UNIT-I

12/6/19

IRRIGATION ENGINEERING

Definition :-

The process of supplying water to the soil for rising of crops from several hydraulic structures.

Need :-

* Less rainfall.
* Non uniform distribution of rain.
* Growing a no. of crops during a year.
* Perennial crops (onions, apples..etc).
* Commercial crops with additional water (Tea, cofee, ..etc).
* Controlled water supply.

Scope :-

Scope is divided into two aspects that are Engg. aspect & Agricultural aspect.

Engg. aspect :-

→ storage, diversion or lifting of water.

→ Conveyance of water to the agricultural fields. (by proper distribution system).

Reserviors → canals → field channel → crops.

→ Application of water to agricultural fields (by methods of irrigation).

→ Drainage & relieving water - logging development of water power.

Agricultural aspect :-

-> Maintaining proper depth of water to crops.

-> Distribution of water uniformly & periodically.

-> Capacities of different soils for irrigation water & the flow of water in the soils.

-> Reclamation of waste & alkaline lands where this can be carried out through the agency of water.

Benefits :-

* Increase in food production
* Protection from famine (lack of food during a long period of time in a region).
* Cultivation of cash crops.
* Elimination of mixed cropping.
* Addition to the wealth of the country.
* Increase in prosperity of people.
* Generation of hydro-electric power.
* Domestic & industrial water supply.
* In-land navigation.
* Improvement of communication.
* Canal plantations.
* Improvement in the ground water storage.
* Aid in civilization.
* General development of the country.

Ill effects :-

* Breeding places for mosquitoes.
* water logging
* Damp climate.

Types of Irrigation :-

Irrigation methods
- Surface irrigation
  - flooding
    - wild flooding
    - controlled flooding
      - free flooding
      - contour laterals flooding
      - Border strips flooding
      - checks basin flooding
      - Basin flooding
      - zigzag method of flooding.
  - Furrow method
  - contour farming.
- Sub-surface irrigation
- sprinkler irrigation.

⇒ Surface Irrigation :-

→ Free flooding :-

* Free flooding consists of dividing the entire land to be irrigated into small strips by a no. of field channels & levees known as laterals.

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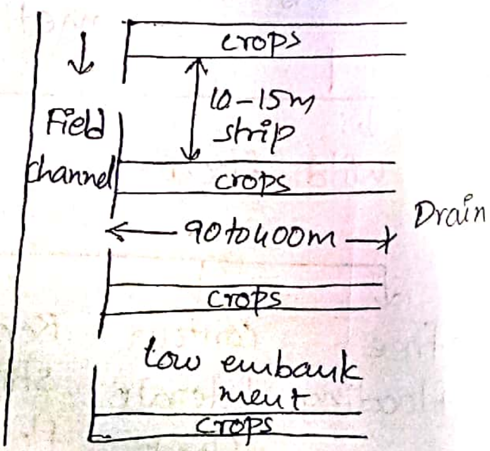
* These laterals may be either at right angles to the sides of the field or at right angles to the contour lines.

→ **Contour laterals :-**

* This is a special case of free flooding in which the field channels & laterals are aligned approximately along the contour lines.
* In this method, irrigation is possible only on side of the laterals.

→ **Boarder strip method :-**



→ **check basin Irrigation :-**

check basins are rectangular & square small plots surrounded by levees & checks.

→ **Ring basin method :-**

This method is a modification of check basin method & is suitable for

→ Furrow method :-

* Used for maize, sugar cane, tobacoo etc.
* Land is wetted only 1/2 to 1/5th portion.
* Evaporation is reduced.
* Consists of narrow ditches (Furrows) b/w row of plants.
* Common length is 100 – 200 m.
* Labour requirements are less.
* straight furrows, contour furrows.

Avg. depth of water application (d in mm) of duration (t) is $d = 3600\, q \cdot t / WL$.

q = discharge of the furrow, lit/sec

L, W are length & width of furrows in meters

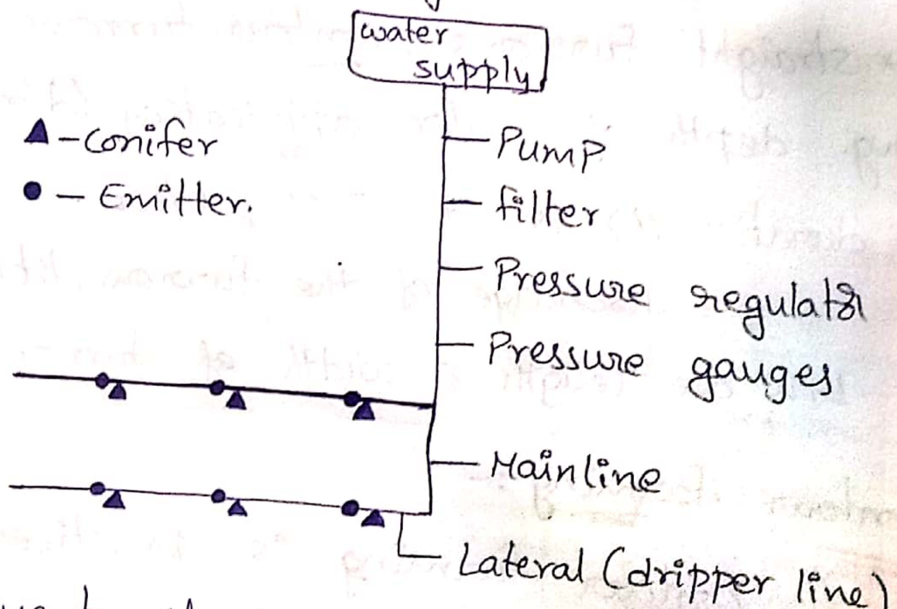
→ Contour farming :-

Contour farming is practiced in hilly areas with slopes & with falling contour. The land is divided into series of horizontal strips called terraces. Small bunds are constructed at the end of each terrace to hold water upto equal ht. Contour farming besides producing crop yields, helps in mitigating indirectly controlling floo soil conservation.

⇒ Sub-surface Methods :-

In this method, the water is

applied to the root zone of the crops by under ground network of pipes. The network consists of main pipe, sub main pipes & lateral perforated pipes. The perforated pipes allow the water to drip out slowly & thus the soil below the root zone of the crops absorbs water continuously. This method is suitable for permeable soil like sandy soil. The method is also known as drip method or trickle method of irrigation.



Arrangement of Drip irrigation :-

→ Pump to lift water.

→ A head tank to store water & to maintain pressure head of 5-7 m.

→ Central distribution system which filters, add nutrients & regulates the pressure & amount of water to be applied.

→ Mains & secondary lines (20-40 mm).

→ Trickle lines (10-20 mm) fitted to the secondary lines to maintain equal space b/w rows.

→ Plastic nozzles attached to trickle lines (2-10 lit/hr).

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Crops classification:-

Agricultural:-

Field crops: wheat, rice, maize, barely, oats.etc.

Oil seed crops: Ground nut, sunflower..etc.

Commercial crops: sugar cane, tobacco..etc.

Horticultural crops: fruits, vegetables & flower crops..etc.

Plantation crops: Tea, cofee, coconut ..etc.

Forage crops: Grass.

Miscellaneous: Medicine, Aromatic..etc.

Based on crop season:-

Rabi:- Octobar - March (Gram, wheat, barely..etc)

Kharif:- June - August mausoon (Rice, maize..etc).

Perennial:- Sugar cane, fruits..etc.

Eight months:- Cotton.

