume of dry soil}}$$

- SMT at field capacity ranges between (1/10 ATM – 1/3 ATM)

Wilting Point/Permanent Wilting Point (PWP)

- It is the moisture content below which plant can no longer extract moisture from the soil for its growth.
- At this moisture content plant leaves will wilt.
- PWP depends on nature of soil.
- PWP is the lower limit of capillary water and upper limit of hygroscopic water.
- At PWP, SMT is in the range of (7-32) ATM, but for calculation purpose we take an average value of 15 ATM for all the soil.

Available Moisture Content (AMC)

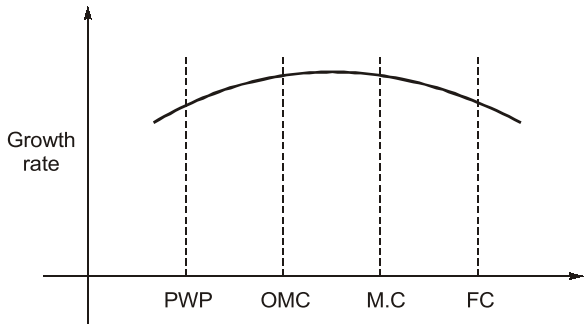
- It is the water available for the growth of crop. It is also called as maximum storage capacity of the soil.

Readily Available Moisture Content (RAMC)

- That portion of available water/moisture which is most easily extracted by the plant and such a limit is called OMC (Optimum Moisture Content).
- In abscence of data available we can assume RAMC = 75% of available moisture content.
- Soil moisture near PWP can't be easily extracted by plant roots.

Soil Moisture Deficiency/Field Moisture Deficiency

- Soil moisture deficiency is the amount of water which is to be added to the soil such that moisture content raised to field capacity.
- Graph between moisture content and growth rate



- For healthy or optimum growth of Plants moisture is allowed to fall only upto OMC and not up to PWP.

Moisture Equivalent

- It is defined as percentage of moisture retained in 10 mm thick saturated sample of soil subjected to a centripetal force of 1000 g for a period of 30 min.
- It can be quickly determine in laboratory and gives very good indication of FC.

1/3rd Atmospheric Moisture Point

- It is percentage of moisture retained in soil sample when placed on a porous plate subjected to atmospheric pressure of 1/3rd ATM.
- It also provides good estimate of *FC*.

4.5 Depth of Water Held in Root Zone

For ease in calculation water present in the voids of the soil needs to be expressed as depth of water.

Let root zone depth = dm

Specific weight of dry soil = γ_d

cross-section area of soil considered = A

equivalent depth of water present in voids of the soil = Dm

$$FC = \frac{\text{Weight of water retained in certain volume of soil}}{\text{Weight of same volume of dry soil}}$$

$$= \frac{A \times D \times \gamma_w}{Ad \times \gamma_d}$$

$$D = \frac{\gamma_d}{\gamma_w} \cdot d \cdot FC$$

It is the depth of water stored in the root zone for full field capacity.

But this entire depth of water can't be extracted by the plants, hence available moisture content will be given as:

$$\text{Available depth of water} = \frac{\gamma_d}{\gamma_w} \cdot d \cdot (FC - PWP)$$

$$\text{Not available water} = \frac{\gamma_d}{\gamma_w} d(PWP)$$

$$\text{Equivalent depth of water readily available, RAMC} = \frac{\gamma_d}{\gamma_w} d(FC - OMC)$$

When moisture content falls to 15%, the deficiency of water depth created will be given by

$$= \frac{\rho_d}{\rho_w} \times d \text{ [F.C. – Fall in moisture content]}$$

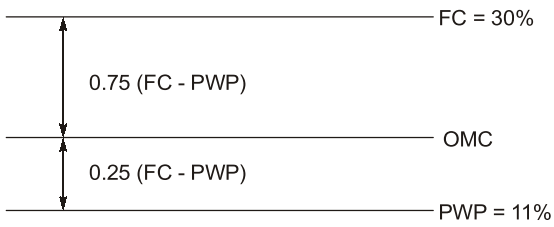
$$= \frac{1.5}{1} \times 60 \text{ [0.25 – 0.15]} = 9 \text{ cm}$$

Hence, 9 cm depth of water is the net irrigation requirement.

