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CMRIT

Internal Assessment Test 1 – Sept. 2019

Sub:	Hydrology and Irrigation Engineering				Sub Code:	15CV73	Branch:	CIVIL
Date:	18/11/2019	Duration:	90 min's	Max Marks: 50	Sem / Sec:		A&B	

Answer any FIVE FULL Questions

		MARKS	OBE CO	OBE RBT
1	Define Irrigation. Explain the necessity of irrigation.	[10]	CO1	L2
2	What is irrigation efficiency? Explain depth and frequency of irrigation with neat diagram.	[10]	CO1	L2
3	Write down relationship between Duty, delta and base period	[10]	CO1	L2
4	Write down the Kennedy's theory design procedure for case 1 and case 2	[10]	CO1	L2
5	For a distributor gross command area 50 hectares culturable command area is 80% of GCA. Intensity of irrigation is 30% for Rabi crop (Wheat) and 12% for Kharif (Rice). If the KOR period is 3 weeks initially and 2 weeks for the later farming, neglecting losses. Determine the outlet discharge. Assume watering for wheat as 9 cm and for rice as 25 cm.	[10]	CO1	L2
6	Compare sprinkler irrigation with drip irrigation system in details.	[10]	CO1	L2

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Q1.

1.1. DEFINITION

Irrigation may be defined as the process of artificially supplying water to soil for raising crops. It is a science of planning and designing an efficient, low-cost, economic irrigation system tailored to fit natural conditions. It is the engineering of controlling and harnessing the various natural sources of water, by the construction of dams and reservoirs, canals and headworks and finally distributing the water to the agricultural fields. Irrigation engineering includes the study and design of works in connection with river control, drainage of water-logged areas, and generation of hydroelectric power.

1.2. NECESSITY

India is basically an agricultural country, and all its resources depend on the agricultural output. Water is evidently the most vital element in the plant life. Water is normally supplied to the plants by nature through rains. However, the total rainfall in a particular area may be either insufficient, or ill-timed. In order to get the maximum yield, it is essential to supply the optimum quantity of water, and to maintain correct timing of water. This is possible only through a systematic irrigation system—by collecting water during the periods of excess rainfall and releasing it to the crop as and when it is needed. Thus, the necessity of irrigation can be summarised in the following points:

1. ***Less Rainfall***

When the total rainfall is less than needed for the crop, artificial supply is necessary. In such a case, irrigation works may be constructed at a place where more water is available, and then to convey the water to the area where there is deficiency of water. Rajasthan canal is one such example. It conveys water to the arid zones of Rajasthan, where the annual rainfall hardly exceeds 100 to 200 mm.

2. ***Non-uniform Rainfall***

The rainfall in a particular area may not be uniform over the crop period. During the early periods of the crop, rains may be there, but no rain water may be available at the end, with the result that either the yield may be less, or the crop may die altogether. By the collection of water during the excess-rainfall period, water may be supplied to the crop during the period when there may be no rainfall. Most of the irrigation projects in India are based on this premise. The rainfall during the winter is very scanty, and hence rabi crops need artificial supply of water through the irrigation works.

3. *Growing a number of crops during a year*

The rainfall in an area may be sufficient to raise only one type of crops during the rainy season (i.e. kharif crops), for which no irrigation may be required. However, with the provision of irrigation facilities in that area, crops can be raised in other season also (i.e. rabi crops).

4. *Growing perennial crops*

Perennial crops, such as sugar cane etc, which need water throughout the year, can be raised only through the provision of irrigation facilities in the area.

5. *Commercial Crops with Additional Water*

The rainfall in a particular area may be sufficient to raise the usual crops, but more water may be necessary for raising commercial and cash crops.

6. *Controlled Water Supply*

By the construction of proper distribution system, the yield of the crop may be increased because of controlled supply of water.

The importance of irrigation is well stated by Shri N.D. Gulati : "Irrigation in many countries is an old art – as old as civilisation – but for the whole World it is modern science – *the science of survival*".

Advantage of application of water by modern methods.

