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NAME: ______ STD.: ______ SEC.: ______ ROLL NO.: ______ SUB.: Irrigation

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IRRIGATION

irrigation

INTRODUCTION

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 systems for the regular supply of water to the culturable (i.e cultivable) lands.

Necessity Of Irrigation:-

⇒ Throughout the crop period adequate quantities of water is required near the root zone of the plant for their growth. At times during the crop period the rainfall may not be adequate to fulfill 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

⇒ So, irrigation becomes absolutely necessary to fulfill the water requirment of crops. The Following are the factors which govern the necessity of Irrigation.

Insufficient Rainfall:-

When the seasonal rainfall is less than the minimum requirement for the growth. At times during ~~th~~ the satisfactory growth of crops, the irrigation System is essential.

Uneven Distribution of Rainfall:-

When the rainfall is not evenly distributed during the crop period are throughout the culturable area the irrigation is extremely neccessary.

Improvement of perennial crops:-

Some perenial crops like sugarcane, cotton etc required water throut the major part of the year. But the rainfall may fulfill ~~may~~ the water requirment is rainy season only. so, for the remaining part of the year, irrigation becomes neccessary.

Development of agriculture in Desert area:-

In desert area where the rainfall is very scanty Irrigation is required for the devlopment of agriculture.

Benefits of Irrigation:-

The following are the important benefits of irrigation.

Yeild of crops:-

In the period of low rainfall or drought, the yield of crop may be increased by the irrigation system.

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.

Improvement of cash crops:-

Irrigation helps to improve the cultivation of cash crops like vegetables, Fruit, tobacco, etc.

Prosperity of Farmers:-

when the supply of irrigation water is assured, the Farmers 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.

Source Of Revenue:-

when irrigation water is supplied to the cultivators in lieu of some taxes, It helps to earn revenue which may be spent on other development schemes.

Navigation:-

The irrigation canals may be utilised for inland navigation which is further useful for communication and transporte of agricultural goods.

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.

Water Supply :-

The irrigation canals may be the source of water supply for domestic and industrial purpose

General Communication:-

The inspection road along the canal banks may serve as a communication link with the otherwise remote villages.

Development of Fishery:-

The reservoir and the canals can be utilised for the development of fisher projects.

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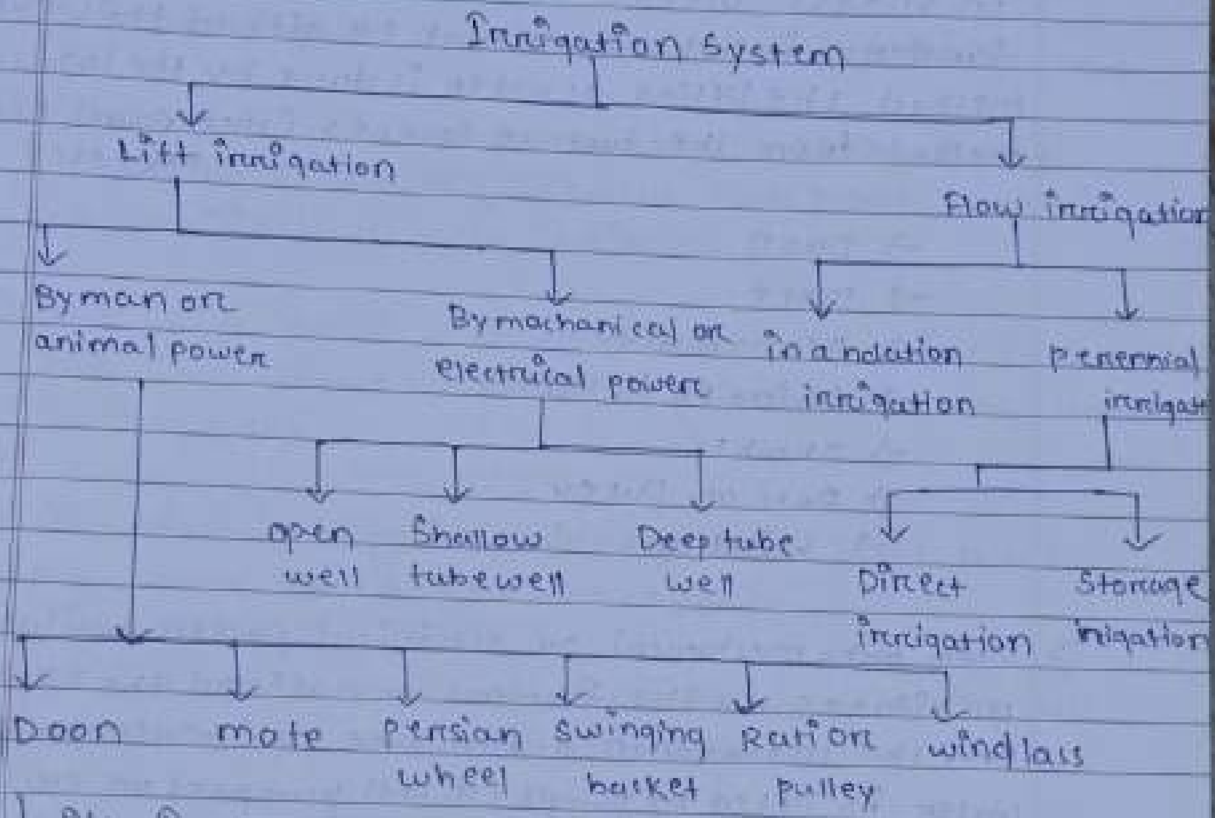
System of Irrigation:-



Lift Irrigation:-

=> when water is lifted from surface sources or underground by man or animal power, mehanical or electrical power and directly supplied to the agricultural land, then it is known as lift irrigation, In this method isolated small areas can be irrigated

The vas areas cannot be included in this system, Lift irrigation can be divided into 2 groups.

