Discipline: MS Civil Engineering	***Course Title:*** IRRIGATION ENGINEERING AND PRACTICE	
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Final-Term Assessment

Question #1: (*20 Marks)*

(a) Define "Delta" and "Duty" and write the significance of duty of crop.

(b) Wheat requires about 10cm of water after every 35 days and the base period or crop period of wheat is 140 days. Find out the delta for wheat?

(c) Explain the factors affecting consumptive use.

Answer #1:

Part (a): Define "Delta" and "Duty" and write the significance of duty of crop.

Delta*:*

A crop needs a certain amount of water at fixed interval throughout its base period. It is the total depth of the water required by a crop during the entire period the crop is in the field and is denoted by the symbol Δ. For example, if a crop requires about 12 watering at an interval of 10 days, and a water depth of 10 cm. If the area under the crop is A hectares, the total quantity will be 1.20 X A = 1.2 A hectare-meters in a period of 120 days.

Duty of Water*:*

The duty of water is the relationship between the volume of water and the area of crop it matures. The term duty means the area of land that can be irrigated with unit volume of irrigation water. Duty represents the irrigating capacity of a unit. It is the relation the between the area of a crop irrigated and the quantity of irrigation water required during the entire period of the growth of that crop. For example, if 3 cumecs of water supply is required for a crop sown in an area of 5100 hectares, the duty of irrigation water will be 5100/3 = 1700 hectares/cumecs, and the discharge of 3 cumecs will be required throughout the base period.

Significance of duty of crop:

It helps us in designing an efficient canal irrigation system. Knowing the total available water at the head of a main canal, and the overall duty for all the crops required to be irrigated in different seasons of the year, the area which can be irrigated can be worked out. Inversely, if we know the corps area required to be irrigated and their duties, we can work out the discharge required for designing the channel.

Part (b): If wheat requires about 10 cm of water after every 35 days, and the base period for wheat is 140 days, find out the value of **delta** for wheat?

Solution:

Depth = 10 cm
Interval = 35 days
Base Period for Wheat = 140 days

No. of watering required = 140/35 = 4
Total depth of water required in 140 days = 10 × 4 = 40 cm
Δ for wheat = **40 cm**

Part (c): Explain the factors affecting consumptive use.

1. PRECIPITATION

The amount and rate of precipitation may have some minor effect on the amount of water consumptively used during any summer. Under certain conditions, precipitation may occur as a series of frequent, light showers during the hot summer. Such showers may add little or nothing to the soil moisture for use by the plants through transpiration but do decrease the withdrawal from the stored moisture. Such precipitation may be lost largely by evaporation directly from the surface of the plant foliage and the land surface.

Part of the precipitation from heavy storms may be lost by surface runoff. Other storms may be of such intensity and amount that a large percentage of the moisture will enter the soil and become available for plant transpiration. This available soil moisture may materially reduce the amount of irrigation water needed.

2. TEMPERATURE

The rate of consumptive use of water by crops in any particular locality is probably affected more by temperature, which for long-time periods is a good measure of solar radiation, than by any other factor. Abnormally low temperatures retard plant growth and unusually high temperatures may produce dormancy. Consumptive use may vary widely even in years of equal accumulated temperatures because of deviations from the normal seasonal distribution. Transpiration is influenced not only by temperature but also by the area of leaf surface and the physiologic needs of the plant, both of which are related to stage of maturity.

3. HUMIDITY IN AIR

Evaporation and transpiration are accelerated on days of low humidity and slowed during periods of high humidity. During periods of low relative humidity, greater rate of use of water by vegetation may be expected.

4. VELOCITY OF WIND

Evaporation of water from land and plant surfaces takes place more rapidly when there is moving air than under calm air conditions. Hot, dry winds and other unusual wind conditions during the growing period will affect the amount of water consumptively used. However, there is a limit in the amount of water that can be utilized. As soon as the land surface is dry, evaporation practically stops and transpiration is limited by the ability of the plants to extract and convey the soil moisture through the plants.

6. LATITUDE AND SUNLIGHT

Although latitude may hardly be called a climatic factor, it does have considerable influence on the rate of consumptive use of water by various plants. Because of the earth's movement and axial inclination, the hours of daylight during the summer are much greater in the northern latitudes than at the Equator. Since the sun is the source of all energy used in crop growth and evaporation of water, this longer day may allow plant transpiration to continue for a longer period each day and to produce an effect similar to that of lengthening the growing season.