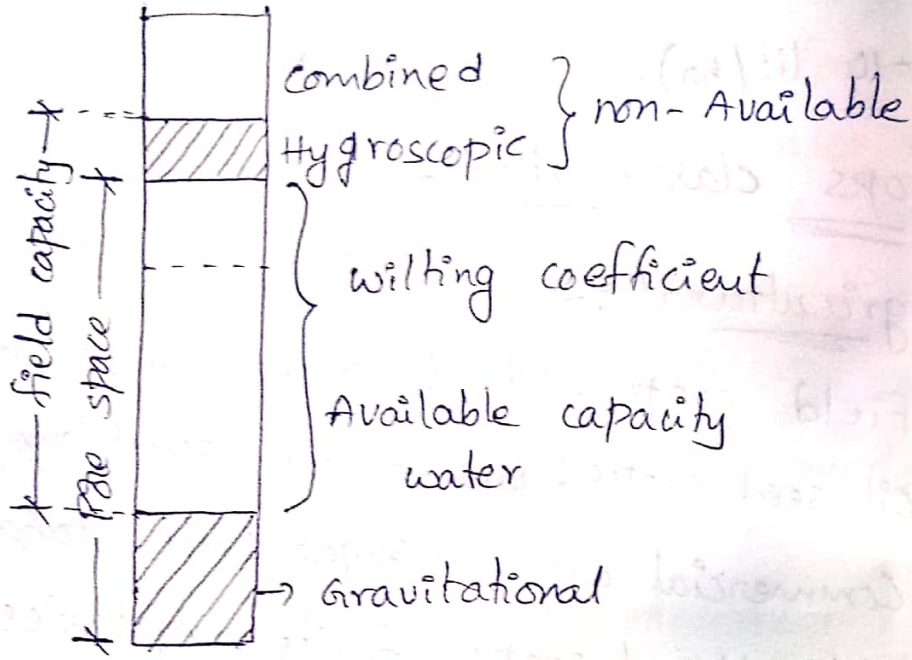
Based on irrigation requirements:-

Dry crops, wet crops, Garden.

Hydroscopic water:-

When an oven dried sample is kept in atmosphere, it absorbs some amount of moisture from atmosphere.

soil moisture content :-



capillary water :-

Part of excess of hygroscopic water which exists in the pore space of soil which is favorable drainage is provide.

Gravitational water :-

Part of excess of hygroscopic & capillary water which will move out of the soil if favorable drainage is provided.

soil moisture tension :-

Force per unit area that must be exerted in order to extract water from the soil.

Soil moisture stress :-

Soil moisture + osmotic pressure (increase in the force caused by the salts present in soils).

Saturation capacity :- (max. moisture holding capacity)

It is defined as the amount of water required to fill all the pore spaces b/w soil particles by replacing all the air.

Field capacity :-

It is defined as the max. amount of moisture which can be held by a soil against gravity, thus immediately after the gravitational water has drained off from a saturated soil mass.

⇒ Permanent wilting point & coefficient :-

It is that water content at which plants can no longer extract sufficient water from the soil for growth & become permanently wilted.

⇒ The permanent wilting point is expressed as a %

It is as low as 2% for light sandy soils & may be as high as 30% for heavy clayey soils.

⇒ Ultimate wilting :-

When it occurs, the plant will not regain its turbidity even after the addition of sufficient water to the soil & plant will die.

⇒ Available moisture :-

It is the different in water content of the soil b/w field capacity & permanent wilting point.

⇒ Readily available moisture :-

It is that portion of available moisture which is most easily extract by plant roots. Only about 75% of available moisture is readily available.

Expression for depth of water held by soil in root zone

The water held by soil, in root zone may be expressed in terms of depth of water as indicated below.

Let, y = depth of water available in root zone in meters.

F_c = field capacity of soil expressed as a ratio.

d = depth of root zone in meters.

γ_s = Density & unit weight of soil.

γ_w = Density & unit weight of water.

Consider one square meter & unit area of soil mass.

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$$y = \frac{\gamma_s}{\gamma_w} \times d \times [\text{field capacity} - \text{Permanent willing point}].$$

Classification of Irrigation water :-

1. Classification based on total concentration of soluable salts :-

The salinity concentration of soil solution can be found from the following formula.

$$C_s = \frac{C \cdot Q}{Q - (C_u - P_{eff})}$$

where,

C - Concentration of salt in irrigation water.

Q - Quantity of water supplied to the soil.

P_{eff} - effective precipitation.

C_u -

S.NO	Type of water	Suitability for irrigation
1.	→ Low salinity water (C_1) conductivity b/w 100-200 μohms/cm at 25°C.	→ suitable for all types of crops & all kinds of soil
2.	→ Medium salinity water (C_2) conductivity 250-270 μohms/cm	→ can be used if a moderate amount of leaching occurs.
3.	→ High salinity water (C_3) conductivity 750-2250 μohms/cm	→ Unsuitable for soil with restricted drainage.
4.	→ Very high salinity water conductivity >2250 μohm/cm	→ Unsuitable for irrigation.

2. (a) Classification based on sodium concentration :-

$$\% \text{ sodium} = ESP = \frac{100\, Na^{+}}{Ca^{++} + Mg^{++} + Na^{+} + K^{+}}$$

$$\text{Sodium absorption ratio, } SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

S.No.	Type of water	Suitability for irrigation.
1.	→ Low sodium water (S_1) SAR range 0-10	→ Suitable for all types of crops & soils except for those crops which are highly sensitive sodium.
2.	→ Medium sodium water (S_2) SAR range 10-18	→ suitable for coarse texture of organic soil with permeability.
3.	→ High sodium water (S_3) SAR range 18-26	→ Harmful for all types of soils.
4.	→ Very high sodium water SAR range >26.	→ Unsuitable for irrigation.

3. Classification based on electrical conductivity, total solids, sodium ion exchange, boron concentration & sulphate concentration:-   18/6/19

water class	Electrical conductivity ($EC \times 10^6$)	Total salt content TDS(PPM)	exchangable sodium % ESP %	Boron concentration (PPM)	choride concentration (PPM)	sulphate concentration
1.	0-1000	0-700	60	0.0 to 0.5	0-142	0-192
2.	1000-3000	700-2000	60-75	0.5-0.2	142-355	192-480
3.	over 3000	over 2000	over 75	over 0.2	>355	>480

Duty - Delta relationship:-

Duty of water is its capacity to irrigate land.

* It is the relation b/w the area of the land irrigated & the quantity of water required.

* Thus Duty(D) is defined as the area of the land which can be irrigated if one cumec of water was applied to the land continuously for the entire base period of the crop.

* It is expressed as hectars/cumecs.

Delta is the total depth of water supplied to the crop during the entire base period.

* If the entire quantity of applied water were spread uniformly on the land surface, the depth of water would have been equal to delta.

* Thus the delta (in m) of any crop can be determined by dividing the total quantity of water

(in ha-m) required by the crop by the area of the land (in ha).

vibhav plastic waste mgt.

Base Period:-

Base period for a crop refers to the whole period of cultivation from the time when irrigation water is first issued for the preperation of ground for planting the crop, to its last watering before harvesting.

$$\text{Duty}, D = 8.64 \times \frac{B}{\Delta}$$

where, B – Base period, Δ – Delta.

Factors effecting Duty:-

* Methods & system of irrigation.
* Mode of applying water to the crops.
* Methods of cultivation
* Time & frequency of tilling.
* Types of crops.
* Base period of the crop.
* climatic conditions of the area
* Quality of water
* Method of assessment.
* Canal conditions.
* character of soil, sub-soil of the canal
* character of soil & sub-soil of the irrigation fields.

***Methods & systems of irrigation :-**

- → Perennial ⇒ More duty
- → Inundation ⇒ less duty
- → Flow ⇒ less duty
- → Lift ⇒ High duty
- → Tank ⇒ High duty.

***Mode of applying water:-**

- → Flood ⇒ Less duty than furrow
- → Ring basin & Uncontrolled ⇒ less duty.
- → Sub surface ⇒ High duty.

***Methods of cultivation:-**

Proper ploughing improves duty.

***Time & frequency of tilling:-**

Good arrangement of soil particles in relation to one another improves duty.

***Type of crop :-** changes.

***climatic conditions :-**

Humidity, Temperature & wind, rainfall.

***Quality of water:-**

Alkaline & salt content - Reduce the duty

More fertilizing matter increases duty.

***Method of assessment of water:-**

Volumetric gives high duty.

***canal conditions :-**

Earthen canal ⇒ less duty.

lined canal => High duty.

Methods of Improving Duty:-

→ If the factors affecting duty may be made less effective, duty of water may be improved. Thus, methods of improving duty are,

→ Suitable & efficient method of applying water to the crop should be used.

→ Canals should be lined to reduce seepage loss. water should be conveyed quickly to reduce evaporation loss.

→ Idle length of the canal should be reduced.

→ Construction parallel canals to run side by side, F.S.L is reduced to minimize the losses.

