Definition of irrigation:-

The process of artificial application of water to the soil for the growth of agricultural crops is termed as irrigation. It is practically a science of planning and designing a water supply system for the agricultural land to protect the crops from bad effect of drought or low rainfall. It includes the construction of weirs, dams, barrages and canal system for the regular supply of water to the culturable lands.

Necessity of irrigation:-

Throughout the crop period adequate quantities of water is required near the root zone of the plants for their growth. At times during the crop period the rainfall may not be adequate to fulfil the water requirement. The intensity of rainfall is practically uncertain and beyond the control of human power and it may not be well distributed throughout the crop season or the culturable area.

a) Insufficient Rainfall:- ~~when the rainfall is not evenly distributed~~ when the seasonal rainfall is less than the minimum requirement for the satisfactory growth of crops, the irrigation system is essential.

b) Uneven Distribution of Rainfall:-

when the rainfall is not evenly distributed during the crop period or throughout the culturable area, the irrigation is extremely necessary.

c) Improvement of perennial crops:- Some perennial crops like sugarcane, cotton, etc. require water throughout the major part of the year. But the rainfall may fulfil the water requirement in rainy Season only, so for the remaining part of the year, irrigation becomes necessary.

d) Development of Agriculture in Desert Area :-

In desert area where the rainfall is very scanty; irrigation is required for the development of agriculture.

BENEFITS OF IRRIGATION

a) Yield of crops :- In the period of low rainfall or drought, the yield of crop may be increased by the irrigation system.

b) protection from famine :- The food production of a country can be improved by ensuring the growth of crops by availing the irrigation facilities. this helps a country to prevent famine situation.

c) Improvement of cash crops :- Irrigation helps to improve the cultivation of cash crops like vegetables, fruits, tobacco, etc.

d) prosperity of Farmers :- when the supply of irrigation water is assured the framers can grow two or more crops in a year on the same land. Thus the farmers may earn more money and improve their living standard.

e) Source of Revenue :- when irrigation water is supplied to the cultivators in lieu of some taxes, it helps ~~for communication and transportation of agricultural goods.~~ to earn revenue which may be spent on other development schemes.

f) **Navigation**: The irrigation canals may be utilised for inland navigation which is further useful for communication and transportation of agricultural goods.

g) **Hydroelectric power Generation**: In some river valley projects, multipurpose reservoirs are formed by constructing high dams where hydroelectric power may be generated along with the irrigation system.

h) **Water supply**: The irrigation canals may be the source of water supply for domestic and industrial purposes.

i) **General communication**: The inspection road along the canal banks may serve as a communication link with the otherwise remote villages.

j) **Development of fishery**: The reservoir and the canals can be utilised for the development of fishery projects.

TYPES OF IRRIGATION SYSTEM

- irrigation system
  - Lift irrigation
    - By man or animal power
      - Doon
      - mote
      - persian wheel
      - swinging basket
      - Ratior pulley
      - wind lass
    - By mechanical or electrical power
      - open well
      - shallow tube well
      - Deep tube well
  - flow irrigation
    - inundation irrigation
    - perennial irrigation
      - Direct irrigation
      - storage irrigation

Crop season: The period during which some particular types of crops can be grown every year on the same land is known as crop season.

a) **Kharif season:** This season ranges from June to October. The crops are sown in the very begining of monsoon and harvested at the end of autumn. The major Kharif crops are - Rice, millet, maize, Jute, Groundnut, etc.

b) **Rabi season:** This season ranges from October to March. The crops are sown in the very beginning of winter and harvested at the end of spring. The major Rabi crops are - wheat, Gram, mustard, Rapeseed, Linseed, pulses, onion, etc.

Again there are serveral crops which are not included in kharif and Rabi as they require more time and they cover both the main seasons.

Ex: Cotton requires eight months to mature and sugarcane requires about whole year to mature. Hence, they are designated as.

i) Cotton - eight month's crop.

ii) Sugarcane - perennial crop.

Cumec Day:

The quantity of water flowing continuously for one day at the rate of one cumec is known as cumec day.

$$1 \text{ cumec day} = \frac{1m^3}{sec} \times 24 \times 60 \times 60 sec.$$

$$= 24 \times 60 \times 60 m^3$$

$$= \frac{24 \times 60 \times 60}{10,000} \times 100 \quad (1 \text{ hector} = 10000 m^2)$$

$$= 8.64 \text{ hectore - metre}$$

Water Requirement of crops :

→ The term water requirement of a crop means the total quantity & the way in which the crop requires water from the time it is sown to the time it is harvested.

→ Hence different crop will have different water requirements and the same crop may have different water requirements at different places of the same country.

Crop season or crop period :

The time period that elapses from start of sowing to the instant of its harvesting is called crop period.

Base period :

The time between the first watering of a crop at the time of sowing to its last watering before harvesting is called base period or base of the crop.

→ Base period is generally represented by B.

Delta of a crop :

The total quantity of water required by the crop for its full growth may be expressed in hectare meter or simply as depth to which water would stand on the irrigated area if the total quantity supplied were to stand above. the surface without percolation or evaporation. this total depth of water (in cm) required by a crop to come to maturity is called its delta (Δ).

Duty of water :-

The duty of water is the relationship between the volume of water and area of the crop it matures.

→ This volume of water is generally expressed by unit discharge flowing for a time equal to the base period of the crop called Base of the duty.

→ The duty is generally represented by 'D'.

→ If water flowing at a rate of one cubic metre per second, runs continuously for B days and matures 200 hectares then the duty of water for that particular crop will be defined as 200 hectares per cumec to the base of B days.

RELATION BETWEEN BASE, DELTA AND DUTY

Let D = Duty of water in hectares / cumec.

B = Base in days.

Δ = Delta in m.

From definition, one cumec of water flowing continuously for 'B' days gives a depth of water Δ over an area 'D' hectares, that is,

1 cumec for B days gives Δ over D hectares.

or 1 cumec for 1 day gives Δ over D/B hectares. — (1)

or 1 cumec for 1 day = $D/B \times \Delta$ hectare - metre.

So, 1 cumec day = $D/B \times \Delta$ hectare-metre.

Again, 1 cumec - day = $1 \times 24 \times 60 \times 60 = 86400 \, m^3$

$= 8.64$ hectare - metre. — (2)

(1 hectare $= 10000 \, m^2$)

From ① & ②

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

$$\Rightarrow \Delta = \frac{8.64 \times B}{D} \text{ in m.}$$

DEFINITION OF IMORTANT TERMS

1. Gross Command Area (G.C.A)

The whole area enclosed between an imaginary boundary line which can be included in an irrigation project for supplying water to agricultural land by the network of canals is known as Gross Command Area (G.C.A)

2. Unculturable Area:

The area where the agriculture cannot be done and crops cannot be grown is known as unculturable area. The marshy lands, barren lands, lakes, ponds, forests, villages, etc, are considered as unculturable area.

3. Culturable Area:

The area where the agriculture ~~and~~ can be done satisfactorily is known as culturable area.

4) Culturable Command Area (C.C.A)

The total area within an irrigation project where the cultivation can be done and crops can be grown is known as culturable Command Area (C.C.A). Again C.C.A may be of two categories.

a) Culturable Cultivated Area:

It is the area within C.C.A where the cultivation has been actually done at present.

b) Culturable uncultivated Area :- It is the area within the C.C.A. where cultivation is possible but it is not being cultivated at present due to some reasons.

5. Intensity of irrigation :-

The total culturable command area may not be cultivated at the same time in a year due to various reasons, some area may remain vacant every year. For example, if total culturable command area is 1000 hectares where wheat is cultivated is 250 hectares then.

intensity of irrigation for wheat $\frac{250}{1000} \times 100 = 25\%$, So area to be irrigated = C.C.A × Intensity of irrigation.

6. Crop Ratio :-

It is defined as the ratio of the areas of the two main crop seasons, e.g., Kharif and Rabi.

7. Cash crop :-

The crops which are cultivated by the farmers to sell in the market to meet their current financial requirements are known as cash crops. the crops like vegetables, fruits, etc.

8. Crop Rotation :-

The process of changing the type of crop for the cultivation on the same land is known as crop rotation.

Few crop rotation possible are.

i) Rice - Gram.

ii) wheat - Millet - Gram.

iii) Rice - Gram - wheat.

9. Crop period:-

The crop period is defined as the total period from the time of sowing a crop to the time of harvesting it. that means. it is the period in which the crop remain in the field.

10. Overlap Allowance:-

Sometimes a crop of one season may overlap the next crop season by a few days more which it requires to mature. During this period of overlapping the irrigation water is to be supplied simultaneously to the crops of both the seasons.

11. Time Factor:-

The ratio of the number of day the canal has actually been kept open to the number of days the canal was designed to remain open during the base period is known as time factor.

for example, a canal was designed to be kept open for 15 days, but it was practically kept open for 10 days for supplying water to the Culturable Area. then the time factor is $10/15$

$$\text{Time factor} = \frac{\text{No. of day the canal practically kept open.}}{\text{No. of day the canal was designed to keep open.}}$$

$$= \frac{\text{Actual discharge}}{\text{designed discharge}}$$

Types of Soil water :-

By spreading the water over Soil through irrigation or by rainfall. the water is absorbed by the pores of Soil. this water is called soil water or soil moisture. The following are the different forms of soil water →

1. Gravitational water :-

If we irrigation or it rains on soil, the water content of the soil increases until a limit of its capability. At this stage the soil pores are completely saturated and no more water is absorbed.

So the reaste surface water flows downwards due to influence of gravity. the portion of water which flows down is called as gravitational water. this water is not useful for plants as it flows rapidly and can't absorbed by root of tree.

2. Capillary water :-

The portion at water accepted by soil after completely eliminating the gravitational water is called Capillary water. this water get absorbed by plant roots.

The water content reduces gradually due to evaporation and traspiration.

→ when there are no plants on the soil water content is reduced only by evaporation which is shown by the curve S-A-B.

→ when there are plants water content reduced due to both evaporation & transpiration which is shown by curve SA₁ PB₁

→ Here the point 'p' is known as permanent wilting point and the water content from soil to A or A_1 is called field capacity.

3. Hygroscopic water :-

The water content below the permanent wilting point is known as hygroscopic water this water retained by soil on a thin layer on the surface of soil particles. this water can't be absorbed or extracted by the roots of plants, so at this stage the growth of the plants is stopped and it results plants are dead.

4. Field Capacity :-

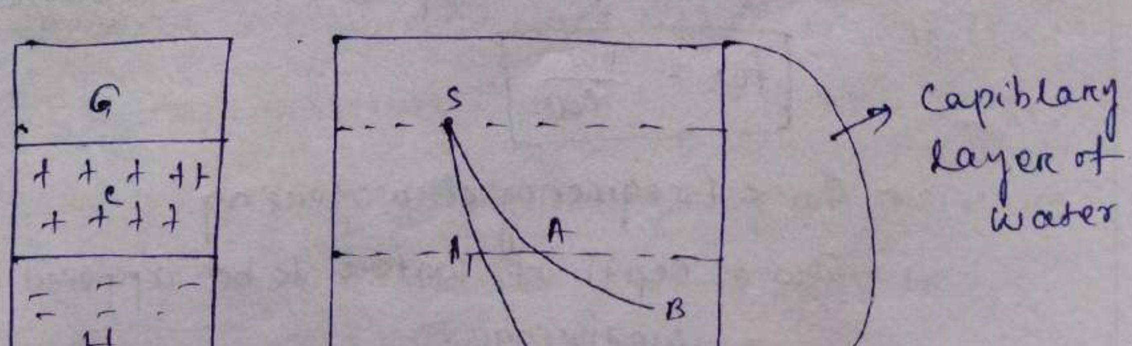
→ The field capacity is defined as the amount of maxm moisture that can be held by soil against gravity.

→ its expressed as percentage.

5. permanent wilting point :-

The amount of moisture held by soil which can't be extracted by the plant roots for transpiration is called permanent wilting point At this point the wilting of the plant occurs.

its also expressed in %.



G - Gravitational water.
C - Capillary water.
H - Hygroscopic water

S ⇒ Saturation point.
AA_1 → field capacity
P → permanent wilting point.

Consumptive use of water :-

The total quantity of water used for the growth of plants by transpiration and the amount of water loss by evaporation is called consumtive use of the water or evapo-transpiration.

Its expressed in hectare metre per heactares or as depth of water (in m) for a specific period

→ The Consumptive use of water is find out to known the water requirement for each crop.

this value varies from crop to crop, time to time and even place to place (mm/day).

Methods of Determining consumptive use →

1 → Lysimeter method.

2 → field experimental method.

3 → soil moisture study

Frequency of irrigation :-

Frequency of irrigation refers to the number of days between irrigation during periods without rainfall. It depends on consumptive use of rate of a crop and on the amount of available moisture in the crop root zone. It is function of crop, soil and climate.

$$f_w = \frac{D_w}{C_u}$$

f_w = frequency of watering.

D_w = Depth of water to be applied in each watering.

C_u = Consumptive use of water.

Again $\boxed{D_w = \frac{w_s \times d}{w_w} \times (f_c - M_o)}$

w_s = unit wt. of soil.

d = Depth of root zone.

w_w = unit wt. of water.

f_c = field capacity.

M_o = optimum moisture content.

Example-1

Determine the frequency of irrigation from the following data.

i) field capacity of soil = 35%.

ii) permanent wilting point = 18%.

iii) Density of soil = 1.5 g/cm³.

iv) Depth of root zone = 70 cm.

v) Daily consumptive use of water = 17 mm

Ans- Given $f_c = 35\%$.

permanent wilting point (p) = 18%.

As available moisture = f_c - permanent wilting point

$= 35 - 18 = 17\%$.

Let readily available moisture is 75% of the available moisture.

Readily available moisture $= 17 \times 0.75 = 12.75\%$.

optimum moisture content $= 35 - 12.75 = 22.25\%$.

Now, By applying irrigation water the moisture content is to be raised from 22.25% to 35%.

from, $D_w = \frac{w_s \times d}{w_w} \times (f_c - M_o)$

$W_s = 1.5 g/cm^3$ $W_w = 1 g/cm^3$

$d = 70 cm = 0.7 m$ $F_c = 35\% = 0.35$

$M_o = 22.25\% = 0.2225$.