Application of water to the soil by modern methods of irrigation serves the following purposes :

1. It adds water to the soil to supply the moisture essential for the plant growth.
2. It saves the crops from drying during short duration droughts.
3. It cools the soil and the atmosphere, and thus makes more favourable environment for healthy plant growth.
4. It washes out or dilutes salts in the soil.
5. It reduces the hazard of soil piping.
6. It softens the tillage pans.

Q2.

3.7. DEPTH AND FREQUENCY OF IRRIGATION

As explained earlier, *available moisture* is the moisture between wilting point and the field capacity. The *readily available moisture* is that moisture which is easily extracted by the plants, and is approximately 75 % of the available moisture. At any time, therefore, the moisture content in the soil should be between the *field capacity* and the *lower limit* (m_0), of the readily available moisture, as shown in Fig. 3.5.

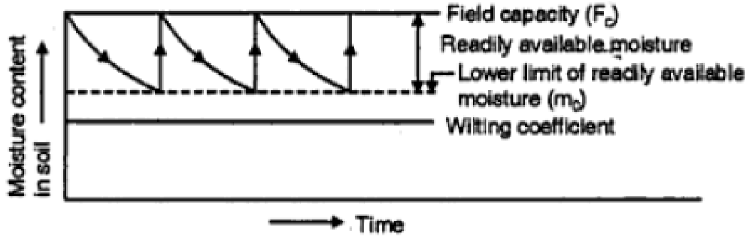

FIG. 3.5. FREQUENCY OF IRRIGATION

Thus, m_0 is the maximum level upto which the soil moisture may be allowed to be depleted in the root zone without fall in the yield.

When watering is done, the amount of water supplied should be such that the water content is equal to the field capacity. Water will be gradually utilized consumptively by plants after the water application, and the soil moisture will start falling. When the water content in the soil reaches the value m_0, fresh doses of irrigation may be done so that water content is again raised to the field capacity of the soil.

The frequency of irrigation is controlled by the amount of available water contained in the root zone of the soil and the consumptive use rate. If d is the root zone depth (metres), F_c is the field capacity and m_0 is the lower limit of readily available moisture content, the depth of water d_w to be given during each watering is found from the following expression,

$$d_w = \frac{\gamma_d}{\gamma_w} \cdot d \left[F_c - m_0 \right] \text{ metres} \quad ...(3.3)$$

(where γ_d is the dry unit weight of soil and γ_w is the unit weight of water). Both F_c and m_0 are the moisture contents to be expressed as ratio.

If C_u is the daily consumptive use rate, frequency of watering f_w is given by

$$f_w = \frac{d_w}{C_u} \text{ days} \quad ...(3.4)$$

Time required to irrigate a certain area

Let t be the time required to apply the desired water depth d_w to bring the water level in the soil from m_0 to the field capacity F_c, over an irrigation field of area A. If q is the discharge in the field channel in cumecs, we have

Q.3

Base Period:

The time on which crop is watered, the time from first watering to last watering of crop by which the crop grows.

The base period is in days and denoted by B

The base period is less than crop period

Crop period is whole time on a crop

Base period is only watering period in which crop is irrigated

Note: *Base period is different than Crop Period, because crop period is total time taken by any crop up to harvesting but base period is only watering period.*

Duty:

Duty is the area of land irrigated in one cumec of watering.

It is calculated in hectare

Delta:

Delta is the depth of water required for a crop to fully grow in entire season

Delta is calculated in centimetre or metre and denoted by

Relation Between Duty, Delta and Base period

Relationship clarify that the volume of water supplied to crop in its base period and volume of water necessary to matures an area of D hectare.

$$D = \frac{8 \cdot 64B}{\Delta}$$

Let

D = Duty in hectare/cumec

B = Base period in days

Δ = Delta in metre

The volume of water(V) supplied to a crop during base period(B)

V1 = Bx24x60x60

V1 = 86400 B m^3

suppose that we supply V volume of water, and the one cubic metre of water per second for a base period matures an area of D hectare.