7. SOIL FERTILITY

If a soil is made more fertile through the application of manure or by some other means, the yields may be expected to increase with an accompanying small increase in use of water. However, an increase in fertility of the soil causes a decrease in the amount of water consumed per unit of crop yield.

Question #2: (***20 Marks)***

(a) *What are the principal causes and ill effects of water logging?*

(b) *Describe the anti-water logging measures.*

(c) *Explain the methods adopted to reclaim saline soils.*

Answer #2:

Part (a): What are the principal causes and ill effects of water logging?

Water logging: Soaking of agricultural land caused by a rising water-table [the surface of groundwater in the soil] or excessive irrigation. [Waterlogging] compacts soil, deprives roots of oxygen and contributes to salinization.

The Principal Causes and ill Effects of Water Logging:

1. **Intensive Irrigation:**
   If max. area of land is irrigated, percolation of water takes place. This causes the rise of Water Table. Extensive irrigation (irrigation spread over wider regions) to be followed to avoid water logging.
2. **Seepage of water from adjoining high lands.**
3. **Seepage of water through canal reservoirs.**
4. **Impervious obstruction:**
   water seeping below the soil moves horizontally. It may find obstruction & WT may rise.
5. **Inadequate surface Drainage:**

Storm water & excess of irrigation water should be removed. If proper drainage is not provided water percolates to rise water table.

6. **Excessive Rains:**
   Causes temporary water logging.
   No drainage causes permanent.
7. **Submergence due to floods:**
   Continued floods cause the growth of water-loving plants which obstruct natural surface drainage & increase the water-logging.
8. **Irregular & flat topography: In depressions**
   the drainage is poor, water detention is more the percolation increases the water table.

Part (b): Describe the anti-water logging measures.

Quantity of water into soil below is reduced. Inflow into underground reservoir is reduced & outflow should be increased.

1. **Lining of canals and water courses:** It reduces seepage of water.
2. **Reducing intensity of irrigation:** Only small portion of land should receive canal water in one particular season. Remaining areas can receive water in next season by rotation.
3. **By introducing crop rotation:** High water requiring crop should be followed by one requiring less water, and then by one requiring almost no water.
   Example: Rice followed by wheat and then by cotton.
4. **Optimum use of water:** Certain amount of water gives the best result. Less or more water reduce the yield. Cultivators should be educated so that not to use more water. Revenue should be charged on the basis of quantity of water rather than the area of land.
5. **Improving natural drainage of area:** water should not be allowed to stay in one area. Natural flow is provided by bush and jungle cutting.
6. **Pumping or Tube wells or Vertical Drainage:** Lift irrigation should be introduced to use GW. Canal irrigation may be substituted by tube well irrigation.
7. **Economical use of water according to need:**
8. **Adoption of sprinkler method of irrigation:** Only predetermined amount of water is supplied to land, No percolation losses from water courses.

Part (c): Explain the methods adopted to reclaim saline soils.

A: Salt leaching:

The amount of crop yield reduction depends on such factors as crop growth, the salt content of the soil, climatic conditions, etc. In extreme cases where the concentration of salts in the root zone is very high, crop growth may be entirely prevented. To improve crop growth in such soils the excess salts must be removed from the root zone. The term reclamation of saline soils refers to the methods used to remove soluble salts from the root zone. Methods commonly adopted or proposed to accomplish this include the following:

1. **Scraping:** Removing the salts that have accumulated on the soil surface by mechanical means has had only a limited success although many farmers have resorted to this procedure. Although this method might temporarily improve crop growth, the ultimate disposal of salts still poses a major problem.
2. **Flushing:** Washing away the surface accumulated salts by flushing water over the surface is sometimes used to desalinize soils having surface salt crusts. Because the amount of salts that can be flushed from a soil is rather small, this method does not have much practical significance.

3. **Leaching:** This is by far the most effective procedure for removing salts from the root zone of soils. Leaching is most often accomplished by ponding fresh water on the soil surface and allowing it to infiltrate. Leaching is effective when the salty drainage water is discharged through subsurface drains that carry the leached salts out of the area under reclamation. Leaching may reduce salinity levels in the absence of artificial drains when there is sufficient natural drainage, i.e. the ponded water drains without raising the water table. Leaching should preferably be done when the soil moisture content is low and the groundwater table is deep. Leaching during the summer months is, as a rule, less effective because large quantities of water are lost by evaporation. The actual choice will however depend on the availability of water and other considerations. In some parts of India for example, leaching is best accomplished during the summer months because this is the time when the water table is deepest and the soil is dry. This is also the only time when large quantities of fresh water can be diverted for reclamation purposes.