$D_w = \frac{1.5 \times 0.70}{1} \times (0.35 - 0.2225)$

$= 1.05 \times 0.1275$

$= 0.133875 m$

$= 13.39 cm$.

Daily consumptive use of water (C_u) = 17mm = 1.7 cm

Now $f_w = \frac{D_w}{C_u} = \frac{13.39}{1.7 cm} = 7.87 = 8 days$.

∴ So water should be applied in the field at an interval of 8 days.

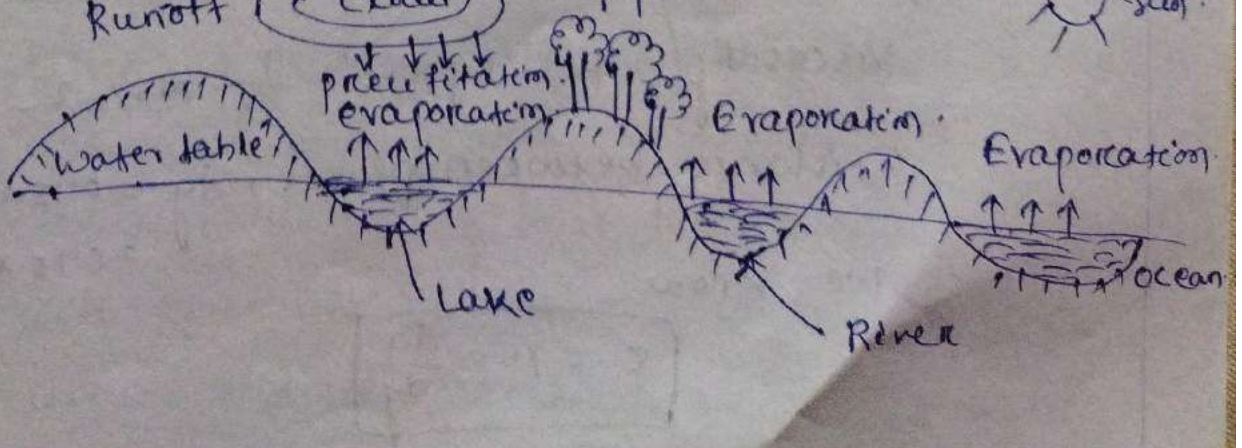
chapter-1

Hydrology

The art of studying different forms of water available above the earthsurface or below the earthsurface is known as hydrology.

Hydrology cycle:-

The earth's water sources like rivers, lakes oceans and underground surface get their water in ~~rainy~~ rainy season and their water converts to vapour by evaporation due to sun light. the vapour goes on accumulating continuously. in the atmosphere. this vapour again condensed due to the sudden fall of temp. and pressure so clouds are formed these cloud again causes the precipitation (rainfall) some of vapour also converted to ice at the peak of mountains the ice again melts in summer and flows as rivers to meet ~~melts in~~ the sea or ocean. this process of evaporation and precipitation continues for ever so a balance is maintained between the two this process is known as hydrologic cycle.



Rainfall or precipitation :

According to the principle of hydrologic cycle, the water goes on evaporation continuously from the water surface on earth (eg. river, lake, sea, ocean, etc) by the effect of sun. the water vapour goes on collecting in the atmosphere upto a certain limit when this limit exceeds and the temp. & pressure fall to a certain value, the water vapour will get condensed and therefore cloud is formed so droplets are formed and returned to earth in the form of rain, snow fall, hail, etc. this is known as precipitation or rainfall.

Types of Rainfall →

Due to the various atmospheric condition the rainfall may be of 3 types:

1. cyclonic Rainfall.
2. Convective Rainfall.
3. ~~orogra~~ orographic precipitation.

1. Cyclonic Rainfall or precipitation →

This type of precipitation is caused by the difference of pressure within the air mass on the surface of the earth. If low pressure is generated at some place the warm moist air from the surrounding area rushes to the low pressure area with a big force the warm moist air rises up with circular motion and get condensed at higher altitude and ultimately heavy rain occurs.

This may be of two types.

a. Frontal precipitation.

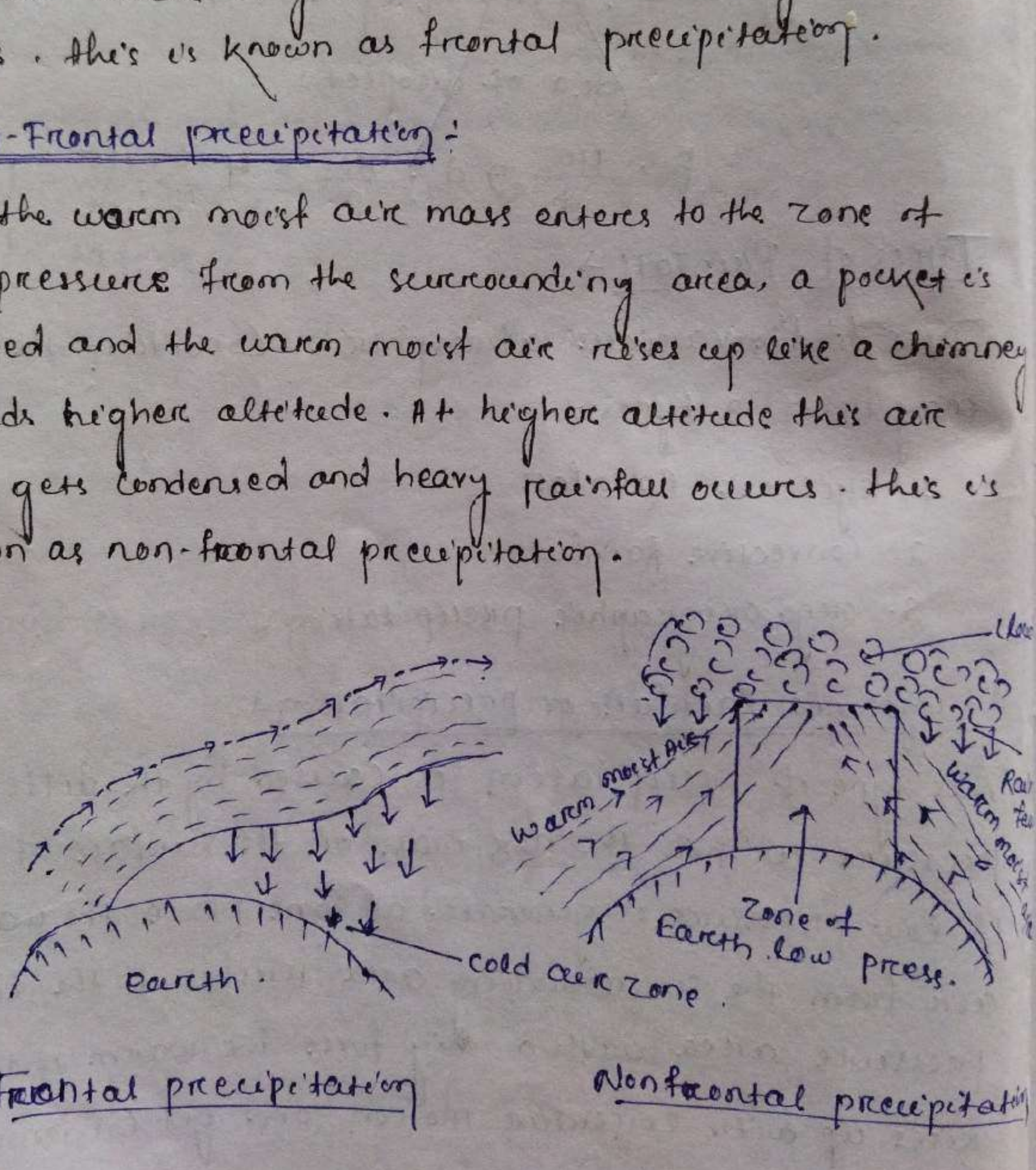
b. Non-frontal precipitation.

a) Frontal precipitation:

when the moving warm moist air mass is obstructed by the zone of cold air mass, the warm moist air rises up (as it is lighter than cold air mass) to higher altitude where it gets condensed and heavy rainfall occurs. this is known as frontal precipitation.

b) Non-Frontal precipitation:

When the warm moist air mass enters to the zone of low pressure from the surrounding area, a pocket is formed and the warm moist air rises up like a chimney towards higher altitude. At higher altitude this air mass gets condensed and heavy rainfall occurs. this is known as non-frontal precipitation.

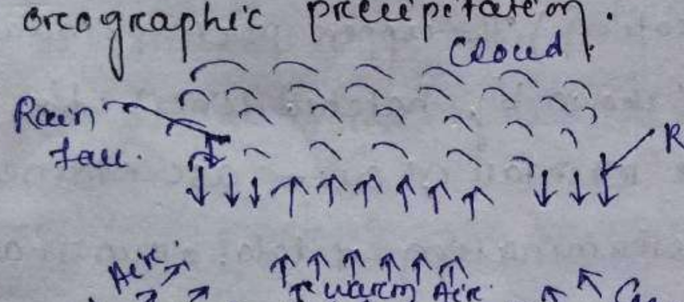


2 > Convective Rainfall

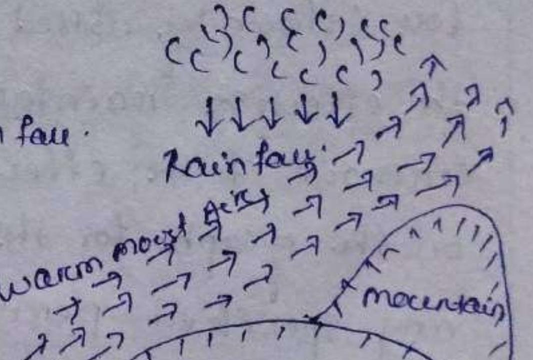
In tropical countries when on a particular hot day the ground surface gets heated unequally. In such cases the warm air is lifted to high altitude and the cooler air takes its place with high velocity. thus the warm moist air mass is condensed at the high altitude causing heavy rainfall. this is known as convective Rainfall.

3> Orographic Precipitation:-

The moving warm moist air when obstructed by some mountain it rises upto a high altitude. It then gets condensed and rainfall occurs this is known as orographic precipitation.



Convective Rainfall.



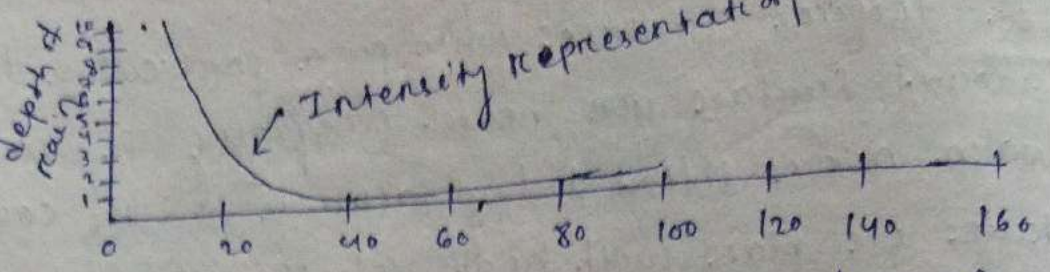
Orographic Rainfall.

Intensity of rainfall:-

In some places rainfall occurs in time intervals such as 5min, 10mins, 15mins, 30mins - - - etc. In some place continuous raining occurs for sometimes.

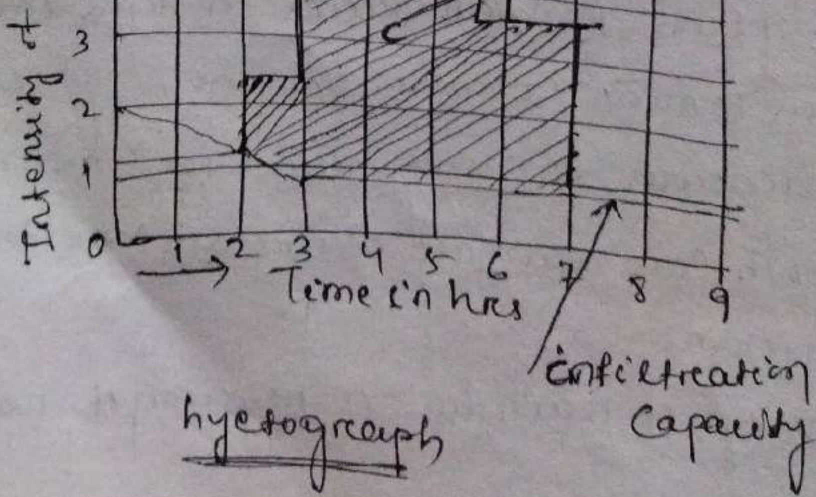
In this both case rainfall occurs at some depth with a time interval.

So intensity of rain fall is relation of rain depth to duration.
which is expressed in cm/hr.



Hyetograph:-

The graphical representation of rainfall and run-off is called as hyetograph. the graph is prepaired with intensity of rainfall (in cm/hr) as ordinate (y-axis) is time (in hrs) as abscissa (x-axis). this infiltration capacity curve is drawn on this graph to show the amount of infiltration loss (shown by dotted protion) The upper portion indicates the effective rainfall (shown by hatched lines). the centroid of the effective rainfall is ascertained on the graph for the determination of total runoff at any specified period.



hyetograph

Estimation of rainfall →

It is the process to known or measure the amount of rainfall.

To measure the rainfall amount we need instrument which is known as raingauge.

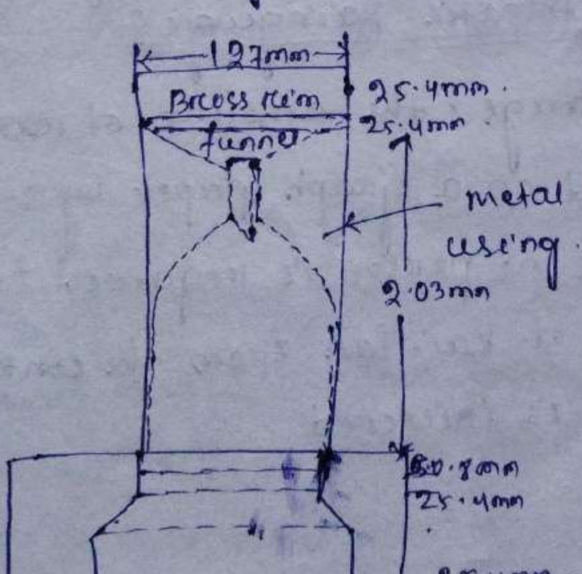
→ The principle of raingauge is that the amount of rainfall in a in a small area will represent the amount of rainfall in a large area provided the meteorological characteristics of both small and large area are similar.

