OPSC-AEE 2020

Odisha Public Service Commission

Assistant Executive Engineer

Civil Engineering

Irrigation Engineering

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

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Irrigation Engineering

Contents

CHAPTER 6

Water Logging and Land Reclamation

6.1 Water Logging

- It is a phenomena in which productivity of land gets affected due to rise in water table, thus leading to the flooding of root zone of the plants
- In this process, the productivity of land is affected by rise in water table.

6.2 Causes of Water Logging

1. Over and Intensive irrigation.
2. Seepage of water from the adjoining high lands.
3. Seepage of water through the canals.
4. Impervious obstructions.
5. In adequate natural drainage.
6. In adequate surface drainage.
7. Excessive rains.
8. Submergence due to floods.
9. Irregular or flat topography.

6.3 Effects of Water Logging

(i) Inhibiting activity of soil bacteria
(ii) Decrease in available capillary water
(iii) Fall in soil temperature
(iv) Rise in level of salts in the surface soil
(v) Delay in cultivation operations
(vi) Growth of wild flora (leading to decrease in crop yield)
(vii) Adverse effect on community health.

6.4 Control of Water Logging

1. Lining of canals & water course.
2. Reducing the intensity of the Irrigation.
3. Crop rotation.
4. Optimum use of water
5. Providing intercepting drains
6. Efficient drainage system
7. Improving natural drainage of the area.
8. Introduction of lift irrigation.

6.5 Reclamation of Saline and Alkaline lands

- Whenever there is water logging, it leads to salinity.
- Land reclamation is a process by which an unculturable land is made fit for cultivation.
- Agricultural soil contains salt, some of these are beneficial for plants while certain other prove injurious to plant growth. These injurious salts are called alkali salts, some of these are Na_2CO_3, Na_2SO_4 and NaCl.
- Na_2CO_3 is known as black alkali because it dissolves some organic constituents of soil, which appear as black patches when soil dries. Out of the above alkali salts Na_2CO_3 is most harmful; and NaCl is the least harmful. These salts are soluble in water.
- Phenomenon of salts coming up in solution and forming a thin (5 to 7.5 cm) crust on the surface, after the evaporation of water is called efflorescence. Land affected by efflorescence is called saline soil.

- If the salt efflorescence continues for a longer period a base exchange reaction sets up, particularly if the soil is clayey, thus sodiumising the clay, making it impermeable and therefore ill aerated and highly unproductive. Such soils are called alkaline soils.

Reclamation of Salt Affected Land by Leaching

- An efficient drainage system consisting of surface drains as well as subsurface drains must be provided in order to lower the water table in saline lands.
- In the process called Leaching, land is flooded with adequate depth of water, the alkali salt get dissolved in this water, which percolate down to join the water table or drained a way by sub surface drains. There after salt resistant crops like fodder, berseem and bajra etc. are grown.
- When Na_2CO_3 (black alkali) is present in the saline soil, gypsum ($CaSO_4$) is generally added to the soil before leaching and thoroughly mixed with water. Na_2CO_3 reacts with $CaSO_4$ forming Na_2SO_4, which can be leached out easily.

Leaching Requirement of a Soil

It is necessary to apply excess water to consumptive use to meet the requirements of leaching and is generally expressed as the percentage of the total irrigation water applied to the soil, to meet the consumptive use as well as the leaching needs.

This percentage quantity of water required for maintaining equilibrium in the salt content of the soil, has been computed to be expressed by the following equation:

$$\text{LR (Leaching requirement)} = \frac{\text{Depth of water drained out per unit area}}{\text{Depth of irrigation water applied per unit of area}}$$

$$LR = \frac{D_d}{D_i}$$

Where, D_i = Total irrigation water depth applied; $D_i = C_u + D_d$; D_i = Consumptive use + Drained out water depth.

- For salt equilibrium $\frac{D_d}{D_i}$ is found equal to $\frac{C_i}{C_d}$

  Where, C_i = salt content of irrigation water ; C_d = salt content of drained or leached water.
- Since salt content is directly proportional to electrical conductivity (EC), hence

$$LR = \frac{D_d}{D_i} = \frac{C_i}{C_d} = \frac{E.C._{(i)}}{E.C._{(d)}} = \frac{E.C._{(i)}}{2E.C._{(e)}}$$

NOTE: In general $EC_{(d)}$ value is twice the value of Saturation soil extract $EC_{(e)}$ {The water solution extract from a soil at its saturation percentage}.

Example - 6.1 Determine the leaching requirement when the electrical conductivity of drainage water from soil was found as 20 m-mho/cm at 20% reduction in yield of the crop.