=> Lifting of water by man or animal power

=> lifting of water by mehanical or electrical power

⇒ When mechanical or electrical powers are not available in villages or the economic condition of the farmers is not good enough to afford this expensive method, the lifting of water is done by the following method from the surface sources (like pound, river lake etc)

→ Doon
→ Mote
→ persian wheel
→ Swinging bucket
→ Dhenkli
→ Rati or pulley
→ wind lass

⇒ When ~~meba~~ mechanical or electrical power available in villages or the farmers can afford the expenditure for the installation of the same. the underground water is lifted by pumps (diesel pumpset or electrical pump set) and directly supplied to the agricultural land. The underground water may be available from the following sources.

→ open well
→ shallow tube well
→ Deep tube well

Now a day, the pumping system of lift irrigation from shallow or deep tube well is ~~wiede~~ widely practised.

(Details of lift irrigation system will be studied in chapter 4)

Advantages of lift Irrigation:-

The following are the advantages of lift Irrigation-

-> The farmers can suppy water to their fields according to the requirement. and hence there is no possibility of over irrigation.

-> The water table is lowered when water is lifted from the wells there by reducing chances of water logging in the area.

-> As water is supplied directly to the field, there is no water loss due to conveyance.

-> Initial cost is low as there is no necessity of constructing hydraulic structure.

-> As the loss of water is low, the duty of water is hig

-> The maintanance cost is Low.

-> More ~~too~~ than one crop can be grown in a year on the same land

-> Loss of valuable land is prevented as there is no necessity of constructing the network of canals.

-> The water of the well is cooler in hot season and warmer in cold season this phenomenon is favourable for the crops.

Disadvantages of lift irrigation:-

The following are the disadvantages of lift irrigation

-> In summer the surface water maybe dried up and the water table may go dowen below the suction head. Hence, the lift irrigation from the surface source and from the shallow tube well may fail in summer.

-> If the lifting mechanism (i.e pump) fails due to mechanical or electrical failure, then water can not be supplied until the mechanism is restored.

-> The well water has no silt content. The yield of crop therefore depends on chemical fertilisers, which is costly.

-> The lift irrigation in consideration with the yeild of crop is not cost effective.

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Flow Irrigation:-

When water flows under gravitational pull through the artificial canal towards the agricultural land It is termed as flow irrigation. In this system the head of the canal should always be at higher elevation the land to be irrigated. The following are the different systems of flow irrigation)

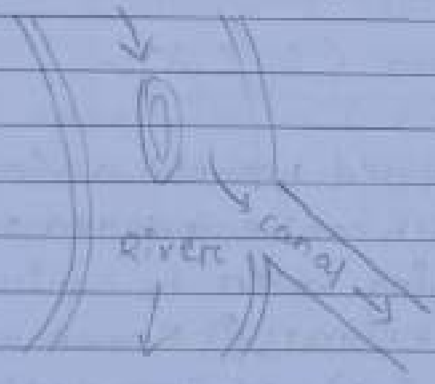
Inundation Irrigation System:-

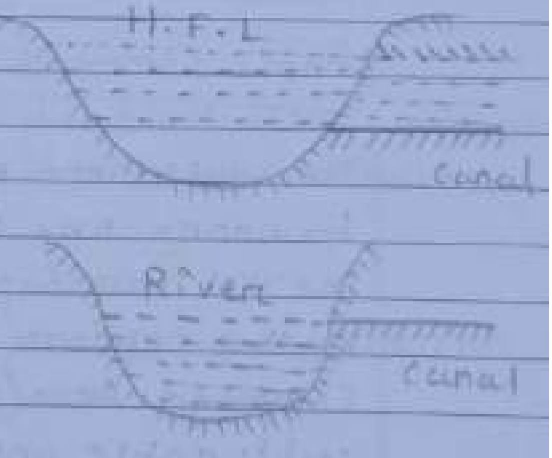
=> ~~In this case water case~~ In this system, a canal is excavated from the bank of the indation river (i.e. the river which overflows in rainy season but nearly dried up in summer and water).

=> In this case water flows to the agricultural land in rainy season only. There is no regulator at the head of the canal to control the flow of water.

=> the bed level of the canal is fixed at such level that the water can flow through the canal only when the water level of the river rises above the canal bed.

=> So, this system of irrigation depends completly on the water level of the river As there is no Regulator at the head of the canal, over irrigation is possible resulting in damaging the crops.





Perennial System Of Irrigation:-

=> In this System, a weir or barrage is constructed across the perennial river (i.e the river which flows thorough out the year in its full capacity) to rise the water level on the up stream side or a dam is constructed to form a storage reservoir.

=> Then the main canal is constructed on either or both the banks of the river. Regulator is constructed at the head of the canal to control the flow of water through the canal towards the agricultural land.

=> This system is reliable as water is available through out the year the perennial system of irrigation may be of the following types

Defination Of Important Terms:-

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). It includeds both the culturable and unculturable areas.