Volume = matures 1 hectare of depth

V2 = 10000 D sq mtr x Δ

So equant the volume of supply and volume of maturity crop

V1 = V2

86400 B = 10000 D x Δ

$$D = \frac{8 \cdot 64B}{\Delta}$$

Duty of water in hectare/cumec is calculated by 8.64 base period divided by depth of Δ

Q.4)

Kennedy's Theory-Design Steps

Case 1: Q, N, m and S are known

Step1:	Assume a value of D
Step 2:	Calculate V_o from $V_o = 0.55mD^{0.64}$
Step 3:	Find A from $A=Q/V_o$
Step 4:	Knowing D and A Find bed width B for a trapezoidal channel (side slope is ½:1) $A= BD+ (D^2/2)$
Step 5:	Calculate Perimeter and hydraulic mean depth $P=B+D\sqrt{5}$ $R=A/P$ $R=(BD+ (D^2/2) /(B+D\sqrt{5})$
Step 6:	Calculate the mean velocity by Kutter's equation V= $C = \frac{23+\frac{1}{n}+\frac{0.00155}{S}}{1+\left(23+\frac{0.00155}{S}\right)\frac{n}{\sqrt{R}}}$ $\sqrt{RS}$ If the value of $V=V_o$, the assumed depth is correct, if not repeat the calculations by changing D till the velocities are same

Kennedy's Theory-Design Steps

Case 2: Q, N, m and B/D=x ratio are known

Step1:	Calculate A in terms of D, $A= BD+ (D^2/2) = D^2 (x+0.5)$
Step 2:	We know that $V_o= 0.55mD^{0.64}$ Find Discharge $Q= A*V_o = 0.55m(x+0.5)D^{2.64}$ $D= (Q/ (0.55m(x+0.5))^{(1/2.64)}$
Step 3:	Calculate V_o from $V_o= 0.55mD^{0.64}$
Step 4:	Calculate the Slope S by Kutter's equation by trial & error V= $C = \frac{23+\frac{1}{n}+\frac{0.00155}{S}}{1+\left(23+\frac{0.00155}{S}\right)\frac{n}{\sqrt{R}}}$ $\sqrt{RS}$

Q.5

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Soln: CCA = 0.8×50 = 40 hectares

Rabi crop

Area under Irrigation Intensity = 0.3×40
= 12 hectares

Kor period = 3 weeks

$b = 3\times7 = 21$ days

Kor depth $\delta = 9$ cms = 0.09 m

We know that,

$$\Delta = 8.64 \times \frac{B}{D}$$

$$\text{or } \delta = 8.64 \times \frac{b}{D}$$

$$\therefore D = 8.64 \times \frac{b}{\delta}$$

$$= 8.64 \times \frac{21}{0.09} = 2016 \text{ hec/cumec}$$

From the definition of duty discharge $Q = \frac{\text{Area}}{\text{duty}}$

$$Q_{Rabi} = \frac{12}{2016} = 5.95\times10^{-3}\ m^3/sec$$

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For Kharif Crop

Area under Irrigation Intensity = 0.12 × 40

= 4.8 hector

Kor period = 2 weeks

$b = 2 \times 7 = 14$ days

Kor depth $\delta = 25cm = 0.25 m$

We know that,

$$D = 8.64 \frac{b}{\delta}$$

$$= 8.64 \times \frac{14}{0.25}$$

= 483.84 hec/cume

$$Q = \frac{4.8}{483.34} = 9.92 \times 10^{-3} m^3/s$$

Q6.

2.12. SPRINKLER IRRIGATION

The sprinkler method consists of applying the water in the form of a spray, somewhat as in ordinary rain, as is done in the garden lawn sprinkling. The greatest advantage of sprinkler irrigation is its adaptabilities to use under conditions where surface irrigation methods are not efficient. This method is more useful where :

(*i*) The land cannot be prepared for surface methods

(*ii*) Slopes are excessive

(*iii*) Topography is irregular

(*iv*) Soil is erosive

(*v*) Soil is excessively permeable or impermeable

(*vi*) Depth of soil is shallow over gravel or sand.