Types of raingauge:-

It is of two types.

1. Automatic or Recording type raingauge.
2. Non-automatic or Non-recording type raingauge.

2- Non-Recording type Raingauge:-



Simon's raingauge

Simon's raingauge is a non-recording of or non-automatic raingauge which is most commonly used It consist of metal casing of dia 127mm which is set on a concrete foundation a glass bottle of capacity about 100mm of rainfall is placed within the casing. A funnel with brass rim is placed on the top of the bottle. The rainfall is recorded at every 24 hours. Generally the measurement is taken at 8.30 a.m everyday in case of heavy rainfall the measurement should be taken 2 or 3 times daily. so that the bottle does not overflows to measure the amount of rainfall the glass bottle is taken off and the collected water is measured in a measuring glass, and recorded in the raingauge record book, when the glass bottle is taken off it is immediately replaced with a new bottle of same capacity.

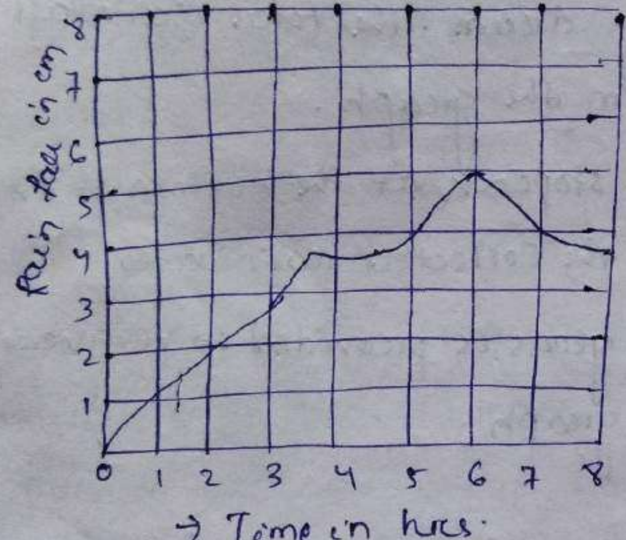
1. Recording type or Automatic Raingauge:

In this type of raingauge, the amount of rainfall is automatically recorded on a graph paper by some mechanical device. Here no person is required for measuring the amount of rainfall from the container in which the rain water is collected.

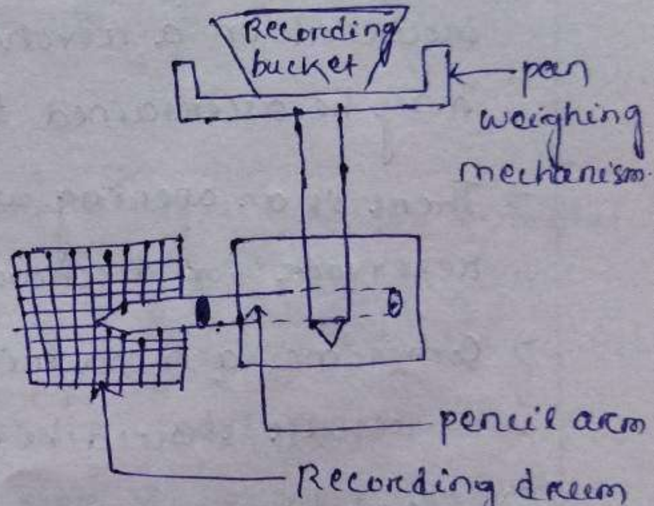
It is of 3 types.

a) weighing Bucket Raingauge:

This type of raingauge consists of a receiving bucket which is placed on pan. The pan is again fitted with some weighing meachanism. A pencil arm is pivoted with the weighing mechanism in such a way that the movement of the bucket can be traced by a pencil on the moving recording drum. So when the water is collected in the bucket the increasing weight of water is transmitted through the pencil which traces a curve on the recording drum. the raingauge produces a graph of cumulative rainfall versus time and hence it is some times called as integrating raingauge. the graph is known as the mass curve of rainfall.



Rain Recording graph.

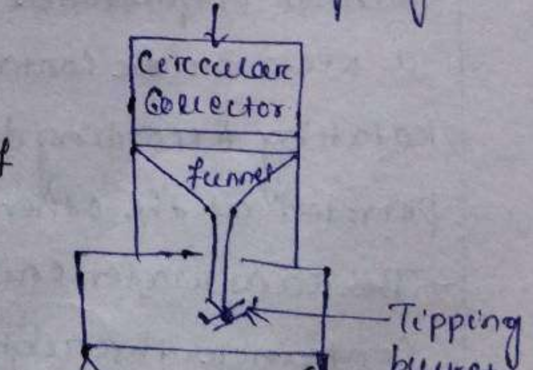


weighing bucket rain gauge.

b) <u>Tipping Bucket Raingauge</u> :-

It consists of a circular collector of diameter 30cm in which the rain water is initially collected.

→ The rain water then passes through a funnel fitted to the circular collector and gets collected in two compartment tipping buckets pivoted below the funnel.



(Typping Bucket raingauge)

→ when 0.25mm rain water is collected in one bucket then it tips the discharges the water in a reservoir kept below the buckets. At the same time the other bucket comes below the funnel and the rain water goes on collecting in it.

→ when the requisite amount of rainwater is collected, it also tips and discharges the water is generated by the buckets

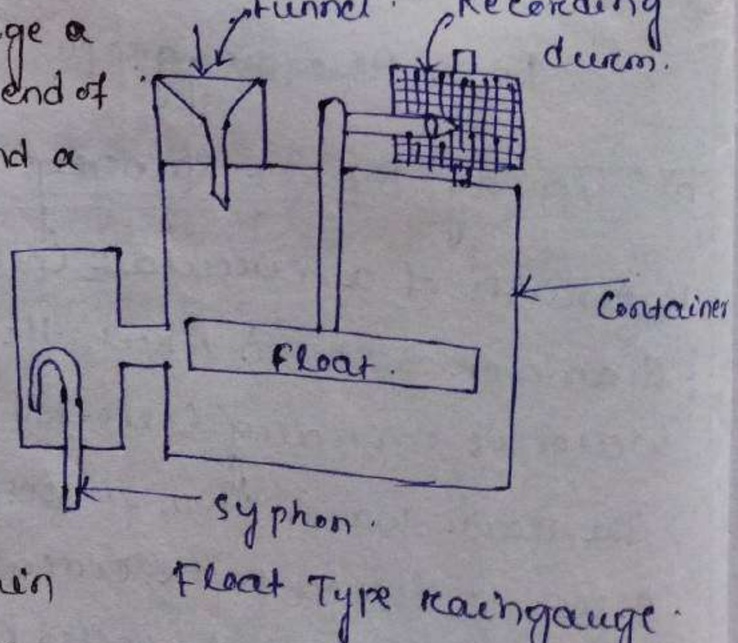
→ This circular motion is transmitted to a pen or pencil which traces a wave like curve on the sheet mounted on a revolving drum. the total rainfall may be ascertained from the graph.

→ There is an opening with stopcock at the bottom of the reservoir for discharge the collected rainwater

→ Sometimes a measuring glass is provided to ~~very~~ verify the result showed be the graph.

c) <u>Float type Raingauge</u>:-

In this type of rain gauge a funnel is provided at one end of a rectangular container and a rotating recording drum is provided at the other end.



Float Type raingauge.

→ The rain water enters the container through the funnel.

→ A float is provided within the container which rises up as the rainwater gets collected there.

→ The float consists of a rod which contains a pen arm for recording the amount of rainfall on the graph paper wrapped on the recording drum.

→ It consists of a syphon which starts functioning when the float rises to some definite height and the container goes on emptying gradually.

Catchment Area :

→ The catchment area of a river means the area from where the surface run-off flows to that river through the tributories, streams springs etc. the area is bounded by water shed line.

Run-off :

→ when it rains, some portion of rain water infiltrates into the soil, some is intercepted by vegetation, some evaporates & the remaining portion flows over the ground surface to join the rivers, streams, lakes etc. this portion of water which flows over the ground surface is called as surface runoff or run-off.

→ It also called as rainfall excess or effective rainfall.

water loss :

water loss = precipitation - surface runoff.

Causes of water losses :

1. Interception
a. Type of vegetative cover
b) wind velocity.
c) Duration of rainfall
d) Intensity of rainfall
e) season
f) climatic condition.

2. Evapouration.
a) Evapouration from free water surface.
b) Evapouration from soil surface.
c) Evapouration from vegetation or transpiration

3. Infiltration.
a) Texture of soil.
b) cond^n of soil surface.
c) Content of soil moisture.
d) soil temperature.
e) Agriculture.
f) Type of vegetative surface cover.

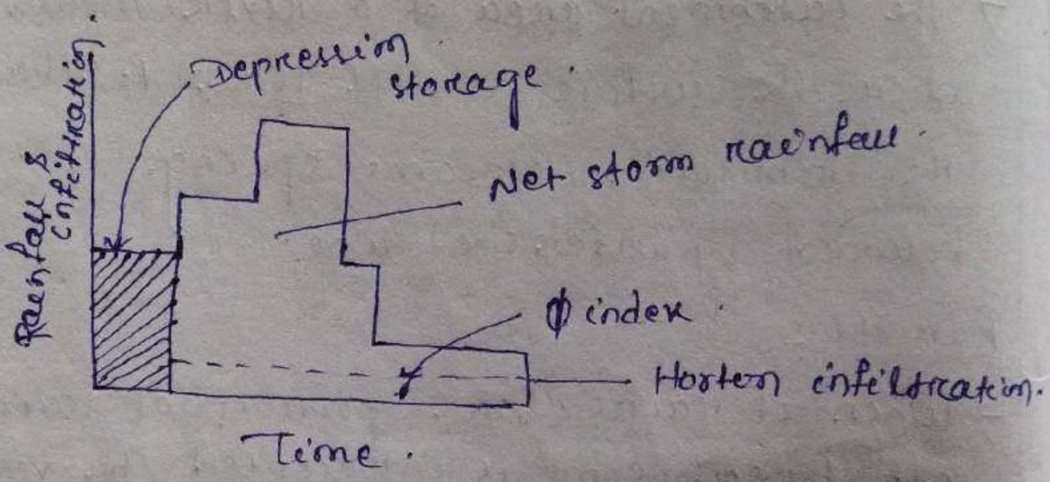
Determination of infiltration losses :-

Two Methods or Index.

1. φ-index 2- w-index.

1. φ-index :-

It is defined as the average rate of rainfall during any storm, above which the volume of rainfall is equal to the volume of direct run-off.



2- w-index :-

It is defined as the average rate of infiltration which is calculated by this expression.

$$w\text{-index} = \frac{R-Q}{T_R}$$

R → Total rainfall

Q → Total direct runoff.

T_R → Duration of rainfall in hrs.

* for uniform rainfall the value of

φ-index = w-index.

for non-uniform rainfall.

value of φ-index ≠ w-index.

Example on infiltration index:

Ex-1 The follows are the rates of rainfall for successive 30 min period for a storm duration of 210 min.

5.5, 6.0, 12.5, 8.0, 3.25, 3.25, 6.5 cm/hr. Take ϕ-index 4.50 cm/hr.

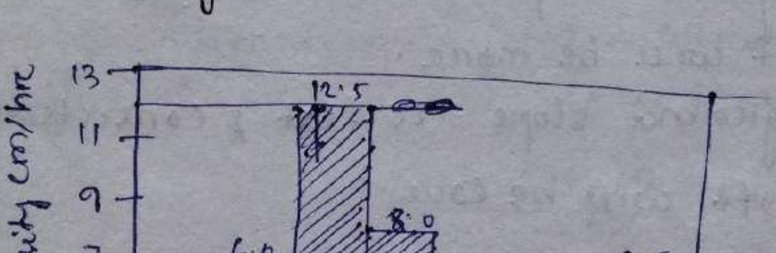
Calculate a) The run off in cm.

b) Total rainfall

c) The value of w-index.

Ans The given intensity of rainfall is plotted in a graph then value of ϕ-index is findout.

They are shown by hatched lines represent the value of run-off.



a) Run-off $= (5.5-4.4)\frac{30}{60} + (6.4.5)\frac{30}{60} + (12.5-4.5)\frac{30}{60} + (8.0-4.5)\frac{30}{60} + (6.5-4.5)\times\frac{30}{60}$

$= 8$ cm.

b) Total Rainfall

$= 5.5\times\frac{30}{60} + 6\times\frac{30}{60} + 12.5\,\frac{30}{60} + 8\times\frac{30}{60} + 3.25\times\frac{30}{60} + 6.5\times\frac{30}{60}$

$= 20.875$ cm.

c) w-index $= \frac{P-Q}{T_R} = \frac{20.375-8}{210/60} = 3.679$ cm/hr.

Factors affecting Run-off :

a) Intensity of Rainfall →

If intensity is more than Run-off is more.

If its low run-off also low.

b) Soil characteristics of catchment area →

In case of sandy soil of catchment area the run off will low & infiltration is more.

But in case of catchment of clayey or rocky soil, the runoff is more.

c) Topography of the Catchment →

If the ground slope of the catchment is steep, the run-off will be more.

If the ground slope is flat & consists of depressions the runoff will be low.

d- Shape & size of catchment :

If the catchment area is large & fan shaped the run of will more. If the catchment area is small & fern shaped the runoff will low.

e → Geological condition of catchment.

f → Cultivation & vegetative cover in catchment Area.

g → weather Condition.

Ex-2
The rainfall intensity for the successive hour-period 8 hrs storm are given as 20, 24, 30, 15, 35, 20, 10, 12 mm if the total surface runoff is 80 mm, determine the value of ϕ-index.

Ans- Total rainfall in 8 hours.

$= 20 m/hr + 2 mm/hr + 30 mm/hr + 15 + 35 + 20 + 10 + 10$ mm/hr

$= 166 mm/hr = 16.6 cm$.

Total run-off in 8 hrs $= 80 mm = 8.0 cm$.