Unculturable Area:-

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

Culturable Area:-

There are where the agriculture can be done satisfacorily is known as culturable area.

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.

Culturable Cultivated Area:-

~~It is the area within C.C.A where the cultiv cultivation is possible but it is not being cultivated at present due to some reason.~~

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

Culturable Uncultivated Area:-

It is the area with in the C.C.A where cultivation is possible but it is not being cultivated at present due to some reasons.

(I) Direct Irrigation System:-

=> In this system, a weir generally constructed across a perennial river to rise the water level on the up stream side up to a certain limit so that the water can flow through the canal.

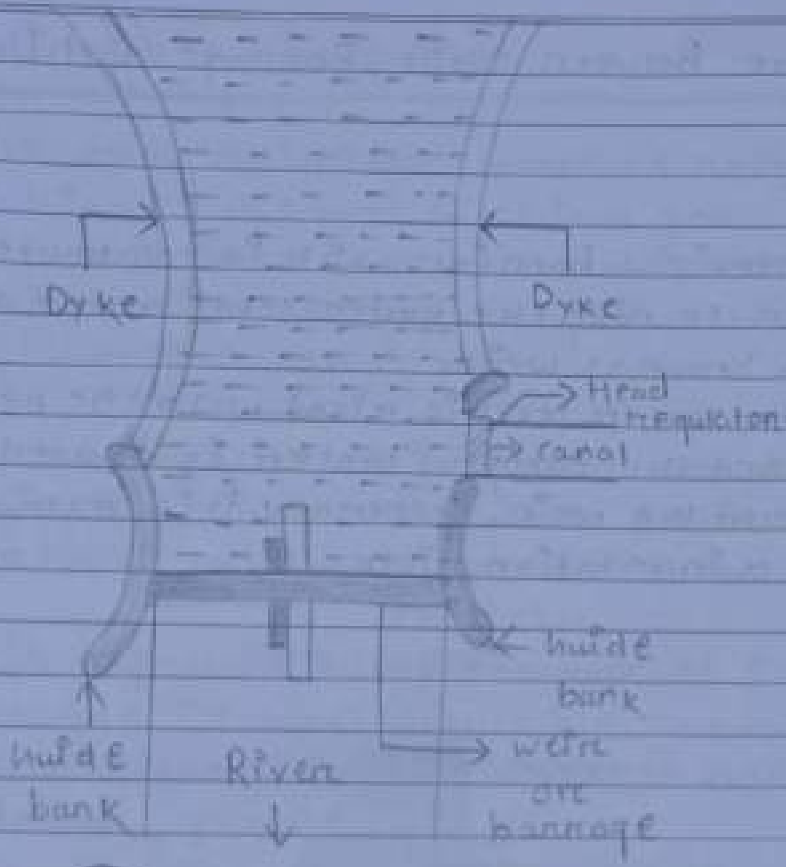
=> Here, the water level on the upstream side will remain at a constant height and the excess water flows over the weir. sometimes, a barrage is constructed, in place of ~~water~~ weir, to regulate the water level on the upstream side.

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

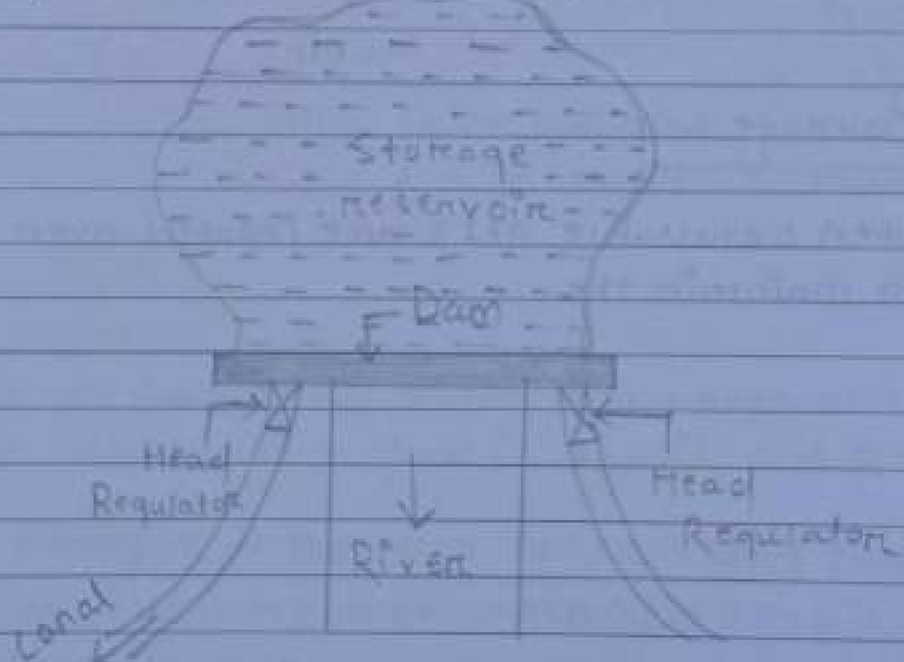
Storage Irrigation System:-

In this system a dam is constructed across a river valley to form a storage reservoir the main canal may be taken from both sides of the dam. the flow of water through the canal is controlled by head regulator. This storage reservoir is also known as multipurpose reservoir as it serves the following purposes.