Take E_{ci} = 1.5 m mho/cm

What will be the required depth of water to be applied if the consumptive use is 55.5 mm.

Solution:

$$L_R = \frac{E_{ci}}{E_{cd}} \times 100\% = \frac{1.5}{20} \times 100 = 7.5\%$$

$$D_i = \frac{D_c}{1 - L_R} = \frac{55.5}{1 - \frac{7.5}{100}} = 60 \text{ mm}$$

For maximum capillary height ($\theta = 0°$)

$$H_c = \frac{4\sigma\cos\theta}{\gamma_w d}$$

$$= \frac{4\times 0.054\cos 0°}{(9.81\times 10^3)\times(0.08\times 10^{-3})} \quad (\because \gamma_w = 9.81\ \text{kN/m}^3 = 9.81\times 10^3\ \text{N/m}^3)$$

$$= 0.275\ \text{m}$$

Distance from the G.L to the top of the capillary saturated zone = 2 – 0.275 = 1.725 m

Depth of root zone = 1.8 m

As the roots reaches the capillary saturated zone by 0.075 m (i.e. 1.8 – 1.725 = 0.075 m) from the top of the level of maximum capillary rise.

Yes, field will be highly water logged.

Using the formula,

$$q = \frac{4k(b^2 - a^2)}{S} \quad \text{...(ii)}$$

Where, q = Drainage coefficient × S × length of tile drain

$$= \frac{0.116}{10^6}\times 15\times 1 \quad \text{(Considering unit length of the drain)}$$

$$= 1.74\times 10^{-6}\ \text{cumecs}$$

$$b = 7 - (2 - 0.275) = 7 - 1.725 = 5.275\ \text{m}$$

Putting the values of k, q, b in (ii), we get

$$1.74\times 10^{-6} = \frac{4\times 10^{-6}(5.275^2 - a^2)}{15}$$

$$\Rightarrow \quad 5.275^2 - a^2 = \frac{(1.74\times 10^{-6})\times 15}{4\times 10^{-6}}$$

$$\Rightarrow \quad a^2 = 5.275^2 - \frac{(1.74\times 10^{-6})\times 15}{4\times 10^{-6}}$$

$$\Rightarrow \quad a^2 = 21.3$$

$$\Rightarrow \quad a = 4.61\ \text{m}$$

So, vertical depth of closed drains below ground level = (7 – 4.61)m = 2.39 m

Example - 6.3 There are two different areas A and B to be drained by means of closed tile drainage system.

If $\frac{k_A}{k_B} = \frac{2}{1}$; $\frac{S_A}{S_B} = \frac{1}{1.5}$ and $\frac{(b^2 - a^2)_A}{(b^2 - a^2)_B} = \frac{5}{6}$

Find the ratio $\frac{(Q_D)_A}{(Q_D)_B}$

If the drains carry 1% of average annual rainfall in 24 hours in both the cases.

Find the ratio $\frac{P_A}{P_B}$

Solution:

$$\because \quad Q_D = \frac{4k\left(b^2 - a^2\right)}{S} \qquad \text{...(i)}$$

As per equation (i),

$$\frac{(Q_D)_A}{(Q_D)_B} = \left(\frac{k_A}{k_B}\right)\cdot\left[\frac{\left(b^2-a^2\right)_A}{\left(b^2-a^2\right)_B}\right]\cdot\left(\frac{S_B}{S_A}\right) = \frac{2}{1}\cdot\frac{5}{6}\cdot\frac{1.5}{1} = 2.5$$

Assume, P_A and P_B be the average annual rainfall at A and B respectively. If 1% of average rainfall is carried by the drains in 24 hours then

$$Q_D = \frac{S\times\left[\frac{1}{100}\times P\times 1\right]}{24\times 60\times 60} \text{ cumecs/m length of the drain.}$$

$$\Rightarrow \quad Q_D \propto SP$$

$$\therefore \quad \frac{(Q_D)_A}{(Q_D)_B} = \frac{S_A P_A}{S_B P_B}$$

$$\Rightarrow \quad \frac{P_A}{P_B} = \frac{S_B}{S_A}\cdot\frac{(Q_D)_A}{(Q_D)_B}$$

$$\Rightarrow \quad \frac{P_A}{P_B} = \frac{1.5}{1}\cdot 2.5 \qquad \Rightarrow \qquad \frac{P_A}{P_B} = 3.75$$

6.6.2 Drainage Coefficient (DC)

The rate at which the water is removed by a drain is called the drainage coefficient. It is expressed as the depth of water in cm or metres, to be removed in 24 hours from the drainage area.