A: Drainage:

Irrigation is the most effective means of stabilizing agricultural production in areas where the rainfall is either inadequate for meeting the crop requirements or the distribution is erratic. Provision of adequate drainage measures is the only way to control the groundwater table. Subsurface drainage problems may also arise due to the presence, at some soil depth, of a clay barrier, a hardpan, bed rock, or even a subsoil textural change.

1. Surface drainage

In surface drainage, ditches are provided so that excess water will run off before it enters the soil. However, the water intake rates of soils should be kept as high as possible so that water which could be stored will not be drained off. Field ditches empty into collecting ditches built to follow a natural water course. A natural grade or fall is needed to carry the water away from the area to be drained. The location of areas needing surface drainage can be determined by observing where water is standing on the ground after heavy rain. Field ditches and collection or outlet ditches should be large enough to remove at least 5 cm of water in 24 hours from a level to a gently sloping land. The capacity of a drainage system should be based on the amount and frequency of heavy rains. How quickly water runs into ditches depends on the rate of rainfall, land slope and the condition of the soil surface including the plant cover. The area that a ditch can satisfactorily drain depends on how quickly water runs into the ditch, the size of the ditch, its grade or slope and its irregularity.

2. Subsurface drainage:

If the natural subsurface drainage is insufficient to carry the excess water and dissolved salts away from an area without the groundwater table rising to a point where root aeration is affected adversely and the groundwater contributes appreciably to soil salinization, it may be necessary to install an artificial drainage system for the control of the groundwater table at a specified safe depth. The principal types of drainage systems may consist of horizontal relief drains such as open ditches, buried tiles or perforated pipes or in some cases pumped drainage wells (Plate 5).

a. Open ditches: Open drainage ditches are advantageous for removing large volumes of either surface or subsoil water from land and for use where the water table is near the surface and the slope is too slight for proper installation of tile drains. Where subsurface tile drains are uneconomic or physically impossible, as in many heavy clay soils and where the topography is nearly flat, open drains may be the only practical means of draining the land.

b. Mole drains: these are channels left by a bullet shaped device pulled through the soil, they have been used successfully for shallow subsurface drainage of heavy clay soils in many, relatively humid, parts of country but have been found impractical with soils of coarser texture. Mole drains are generally cheaper to install than tile or plastic tubing’s but may last only for two or three years. In addition to being temporary, mole drains are generally shallow and have not been used extensively where salinity build up from the groundwater table is a major problem.

c. Other subsurface drains: These include any type of buried conduit with open joints or perforations that collect and convey excess water from the soil. The conduits may be made from clay, concrete, plastic or other synthetic material but clay and concrete tiles have been the most widely used.Both clay and concrete tiles may have fitted ends and be perforated for easier entry of water. All drain tiles should meet standard specifications.

3. Filter materials

These are sometimes placed around subsurface drains primarily to prevent the inflow of soil into the drains which may cause failure, and/or to increase the effective diameter or area of openings in the drains which increases inflow rate. Two types of materials are generally used:

- thin sheets such as of fibre glass or spun nylon, and
- sand and gravel envelopes or other porous granular materials.

The thin sheet filters may be sealed on to the plastic tubing at the manufacturing site or they may be installed above and/or below the drains as they are being laid. Granular materials should be placed above or below the drains during installation. Such materials must have the proper gradation of sizes to prevent the inflow of soil.

4. Pump drainage

The chief drawback of gravity drainage systems is their inability to lower the water table to an adequate depth. Pumping groundwater in areas where a suitable permanent aquifer exists is often an effective means of lowering the water table. A decision to pump groundwater for drainage is generally favored by adequate depths and permeabilities of the water bearing formations, by high values of pumped water for irrigation and by low power costs (see section 4.8.1 on drainage of sodic soils). To determine if pumping would be effective, pumping tests have to be carried out in test wells to determine the feasibility and area of influence by measuring water levels in adjacent observation wells or piezometers. Spacing, depth, and capacity of the pumped wells and other operational details also need to be evaluated from these tests.

5. Maintenance of drainage systems

After a subsurface drainage system has been installed, a suitable map should be made and filed with the property deed. The map should show the location of all ditches and subsurface drains, tile size and grade, depth and spacing. Any subsequent changes should also be recorded on the map. The record is of considerable value to the present and future land owners when the drainage system might need repairs or maintenance.