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Gross command area (GCA):-

It is the total area ~~line~~ lying b/w drainage boundaries which can be commanded & irrigated by a canal system.

Culturable command area (C.C.A):-

→ The gross command area also contains unfertile bare land, alkalin soil, villages & other areas of inhabitations. These areas are known as Unculturable areas.

→ The remaining area on which crops can be grown satisfactory is known as culturable ~~Cou~~ command area.

Culturable cultivated area:-

It is the area in which crop is grown at a perticular time & crop season.

Korperiod & kordepth:-

The first watering to the crops growth is known as kore watering. The depth applied for kore watering is kore depth. The Portion of the base period in which kore watering is needed is known as kore period.

Outlet factor:-

It is defined as the duty at the outlet.

Time factor:-

It is the ratio of no. of days the canal ~~have~~ has actually to the no. of days of irrigation period.

Capacity period:-

It is the ratio of mean supply to the full supply of a canal.

Root zone depth:-

It is the max. depth of soil strata in which the crop spreads its root system & ~~ete~~ derives water from the soil.

⇒ Find the Delta for a crop if the duty for a base period of 110 days is 1400 hec/cumec

Sol:- B = 110 days

Duty, Δ 1400 hec/cumec.

Delta, Δ = ?

$$\text{Duty} = 8.64 \times \frac{B}{\Delta}$$

$$1400 = 8.64 \times \frac{110}{\Delta}$$

$$\Delta = 0.66$$

⇒ An irrigation canal has G.C.A of 80,000 hects out of which 85% is culturable, irrigable. The Intensity of irrigation for kharif season is 30% & for Rabi season 60%. Find the discharge required at the head of the canal if the duty at its head is 800 hect/cumec for kharif season & 1700 hect/cumec for Rabi season.

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Sol:-

G.C.A = 80,000 hect.

C.C.A = 85% of G.C.A

$$= \frac{85}{100} \times 80000$$

$$= 68,000 \text{ hect.}$$

Kharif

Intensity of irrigation = 30% of C.C.A

$$= \frac{30}{100} \times 68,000$$

$$= 20,400 \text{ hect.}$$

Duty at the head of canal = 800 hect/cumec.

$$\text{Discharge at the head of canal} = \frac{\text{Intensity}}{\text{Duty}}$$

$$= \frac{20400}{800} = 25.5 \text{ cumecs.}$$

Rabi

Intensity of irrigation = 60% of C.C.A

$$= \frac{60}{100} \times 68000$$

$$= 40,800 \text{ hect.}$$

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Duty at the head of canal = 1700 hect / cumec.

Discharge at the head of canal = $\frac{\text{Intensity}}{\text{Duty}}$

$= \frac{40,800}{1700}$

$= 24$ cumec.

⇒ The root zone of an irrigation soil has dry unit wt. of 15 kN/m³ & a field capacity of 30%. The root zone depth of a certain crop having ~~permeabi~~ perminant wilting % of 8% is 0.8m. Determine (a) Depth of moisture in the root zone at field capacity. (b) Depth of moisture in the root zone at perminant wilting point & Depth of water available in root zone.

Sol:-

Dry unit wt. of soil, $\gamma_s = 15$ kN/m³.

$\gamma_w = 9.81$ kN/m³.

P.W.P = 8%

Root zone Depth of crop, d = 0.8 m.

Field capacity = 30%.

(a) ⇒ Depth of moisture in the root zone at field capacity $= \frac{\gamma_s}{\gamma_w} \times$ field capacity.

$= \frac{15}{9.81} \times (30/100)$

$= 0.458$ m.

(b) Depth at Permanent wilting point $= \frac{\gamma_s}{\gamma_w} \times$ P.W.P

$= \frac{15}{9.81} \times \left(\frac{8}{100}\right)$

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(c) Depth of water available $= \frac{\gamma_s}{\gamma_w} \times d(F.C - PWP)$

$= \frac{15}{9.81} \times 0.8 \times \left(\frac{30}{100} - \frac{8}{100}\right)$

$= 0.269$ m.

⇒ Wheat is to be grown in a field having field capacity = 27% & the permanent wilting point is 13%. Find the storage capacity in depth of soil, If the dry unit wt of soil is 1.5 gm/cc. If the irrigation water is to be supplied when the avg. soil moisture falls to 18%, Find the water depth required to be supplied to the field if the field application efficiency is 80%. What is the amount of water needed at the canal outlet, if the water loss in the water coarse of the field channel is 15% of the ~~of~~ outlet discharge.

Sol:-

Field capacity = 27%

PWP = 13%

d = 80cm = 0.8m.

$\gamma_s = 1.5$ g/cc.

$\gamma_w = 1$ g/cc.

storage capacity, $y = \frac{\gamma_s}{\gamma_w} \times d(F.C - P.W.P)$

$= \frac{1.5}{1} \times 0.8 (0.27 - 0.13)$

$= 0.168$ m.

avg. soil moisture falls to 18%.

∴ Depth of water required $= \frac{1.5}{1} \times 0.8 \times (0.27 - 0.18)$

$= 0.108$ m

Field application efficiency = 80%.

∴ Depth of water supplied = $\frac{0.108}{80/100}$ = 0.135m.

Amount of water needed @ canal outlet for

15% of water loss = $\frac{0.135}{(100-15)\%}$ = $\frac{0.135}{85\%}$ = 0.158m

⇒ ~~A water coarse command~~

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Functions of Irrigation water:-

1. To supply water partially & totally for crop need.

2. To cool both the soil & the plant.

3. Provides water for its transpiration.

4. Dissolves minerals for its nutrition.

5. Provides oxygen for its metabolism.

6. Serves as anchor for its roots.

7. To enhance fertilizer application - fertigation

8. To leach Excess salts.

9. To improve groundwater storage.

10. To facilitate continuous cropping.

Soil fertility:-

* Containing of organic materials to crop for growing.

* Containing of nitrogen.

* Sufficient soluble compounds of the mineral elements needed for the growth of food plants.

The above requirements coupled with satisfactory surface topography, physical properties, subsoil drainage & application of adequate water at proper intervals leads to the production of rich crops.

Maitenance :-

-> Use of proper cultivation methods.

-> Crop rotation.

-> Application of careful fertilizers.

-> Proper ploughing.

Crop rotation :- It is the systematic planting of diff. crops in a perticular order over several years in the same growthing space. Nature of a crop ~~sown~~ shown in a perticular field is changed year after year.

-> In order to increase soil fertility.

-> To reduce crop disease. -> Prevent the soil erosion.

-> To increase Nitrogen content.

Assessment of Irrigation water :-

Irrigation projects are undertaken by the government with the primary object of supplying water to the cultivator for raising crops to give max. yield. Charges are levied on the cultivator for making use of irrigation water. The charges are not only defray maintenance & operation costs but also include some return on the capital investment on the project.

Irrigation charges are not uniform in all the states of India. Generally the water charges comprises of on or more of the following elements.

→ water rate, depending on the kind & extent of crop.

→ Increment in land revenue, base on increased benefit derived annually.

→ Providing Irrigation facilities.

Method of Assessment:-

(i) Assessment on area basis & crop basis:-

The factors to be considered: Cash value of the crops.

water requirements of crops.

Time & demand of irrigation water.

Drawbacks of this system are., wasteful use of water as the charges are not made on the basis of actual quantity of water but on the area of crop.

Unequal distribution of water. The irrigators at the head reach of canal draw more water than due share & irrigators at the tail end of canal suffer.

(ii) Volumetric assessment:-

charges are levied on the basis of actual volume of water supplied at the outlet head. Most economical use of water in the field leads to more extent of irrigation area

It requires installation of water meters at all irrigation outlets in the canal system.

(iii) Composite rate assessment:-

Combined land revenue & water tax are levied from the cultivators. It is not much comm method of assessment.

(iv) Permanent assessment & betterment levy:-

In area where canals are provided as insurance against drought, the farmers are levied at a fixed rate every year irrespective of the fact whether & not they use the canal water. In drought year, the farmers are allowed to draw canal supplies without paying charges extra to normal betterment levy.

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Water logging & its control:-

water logging

It is the natural flooding & over-irrigation that brings water at underground levels to the surface. As a consequence, displacement of the air occurs in the soil with corresponding changes in soil processes & an accumulation of toxic substances that impede plant growth.