- -> Irrigation
- -> water supply
- -> Hydro-electric generation
- -> Fishery
- -> flood control.



Diversion head works



Storage Reservoir

Diffrence Between Weir, Barrage and Dam:-

Weir :-

An impervious barriere which is constructed across a rivere to rise the water level on the upstream side is known as weir.
Here the water level is rised upto the required height and the sureplus water is allowed to flow over the weir. Generally it is constructed across a inundation river.

Weir

Barrage :-

When adjustable gets are installed over a weir to maintain the

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Intensity of Irrigation:-

=> The total culturable command area may not be cultivated the same time in a year due to various reasons. Some area may remain vacant year. Again various crops may be cultivated in the culturable command area.

=> So the intensity of irrigation may defined as a ratio of cultivated land for a particular crop to the total culturable command area.

=> It is expressed as a percentage of C.C.A For example. If total culturable command area is 1000 hectares where wheat is cultivated in 250 hectares, then,

$$\text{Intensity of irrigation for wheat} = \frac{250}{1000} \times 100 = 25\%$$

So, area to be irrigated

= C.C.A × Intensity of Irrigation

Crop Ratio :-

It is defined as the ratio of the area of the two main crop seasons that is Kharif and Rabi

For example, if the area under Kharif crop is 2500 hectares and the area under Rabi crop is 5000 hectares then, crop ratio of Kharif to Rabi is 1:2

$$\left(\text{i.e. } C.R = \frac{2500}{5000} = 1:2\right)$$

the crop ratio should be so selected that the discharge of the canal for supplying water to kharif and Rabi may be nearly equal.

Crop Season :-

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

The following are the main crop seasons:-

Kharif Season:-

=> The season ranges from June to october. The crops are shown in the very beginning of monsoon and harvested at the end of autumn.

=> The major kharif crops are - Rice, millet, maize Jute, Ground nut etc

Rabi Season:-

This season ranges from October to March. The crops are shown in very beginning of ~~monsoon~~ spring and harvested at the end of ~~autumn~~ winter

The major Rabi crops are :- Wheat, Gram, Mustard Repeseed, Linseed, pulses Onion etc.

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

As for example, cotton requires eight months to mature and sugarcane requires about whole year to mature. Hence they are designated as follows,

→ cotton – eight month's crop.

→ sugarcane – perennial crop.

Cash crop :-

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

Crop Period :-

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

Time Factor :-

The ratio of the number of days 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 $\frac{10}{15}$

So,

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

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

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Base, Delta, and Duty:

Base:-

The base is defined as the period from the first to the last watering of the crop just before its maturity. It is also known as base period. It is denoted by 'B' and expressed in number of days.

Crop	Base in days
Rice	120
wheat	120
maize	100
cotton	200
Sugarcane	320

Delta:-

Each crop require certain amount of water per hectare for its maturity. It as depth of total water supplied to the crop (From first to last watering) is stored on the land without any loss, then there will be a thick layer of water standing on that land. this depth of water layer is known as Delta for the crop. It is denoted by 'Δ' and expressed term of depth.

Kharif crop	Delta in cm
Rice	125
maize	45
Ground nut	30
millet	30
Rabi crop	**Delta in cm**
Wheat	40
mustard	45
Gram	30
potato	75

Duty:-

The duty of water it defined as number of hectares that can be irrigated by constant supply of water at the rate of one cumec throughout the base period. It's expressed in hectares/cumec. and is denoted by 'D'. The duty of water is not constant. but it varie with various factors like soil condition, method of ploughing method of application of water etc.

Crop	Duty in hectre/cumec
Rice	900
Wheat	1800
Cotton	1400
Sugarcane	800

Implementation of Tax:-

the water tax should be imposed on the basis of volume of water consumption.

Relation Between Base, Delta and Duty:-

Let,

D = Duty of water in hectares/cumec

B = Base in days

Δ = Delta in m

From defination, 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 days gives Δ over $\frac{D}{B}$ hectares

or 1 cumec for 1 day = $\frac{D}{B} \times \Delta$ hectare-metre

So, 1 cumec-day = $\frac{D}{B} \times \Delta$ hectare-metre

Again, 1 cumec day = $\frac{D}{B} \times \Delta$ hectare-metre

Again, 1 cumec-day = 1 × 24 × 60 × 60 = 86400 m³
= 8.64 hectare-metre
(1 hectare = 10,000 m²)

From (1) and (2)

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

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

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Problem-1

A channel is to be designed for irrigating 5000 hectares in Kharif crop and 4000 hectares in Rabi crop. The water requirement for Kharif and Rabi are 60cm and 25cm, respectively. The kor period for kharif is 3 weeks and for Rabi is 4 weeks, Determine the discharge of the channel for which it is to be designed.

Using the relation

$$\Delta = \frac{864 \times B}{D}$$

Discharge for kharif crop

Here,

Δ = 60cm = 0.60 m

B = 3 weeks = 21 Days

$$\text{Duty} = \frac{8.64 \times 21}{0.60} = 302.4 \text{ hectares/cumec}$$

Area to be irrigated = 5000 hectares

Required discharge of channel = $\frac{5000}{302.4}$ = 16.53 cumec

Discharge for Rabi crop

Here,

Δ = 25 cm = 0.25 m

B = 4 weeks = 28 Days

$$\text{Duty} = \frac{8.64 \times 28}{0.25} = 967.68 \text{ hectares/cumec}$$

So, the channel is to be designed for the maximum discharge of 16.53 cumec, because this discharge capacity of the channel will be able to supply water to both the seasons.