Question #3: (*20 Marks)*

(a) *How does Kennedy's theory differ from Lacey's theory for the design of irrigation canals?*

(b) *Design a regime channel for a discharge of 30 cumecs and mean diameter of the particle of 0.56 mm using Lacey's theory.*

Answer #3:

Part (a): How does Kennedy's theory differ from Lacey's theory for the design of irrigation canals?

No	Kennedy's theory	Lacey's theory
1	It states that the silt carried by the flowing water is kept in suspension by the vertical component of eddies which are generated from the bed of the channel.	It states that the silt carried by the flowing water is kept in suspension by the vertical component of eddies which are generated from the entire wetted perimeter of the channel.
2	Relation between 'V' & 'D'.	Relation between 'V' & 'R'.
3	Critical velocity ratio 'm' is introduced to make the equation applicable to diff. channels with diff. silt grades.	Silt factor 'f' is introduced to make the equation applicable to diff. channels with diff. silt grades.
4	Kutter's equation is used for finding the mean velocity.	This theory gives an equation for finding the mean velocity.
5	This theory gives no equation for bed slope.	This theory gives an equation for bed slope.
6	In this theory, the design is based on trial and error method.	This theory does not involve trial and error method.
7	All channels which are not silting or scouring are in regime	Lacey differentiated between initial and final regime

Part (b): Design a regime channel for a discharge of 30 cumecs and mean diameter of the particle of 0.56 mm using Lacey's theory.

Solution:

$$Q = 30\ Cumecs \quad M = 0.56mm$$

1: $f = 1.76m^{0.5}$ $\qquad f = 1.760.56^{0.5} = 1.317$

2: $v_m = \left(\frac{Qf^2}{140}\right)^{1/6}$ $\qquad v_m = \left(\frac{30\ x\ 1.317^2}{140}\right)^{1/6} = 0.848\ m/sec$

3: $R = \frac{5}{2} \cdot \left(\frac{v^2}{f}\right)$ $\qquad R = \frac{5}{2} \cdot \left(\frac{0.848^2}{1.317}\right) = 1.37m$

4: $P = 4.75\sqrt{Q}$ $\qquad P = 4.75\sqrt{30} = 26.02m$

5: $s = \frac{f^{5/3}}{3340\ Q^{1/6}}$ $\qquad s = \frac{1.317^{5/3}}{3340\ 30^{1/6}} = 0.0002687 \cong 0.0003 = \frac{3}{10000}$

6: $A = \frac{Q}{v_m}$ $\qquad A = \frac{30}{0.848} = 35.38\ m^2$

Question #4: *Write notes on the following:* (***20 Marks)***

(a) *Field Capacity*
(b) *Permanent wilting point*
(c) *Canal Head Regulator*
(d) *Under Slucies*

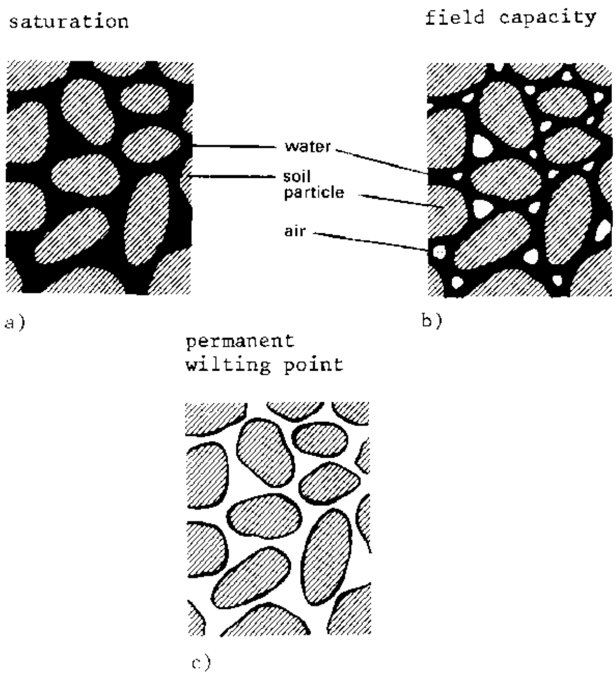
Answer #4:

(a) Field Capacity:

After the drainage has stopped, the large soil pores are filled with both air and water while the smaller pores are still full of water. At this stage, the soil is said to be at field capacity. At field capacity, the water and air contents of the soil are considered to be ideal for crop growth, Field capacity is the amount of soil moisture or water content held in soil after excess water has drained away and the rate of downward movement has materially decreased, which usually takes place within 2–3 days after a rain or irrigation in pervious soils of uniform structure and texture.
The **physical definition** of field capacity (θfc) is the bulk water content retained in soil at −33 J/kg (or −0.33 bar) of hydraulic head or suction pressure.