In this system, the cost of land preparation and permanent water delivery system of channels or conduits is less. However, there is large initial investment in the purchase of the pumping and sprinking equipment.

Sprinkler system can be classified under three heads :

(*i*) Permanent system,

(*ii*) Semi-permanent system, and

(*iii*) Portable system.

Earlier, stationary over-head perforated pipe installations were used. However, with the introduction of light weight steel pipes and quick couplers, portable sprinkler system were devloped. In the permanent system, pipes are permanently buried in such a way that they do not interfere with tillage operations. In the semi-permanent system, the main lines are buried while the laterals are portable. Portable system have both portable mains lines and laterals. These systems are designed to be moved from around the farm from field to field. A pump usually lifts the water from the source, pushes it through the distribution system and through the sprinkler nozzel on the sprinkler heads mounted on rising pipes attached to the laterals. Turbine and horizontal centrifugal pumps are used. Sprinkler system usully is composed of perforated pipes or revolving head sprinklers and may be 'high pressure' (2.1 kg/cm^2) or "low pressure" (1.4 kg/cm^2) system. Generally, a perforated pipe system operates on the low pressure where as the revolving head sprinklers operate in both ranges depending on the type of rotary head used.

Type of sprinklers

Sprinklers may be of three types : (*i*) fixed nozzle pipe system (*ii*) perforated pipe system and (*iii*) rotating sprinklers system. In the *fixed nozzle pipe system* lateral pipes, supported on row of posts, are installed parallel to each other at a distance of 15 m apart. These pipes have a line of small holes drilled at top at regular interval along their length, and small nozzles are fitted in these holes. The spray of water is developed through these nozzles. By turning the pipes through 135°, the entire width of 15 metres between the pipe lines can be irrigated. In the *perforated pipe system*, the laterals, having perforations drilled along the sides and top, are laid on the ground parallel to each other at distances of 6 to 15 m. Sprays of water are developed from both the sides and top of the pipe. However, the more commonly used *rotating sprinker system* consists of single-nozzle or twin-nozzle rotating sprinkler mounted on a body which is rotated slowly about its vertical axis by the action of deflecting vane connected to it. The spray of water developed through the nozzles sprinkles over a circular area of land around each sprinkler. The rotating sprinklers are mounted on the riser pipes and are located just above the crop to be irrigated, the height of riser pipes being dependent on the maximum height of crops. Such riser pipes fitted with sprinklers, are fixed at regular intervals along the length of the laterals. The spacing of the sprinklers is so selected that area of spread from each sprinkler overlap with the spread from the adjacent sprinkler, so that uniform application of water is achieved. The percentage overlap depends on wind velocity. Normally, the spacing between the sprinklers varies from 65% to 30% of the diameter of water spread area, *for no wind condition* to *high wind condition* (> 13 km/hour) respectively.

The discharge, required through each rotating sprinkler is given by the following expression :

$$q = \frac{S_l \times S_m \times I}{3600}$$

where q = discharge required from each sprinkler (litres/sec.)

S_l = spacing of sprinklers along the laterals (m)

S_m = spacing of laterals along mains (m)

I = optimum water application rate (mm/hour)

Advantages of Sprinkler Irrigation

(*i*) Erosion can be controlled

(*ii*) Uniform application for water is possible.

(*iii*) Irrigation is better controlled; light irrigation is possible for seedling and plants which are young.

(*iv*) Land preparation is not required. Labour cost is reduced. More land is available for cropping, as borders and ditches are not required. Surface run off is eliminated.

2.13. DRIP IRRIGATION

In drip irrigation, also known as *trickle irrigation*, water is applied in the form of drops directly near the base of the plant. Water is conveyed through a system of flexible pipe lines, operating at low pressure, and is applied to the plants through drip nozzles. This technique is also known as *'feeding bottle'* technique where by the soil is maintained in the most congential form by keeping the soil-water-air proportions in the optimum range. Drip irrgation limits the water supplied for consumptive use of the plant by maintaining a minimum soil moisture, equal to the field capacity, thereby maximising the saving. The system permits the fine control on the application of moisture and nutrients at stated frequencies.