Problem - 2

The gross command area of an irrigation project is 1.5 lakh hectares where 7,500 hectare are unculturable. The area of Kharif crop is 60,000 hectares and that of Rabi crop is 40,000 hectares. The Duty of Kharif is 3000 hectare/cumec and the Duty of Rabi is 4000 hectare/cumec.

Find (a) The design discharge of channel assuming 10% transmission loss.

(b) intensity of irrigation for kharif and Rabi

Calculate command area = 1,50,000 − 7500 = 142500 hectare

Discharge for kharif crop.

Area of kharif crop = 60,000 hectars

Duty of kharif crop = 3000 hectare/cumec

Required discharge of channel = $\frac{60,000}{3000}$ = 20 cum

Considering 10% loss

Design discharge = $20 \times \frac{110}{100}$ = 22 cumec.

Discharge for Rabi crop,

Area of Rabi crop = 40,000 hectars

Duty of Rabi crop = 4000 hectare/cumec

Required discharge of channel = $\frac{40000}{4000}$ = 10 cumec

Considering 10% loss

Design discharge = $10 \times \frac{110}{100}$ = 11 cumec

=> So, the design discharge of the channel should be 22 cumec, as it is maximum

=> intensity of irrigation for kharif = $\frac{60,000}{142500} \times 100$ = 42.11%

intensity of irrigation for Rabi = $\frac{40,000}{142500} \times 100$ = 28.07%

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Problem-3 The gross command area of an irrigation project is 1 lakh hectares. The culturable command area is 75% of G.C.A. The intensities of irrigation for Kharif and Rabi are 50% and 55% respectively. If the duties for Kharif and Rabi are 1200 hectares / cumec and 1400 hectares /cumec respectively. determine the discharge at the head of the canal considering 20% provisions for transmission loss overlap allowance, evaporation loss etc.

Culturable command area $= 100000 \times \frac{75}{100} = 75,000$ hectare

for Kharif crop,

area under Kharif $= 75,000 \times \frac{50}{100} = 37500$ hectares

Duty for kharif = 1200 hectares / cumec

Required discharge for kharif $= \frac{37500}{1200} = 31.25$ cumec

For Rabi crop,

Area under Rabi $= 75,000 \times \frac{55}{100} = 41250$ hectare

Duty for Rabi = 1400 hectares/ cumec

Required discharge for Rabi $= \frac{41250}{1400} = 29.46$ cumec

So, to meet up the actual water requirement of the crops, the discharge of the canal at the head of the field should be 31.25 cumec (as it is max^m) now considering 20% provision for losses.

Required discharge at the head of canal $= 31.25 \times \frac{120}{100}$

$= 37.5$ cumec.

Problem-4 Determine the head discharge of a canal from the following data. the value of time factor may be assumed as 0.75.

Crop	Base period in days	Area in hectare	Duty in hectare/cumec
Rice	120	4000	1500
Wheat	120	3500	2000
Sugarcane	310	3000	1200

Soln

Discharge of canal required

=> For rice = $\frac{4000}{1500}$ = 2.667 cumec (Kharif)

=> For wheat = $\frac{3500}{2000}$ = 1.750 cumec (Rabi)

=> For sugarcane = $\frac{3000}{1200}$ = 2.500 cumec (perennial)

As, the base period of sugarcane is 310 days, it will require water both in Kharif and Rabi seasons

Now, actual discharge required in Kharif season
= 2.667 + 2.500 = 5.167 cumec

Actual discharge required in Rabi season = 1.750 + 2.500
= 4.250 cumec

So, the max^{m} discharge in Kharif season (i.e 5.167 cumec) should be taken into consideration as it will be able to serve both the seasons.

Time factor = 0.75 = $\frac{\text{Actual discharge}}{\text{Design discharge}}$

$= \frac{5.167}{\text{Design discharge}}$

Design discharge = $\frac{5.167}{0.75}$ = 6.889 cumec

Therefore, the required head discharge of the canal is 6.889 cumec.

Problem-5 Findout the capacity of a reservoir from the following data. The culturable command are is 80,000 hectare

Crop	Base in days	Duty in hect/cumec	intensity of irrigation in Percentage
Rice	120	1800	25
Wheat	120	2000	30
Sugarcane	320	2500	20

Assume the canal and reservoir losses as 5% and 10% respectively.

using relation

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

Calculation of delta for each crop

delta for rice = $\frac{8.64 \times 120}{1800}$ = 0.576m

delta for weat = $\frac{8.64 \times 120}{2000}$ = 0.518m delta for sugar cane = $\frac{8.64 \times 320}{2500}$ = 1.106 m

calculation of area for each crop

Area for rice = $\frac{80,000 \times 25}{100}$

= 20,000 hectare

Area for wheat = $\frac{80000 \times 30}{100}$ = 24000 hect

Area for sugar cane = $\frac{80,000 \times 20}{100}$ = 16,000 hect

Volume of water required for each crop

we know, volume = area × delta

Volume for rice = 20,000 × 0.576

= 11520.00 ha-m

Volume for wheat = 24,000 × 0.518

= 124321.00 ha-m

Volume for sugarcan = 16,000 × 1.106

= 17696.00 ha-m

total volm of water = 41648.00 ha-m

considering canal loss of 5%.