Causes of water logging

* Inadequate surface drainage.
* seepage from canal system.
* Over irrigation of fields.
* Obstruction of natural drainage.
* Impermeable clay layer below the soil.

Problems due to water logging :-

→ It creates anaerobic condition in soils for which microbial activity is hampered.

→ The availability of nutrient elements in soil is reduced & leaching loss is higher.

→ Increases soil pH in coastal & dry area which leads salinity & alkalinity.

→ Pollutes soil water & favors excessive weed growth.

Measures to reduce water logging :-

→ Construction of dams & embankments along the coast to restrict saline to enter the agricultural lands. Could be an effective measure of reducing the water logging.

→ Providing adequate number of bridges & culverts, along the roads, railroads, highways, across the canal etc. could be a handy measure against water logging.

Irrigation efficiencies :-

water conveyance efficiency :-

It is the ratio of water delivered to the irrigation plot to water supplied & diverted from the river & reservoir.

water application efficiency :-

It is the ratio of quantity of water stored in the root zone of the crops to the quantity of water delivered to the field.

Water use efficiency :-

It is the ratio of water benefitially used including leaching water to the quantity of water delivered.

Water storage efficiency:-

It is the ratio of water stored in root zone during irrigation to the water needed in the root zone prior to irrigation.

Water distribution efficiency:-

$$\eta_d = 100\left[1 - \frac{y}{d}\right]$$

where,

y = Avg. numerical deviation in depth of water stored from avg. depth stored during irrigation.

d = Avg. depth of water stored during irrigation.

Consentive use efficiency :-

It is the ratio of normal ~~consentive~~ consumptive use of water to the net amount of water depleted from root zone of soil.

Effective rainfall :-

It is the part of precipitation falling during the growing period of a crop ~~i.e, a~~ that is available to meet the evapotranspiration needs of the crop.

Consumptive irrigation requirement :-

It is defined as the amount of irrigation water that is required to meet the evapotranspiration needs of the crop during its full growth i.e., C.I.R = CU − Effective rainfall.

Net irrigation requirement:-

It is defined as the amount of irrigation water required at the plot to meet the evapotranspiration needs of water as well as other needs such as leaching...etc.

∴ NIR = CU − Effective rainfall + water lost in deep percolation for the purpose of leaching..etc.

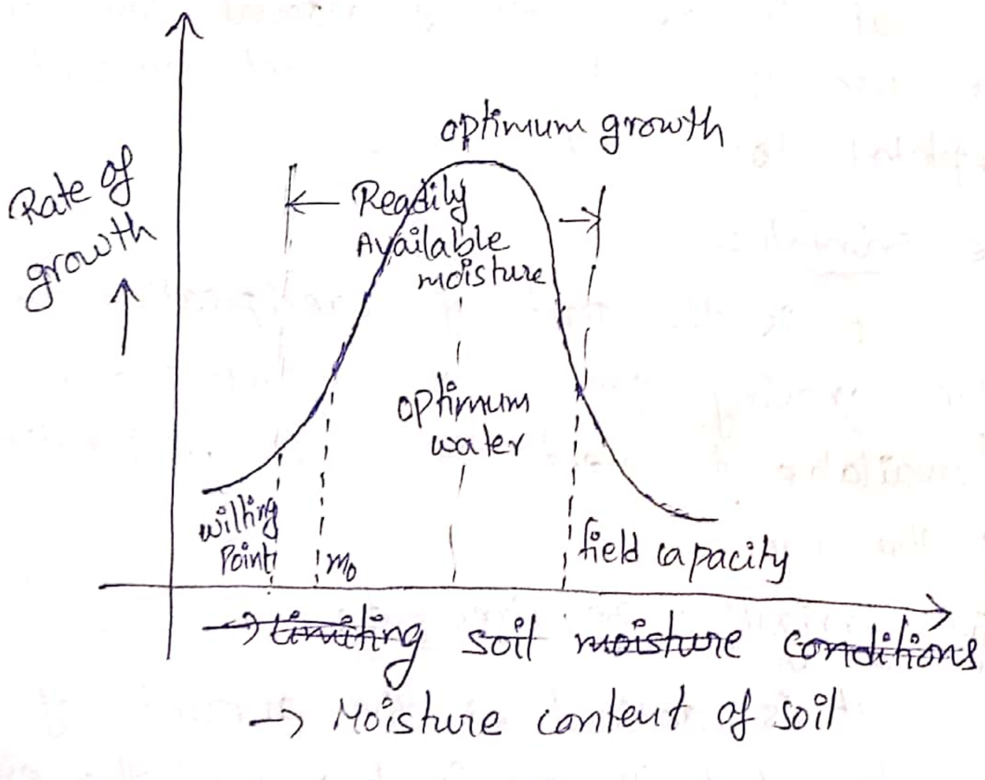
Field irrigation requirement:-

It is the ratio of net irrigation requirement to the water application efficiency.

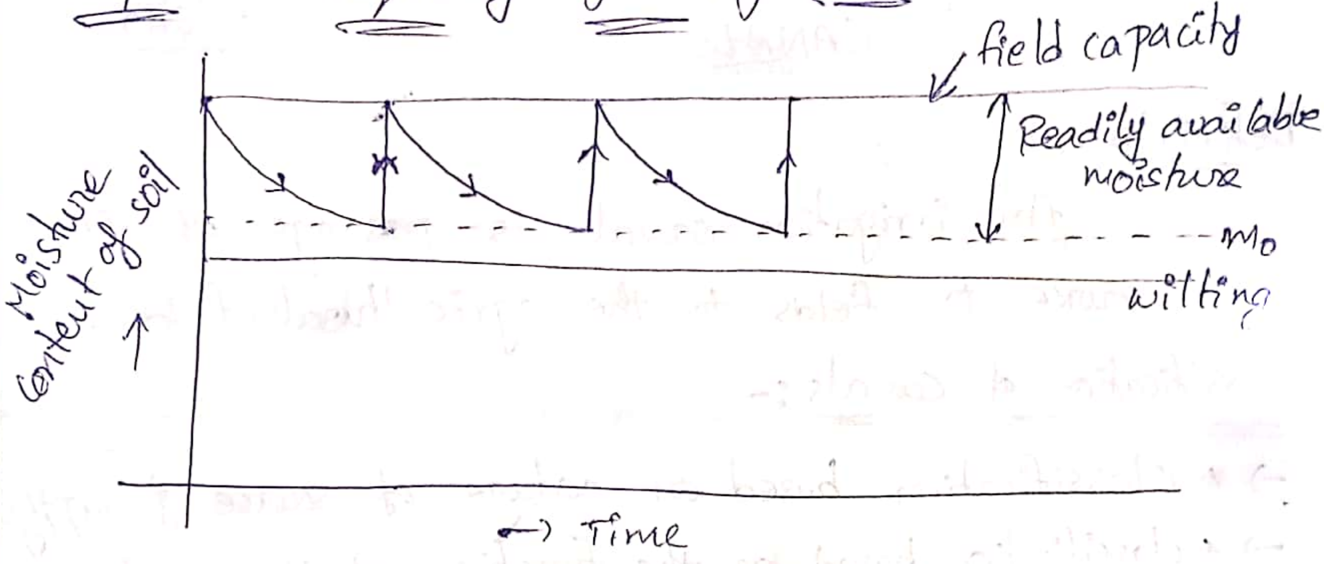
Gross irrigation requirement:-

It is the ratio of field irrigation requirement to the water conveyance efficiency.