Example - 6.4 **A tile drainage system draining 12 hectares, flow at a design capacity for two days, following a storm. If the system is designed using a DC of 1.25 cm, how many cubic meters of water will be removed during this period?**

Solution:

D.C. of 1.25 cm means that 1.25 cm of water depth from the drainage are shall be removed by the drain in 24 hours.

$\therefore$ Volume of water entering the drain per day = $\frac{1.25}{100}\times 12\times 10^4 = 1500 \text{ m}^3\text{/day}$

Volume of water passing the drain with 2 days of flow = 2 × 1500 = 3000 m^3

Size of the Tile Drains

- The tile drains are designed according to the Manning's formula to carry a certain discharge decided by D.C. and drainage area.
- The drains are laid on a certain longitudinal slope varying from 0.05 to 3%. A desirable minimum working grade is 0.2%.
- 10 to 15 cm tiles are minimum recommended sizes.

Example - 6.5 Determine the size of a tile at the outlet of a 6 hectare drainage system if the D.C. is 1 cm and the tile grade is 0.3%. Assume rugosity coefficient for the tile drain materials as 0.011.

Solution:

Volume of water passing the drain in 1 day = $\left(\frac{1}{100}\times 6\times 10^4\right) = 600\ m^3/day$

Volume of water passing drain in 1 second = $\frac{600}{24\times 3600} = \frac{1}{144}\ m^3/s$

$$\therefore \qquad Q = \frac{1}{144} = \frac{1}{n}AR^{2/3}s^{1/2}$$

For a circular drain of diameter D, we have,

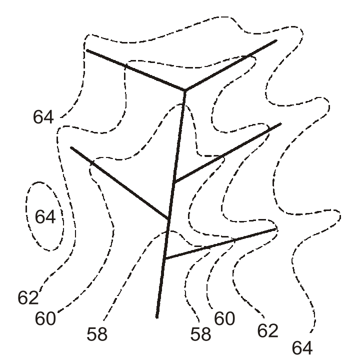
$$A = \frac{\pi}{4}D^2,\ P = \pi D,\ R = \frac{D}{4}$$

$$\frac{1}{144} = \frac{1}{0.011}\times\left(\frac{\pi}{4}D^2\right)\left(\frac{D}{4}\right)^{2/3}\left(\frac{0.3}{100}\right)^{1/2}$$

$$D = 0.132\ m = 13.2\ cm$$

Use 15 cm dia. pipe.

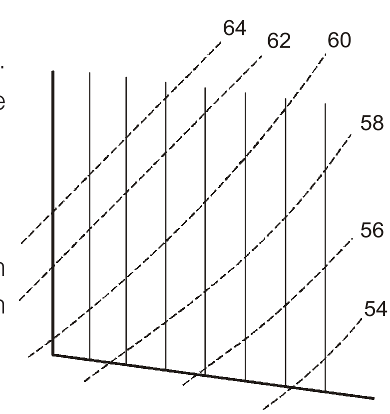
6.6.3 Layout of Tile Drains



6.6.3.1 Natural System

- This system is generally adopted in rolling topography where drainage of isolated area is required.
- This system is suitable when the land is not to be completely drained.
- This system is quite flexible and permits location of drains where they are most needed.

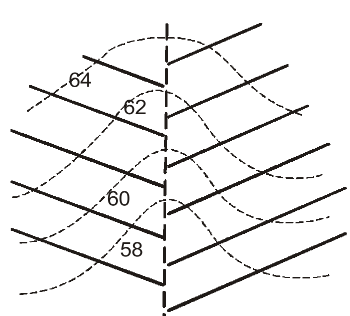
6.6.3.2 Grid Iron System



- In this system, the lateral are provided only on one side of the main.
- This system is adopted when the land is practically level and entire area is to be drained.

6.6.3.3 Herring Bone System

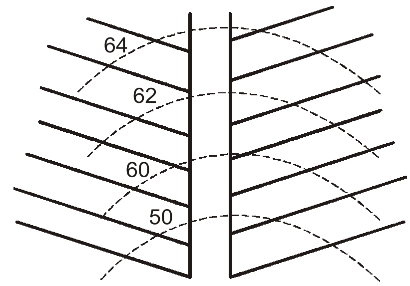
- In this system lateral join the mains or submains from each side.
- The land along the main is double drained, but since it exists in depression, it probably requires more drainage than the land on the adjacent slopes.