water required at the head of canal = 41648 × $\frac{105}{100}$

= 43730.40 ha-m

Again considering, reservoir loss of 10%.

capacity of reservoir $= 43730.40 \times \frac{110}{100}$

$= 48103.44$ ha-m

Problem-6 The command area of a channal is 4000 hectares the intensity of irrigation of a crop is 70%. the crop require 60cm of water in 15days, when the effective rainfal is recorded as 15cm during that period

Find => the duty at the head of ~~channal~~ Field
=> the duty at the head of channal
=> the head discharge at the head of channal

Assume total losses as 15%

Depth of water required = 60mm
Effective rainfall = 15cm

Depth of irrigation water = 60 − 15 = 45cm
∴ Delta = 45cm = 0.45m, B = 15days

from relation, $\Delta = \frac{8.64 \times B}{D}$

Duty $D = \frac{8.64 \times 15}{0.45} = 288$ hectares/cumec

=> So, duty at the head of Field = 288 ha/cumec. Due to the losses of water the duty at the head of the channel will be reduced.

Here, losses are 15%.

⇒ So, the duty at the head of channel = $\frac{288 \times 85}{100}$

= 244.80 hect/cumec

(Duty will be reduced due to loss)

Total area under crop = $4000 \times \frac{70}{100}$ = 2800 hectares

⇒ The discharge at the head of channel = $\frac{2800}{244.8}$ = 11.438 cumec

Hydrology

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Defination :-

The science of studying the diffrent froms of water available above the earth surface below the earth surface is known as hydrology.

Some terms related to hydrology :-

Catchment Area :-

The cathment area of a river means the area from where the surface run off flows to that river through the tributateries, 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 intecepted by vegetation, some evaporates and 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 known as surface run-off or run-off. The surface runoff is also designated by rainfall excess or effective rainfall.

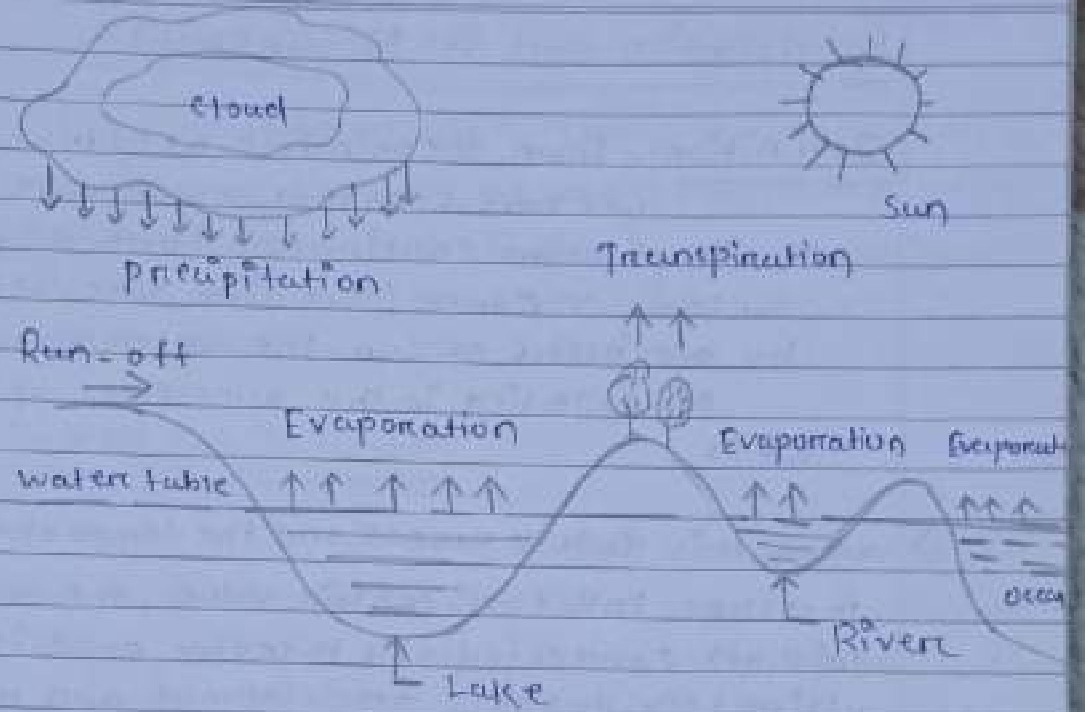
Hydrological cycle:-

=> The water of the universe always change from one state to other under the effect of the sun. The water from the surface source like lakes, rivers, ocean etc converts to vapour by evaporation due to solar heat.

=> The vapour goes on accumulating continuously in the atmosphere. This vapour is again condensed due to the sudden fall of temp and pressure.

=> Thus clouds are formed. These clouds again causes the precipitation (i.e rainfall) Some of the vapour is converted to ice at the peak of the mountains. The ice again melts is summer and flows as rivers to meet the sea or ocean.

=> These processes of evaporation, precipitation and melting of ice go on continuosly like an endless chain and thus a balance is maintained in the atmosphere. This phenomenon is known as hydrologic cycle.