Total infiltration in 8 hrs = Total rainfall − total rainfall

~~Total~~ $= 16.6 - 8 = 8.6 m$.

Average infiltration $= \frac{\text{Total infiltration}}{\text{total time}}$

$= \frac{8.6 cm}{8 hr} = 1.075 cm/hr$.

The ϕ-index for the 8 hrs is obtained by $8 \times \phi = 8.6$

$\Rightarrow \phi = \frac{8.6}{8} = 1.076 cm/hr$ (Ans)

Estimation of run-off →

1. Rational method.
2. Run-off formula: Inglis's formula. / Lacey's formula. / Khasla's formula.
3. Infiltration method.
4. unit hydrograph method.

1. Rational method

$$Q = \frac{KiA}{36}$$

where
K = Co-efficient of run-off
i = Rainfall intensity in cm/hr
A = Catchment area in hectores
Q = Runoff in cumec.

2- Run-off Formula.

a - Inglis's formula →

For ghat areas.

$$R = 0.85P - 30.5$$

For non-ghat areas.

$$R = \frac{(P-17.8)}{254} \times P$$

where R = Run-off in cm.

P = Rainfall in cm.

b - Lacey's Formula →

$$R = \frac{P}{1 + \frac{304.8F}{P \times S}}$$

where R = Run-off in cm.

P = Rainfall in cm.

S = catchment factor varies from 0.25 to 1.7

F = monsoon direction factor varies 0.5 to 1.5

c - Khosla's formula →

$$R = P - \frac{T-32}{3.74}$$

where R = Run-off in cm.

P = Rainfall in cm.

T = mean temp. in °F on catchment area

3 - Infiltration method.

4 - unit hydrograph method.

Estimation of peak flow or flood discharge →

1 - Empirical formula.

2. Boston society of civil engineers formula.

3 - formula involving Rainfall intensity & drainage area.

Estimation of flood discharge

- Emprical formula
  - → Involving drainage area only.
  - → Involving drainage area & its shape.
  - → Involving rainfall & drainage area variables.
- Boston society of civil engineers formula.
- Formula involving rainfall intensity & drainage area of rational method.

Involving drainage area only

- IMP. Dicken's formula
- IMP Ryve's formula.
- Inglis's formula.
- Nowabjung Bahadur formula.
- Jarvis's formula.
- modified Myer's formula.

1. Dicken's formula.

$$Q = C \times A^{3/4}$$

where Q = discharge in cumec.

A = Catchment area in sq km.

C = Constant depending upon factors affecting the flood discharge.

2- Ryve's formula →

$$Q = C \times A^{2/3}$$

here C = Constant, its average value is considered as 6.8.

3- Inglis's formula →

$$Q = \frac{123A}{\sqrt{A+10^4}}$$

4- Nawabjung Bahadur formula →

$$Q = CA'\left(0.92 - \frac{1}{14}\log A\right)$$

here C = Constant varies from 48 to 60

A = Area in sq·km·

$A' = 0.39A$

5. Jarve's formula →

$Q = C \times \sqrt{A}$

C = value of Constant maximum 177 ·

6 - Modified myer's formula →·

$Q = 177 \times p \times \sqrt{A}$

here p = A factor varies 0·002 to 1 generally as 1.

→ Involving Drainage Area & it's shap·

Dredge or Burge formula·

$Q = 19.6 \times \frac{A}{L^{2/3}}$

where Q = Discharge in cumec L - Length of basin in km·

A = Catchment area in sq·km

If B is the average width of the basin in km.

then $A = B \times L$·

So $Q = 19.6 \times \frac{B \times L}{L^{2/3}} = 19.6 \times B \times L^{1/3}$·

→ Involving Rainfall & Drainage Area variables·

$Q = C \cdot (P \cdot B)^{5/4}$·

Q = Discharge in cumec

P = Probable 100 years max^m one day rainfall in cm.

B = Average width of the basin in km

C = A constant generally taken as 1·5·

2 - Boston Society of civil engineer formula.

$$q = 0.0056 \times D/t$$

q = peak flow in cumec.

D = Total depth of flood run-off on the basin in cm.

t = Total flood period in hrs.

In this formula flood hydrograph considered as where flood hydrograph is not available.

$$q = \frac{Cf \times D}{A} \text{ or } Q = Cf \times D \times \sqrt{A}$$

Cf → Co-efficient of flood & characteristics.

it varies 0.7 to 3.5

A = Catchment Area in sq. km.

Q = Peak flow in cumec.

3 → formula involving Rainfall intensity & drainage Area. Rational method.

$$Q = \frac{K \times i \times A}{36}$$

i → Rainfall intensity in cm/hr.

k → Runoff Coefficient.

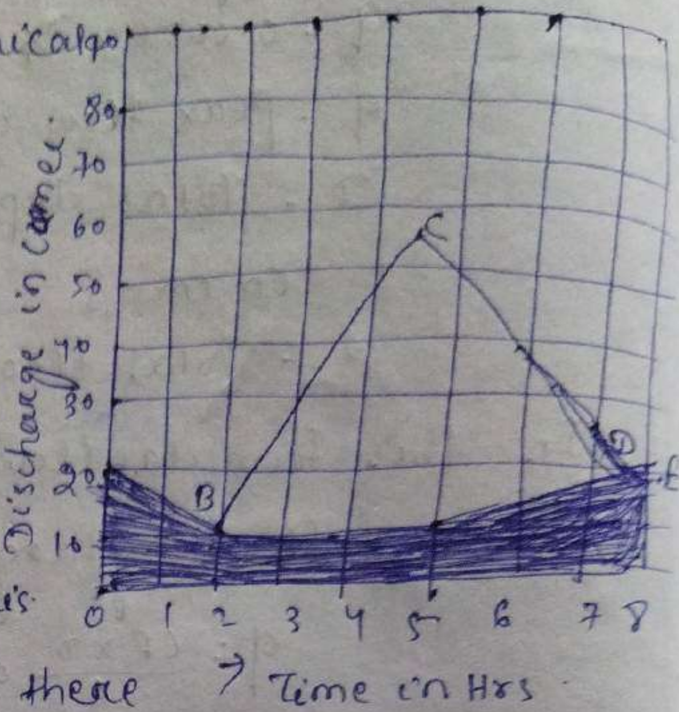
K varies according to various types of soil.

Hydrograph

The hydrograph is a graphical representation of the discharge of a river (in cumec) against the time (in hr or days)

→ The discharge is plotted as Y-axis

The time is plotted as x-axis



→ During the dry season, there is only ground water flow but no run-off.

→ This may be shown by a line which is approximately straight (not shown in the fig).

→ In rainy season, at the beginning of the rainfall there is only base flow (shown by the line AB) After some period, when the initial losses like interception, evaporation & infiltration are fulfilled the surface run-off starts and hence the discharge of river goes on increasing.

So the depth of curve rises which is called rising limb (shown by line BC)

This line reaches to the peak value at 'c'

→ Again when the rain stops, the flow in the river decreases & the limb of curve also decreases. This limb is known as recession limb (as shown by CD)

→ The discharge at point (indicates the max^m discharge) i.e peak of flood discharge)

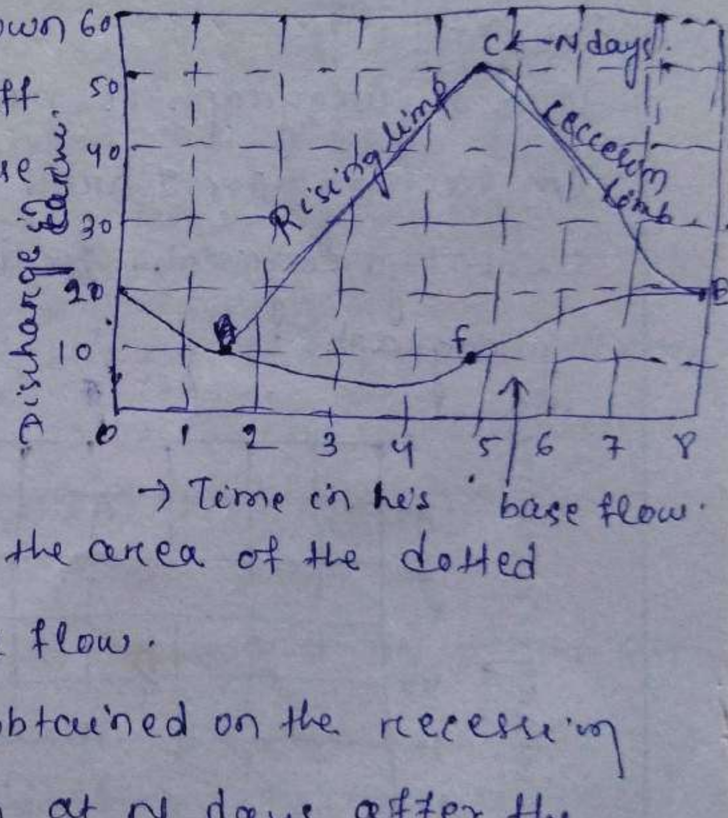
→ The total area under the curve ABCDE indicates the total run-off.

→ But this run-off includes the base flow & the direct run-off.

So the get the actual runoff the base flow is to be deducted by separating it from total area.

<u>The method separation of Base flow :-</u>

Here the hydrograph is shown which represent total run-off & direct run-off so the base flow is to be separated to get the actual run-off



→ AB curve is extended to meet the vertical line CF. The line FD is joined. the area of the dotted portion is indicates base flow.

→ Again the point D is obtained on the recession limb of the hydrograph at N days after the peak flow, the value of N is calculated.

$$N = 0.83 A^{0.2}$$

A → Area of drainage basin in sq. km.

N → No. of days.

Unit hydrograph:

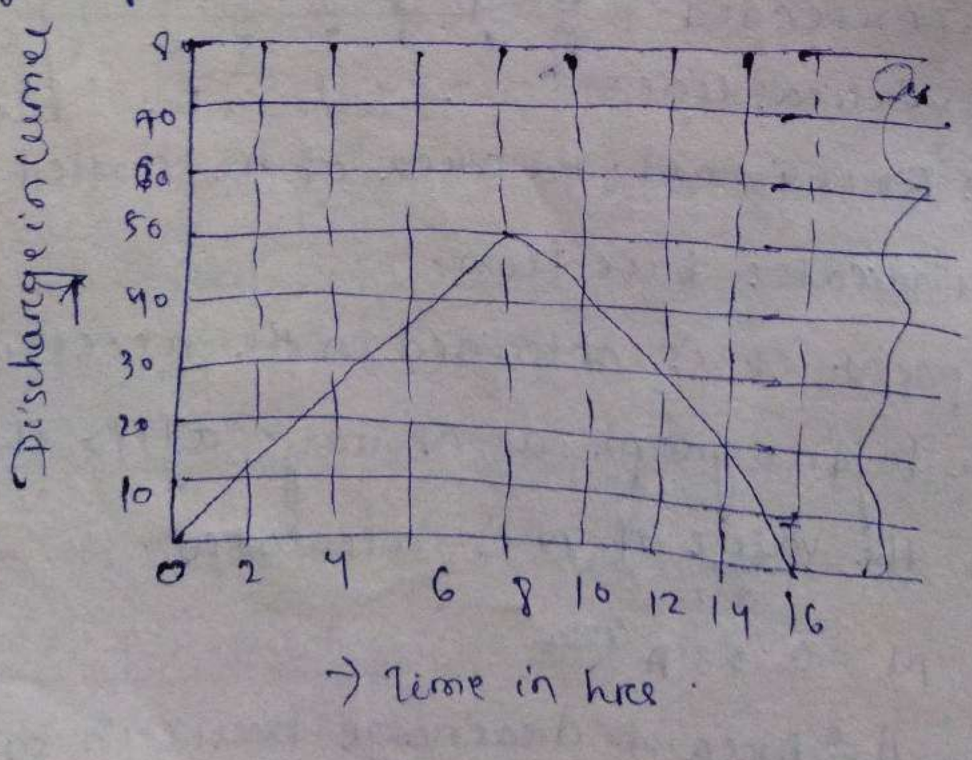
A unit hydrograph may be defined as a hydrograph which is obtained from one cm of run-off for unit duration.

→ The unit duration is the period during which the effective rainfall or run-off is assumed to be uniformly distributed.

→ The unit duration may be considered as 1hr, 2hr, 3hr, 4hr - - - etc.

for ex:

If a hydrograph is prepared for a run-off of one cm lasting for 2 hrs, then it is known as 2hr. unit hydrograph, for duration 3hrs it is 3 hrs unit hydrograph.

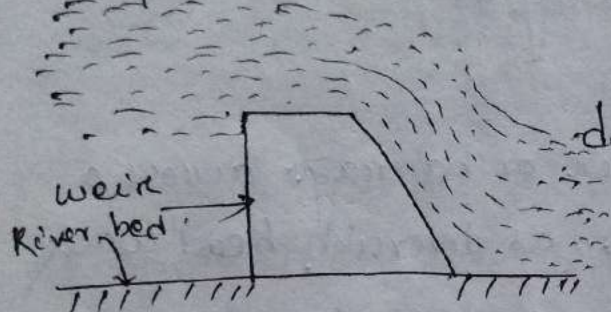


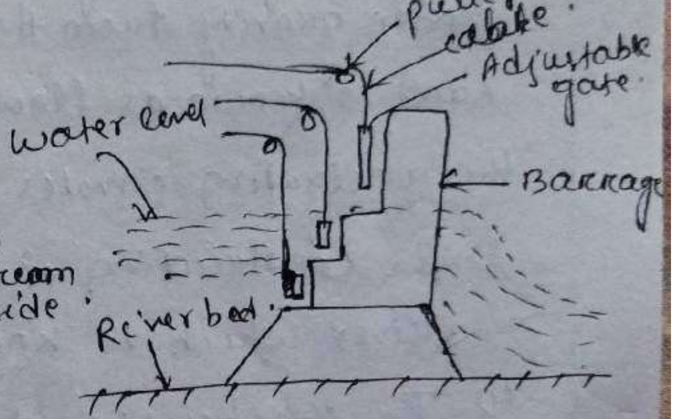
chapter-4 ÷ FLOW IRRIGATION ÷

weir → An impervious barrier which is constructed across a river to raise the water level on the upstream side is known as weir.