Herring Bone

6.6.3.4 Double Main System

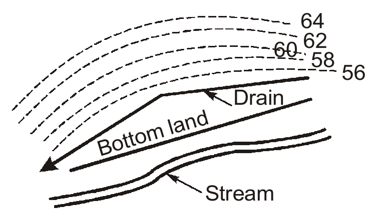
- This system has two mains with separate laterals.
- This layout is adopted when the bottom of depression is wide. This arrangement reduces the length of the laterals.



Double Main

6.6.3.5 Intercepting Tile Drains System

- In this system, there is no lateral drain. A main or submain is provided at the toe of the slope.
- This arrangement is preferred when the main source of drainage is from a hilly land.



Intercepting Drain

Student's Assignment

Q.1 A land is said to be waterlogged, when
(a) the land is necessarily submerged under standing water
(b) there is a flowing water over the land
(c) the pH value of the soil becomes as high as 8.5
(d) the soil pores in the root zone get saturated with water, either by the actual water-table or by its capillary fringe

Q.2 Which one of the following, is not a remedial measure for water logging?
(a) good drainage for irrigated land
(b) conjunctive use of water in the basin
(c) lining of canals and after courses
(d) contour bunding

Q.3 A tile drain is laid below a cropped land to remove excess irrigation water. The Drainage Coefficient of this drain, is usual.
(a) cm of water depth removed from the drainage area per day
(b) cum of water removed per second
(c) percentage of applied water, which is intercepted by this drain
(d) None of these

Q.4 The method, which uses dead furrows on cropped farms for drainage of excess irrigation or rain water, is called
(a) surface inlet (b) tile drainage
(c) bedding (d) french drain

Q.5 The spacing of tile drains to relive waterlogged land is directly proportional to the
(a) depth of drain below the ground surface
(b) depth of impervious strata from the drain
(c) depth of drain below the water level
(d) coefficient of permeability of the soil to be drained

Q.6 Water logging of cropped land leads to reduce crop yields, due to
(a) ill aeration of root zone, causing lack of oxygen to plants
(b) growth of water loving plants interfering with the sown crop
(c) surrounding of root zone by resultant saline water, which extra good water from plant roots by osmosis
(d) all of these

Q.7 Which one of the following does not contribute to water logging?
(a) inadequate drainage
(b) seepage from unlined canal
(c) frequent flooding
(d) excessive tapping of ground water

Q.8 Point out incorrect statement:
(a) Salinity is caused by water-logging.
(b) Water logging is not cause by salinity.
(c) Salinity subsides, when once the water logging is removed
(d) None

Q.9 Alkaline soils are best reclaimed by
(a) leaching
(b) addition of gypsum to soil
(c) providing good drainage
(d) addition of gypsum to soil and leaching

Q.10 A recently reclaimed alkaline soil should preferably be sown with a salt resistant crop like
(a) Wheat (b) Cotton
(c) Barseen (d) Any of the above

Q.11 The soil becomes practically infertile when its pH value is about
(a) 0 (b) 7
(c) 11 (d) None

Q.12 When a subsurface open jointed drain is laid below a farm land to intercept excess irrigation water then its capacity depending upon soil type, should be of the order of
(a) 5-10% of applied water
(b) 10-50% of applied water
(c) 50-80% of applied water
(d) None

Q.13 Which one is best method of the reclamation of the acidic soil?
(a) Leaching
(b) Provision of good drainage
(c) Use gypsum as a soil amendment
(d) Use limestone as soil amendment

Q.14 Leaching is a process
(a) by which alkali salts present in soil are dissolved and drained away
(b) by which alkali salt in soil come up with water
(c) of draining excess water of irrigation
(d) which controls water-logging

Q.15 A drainage coefficient
(a) decides choice of method of drainage
(b) decides kind of crop that can be grown on the land
(c) is the depth of water that can be removed from drainage area in unit time
(d) is the flow of water from the soil into the tile laterals per unit time

ANSWER KEY — STUDENT'S ASSIGNMENT

1. (d)	**2.** (d)	**3.** (a)	**4.** (c)	**5.** (d)
6. (d)	**7.** (d)	**8.** (c)	**9.** (d)	**10.** (c)
11. (c)	**12.** (b)	**13.** (d)	**14.** (a)	**15.** (c)

HINTS & SOLUTIONS — STUDENT'S ASSIGNMENT

5. (d)

The spacing of tile drains is given by

$$s = \frac{4K}{q}(b^2 - a^2)$$

$\therefore$ Spacing $\propto K$

$K \rightarrow$ Coefficient of permeability of soil.

7. (d)

Due to excessive tapping of ground water, the water table falls, which does not cause water logging.

15. (c)

Drainage coefficient is the rate at which water is removed by a drain. It is expressed as the depth of water in cm on metres, to be removed in 24 hours from the drainage area.

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