Example - 4.3 For best growth of a particular crop, F.C = 30%, PWP = 11%, γ_d = 1300 kg/m^3. Effective depth of root zone = 800 mm, C_u per day = 12 mm. Moisture content must not fall below 25% of water holding capacity between field capacity and permanent wilting point. The frequency of irrigation is _____

(a) 12 days
(b) 9 days
(c) 8 days
(d) 11 days

Solution : *(c)*



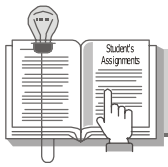
$$OMC = PWP + 0.25\,(FC - PWP) = FC - 0.75\,(FC - PWP)$$
$$FC - OMC = 0.75\,(FC - PWP)$$

$$\therefore \quad RAMC = \frac{\gamma_d}{\gamma_w} d \cdot (FC - OMC)$$

$$RAMC = \frac{1300}{1000} \times 0.8 \times 0.75(0.3 - 0.11) = 0.1432 \text{ m}$$

$$\therefore \quad \text{frequency of irrigation (FW)} = \frac{RAMC}{C_u \text{ per day}} = \frac{143.2 \text{ mm}}{12 \text{ mm}} = 12.35 \text{ day}$$

$$\therefore \quad \text{frequency of irrigation} = 12 \text{ day}$$



Student's Assignment

Q.1 The water which can be utilized by the crops from soil is called
(a) field capacity water
(b) capillary water
(c) hygroscopic water
(d) none of the above

Q.2 The moisture held by a well drained soil against gravity drainage, by force of surface tension

between the soil grains and water drops, is called
(a) Field capacity water
(b) Hygroscopic water
(c) Capillary water
(d) Water of adhesion

Q.3 Available moisture for a crop is equal to
(a) Field capacity moisture content-wilting point moisture content
(b) field capacity moisture content-hygroscopic moisture content
(c) both (a) and (b)
(d) none of the above

Q.4 The state of soil when plants fail to extract sufficient water for their requirements is
(a) maximum saturated point
(b) permanent wilting point
(c) ultimate utilization point
(d) none of these

Q.5 The optimum Moisture Content (M.C.) which is retained in the root zone of a soil, before applying irrigation water is
(a) equal to : (the field capacity M.C.-wilting point M.C.)
(b) less than : (the field capacity M.C.-wilting point M.C.)
(c) more than : (the field capacity M.C.-wilting point M.C.)
(d) may be more than or less than : (the field capacity M.C.-wilting point M.C.)

Q.6 Irrigation water is usually applied to the fields, when available moisture content in the root zone of crop, get depleted by
(a) 0-10% (b) 10-25%
(c) 50-80% (d) 100%

Q.7 What is moisture depth available of evapotranspiration in root zone of 1 m depth soil if dry weight of soil is 1.5 gm/cc, field capacity 30% and permanent wilting point is 10%
(a) 450 mm (b) 300 mm
(c) 200 mm (d) 150 mm

Q.8 Irrigation water has to be supplied to crops when the moisture level falls
(a) below field capacity
(b) to wilting point
(c) below wilting point
(d) none of the above

Q.9 The field capacity of soil is 25%, its permanent wilting print is 15% and specific dry unit weight is 1.5, if depth of root zone of crop is 80 cm, the storage capacity of soil is
(a) 8 cm (b) 10 cm
(c) 12 cm (d) 14 cm

Q.10 The following data were noted from an irrigation field: FC = 20%, PWP = 10%
Permissible depletion of available soil moisture = 50%
Dry unit weight of soil = 15 kN/m^3
Effective rainfall = 50 mm
The net irrigation requirement per meter depth of soil will be
(a) 75 mm (b) 125 mm
(c) 50 mm (d) 25 mm

Q.11 Consider the following statements:
Irrigation water has to be supplied to the crops when the moisture level falls
1. below field capacity
2. to wilting point
3. below wilting point
Which of these statements is/are correct?
(a) 1 (b) 2 only
(c) 3 only (d) 2 and 3

Q.12 Permanent wilting point moisture content for a crop represents the
(a) hygroscopic water
(b) capillary water
(c) field capacity water
(d) none of the above

Q.13 At field capacity, water is held in most of the soils at a tension of
(a) 15 atm (b) Zero atm
(c) $\frac{1}{3}$atm (d) 1 atm

Q.14 A clayey soil has a field capacity of 35% and permanent wilting point of 20%. If the specific weight of the soil is 12.75 kN/m^3, the available

14. (a)

Available moisture holding capacity

$$d_w = \frac{\gamma_d}{\gamma_w} d\,(FC - PWP)$$

$$d_w = \frac{12.75}{9.81} \times 0.8(0.35 - 0.20)$$

$$= 0.1559 \text{ m} \simeq 15.6 \text{ cm}$$

15. (c)

Available water = 25% of 80 mm depth required water to reach to field capacity = 80 – 20 = 60 mm.

$\therefore$ Frequency of irrigation

$$= \frac{60 \text{ mm}}{2.8 \text{ mm/day}}$$

$$= 21.42 \text{ days}$$

$$\simeq 21 \text{ days}$$

16. (b)

Capillary water is that water which is retained in the soil after the gravitational water has drained off from the soil.

The plant roots gradually absorb the capillary water which thus constitutes the principal source of water for the plant growth.

17. (c)

Soil moisture deficiency is defined as the water required to bring the soil moisture content of a given soil to its field capacity.

■■■■