Limiting soil moisture conditions:-



Depth & frequency of irrigation :-



If d is the root zone depth (m), F_c is the field capacity & m_o 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:

$$d_w = \frac{\gamma_d}{\gamma_w} d \left[F_c - m_o\right] \text{ mt.}$$

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

$$f_w = \frac{d_w}{C_u} \text{ days.}$$

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_o to field capacity (F_c) over an irrigated field of area 'A'. If 'q' is the discharge in the field channel in cumecs,

$$t = \frac{A d_w}{q} \text{ sec.}$$

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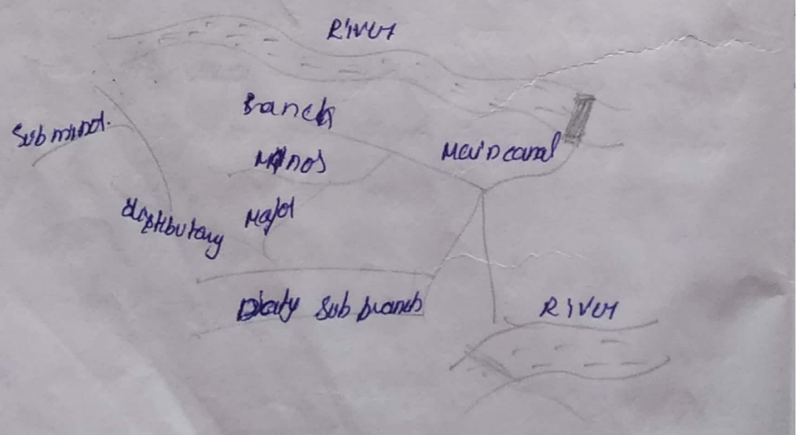
2. Canals

Canal is a passage of flow from source to fields mostly for irrigation.

Classifications of canals:

→ classification based on nature of source of supply.
→ classification based on the function of the canal.
→ " " " " discharge & relative importance in a given network of canals.
→ classification based on canal alignment.
→ " " " " financial output.
→ " " " " the soil through which constructed.
→ classification based on the lining being provided (or) not.



classification based on nature of Source of Supply.

i) permanent canals: Is the one which is fed by a permanent Source of Supply.

→ perennial canals: which get continous Supply from the Source through out the year.

→ Non-perennial canals: which get Supplies only for a part of the year.

ii) Inundation canals: which gets its Supplies only when the water level in the river rises during flood.

classification based on the function of the canal:

i) feeder canals:

Its function is to feed two (or) more canals and its also called link canal.

ii) carrier canals:

It is a canal which carries water either from the headwork's (or) from the feeder canal up to the distribution canal network and also does irrigation.

~~classification based on the fu~~

iii) Distribution canals:

It is a canal composed of distributaries and minors which have direct outlets to the fields.

iv) Hydel canals:

It is a canal which power houses are set up for hydel power generation.

v) Navigation canals:

It is a canal which is primarily used for transporta-tion by water. Multipurpose canal.

Classification based on discharge and relative importance in a given network of canals:

i) Main canals:

→ Main canals takes off water directly from the upstream side of weir headwork's (or) dam.

→ Usually no cultivation direct to proposed.

ii) Branch canal:

→ To supply the water to major and minor distributary

→ Its discharge is 14-15 cumecs.

iii) Major distributor:

→ The major canal take water from branch canal and feed the water to minor distributary (or) used for direct irrigation and hence they supply water through outlets to water courses.

→ The head discharge is 0.25 to 15 cumecs

iv) Minor distributor:

→ The minor canal take water from major distributary (or) branch canal.

→ Its discharge is less than 0.25 cumess

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v) water course (or) field channel:

→ water courses are small channels which carry water from the outlets of major & minor distributories.

classification based on canal alignment:

i) Ridge canal (or) watershed canal.

ii) contour canal

iii) Side slope canal.

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Ridge (or) watershead canal:

→ The canal is aligned along a natural watershed known as ridge these canals usually take off from the contour canal. It irrigates on both sides. C.D can be avoided and hence it is more economical.

Advantages:

→ This canal can supply water on both sides and thus a large area may be taken under cultivation.

→ As it flows along the highest line, it does not require to cross natural drainage on its way. therefore, costly cross drainage works (CDWs) are not at all necessary.

→ It is the best irrigation canal & most economical

Contour Canal

→ canal aligned nearly parallel to the contour is called contour canal.

→ In this canal system, C.C.A. lies on one side of it. So, that it can irrigate on one side.

Advantages:

→ Low initial cost of construction.

→ Discharge capacity increases as rain water from higher side is collected in canal.

Disadvantages:

→ Drainage enters from hill side causes silting.

→ Involves in crossing the natural drainage, therefore costly drainage works are to be on constructed.

Side-Slope canal

This canal is aligned roughly perpendicular to contour of the contour. Since it is perpendicular to the contour construction of cross drainage works (CDWs) does not arise, Since constructed along the falling contour, Slope of this canal is steep, which is not essential for unlined canal.

It irrigates only on one side just like contour canal.

Advantages:

construction of CDWs is not necessary

Disadvantages

Slope of this channel is more. If it is unlined erosion takes place. It also irrigates one side of the canal.

Based on financial output:

productive : Gives income to the nation.

protective : protecting from famine (shortage of food)

Based on function of canal:

Classification based on Soil throug which constructed

Alluvial : canal excavated in alluvial soil (silt).

Non-alluvial: clay, hard work.

Rigid boundaries: canals, having rigid sides & rigid base.

Branch canal: Branches of main canal is either direction taking off at regular intervals (5 cumecs)

Main canal: Carries water directly from reservoir or rivers

~~Major distributaries~~:

Outlet:

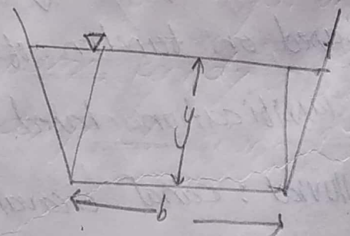
Outlet means a pipe (or) hole through which water is supplied to fields.

Design of Non Erodable canal

Most economical channel Section.

A channel Section is said to be a most economical Section whenever its gives max. discharge for a given c/s area, slope and roughness coefficient.

$A = (b+my)y$ —(1)



$P = b + 2y\sqrt{1+m^2}$ —(2)

$R = A/P$

$b = A/y - my$

$P = A/y - my + 2y\sqrt{1+m^2}$

$\frac{dP}{dy} = 0 \Rightarrow -A/y^2 - m + 2\sqrt{1+m^2} = 0$

$\frac{-(b+my)y}{y^2} - m + 2\sqrt{1+m^2} = 0$

$-\frac{b+my}{y} - m + 2\sqrt{1+m^2} = 0$

$$-b+my+my+2y\sqrt{1+m^2}=0$$

$$-b+2my+2y\sqrt{1+m^2}=0$$

$$b+2my=2y\sqrt{1+m^2}$$

$$R=A/P=\frac{(b+my)y}{b+2y\sqrt{1+m^2}}=\frac{(b+my)y}{b+b+2my}$$

$$=\frac{(b+my)y}{2b+2my}=\frac{(b+my)y}{(b+my)2}$$

$$\frac{dp}{dm}=0;\quad \frac{d}{dm}\left(A/y-my+2y\sqrt{1+m^2}\right)=0$$

$$0-y+2y\frac{m}{\sqrt{1+m^2}}=0$$

$$\frac{2my}{\sqrt{1+m^2}}=y$$

$$2m=\sqrt{1+m^2}.$$

$$4m^2=1+m^2 \Rightarrow 3m^2=1$$

$$m^2=1/3$$

$$\therefore m=\pm\sqrt{1/3}$$

Design of Erodible canals

Silt theories

A velocity which will just keep the Silt in suspension, without scouring the channel is known as non-silting non-scouring velocity.

→ whenever flow of water in channels carries silt either in suspension (or) along the bed and boundaries which will reduce the velocity of the flow in channels So, that it effects flow rate So that it also reduces process of irrigation.

→ To over comes these problems, kennedy & lacey propose silt theories for design of channel sections.

i) kennedy's channel design:

As per kennedy's theory the flow of water counteract some amount of friction against the bed of canal So, that vertical heads are formed.

→ He introduce critical velocity ratio i.e, 'm'. for design of channel sections.

→ He rulz kutters equation for design of channel section.

$$C = \frac{23 + \frac{1}{N} + \frac{0.00155}{S}}{1 + \left[23 + \frac{0.00155}{S}\right]\frac{N}{\sqrt{R}}}$$

Design procedure:

Case-1:

For a given Q & N, side slopes and bed slope

Step-1: Assume a trail value of 'D' in meters.

Step-2: Calculate velocity 'V' from the equation

$V = 0.55\, 8 D^{0.64}$

Step-3: Calculate area of the cross-section 'A'.

$A = Q/V$ [∴ continuity equation]

Step-4: By knowing 'D' & 'A' calculate bed width 'B'.