In this construction the water level is raised upto the required height and the surplus water is allowed to flow over the weir.

Generally weir is constructed across a inundation river.





Barrage ÷ when adjustable gates are installed over a weir to maintain the water surface at different levels at different times, then it is known as barrage.

→ The water level is adjusted by operating the adjustable gates or shutters.

The gates are placed at different tiers and these are operated by cables from the cabin.

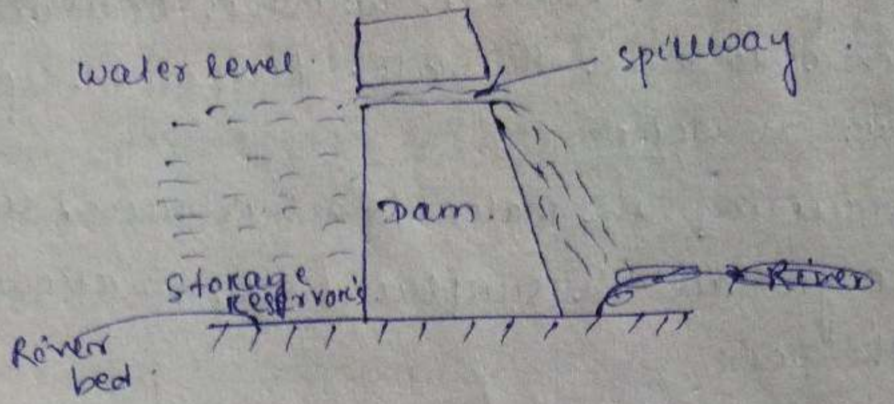
The gates are supported on the piers at both ends.

the distance betn pier to pier's known as bay.

Dam →

The high impervious barrier constructed across a river valley to form a deep storage reservoir is known as dam

→ The surplus water is not allowed to flow over the dam but it flows through the spillways provided at some designed level.



→ The irrigation system in which the water flows under gravity from the source to the agricultural land is known as flow irrigation.

This irrigation involves.

i) The construction of weir or barrage across a river which is known as diversion head work.

ii) The construction of dam across river valley.

iii) The excavation of canal system.

Ex:- Bhakra Nangal project, ukai project, Damodar valley project, etc.

This is of two types.

i) perennial ii) inundation.

perennial irri	~~inundation irri~~
→ In perennial irr. either a ~~across~~ weir or a barrage is constructed across the perennial river to increase the water level or a dam is constructed to form a storage reservoir. → Then the network of canals is constructed from the source to agricultural lands.	→ In this irr. the canals are excavated from the banks of the inundation river. → The bed level of canal in ~~inundation~~ such that the water can flow in rainy season only when the water level in the river rises above the canal bed.

→	The construction of hydraulic structure is not necessary in this system.
→ Here, head regulators constructed to control the flow of water through the canal.	→ There is no head regulator control
→ In this system waters available through out the year.	→ In this water is not available through out the year.

1- perennial irrigation :-

The irrigation system which is constructed across the perennial river (the river which flows throughout the year in its full capacity) to raise the water level on the upstream side or a dam is construct to form a storage reservoir is known as perennial irrigation.

→ In this system crops can be irrigated according to their requirement for the whole year available of water.

→ water is supplied to land through of storage canal head works and canal distribution system.

→ It is of two types.

1. Direct irrigation system.

(ii) storage irrigation system or flood " "

i) Direct irrigation system :-

In this system a weir is generally constructed across a perennial river to raise the water level on the up stream side upto a certain limit so that the water can flow through the canal.

Some times barrage also constructed in place of weir to regulate the the water level of upstream side.

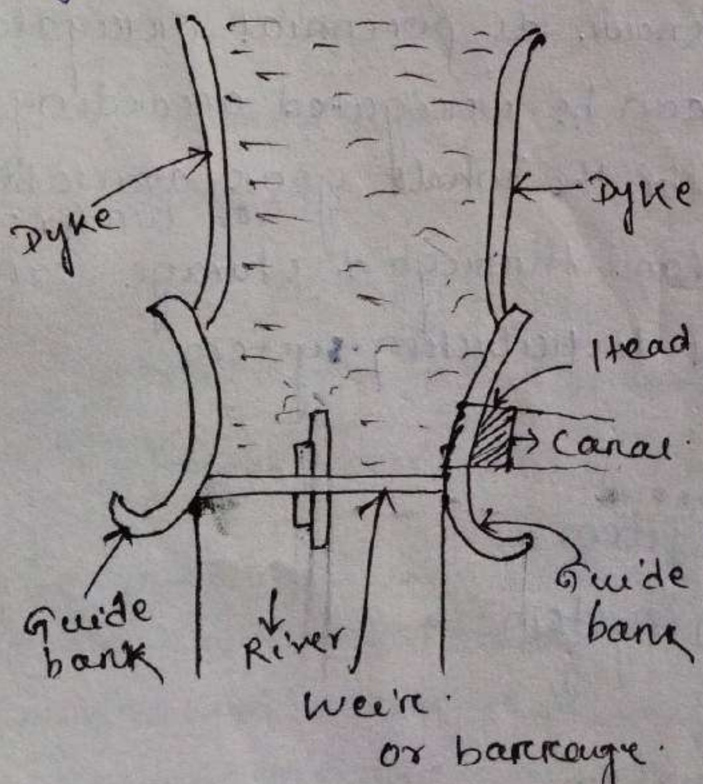
→ The hydraulic structure which is constructed in direct irrigation system is known as Diversion head works.

(ii) <u>Storage irrigation system</u>:-

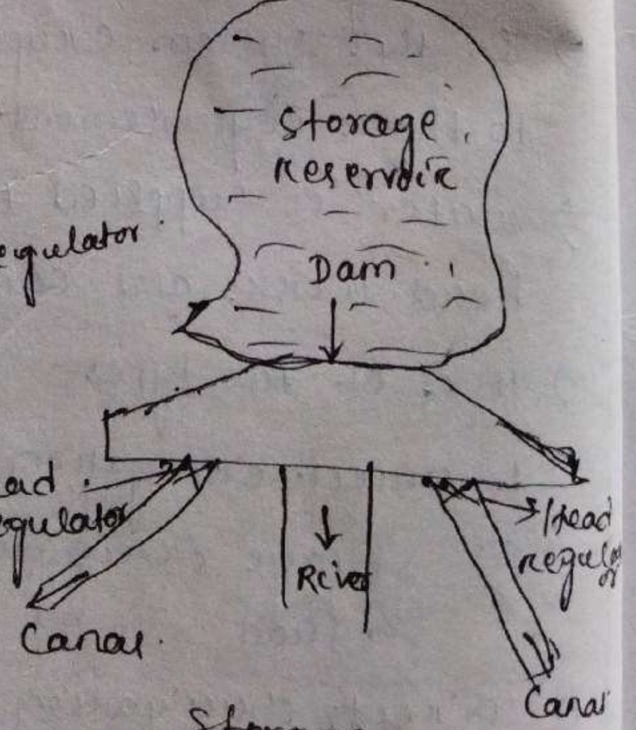
In this system a dam is constructed across a river valley to form a storage reservoir. the main canal can be taken from both sides of dam.

the flow of the canal is controlled by head regulator.

→ From this storage we get many benefits like, irrigation, water supply, hydro-electric power generation, fishery, flood control.



(Diversion head works)



Storage reservoir.

2) Inundation irrigation :

The irrigation system in which a canal is excavated from the bank of a inundation river (the river which overflows in raining season but in other season its day) is called inundation irrigation.

→ In this case water flows to agricultural land in raining season only.

So there is no regulator at the head of canal to control the flow of water.

The irrigation stops automatically in other season for ~~the irrigation~~ the shortage of water.

→ The bed level of water is fixed at such a level that the water can flow when the river water level rises.

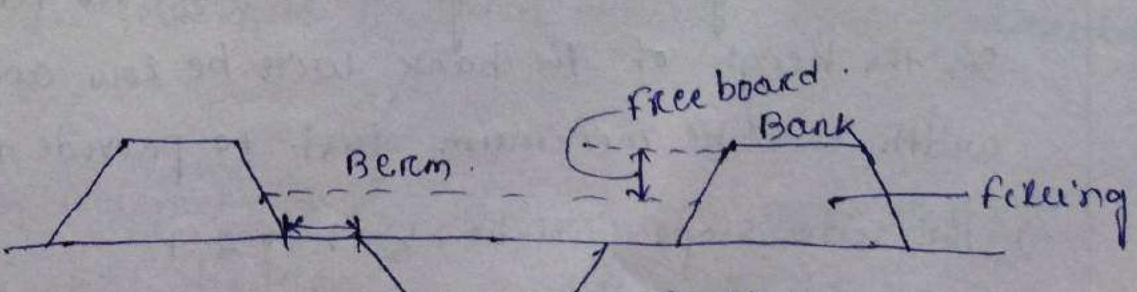
→ This irrigation may cause damage of crops for its irrigation watering system.

Different Canal cross sections :

The cross-sections of canal may be of following types.

1. Canal fully in cutting.
2. Canal in partial cutting and Banking.
3. Canal in full banking.

Canal crossing a section or Area.



Berm of bank

1 - Side slope → Nature of soil.

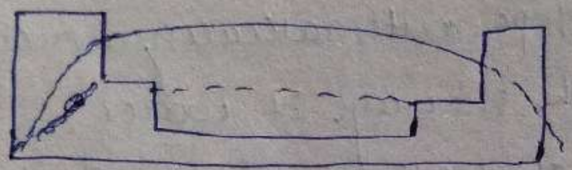
Cutting : 1 horizontal : 1 vertical (1:1) (1½:1)

filling (1½:1) to (2:1)

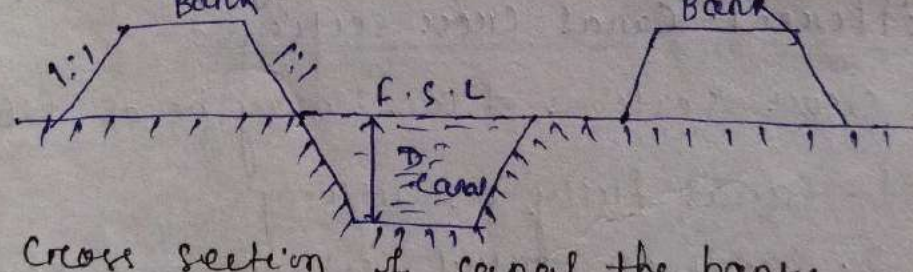
Berm → fine & impervious lining & losses decrease (leakage)

FSL → Free surface level.

Bank → to retain or contain water inspection path.



1. The canal fully in cutting :-

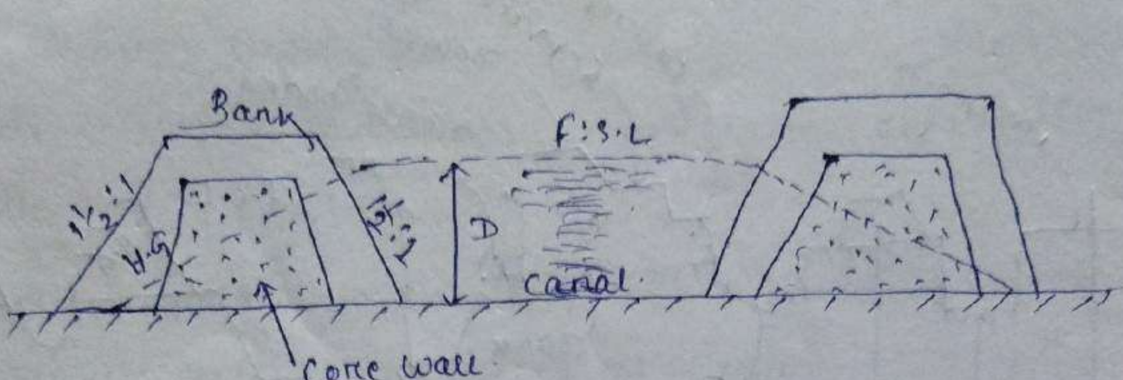


In this cross section of canal the banks are constructed on both sides of the canal to provide only a inspection road.

→ Here the hydraulic gradient has no function. So, the heigh of the bank will be low and the top width will be minimum just to provide the road way

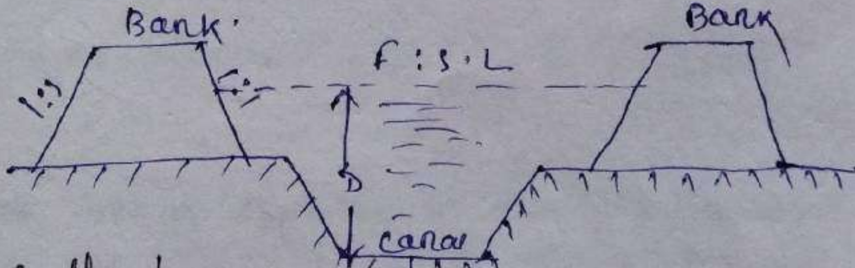
→ The side slope will be 1½:1 or 2:1 according to the nature of soil. the hydraulic gradient downwards.

③ The Canal in fully Banking or Filling :-



In this case, the canal & bo the canal banks are constructed above the ground level. the height of the bank will be high and its section will be large due to hydraulic gradient. But to minimise the cross of the bank a core wall of puddle clay is provided which deflects the hydraulic gradient downwards.