HYDROLOGICAL CYCLE

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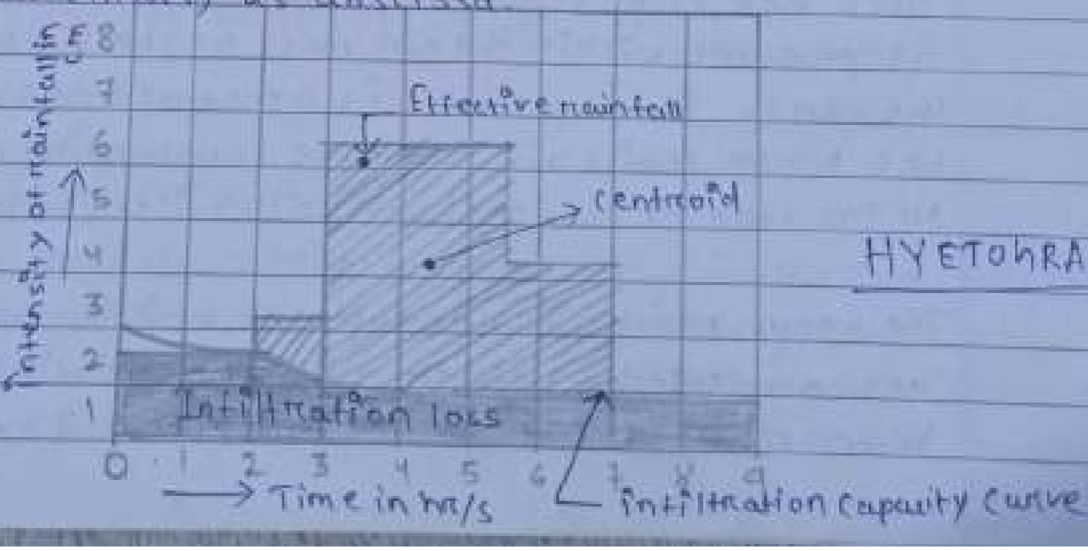
Hyetograph :-

The graphical representation of rainfall and run-off is known as hyetograph the graph is prepared with intensity of rain fall (in cm/hr) as ordinate and time (in hrs) as abscissa.



HYETOGRAPH

Precipitation and Its Measurement :-

Definition :- From the principle of hydrologic cyle we have seen that water goes on evaporation continuosly from the water surfaces on earth (e.g river, lake, sea, oceanes) by the effect of sun. The water vapour goes on collecting in the atmosphere up to a certain limit.

=> when this limit exceeds and the temprature and pressure fall to a certain value, the water vapour will get condensed and thereby cloud is formed ultimately droplets are formed and returned to earth in the form of rain, snowfall, hail etc this is known as precipitation.

Types of precipitation of Rainfall :-

Depending upon the various atmospheric condition the precipitation may be of the following types.

(I) Cyclonic precipitation :-

This type of precipitain is caused by the diffrence 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 zone of low pressure with voilent force.

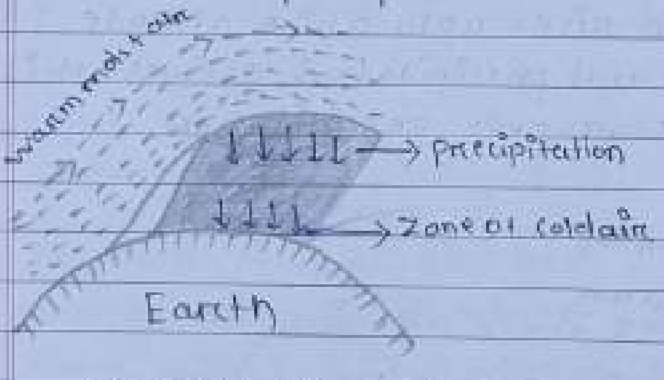
The warm moist air rises up with whirling motion and get condensed at higher altitude and ultimately heavy rain fall occurs. This maybe of 2 types.

i) Frontal Precipitation:-

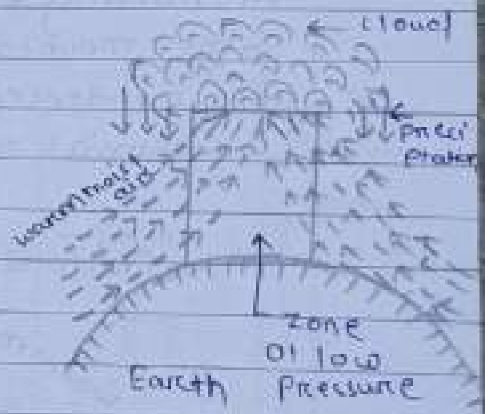
when the moving warm moist air mass is obstructed by the zone of cold air mass, the warm moist air rises up (as it is lighter than cold air mass) to higher altitude where it gets condensed and heavy rainfall occures. This is known as Frontal precipitation.

ii) Non frontal precipitation:-

When the warm moist air mass rushes 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 raintall occurs. this is known as non frontal precipitation.