The side slope of the channel in alluvial soil is assumed to be 1/2 : 1 when the channel has run for some time.

$A = (B + nD)D$

$A = (B + 1/2 D)D$

$A = BD + \frac{D^2}{2}$

From which 'B' can be calculated.

Step-5: Calculate the perimeter and hydraulic mean depth from the following relations:

$$P = B + 2D\sqrt{1+n^2} \Rightarrow B + 2D\sqrt{1+(0.5)^2}$$

$$\Rightarrow P = B + D\sqrt{5} \; ; \; R = A/P \qquad [\because \sqrt{5} = 2.236]$$

Step-6: Calculate the actual mean velocity of the flow from Kutter's equation.

$$V = C\sqrt{RS} \; ; \; C = \frac{23 + 1/N + \frac{0.00155}{S}}{1 + \left[23 + \frac{0.00155}{S}\right]\frac{N}{\sqrt{R}}}$$

→ If this value of velocity is the same as that formed in 'Step-2', the assumed depth is correct. If not repeat the calculation with a changed value of 'D' till the two velocities are same.

Design an irrigation channel to carry a discharge of 45 m3/sec. Assume ~~Kruga~~ Rugosity coefficient (N) 0.0225 & critical velocity ratio is 1. The channel has bed slope of 0.16 m/km.

Given data is

$Q = 45\,m^3/sec$ $\quad m = 1$

$N = 0.0225$ $\quad S = 0.16\,m/km$

$$= 0.16 \times \frac{1}{1000} \Rightarrow S = \frac{0.16}{1000}$$

S-i) $D = 1.8m$

S-ii) $V = 0.55\,m\,D^{0.64}$

$= 0.55(1)(1.8)^{0.64}$

$V = 0.801\ m/s$

Step-3

Area of cross-section, $A = Q/V$

$= \frac{45}{0.801} = 56.17 m^2$

Step-4:

$A = BD + \frac{D^2}{2}$

$56.17 = B[1.8] + \frac{1.8^2}{2}$

$56.17 - \frac{1.8^2}{2} = 1.8 \times B$

$B = 30.30 m$

Step-5:

$P = B + D\sqrt{5}$

$= 30.30 + 1.8\sqrt{5}$

$= 34.32 m$

$R = A/P$

$= \frac{56.17}{34.32} = 1.636$

Step-6 $V = C\sqrt{RS}$

$$C = \frac{23 + \frac{1}{N} + \frac{0.00155}{S}}{1 + \left[23 + \frac{0.00155}{S}\right]\frac{N}{\sqrt{R}}}$$

$$= \frac{23 + \frac{1}{0.0225} + \frac{0.00155}{0.16/1000}}{1 + \left[23 + \frac{0.00155}{0.16/1000}\right]\frac{0.0225}{\sqrt{1.636}}}$$

$C = 49.577$

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$V = C\sqrt{RS}$

$= 49.57 \times \sqrt{1.636 \times \frac{0.16}{1000}}$

$V = 0.801 m/s$

The values obtained in step-2 & step-6 are equal

→ Case-2: For the given discharge, rugosity coefficient, critical velocity ratio and B/D ratio from woods table.

Step-1: Calculate area of cross-section of the channel 'A' in forms of 'D'.

Let $B/D = x$

$B = Dx$

$A = (B+nD)D$

$A = (Dx+nD)D$

$A = D^2x + 0.5D^2$

$A = (x+0.5)D^2$

Step-2: The value of velocity 'V' is known in forms of 'D' by kennedy's eq $V = 0.55mD^{0.64}$

Sub, the values of 'V' and 'A' in continuity equation and solve for D.

$Q = AV$

$= D^2(x+0.5) \times 0.55 mD^{0.64}$

$$Q = 0.55m\,(x+0.5)\,D^{2.64}$$

$$D^{2.64} = \frac{Q}{0.55m(x+0.5)}$$

$$D = \left[\frac{Q}{0.55m(x+0.5)}\right]^{1/2.64}$$

In the above relation Q, m and x values are known. Hence D is determined.

Step-3:

By knowing 'D' calculate B & R values from the following relations.

$$B = Dx$$

$$R = A/p = \frac{BD + D^2/2}{B + D\sqrt{5}}$$

Step-4:

calculate the velocity by using the equation

$$V = 0.55mD^{0.64}$$

Step-5:

From the known values of V & R calculate the 'S' value from Kutter's eq.

$$V = C\sqrt{RS}$$

$$C = \frac{23 + \frac{1}{N} + \frac{0.00155}{S}}{1 + \left[23 + \frac{0.00155}{S}\right]\frac{N}{\sqrt{R}}}$$

Design an irrigation canal to carry a discharge of 14m3/s. Assume n=0.0225, m=1 & B/D=5.7.

$Q = 14 m^3/s$, $m=1$

$n = 0.0225$, $B/D = 5.7$

→ Step-1 $A = [x + 0.5]D^2$

$= [5.7 + 0.5]D^2$

$A = 6.2D^2$

Step-2: $V = 0.55 m D^{0.64}$

$= 0.55 \times 1 \times D^{0.64}$

$V = 0.55 D^{0.64}$

$$D = \left[\frac{Q}{0.55m(x+0.5)}\right]^{1/2.64}$$

$$= \left[\frac{14}{0.55 \times 1 \times (5.7+0.5)}\right]^{1/2.64}$$

$$= \left[\frac{14}{3.41}\right]^{1/2.64}$$

$D = 1.7\,m$

Step-3: $B = D x$

$= 1.7 \times 5.7$

$B = 9.69m$

$$R = A/p = \frac{BD + D^2/2}{B + D\sqrt{5}} = \frac{9.69 \times 1.7 + \frac{1.7^2}{2}}{9.69 + 1.7\sqrt{5}}$$

$$\boxed{R = 1.32}$$

Step-4:

$$V = 0.55 m\, D^{0.64}$$
$$= 0.55 \times 1 \times (1.7)^{0.64}$$
$$= 0.77 m/s$$

Step-5:

$$C = \frac{23 + \frac{1}{N} + \frac{0.00155}{S}}{1 + \left[23 + \frac{0.00155}{S}\right] \frac{N}{\sqrt{R}}}$$

$$C = \frac{23 + 44.44 + \frac{0.00155}{S}}{1 + \left[23 + \frac{0.00155}{S}\right] 0.019}$$

$$C = \frac{23S + 44.44S + 0.00155}{S + (23S + 0.00155)\, 0.019}$$

$$C = \frac{23S + 44.44S + 0.00155}{S + 0.437S + 2.945 \times 10^{-5}}$$

$$C = \frac{67.44S + 0.00155}{1.437S + 2.945 \times 10^{-5}}$$

$$v = c\sqrt{RS}$$

$$0.77 = \frac{67.44S + 0.0015S}{1.437S + 2.945\times10^{-5}}\sqrt{1.32\times S}$$

$$1.106S + 2.26\times10^{-5} = 77.485\sqrt{S} + 1.78\times10^{-3}\sqrt{S}$$

$$77.48S^{3/2} + 1.78\times10^{-3}S^{1/2} - 1.106S = 2.26\times10^{-5}$$

→ Design a channel for $Q = 45\ m^3/s$ in non-alluvial soil having maximum permeaible velocity of $0.9\ m/s$. The available bed slope is 1 in 4000. Assume manning's $n = 0.025$.

Step-1: $Q = 45\ m^3/s$

$V = 0.9\ m/s$

$S = 1/4000$

$n = 0.025$

Side slope $= 0.5:1$

Step-2:

Area, $A = (b+md)d$

$P = b + 2d\sqrt{1+m^2}$

$Q = AV$

$V = \frac{1}{n} R^{2/3} S^{1/2}$

$V = \frac{1}{n} R^{2/3} S^{1/2}$

$0.9 = \frac{1}{0.025} R^{2/3} \left(\frac{1}{4000}\right)^{1/2}$

$0.9 = 40 R^{2/3} \times 0.015$

$0.9 = 0.632 \times R^{2/3}$

$R^{2/3} = 1.424$

$Q = AV$

$R = 1.699\ m$

$A = Q/V = \frac{45}{0.9} = 50\ m^2$

$P = A/R = \frac{50}{1.699} = 29.429$

$A = BD + D^2/2$

$50 = (B + 0.5D)D$

$0.5D^2 + BD - 50 = 0$ —(1)

$$P = \frac{0.5D^2 + BD - 50}{1.69}$$

$1.69(B + D\sqrt{5}) = 0.5D^2 + BD - 50$

$1.69B + 1.69D\sqrt{5} = 0.5D^2 + BD - 50$ —(2)

from eq (1) & (2)

$B = 25m$

$D = 1.9m$

→ using Bazin's formula Design a non-Alluvial channel carrying discharge of $15 m^3/s$ with a mean velocity of $0.7 m/s$. the channel has bottom width of five times the depth and has side slopes of 1:1 assume bazin's coefficient.