② Canal in partial Cutting & Banking or filling :-

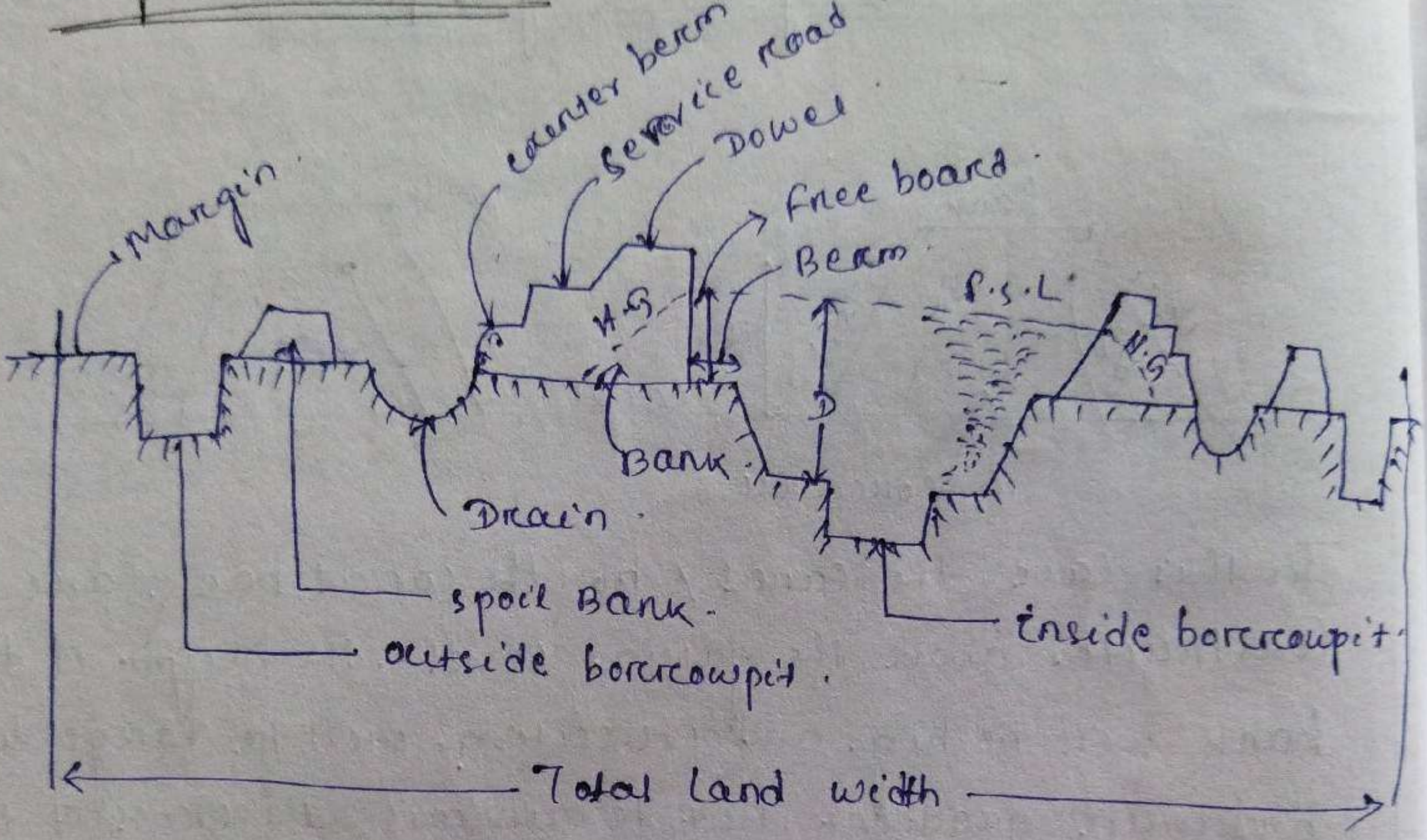


In this case the banks are constructed on sides of the Canal to retain water the height of the Canal depends on the fully supply level of the canal.

→ Again the section of the Canal depends on the hydraulic gradient.

→ The top width & the side slope of the bank should be such that hydraulic gradient should have a minm cover of 0.5m.

Components of Canal



H.G → Hydraulic gradient.

F.S.L → Full supply Level.

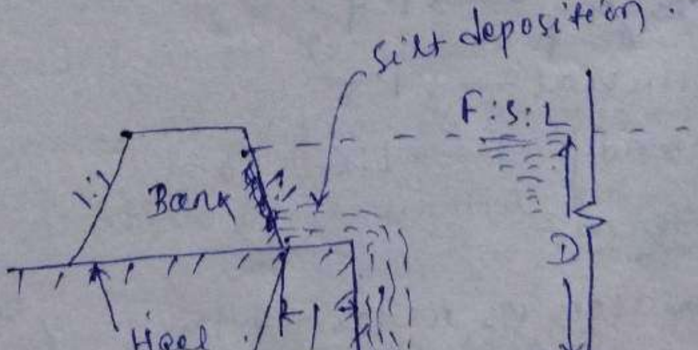
D → Full supply depth of canal.

Canal Bank :

The canal bank is necessary to retain water in the canal to the full supply level.
But section of canal bank is different for different site condition.

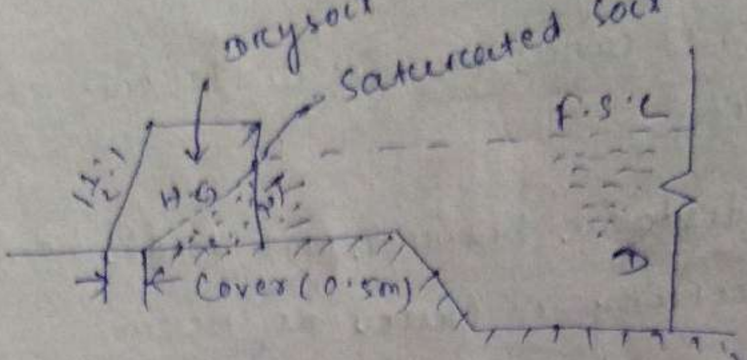
Berm : The distance between toe to the bank and the top edge of cutting is called as Berm.
The berm is provided for following reasons.
i) To protect the bank from erosion.
ii) To provide a space for widening the canal section in future if necessary.
iii) To protect the bank from sliding down towards the canal section.
iv) The silt deposition on the berm makes an impervious lining.
v) If necessary borrow pit can be excavated on the berm.

The width of berm depends on various factors i.e capacity of canal, the nature of soil, the site cond'n etc.



(Berm)

Hydraulic's gradient :-



(Hydraulic's Gradient)

when the water is retained by the canal bank the seepage occures through the body the bank.

→ Due to the resistance of soil, the saturation line forms a sloping line which may pass through countrysidy of the bank.

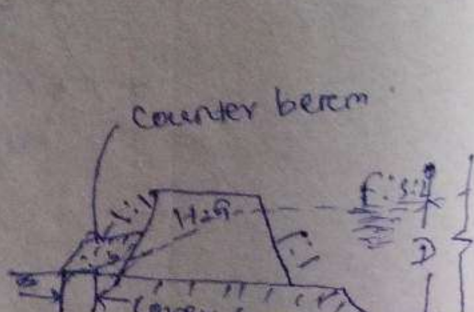
This sloping is called as H.G.

→ It depends on the permeability of soil. So while constructing the bank the soil test should done find H.G.

→ This will help to fix the height, top width and side slope of the bank.

Soil	H.G
Clayeny	→ 1:4
Alluvial	→ 1:5
Sandy	→ 1:6

Counter Berm :-



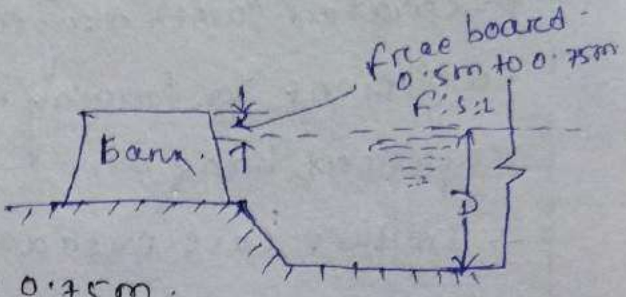
when the water is retained by the canal bank the H.G line passes through the body of the bank.

→ For stability of the bank, this gradient should not intersect the outerside of the bank.

→ It should pass through the base and a minm cover of 0.5m is always maintained.
This is called Counterberm.

Free board ÷

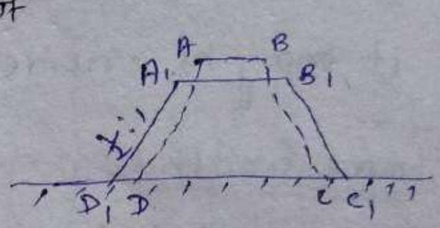
It is the distance between the full supply level and top of the bank.



→ Its values varies from 0.6m to 0.75m.

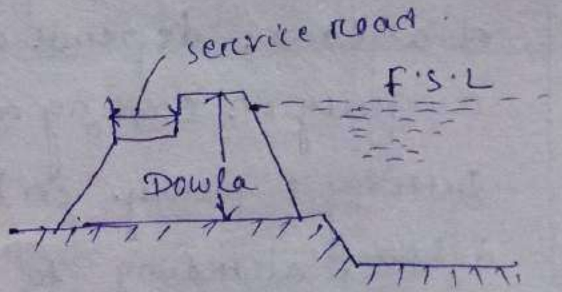
Side slope →

Its depend on the angle of repose of soil existing on the site.
To find out side slope the soil is tested in lab.



Service road →

The road which is provided on the top of the canal bank for inspection and maintenance works is called as service road.

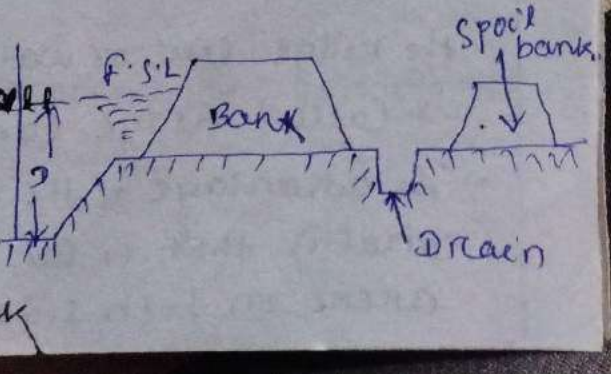


→ for main canal service road width 4 to 6m & for branch 3 to 4m.

Dower or Dowla → The protective small embankment which is provided on the canal side of the service road for saftey of vehicles plying on it is called dowel.
→ It is provided above F.S.L with a provision of freeboard.

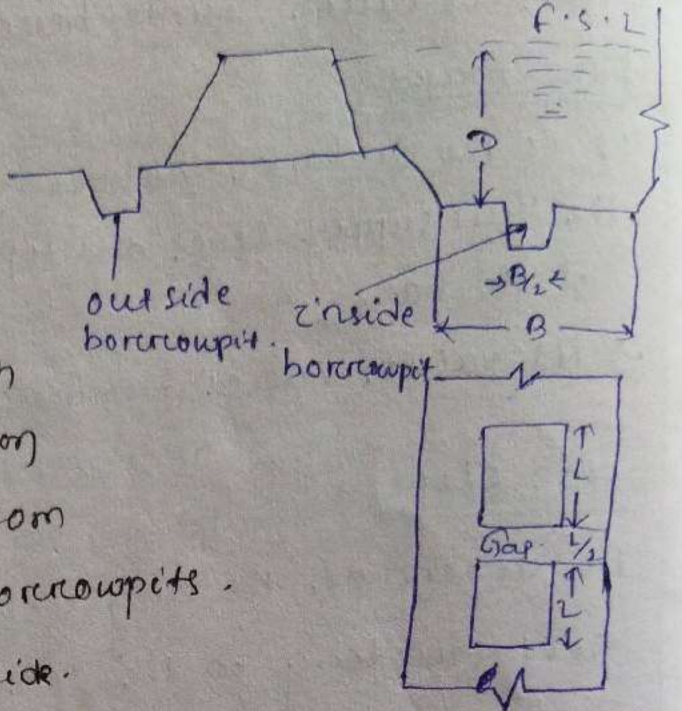
Spoil bank ÷

When the canal is provided in full cutting, the excavated earth is deposited in the form of small bank which is called as spoil bank



Borrowpit :-

when the can is constructed in partial cutting and partial banking, the excavated earth may not be sufficient for forming the required bank.



→ In this case extra earth require for the construction of banks is taken from som pits which are known as borrowpits. It may be inside or outside.

Land width :-

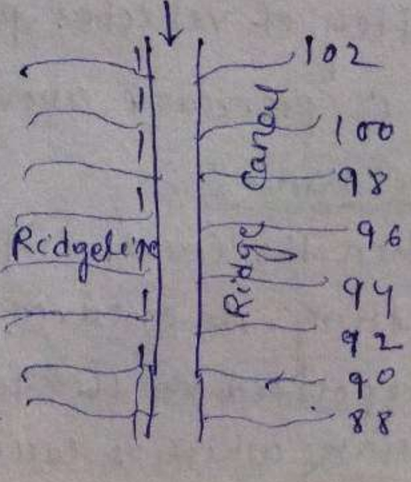
The total land width required for the construction of a canal depends on the nature of side condn, such as fully in cutting or fully in banking or partly in cutting & partly in banking so total land width differs according to side condn.

4. Classification of canals based on alignment

According to alignment the canals are as.

1. Ridge or watershed canal.
2. Contour canal
3. side slope canal.

1. Ridge canal :-



The canal which is aligned along the ridge line or watershed line is called Ridge canal.

→ The advantage of the type of canal is that is can irrigate the areas on both sides.

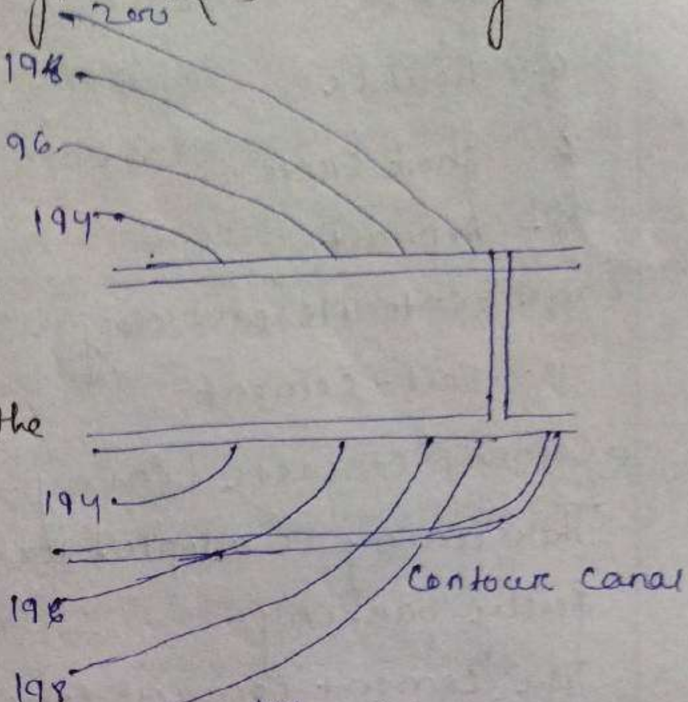
→ There is no possibility of crossing any natural drainage and hence no cross-drainage work is necessary.