(b) Permanent wilting point:

Little by little, the water stored in the soil is taken up by the plant roots or evaporated from the topsoil into the atmosphere. If no additional water is supplied to the soil, it gradually dries out. The dryer the soil becomes, the more tightly the remaining water is retained and the more difficult it is for the plant roots to extract it. At a certain stage, the uptake of water is not sufficient to meet the plant's needs. The plant loses freshness and wilts; the leaves change colour from green to yellow. Finally, the plant dies.

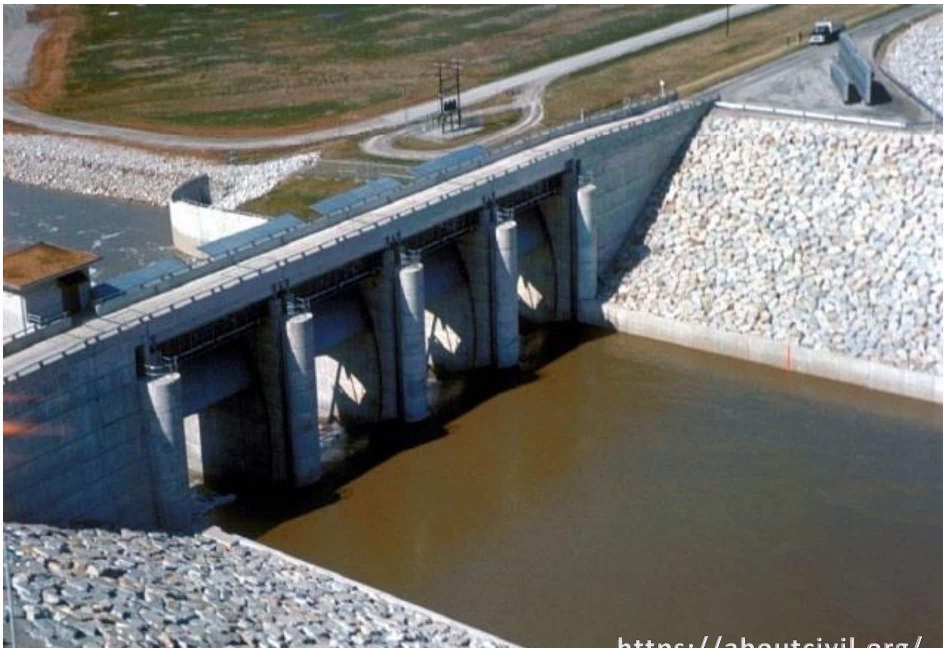


The soil water content at the stage where the plant dies, is called permanent wilting point. The soil still contains some water, but it is too difficult for the roots to suck it from the soil.

(c) Canal Head Regulator:

Structure at the head of canal taking off from a reservoir may consist of number of spans separated by piers and operated by gates. Regulators are normally aligned at 90° to the weir. Up to 10" are considered preferable for smooth entry into canal. The functions of canal head regulator are:

- To admit water into the off taking canal.
- To regulate the supplies into the canal.
- To indicate the discharge passed into the canal from design discharge formula and observed head of water on the crest.
- To control the silt entry into the canal. During heavy floods, it should be closed otherwise high silt quantity will leave to the canal.



(d) Under-Sluices or Scouring Sluices:

The **under-Sluices** are the openings which are fully controlled by gates, provided in weir wall with their crest at a low level. They are located on the same side as the off-taking canal. Under sluices are also called **scouring sluices** because they help in removing the silt near the head regulators. A comparatively less turbulent pocket of water is created near the canal head regulator by constructing under sluice portion. The silt of the under-sluice pocket is kept at or slightly above the deepest river bed and about 0.9 to 1.8 m below silt of the canal head regulator.

Functions of Under-Sluices

- Preserve a clear and defined river channel approaching the regulator.
- Control the silt entry into the canal.
- Pass the low floods without dropping the shutter of the main weir.
- Provide greater water-way for floods, thus lowering the flood level.
- They scour the silt deposited on the river bed above the approach channel.