$k = 1.3$

formula for finding chezy's constant.

$$c = \frac{87}{1 + \frac{k}{\sqrt{R}}}$$

$v = C\sqrt{RS}$

Given data,

$Q = 15m^3/s$

$v = 0.75m/s$

$B = 5$

Side slope $= 1:1$, $n = 1$

$k = 1.3$

$A = (B + nd)d$

$P = B + 2d\sqrt{1+n^2}$

$= B + 2\sqrt{2}d$

$= B + 2.828d$

$Q = AV$

$A = Q/V$

$A = \frac{15}{0.75}$

$\boxed{A = 20m^2}$

$B = 5D$

$A = (5D + nD)D$

$= (5D + D)D$

$A = 6D^2$ — (1)

$\Rightarrow P = 7.828D$

$= 7.828 \times 1.82$

$= 14.24$

$R = A/P$

$= \frac{20}{14.24}$

$\boxed{R = 1.404m}$

from (1)

$A = 6D^2$

$20 = 6D^2$

$\boxed{D = 1.82m}$

$B = 5D$

$\boxed{B = 9.128\,m}$

$= \dfrac{87}{2.097}$

$\boxed{C = 41.485}$

$C = \dfrac{87}{1 + \dfrac{1.3}{\sqrt{1.404}}}$

$0.75 = 41.435\sqrt{1.404 \times S}$

$0.75 = 41.485 \times 1.184 \times S^{1/2}$

$S^{1/2} = 0.015$

$\boxed{S = 0.00023}$

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Design an Irrigation channel which carries on discharge 45 cumecs & having Rugosity coefficient of 0.0225 & critical velocity ratio 1.05 having a bed slope of 1 in 5000.

Given data,

$Q = 45$ cumecs $\quad S = \frac{1}{5000}$

$N = 0.025$

$m = 1.05$

Assume, $D = 2.2m$

$V = 0.55 \times (2.2)^{0.64}$

$V = 0.91$ m/sec

$A = Q/V = \frac{45}{0.91} = 49.45\ m^2$

$A = BD + D^2/2$

$49.45 = B(2.2) + \frac{(2.2)^2}{2}$

$B = 20.28\ m$

$P = B + 2D\sqrt{1+h^2}$ $\quad P = B + D\sqrt{5}$ $\quad 25.19$

$P = 20.28 + 2(0.91)\sqrt{1+(5)^2}$

$P = 67.6\ m$

$R = A/P = \frac{49.45}{25.19} = 1.96$

$V = C\sqrt{RS}$

$$C = \frac{23 + \frac{1}{N} + \frac{0.00155}{S}}{1 + \left[23 + \frac{0.00155}{S}\right]\frac{N}{\sqrt{R}}}$$

$$= \frac{23 + \frac{1}{0.025} + \frac{0.00155}{\frac{1}{5000}}}{1 + \left(23 + \frac{0.00155}{\frac{1}{5000}}\right)\frac{0.025}{\sqrt{1.96}}}$$

$$= \frac{70.75}{1.522}$$

$$= 46.48$$

$$V = C\sqrt{RS}$$

$$= 46.48\sqrt{1.96 \times \frac{1}{5000}}$$

$$V = 0.92 \text{ m/sec}$$

Kennedy's Silt Supporting velocity

According to kennedy's theory the amount of silt held in the suspension is directly proportional to upward force of vertical edges & varies as the bed width 'B' & some power of velocity of flow in channel.

$$Q_t = \alpha \cdot B V_0^n \quad \text{—(1)}$$

Let 'p' is the % of silt in Batter = $\frac{Q_t}{Q}$

$$Q_t = p \cdot Q$$

we know that discharge, $Q = B \cdot D V_0$

$$Q_t = p(B \cdot D V_0) \quad \text{—} \ (2)$$

$$\alpha \cdot B \cdot V_0^n = p \cdot B \cdot D V_0$$

$$V_0 = \left(\frac{p}{\alpha}\right)^{\frac{1}{n-1}} \cdot D^{(1/n-1)}$$

→ constant

$$\boxed{V_0 = C \cdot D^{(1/n-1)}}$$

But, we know that,

$$V_0 = 0.55 \cdot m \cdot D^{0.64} \Rightarrow C \times D^{0.64}$$

From both the velocity eq's we get, $n = 5/2$

∴ The amount of silt held in suspension, $\boxed{Q_t = \alpha B V_0^{5/2}}$

Drawbacks in kenedy's theory

→ kennedy's did not notice the importance of B/D ratio.

→ He aimed to findout only the average regime condition for the design of channels.

→ No account was taken of silt concentration & bed load and the complex silt carrying phenomenon was incorporated in a single factor m.

→ Silt grade & silt charge were not defined.

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→ He didnot give any slope eq.

→ The value of kutter's constant for the determination of mean velocity was did not explained.

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Lacey Regime theory.

Regime channel: A channel will be in regime if it flows in unlimited incoherent alluvials of the same character as that transported & the silt grade & silt charge are constant

In channel alluvium:

It is ~~als~~ a soil composed of loose granular graded material which can be scoured with the same is with which it is deposited

Regime silt charge:

It is, the min. transported load consistant with fully active bed.

Regime silt grade

This indicates the gradation b/w the small & the big particles. It should not be taken to mean the avg. mean diameter of a particle.

Regime condition:

A channel is said to be in regime when the following conditions are satisfied.

1) The channel is flowing in unlimited incoherent alluvium of the same character as that transported

2) Silt grade & silt charge are constant.

3) discharge is constant

If the above 3 conditions are satisfied then the channel is said to be in "true regime condition".

Initial Regime:

It is the state of channel that has formed its section only and yet not secured the longitudinal slope.

Final regime:

It is the state of channel that has formed its section along with longitudinal slope.

Lacey formula for the design of channel section

S.No.	Designation of formula	Expression.
1.	V-f-R	$V = \sqrt{\frac{2}{5} f R}$
2.	A-f-V	$Af^{2} = 140 \cdot 0 V^{5}$
3.	V-R-S	$V = 10.8 R^{2/3} S^{1/3}$
4.	P-Q	$P = 4.75\sqrt{Q}$
5.	V-Q-f	$V = \left(\frac{Q \cdot f^{2}}{140}\right)^{1/6}$
6.	S-f-R	$S = f^{3/2}/4980 R^{1/2}$
		~~$S = 0.000172 f^{5/3}/q^{1/3}$~~
7.	S-f-q	$S = 0.000172 f^{5/3}/q^{1/3}$
8.	S-f-Q	$S = f^{5/3}/3340 Q^{1/2}$
9.	Regime scour depth relation	$R = 0.47 (Q/f)^{1/3}$
10.	(or) Regime scour depth relation	$R = 1.35 (q^{2}/f)^{1/3}$
11	V-Na-R-S	$V = 1/Na \cdot R^{3/4} \cdot S^{1/2}$
12.	Na-f	$Na = 0.0225 \cdot f^{1/4} \rightarrow V = 1/Na \cdot R^{3/4} \cdot (S-s)^{1/2}$
13.	Shock	

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Laceys channel design procedure

For the given discharge & mean diameter of silt particles (m_r) & silt factor (f) are known.