2. Contour Canal :-

The canal which is aligned approximately parallel to the contour lines is called as contour canal.

→ This canal can irrigate the areas on one side only.

→ This may cross natural drainage and hence cross-drainage works are necessary.

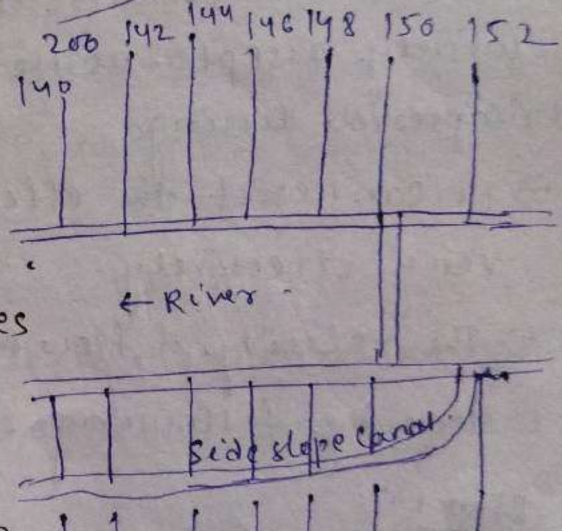


3. Side slope canal :-

The canal which is aligned approximately at right angles to the contourline is called side slope canal.

→ It can irrigate the areas on one side only.

→ It does not cross any natural drainage and hence cross drainage is not necessary.



← Canal Lining →

Types of canal lining →

It is classified according to various site conditions.

1. Cement Concrete lining.
2. pre-cast concrete ,,
3. Cement mortar ,,

4. Lime Concrete lining.

5. Brick "

6. Boulder "

7. Short crete "

8. Asphalt "

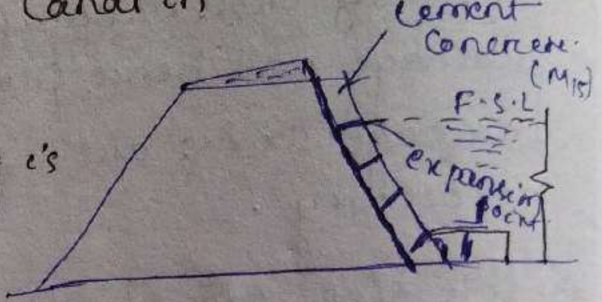
9. Bentonite and clay.

10. Soil - cement.

← Cement Concrete Lining →

This lining is adopted for the canal in fully banking.

The cement concrete lining is widely accepted as the best improved lining.



→ It can resist the effect of scouring & erosion very effectively.

→ The velocity of flow may kept above 2.5 m/sec. Its done by following steps.

Step-1

preparation of subgrade →

It is prepared by removing the surface properly with a layer of sand (about 15cm) Then a slurry of cement and sand (1:3) is spread uniformly over the prepared bed.

Step-2 laying of concrete →

The cement concrete of grade (M_{15}) is spread uniformly according to limited thickness (100mm to 150mm)

→ After laying, concrete is tapped gently until the slurry comes on the top.

The curing is done for two weeks.

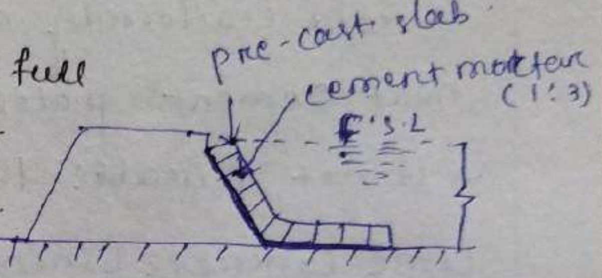
→ After becoming strong & changed according to temp. the expansion joint are provided at proper places.

→ No re-inforcement is required.

→ But in case some special, a network of 6mm dia rods may be provided with spacing 10cm centre to centre.

2. Pre-cast Concrete Lining :

This lining is adopted canal in full banking. It consist of pre-cast concrete slabs of size 60×60×5cm. which are set along the canal bank and bed with cement mortar 1:6.



→ A network of 6mm dia. rod is provided in the slab with spacing 10cm c to c.

→ The proportion of concrete is 1:2:4

→ Rebates are provided on all four sides of the slab so that proper joints may be obtained when they are placed side by side.

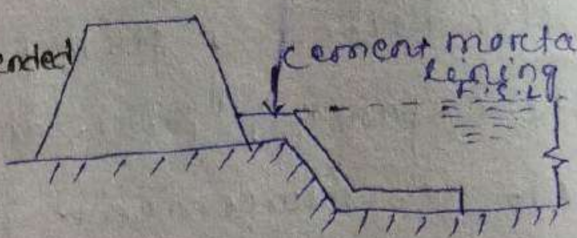
→ The joints are finished by cement mortar 1:3 the slabs are set following steps.

Step-1 : The sub-grade is prepared by properly ramming the soil with a layer of sand. the bed is levelled so that slabs can be placed easily.

Step-2 : The slabs are placed as per estimate along the course of the canal. the slabs are placed with cement mortar (1:6) by setting rebets properly. the joints are finished with cement mortar 1:3 the curing is done for a week.

Cement mortar lining →

This type of lining is recommended for the canal fully in cutting where hard soil or clayey soil is available.



→ The thickness of cement mortar (1:4) is of 2.5cm.

→ Then over compacted sub-grade, the cement mortar is laid uniformly and the surface is finished with neat cement polesh.

→ It not durable the curing should be done properly.

Lime concrete Lining →

when hydraulic lime, surki and brick ballast are available in plenty along the course of the canal or nearby irrigation project, then the lining of the canal may be made by the lime concrete of proportion 1:1:6

→ The procedure of laying this some as the cement concrete lining.

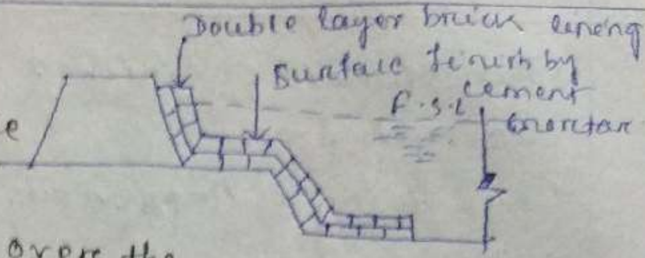
→ The thickness of concrete varies from 150 to 225mm & curing should be done for long period.

→ Its durability is less than the cement concrete lining.

→ Its adopted because of the availability of materials and also because off economies.

Brick Lining →

This lining is done by the double layer brick flat soling laid with cement mortar (1:6) over the compacted sub-grade.



→ The 1st class bricks should be adopted for the work
→ The ~~curing~~ surface of the lining is finished with cement plaster (1:3)
→ The curing should be down properly.
→ This lining is prefered for.

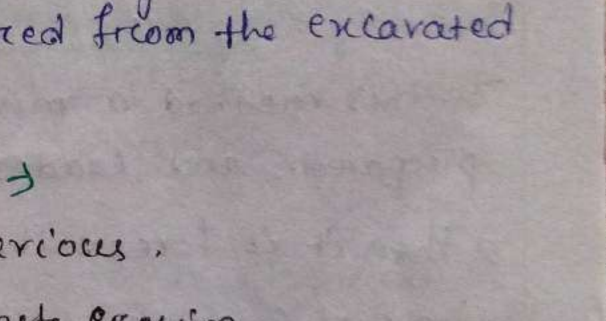
i) This lining is economical
ii) work can be done very quickly.
iii) Expansion joint are not required.
iv) Rapair works can be done easily
v) Bricks can be manufactured from the excavated earth near the site.

Disadvantage of this lining →

i) It is not completely impervious.
ii) It has low resistance against erosion.
iii) It is not so much durable.

Boulder Lining →

In hilly area where boulders are available in plenty, this lining is generally adopted.



→ The boulders and load in single or double layer maintaining the slope of the banks and the bed level of canal.
→ The joint of boulders are grouted with cement mortar (1:6)

→ Then surface is finished with cement mortar (1 : 3) & curing is done.

→ This lining is impervious & durable.

→ But transportation cost of material is very costly so it can't adopted in all cases.

Short crete lining :

In this system the cement mortar (1:4) is directly applied on the sub-grade by an equipment known as cement gun.

→ The mortar is termed as short cretes the lining is called short crete lining.

→ This also called as guniting, as a gun is used for laying the mortar so this lining is called guniting lining this is done in two ways.

1st way → By dry mix :

In this method a mixture cement & moist sand is prepared and loaded in the cement gun.

→ Then it is forced through the nozzle of the gun with help of compressed air.

→ The mortar speade over the sub-grade to a thickness which varies 2.5 to 5 cm.

2nd way · By wet mix →

In this way, the mixture of cement sand and water is prepared according to the approved consistency.

→ Then the mixture is loaded in the gun is forced on the sub-grade.

→ This type of lining is very costly & its not dureable

→ It is suitable for resurfacing the old cement concrete lining.

Asphalt lining :-

This lining is done by spraying asphalt (bitumen) at a very high temperature (about 150°c) on the sub grade to a thickness varies from 3mm to 6mm.

→ when asphalt becomes cold, it forms a water proof member over the sub-grade.

→ This membrane is covered with a layer of earth / gravel.

→ The lining is very cheap and can control the seepage of water very effectively but it can not control the growth of weeds.

Bentonite and clay lining :-

In this lining a ~~the~~ mixture of bentonite and clay are mixed thoroughly to form sticy mass.

→ This mass is spread over the sub-grade to form an impervious membrance which is effective in controling seepage of water but it can't control the growth of weeds.

→ This is generally adopted for small channels.

Soil-cement Lining :-

This is done with a mixture of soil and cement

→ The usual quantity of cement is 10%. of the wt. of dry soil. the soil and cement are thoroughly mixed to get an uniform texture. then the mixture is laid on the sub-grade and it is made thoroughly compact.

→ The lining is fficient to control the seepage of water but it can't control growth of weeds, so it is adopted for small channels only.

Various Canal Linings, advantages & disadvantages.

Advantages of Canal Lining →

1. It reduces the loss of water due to seepage and hence the duty is enhanced.
2. It controls the water logging & hence the bad effects of water-logging are eliminated.
3. It provides smooth surface and hance the velocity of flow can be increased.
4. Due to the increased velocity the discharge capacity of a canal is also increased.
5. Due to the increased velocity, the evaporation loss also be reduced.
6. It eliminates the effect of soouring in the canal bed.
7. The increased velocity eliminates the possibility of silting in the canal bed.
8. It controls the growt of weeds along the canal sides and bed.
9. It provides the stable section of the canal.
10. It prevents the sub-soil salt to come in contact with the canal water.
12. It reduces the maintenance cost for the canals.

Disadvantages :-

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

2- It involves much difficulties for repairing the damaged section of lining.

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

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

Chapter-5

WATER LOGGING AND DRAINAGE

→ In agricultural land, when soil pores within the root zone of the crops get saturated with the sub soil water, the air circulation within the soil pores gets totally stopped.

→ This process is known as water logging.

Causes of water logging:

1. over irrigation.
2. seepage from ~~canals~~ canals.
3. Inadequate surface drainage.
4. obstruction in natural water course.
5. obstruction in sub-soil drainage
6. Nature of soil.
7. Incorrect method of cultivation.
8. seepage from reservoir.
9. poor ~~irr~~ irrigation management.
10. Excessive rain fall.
11. Topography of the land.
12. occasional flood.

1. over irrigation:

In case of inundation irrigation since there is no controlling system of water supply it may cause over irrigation. the excess water percolates & remains stored within the root zone of the crops.

→ In case perennial irrigation system if water is supplied more than what is required. this excess water is responsible for the water logging.

2 - seepage from canals :

In ▬ cenlined canal system, the water percolates through the bank of the canal & gets collected in the low lying areas along the course of canal & thus the water table get raised.

→ This seepage is more in case of canal in banking.

3 - Inadequate surface drainage →

when the rainfall is heavy and there is no proper porision for surface dreainage the water gets collected and submarged large are. when this condition continues for a long period the water table is raised.

4. obstruction in natural water course →

If the bridges or culverts are constructed across a water course with the opening with insufficient discharge capacity, the upstream area gets flooded & this causes water logging.

5 - obstruction in sub-soil drainage →

If some impermeable stratum exists at a lower depth below the ground surface, then.

• the movement of the sub soil water gets obstructed and causes water logging.

6. Nature of soil →

The soil having low permeability, like black cotton soil, does not allow the water to percolate through it so, in ase for over irrigation or flood, the water retains in this type of land & causes water logging.

7- Incorrect method of cultivation :-

If the agricultural land is not levelled properly and there is no arrangement for the surplus water to flow out, then it will create pools of stagnent water leading to water logging.

8. Seepage from reservoir →

If the reservoir basin consists of permeable zones, cracks and fissures which were not detected during the construction of dam, there may cause seepage of water. this sub-soil water will move towards the low-lying areas and cause water logging.

9. poor irrigation management →

If the main canal is kept open for a long period unnecessarily without computing to total water requirement of the crops, then this leads to over irrigation which result water logging.

10- Excessive rainfall →

If rainfall is excessive and the water gets notime to get drained off completely then a pool of stagnant water is formed which might lead to water logging.

11. Topography of the land →

If the agricultural land is flat, i.e with no country slope and consists of depressions or undulations, then this may cause water logging.

12 - Occasional Flood →

If an area gets affected by flood every year and there is no proper drainage system, the water table gets raised and this causes water logging.

Effects of water Logging →

1. Salinization of soil
2. Lack of aeration.
3. Fall of soil temperature.
4. Growth of weeds & aquatic plants.
5. diseases of crops.
6. Difficulty in cultivation
7. Restriction of root growth.

1. salinization of soil :-

Due to water logging the dissolved salts like sodium carbonate, sodium chloride and sodium sulphate come to the surface of the soil. when the water evaporates from the surface, the salts are deposite there. this process is called salinization of soil. Excessive concentration of salt makes the land alkaline it does not allow the plants to thrive and thus the yield of crop is reduced. this process is known as salt efflorescence.