The method of drip irrigation was first introduced in Israel, but is now practiced in many countries of the World. Along with irrigation water, nutrients (fertilizer solution) are also fed to the system. Water is first filtered so that the impurities may not clog the fine holes of the drippers. The whole aarrangement consists of the following components:

(*i*) a *pump* to lift water.

(*ii*) a *head tank* to store the water and to maintain a pressure head of 5 to 7 m.

(*iii*) *Central distribution system* which filters the water, adds nutrients (or fertilizer solution) and regulates the pressure and amount of water to be applied.

(*iv*) *Mains and secondray lines* made of polyethylene, polyvinyle chloride or a alkathyelene material. The diameter of the piping may vary from 20 mm to 40 mm. A water meter may be fixed at the beginning of the mains.

(*v*) *Trickle lines* consisting of 10 to 20 mm dia. PVC pipes with perforations at a distance equal to the spacing of the crops. The trickle lines are fitted to the secondary lines at a distance equal to the row to row spacing of the crops, which

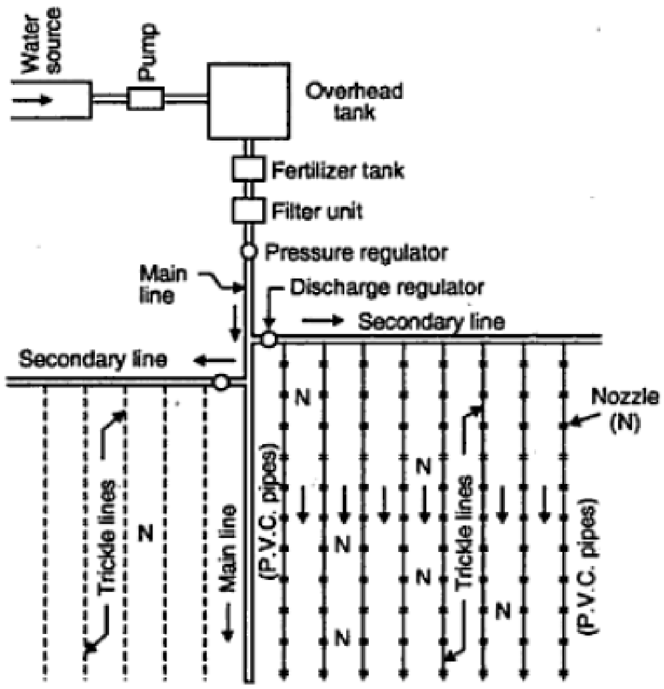

FIG. 2.12 ARRANGEMENT FOR DRIP IRRIGATION SYSTEM.

may vary between 60 cm to 90 cm, a more common value being 75 cm for the most of the crops. The spacing of the nozzles, to be fitted in the perforations of the trickle lines, depends upon the planting distance along a row, and this distance may vary between 30 cm to 50 cm.

(*vi*) *Plastic nozzles* having perforations attached to the trickle line. The perforations are so designed that water leaves the nozzle at a very slow rate, usually ranging between 2 to 10 litres per hour, depending upon the irrigation requirements of the crop.

The whole field is divided into suitable plots. A secondary line is provided for each such plot, and a number of trickle lines are connected to each secondary line. A discharge regulater is provided at the beginning of each secondary line, and its capacity is fixed in accordance with the size and number of nozzles used. The automatic valve at the head is so adjusted to deliver the desired quantity of water and the irrigation terminates automatically after this amount is discharged. The drip irrigation system is suitable to practically all types of crops, except paddy which requires standing water. It is also suitable to all climatic conditions and to all types of soils. However, it is most suited to coarse sandy formations.

Advantages Of Drip Irrigation System

1. ***Less requirement of irrigation water.*** The evaporation and percolation losses, commonly associated with surface irrigation method are reduced.

2. ***Water supply at optimum level.*** An optimum water level, equal to the field capacity can always be maintained, by the water flow controls available in this method. Soil is maintained in most congenial form.