Step-1: calculate silt factor, $f = 1.76\sqrt{m_r}$

Step-2: Find the out velocity; $V = \left(\frac{Q \cdot f^2}{140}\right)^{1/6}$

Step-3: Find out the area of c/s, $A = Q/V$

Step-4: Find out perimeter, $P = 4.75\sqrt{Q}$

Step-5: Find out bed width 'B' & depth 'D' of the channel section. Since A & B are known. The side slope of an irrigation channel is usually $\frac{1}{2}:1$. Hence, area $A = BD + \frac{D^2}{2}$; $P = B + D\sqrt{5}$ by using these both eq's

$$D = \frac{P - \sqrt{P^2 - 6.944A}}{3.472}$$

$$B = P - 2.236D.$$

Step-6: calculate, $R = 5/2\ V^2/f$ & also calculate.

$$R = A/P = \frac{BD + D^2/2}{B + D\sqrt{5}}$$

Both the values of 'R' should be the same this will provide in numerical check from step-1 to step-5.

Step-7:

Find bed slope, $S = \frac{f^{5/3}}{3340\,Q^{1/6}}$

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→ Design a channel section which has to be carrys a discharge of 30 cumecs & silt factor 1.00 & mean dia of silt particles 0.5. Find also the longitudinal slope.

Given data,

$Q = 30 m^3/sec$, $m_r = 0.5$

$f = 1.00$

Step-1: $f = 1.00$

Step-2: $V = \left[\frac{Qf^2}{140}\right]^{1/6} = \left(\frac{30 \times 1^2}{140}\right)^{1/6} = 0.773 m/sec$.

Step-3: $A = Q/V = \frac{30}{0.773} = 38.781 m^2$

Step-4: $P = 4.75\sqrt{Q} = 4.75\sqrt{30} = 26.016 m$.

Step-5: $D = \frac{P - \sqrt{P^2 - 6.944A}}{3.472} = \frac{26.016 - \sqrt{(26.016)^2 - (6.944 \times 38.781)}}{3.472}$

$D = 1.678 m$

$B = P - 2.236 D = 26.016 - (2.236 \times 1.678)$

$B = 22.263 m$

$A = BD + D^2/2 = (22.263) 1.678 + \frac{(1.678)^2}{2} = 38.765 m^2$.

$P = B + D\sqrt{5} = (22.263) + 1.678\sqrt{5} = 26.015 m$.

Step-6:

$R = 5/2 \frac{V^2}{f} = 5/2 \left(\frac{0.773^2}{1.00}\right) = 1.49 m$

$R = A/P = \frac{38.765}{26.015} = 1.49 m$

Step-7:

$S = \frac{f^{5/3}}{3340 Q^{1/6}} = \frac{(1)^{5/3}}{3340 (30)^{1/6}} = 1.698 \times 10^{-3}$, $S = \frac{1}{5887}$

(imp)

Comparision b/w Kennedy's theory & Lacey's theory

→ Kennedy introduce the term critical velocity ratio (m) in this equ's to make it applicable for channels of different grades of silt. But, he did not give any idea to measure the value of 'm'. Lacey introduce the concept of silt factor (f) in his eq's & suggested a method of determination of value 'f' in relation to particle size.

→ Kennedy assumed that kept in suppension because of eddies generated from the bed only and so he proposed a relation b/w 'v' and 'y'.

Lacey is assumed that silt is kept in suppension because of the normal components of the eddies generated from the entire perimeter eq so he proposed relation b/w 'v' & 'R'.

→ Kennedy assumed kutter's formula for finding the mean velocity.

Lacey gives his own formula for finding velocity.

→ Kennedy gave no formula for determination of longitudinal slope of the channel.

Lacey give slope formula.

10/7/19

→ Lacey's theory as applied channel design doesn't involve any trail & error method procedure. Where as Kennedy's theory involves a trail procedure for design of channel.

→ Lacey proposal that shape of regime channel should be semi ellipse since the channel section is trapezoidal in shape it idea can never attained final regime. Kennedy simply gave the idea that a non-silting channel will be a regime channel.

Lacey made a distinction b/w 2 types of resistance in alluvial channels are one determined by grain size & other due to irregularities of the channel. Kennedy did not make any such distinction.

→ Basic concepts of theories is the same that the silt reminds in suspension due to the force of vertical eddies

12/7/19

Drawbacks in Lacey's theory

→ The concept of true regime is only theoretical and cannot be achieved practically.

→ The various equations are derived by considering the silt factor of which is not at all constant.

→ The concentration of silt is not taken into account.

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→ The silt grade and silt charge are not clearly defined.

→ The equations are empirical and based on the available data from a particular type of channel.

→ The characteristics of regime of channel may not be same for all cases.

Canal lining

Lining of canal is necessary to minimise seepage losses, to increase the discharge in canal section by increasing the velocity, to prevent erosion of bed and side due to high velocities and to reduce maintenance of canal.

Advantages of Canal Lining

→ prevents seepage losses

→ Reduces the problem of water logging

→ provide smooth surface and increase velocity of flow.

→ Higher velocity minimise loss due to evaporation.

→ Higher velocity prevents silting of channel.

→ Makes the banks more stable, prevents weed growth

→ Reduces maintenance costs, reduces breaching, provides stability.

→ Assures economical water distribution

→ Prevents water to come in contact with harmful salts

→ Higher velocity helps to provide flatter hydraulic gradient and flatter bed slope.

Disadvantages:

→ The initial cost of canal lining is very high. So, it makes the project very expensive with respect to the output.

→ It involves much difficulties for repairing the damage section of lining.

→ It takes too much time to complete the project work.

→ It becomes difficult, if the outlet are required to be shifted or new outlets are required to be provided because the dismantling of the lined section is difficult.

Types of canal lining

1. Concrete lining
2. Shotcrete lining
3. Brick or burnt clay tile lining
4. Boulder lining

Concrete lining:

→ It has high initial cost so its use is limited.

→ It has excellent hydraulic properties.

→ Thickness varies from 5-10cm for M_{15} concrete and 7.5 to 15cm for M_{10} concrete.

→ A subgrade is prepared and compacted

→ Subgrade is saturated to a depth of 30cm in sandy soil and 15cm in other soils.

→ Lay a base coat of 1:4 cement and sand slurry on the subgrade.

→ Spread oil paper/ crude oil on the subgrade

→ The concrete is usually laid in alternate blocks

Shotcrete lining

→ Shotcrete consumes large amount of cement.

→ Cement and sand in the ratio (1:4) is shot at the subgrade through a nozzle.

→ Thickness of this type of lining varies from 2.5 to 6.5cm.

→ Shotcrete is also used for repair of old but sound concrete lining.

Brick lining.

→ It consists of a single or double layer of brick masonry.

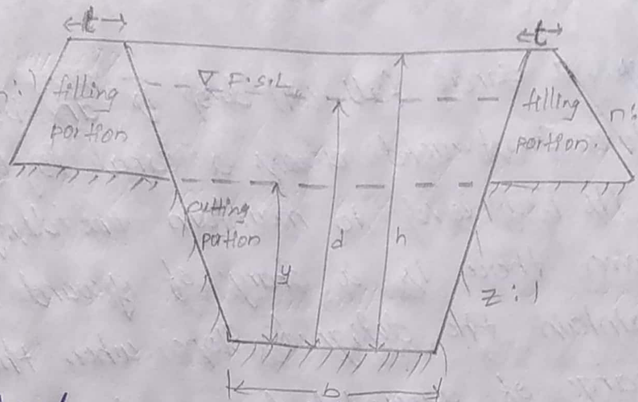
→ The size of brick is restricted to 30x15x15cm for convenience of handling.

→ This type of lining has been used in punjab on Bhakra and Haveli canals.

→ It is hydraulically as efficient as concrete lining

→ In case of failure repair can be done easily

Balancing depth condition:



A channel section will be economical when the earth work involved at a particular section as an equal amount of cut and fill. For a channel section there will be one depth of cutting for which the cutting and filling will be equal this depth is known as balancing depth.

Area of the cut, $A = (B + zy)y$

Area of the fill, $A = 2[\{t + (h-y)n\}(h-y)]$.

By equating the above equations: $(B+zy)y = 2[t + (h-y)n \cdot (h-y)]$

$$\therefore y^2(2n - z) - (b + 4nh + 2t)y + h(2t + 2nh) = 0$$

A canal is usually constructed with a side slope of 1:1 in cutting and a slope of 1.5:1 in filling.

$\therefore n = 1.5,\ z = 1$

$$\therefore y^2 - (b/2 + 3h + t)y + h(t + 3/2\, h) = 0$$