2. Lack of aeration :-

The crops require some nutrients for their growth which are supplied by some bacteria or micro-organism by breaking the complex nitrogeneous compounds into simple compounds which are consumed by the plants for their growth. But bacteria requires oxygen for their life & activity when the aeration in the soil is stopped by water logging, these bacteria can't survive without oxygen & the fertility of land is lost which results is reduction of yield.

3 - Fall of soil Temp. →

Due to water logging the soil temp. is lowered. At low temp. of soil the activity of bacteria becomes very slow & consequently the plants don't get required amount of food in time. so growth of plants is hampered & yield also reduced.

4. Growth of weeds and aquatic plants →

Due to water logging the agriculture land is converted to marshy land & weeds & aquatic plants are grown in plenty. these plants consume the soil foods in advance & thus the crops are destroyed.

5. Diseases of crops →

Due to low temp. & poor aeration, the crops get some diseases which may destroy the crops or reduce the yield.

6. Difficulty in cultivation →

In water logging area it is very difficult to carry out the operation of cultivation such as tilling, ploughing, etc.

7. Restraction of Root growth →

when the water table rises near to root zone the soil gets saturated. the growth of the roots is confined only to the top layer of the soil, so the crops cannot be matured properly & the yield is reduced.

Control of water logging (prevention) :-

1. prevention of percolation from canals →

The irrigation canals should be lined with impervious lining to prevent the percolation of water through the bed & banks of canals, so the water logging may be prevented.
Intercepting drains may be provided along the course of irrigation canals in places where the percolation ~~was~~ of water is detected.
the percolation water is intercepted by the drains & water is carried to other natural water course.

2. prevention of percolation from reservoir →

During construction of dam, the geological survey should be done on the reservoir basin to detect the zone of permeable formations through which water may percolate. these zones should be treated properly to prevent the seepage. If after this it is found that there is still leakage of water through some zone, then sheet piling should be done to prevent the leakage.

3. Control of intensity of irrigation →

The intensity of irrigation may cause water logging so, it should be controlled in a planned way so that there is no possibility water logging in a particular area.

4. Economical use of water :-

If the water is used economically, then it may control the water logging & the yield of crops may be high so special training is required to be given to the cultivators to realise the benifits of economical use of water. It helps them to get more crops by eliminating the possibility of water logging.

5. Fixing of crop pattern →

Soil survey should be done to for the crop pattern the crops having high rate of evapotranspiration should be recommended for the area susceptible to water logging.

6. providing drainage system →

Suitable drainage system should be provided in the low lying areas so that the rain water does not stand for long days. A network of sub-surface drains. the surface drains discharge the water to the river or other water course.

7. Improvement of natural drainage →

Sometimes, the natural drainage may be completely silted up or obstructed by weeds, aquatic plants etc. the affected section of drainage should be improved by excavating & clearing the obstruction.

8. pumping of ground water :-

A no. of openwells or tube wells are constructed in the water logged area & the ground water is pumped out until the water table goes down to a safe level. the lifted ground water may be used for irrigation.

9. Construction of sump well →

sump wall may be constructed within the water logged & they help to collect the surface

The water from this wells may be pumped to the irrigable lands.

Land reclamation →

It's the process of making a land cultureable after it get converted to unculturable area due to bad effect of water logging.

The methods are as follows →

1. Leaching.
2. Addition of chemical agent.
3. surface drainage.
4. sub-surface drainage.
5. Addition of waste products.
6. excavation of ponds.
7. pumping of water from tube wells.

watershed management →

The area enclosed within the watershed line is called watershed line.

The watershed management may be done in two ways.

1. preventive measures
   a. Contour bunds or terrace bonds
   b. Small dams.
   c. Soil conservation.
   d. slip stabilisation.
   e. control of cultivation in catchment area.

2. Curative measures.
   a. Remodelling work.
   b. Construction of water packets.
   c. diversion channel.
   d. Link channel.
   e. Construction of pond.
   f. Construction of Sumpwell.

chapter-6

Diversion head works & Regulatory structures

Diversion head work →

when a weir or barrage is constructed across a perennial river to raise the water level & to divert the water to canal, it is known as diversion head work.

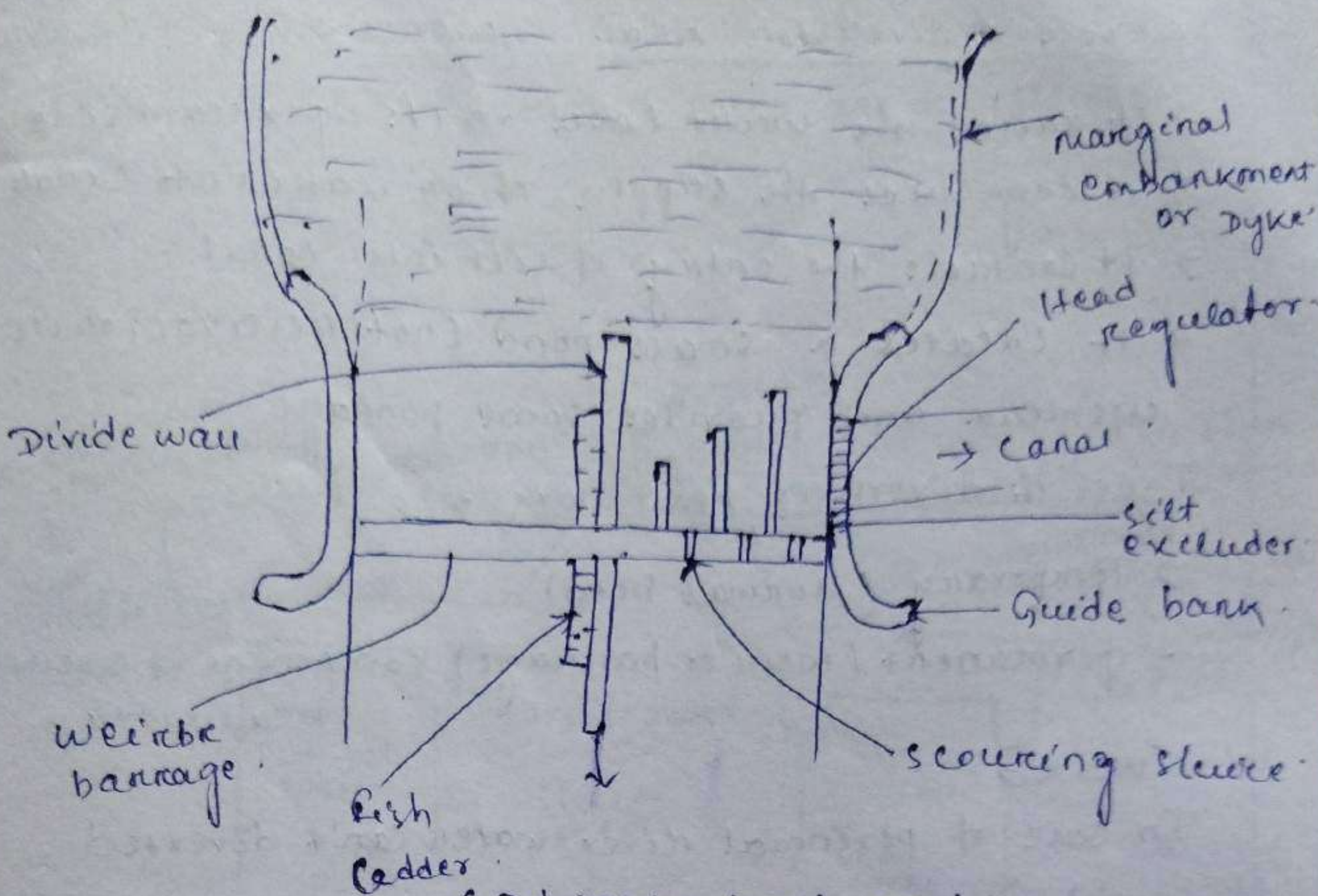
→ The flow of water in canal is controlled by canal head regulator.

Object of diversion head works → (Necessity)

1. To raise the water level at the head of the canal.
2. To form a storage by constructing dykes on both the banks of river so that water is available entire the year.
3. To control the entry of silt into the canal and to control the deposition of silt at the head of the canal.
4. To control the fluctuation of water level in the river during different seasons.

Components or parts of diversion head works →

1. weir or barrage.
2. Divide wall
3. scouring sluices or under sluices.
4. fish ladder.
5. Canal head regulator.
6. silt excluder.
7. Guide bank.
8. Marginal embankment or Dyke.



(Diversion head work)

Head work
↓
Any hydraulic structure which supplies water to the off taking canal is called a headwork.

Head works

- Storage head works
  Ex → Dams
- Diversion head works or distribution head works
  Ex - weir, barrage.

Diversion head works →

The works which is constructed at the head of the canal in order to divert the river water towards the canal, so as to ensure a regulated continuous supply mostly silt free water with certain minm head into the canal, are known as diversion head works.

Purpose of diversion head works →

→ It raises the water level on it's upstream side.
→ It regulates the supply of water into canals.
→ It controls the entry of silt into canal.
→ It creates a small pond (not reservoir) on its upstream and provides some pondage.

Types of diversion head works →

→ Temporary (Normal bond)
→ permanent (weir or barrage)

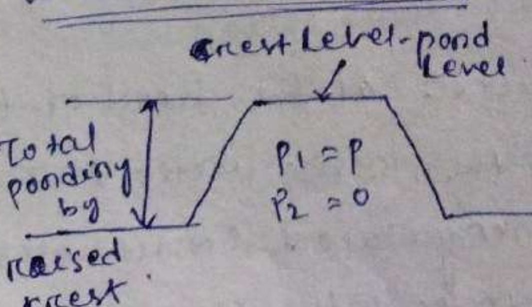
component of direction head work →

weir →

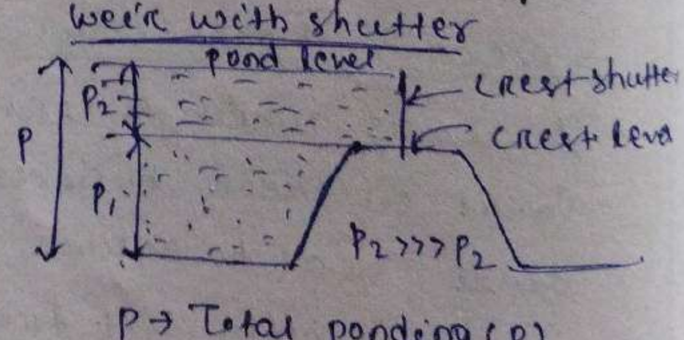
In case of perennial river water can't diverted to the irrigation canal.

→ The bed level of the canal may be higher than the existing water level of river.
→ In this case weir is constructed across the river to raise water level.
→ As a result the raised water automatically passes above the weir.
→ Adjustable shutters are provided on the crest to raise the water level to some required height.

weir without shutter



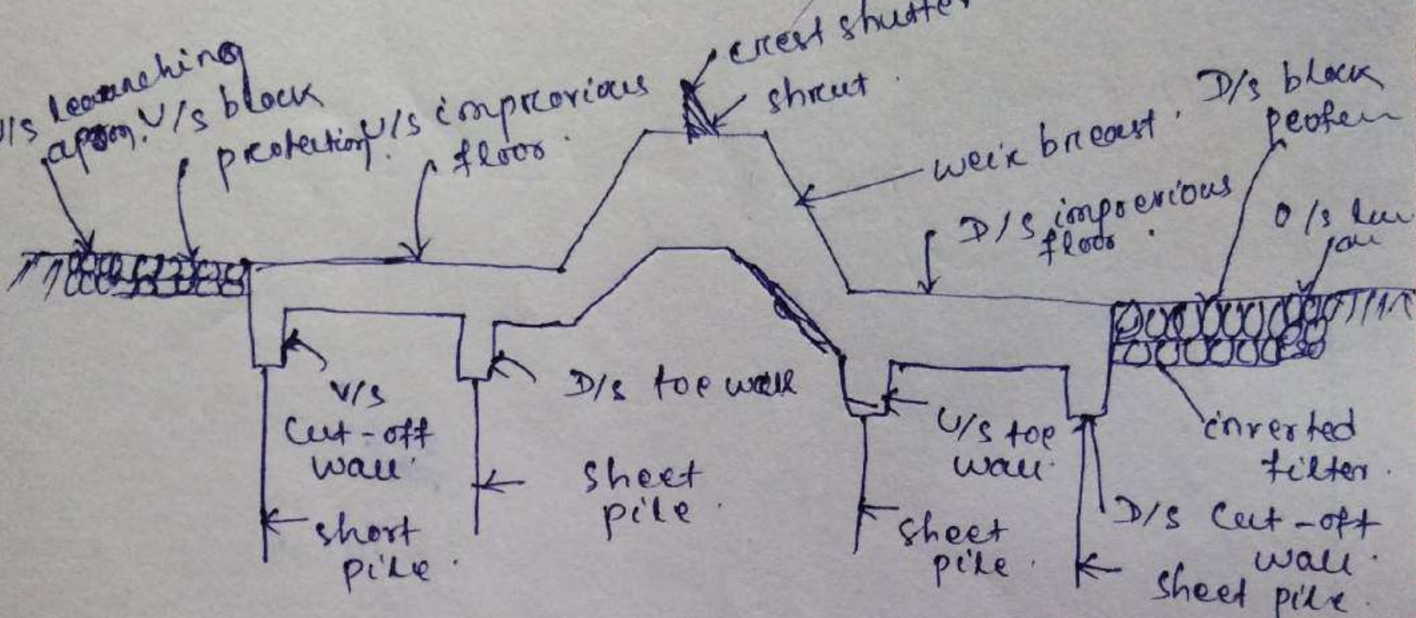
weir with shutter



P → Total ponding (P)
P_1 → ponding by raised crest
P_2 → Ponding by crest shutter

Component parts of weir →

The parts and their function of weir are as follows →



1. weir breast →

Its the main body of the structure it may be constructed with masonry work or concrete. the heigh & the section of breast wall depends on the depth of water to be retained & the nature of foundation. the function of this part is to raise the water level on the U/s side so that the water can be diverted to the irrigation canal through head regulator.

2. crest shutters →

These are adjustable gates or shutters provided on the crest of the weir. the bottom end of these shutter are heinged with the crest and the top are free..