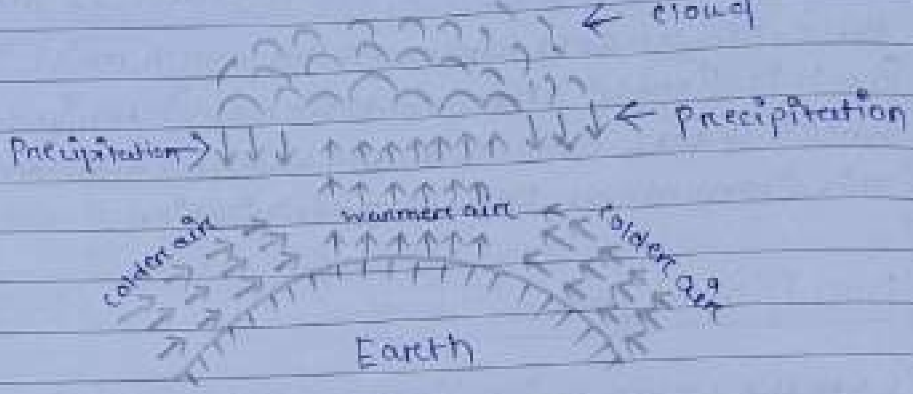
FRONTAL PRECIPITATION



NON-FRONTAL PRECIPITATION

(2) Convective precipitation:-

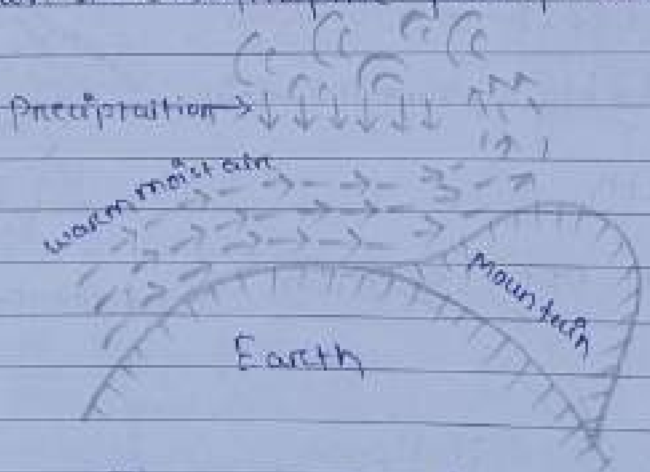
In tropical contries when on a particular hot day the ground surface gets heated unequally, the warm air is lifted to high altitude and the cooler air takes its place with high velocity. Thus the warm moist air mass is condensed at the high altitude causing heavy rainfall. This known as convective precipitation.



CONVECTIVE PRECIPITATION

Orographic Precipitation:-

The moveing warm moist air, when obstructed by some mountain rises upto a high altitude. It then gets condensed and precipitation occurs. This is known as orographic precipitation.



Orographic Precipitation

Measurement of Rainfall (i.e Precipitation) :-

The instrument which is used to measure the amount of rainfall is known as raingauge. The principle of raingauge is that the amount of rainfall in a large area provided the meteorological characteristics of both small and large area are similar. the raingauges are of the following types.

(1) Non-Recording type Raingauge :-

Simon's raingauge is non-recording type of raingauge which is most commonly used. It consists of metal casing of diameter 127 mm which is set on a concrete foundation. A glass bottle of capacity about 100 mm of rainfall is placed within the casing. A funnel with brass rim is placed on the top of the bottle.

(SIMON's Raingauge)

→ The rainfall is recorded at every 24 hours. Generally the measurement is taken at 8.30am everyday.

→ In case of heavy rainfall the measurement should be taken 2 or 3 times daily so that the bottle does not over flows. 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.

② Recording Type Raingauge :-

In this type of rain gauge 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. The recording type rain gauge may be of three types.

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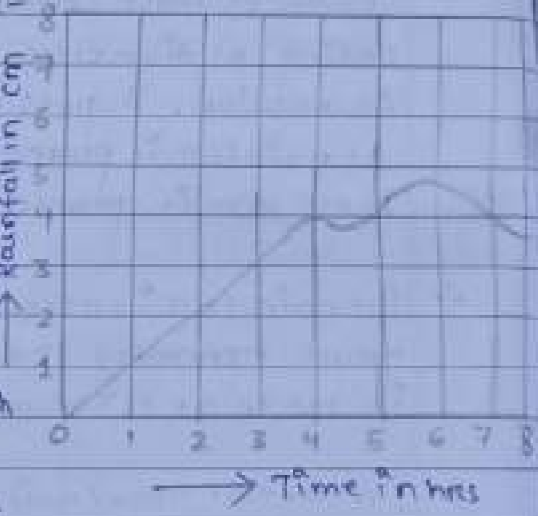
(1) Weighing Bucket Raingauge :-

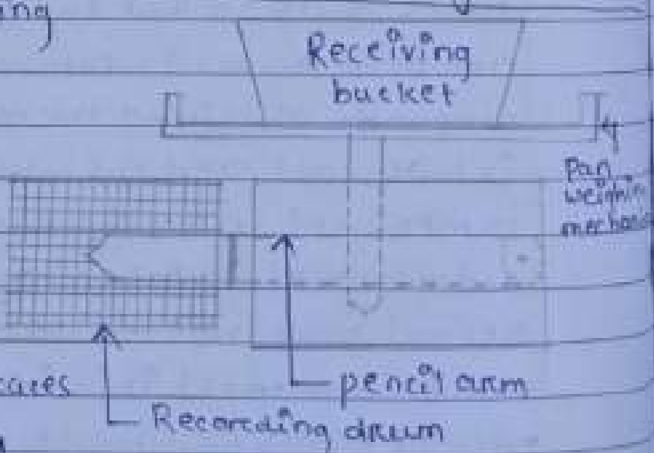
⇒ This type of raingauge consists of a receiving bucket which is placed on pan. The pan is again fitted with some weighing mechanism.



Rain recording graph

⇒ 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.



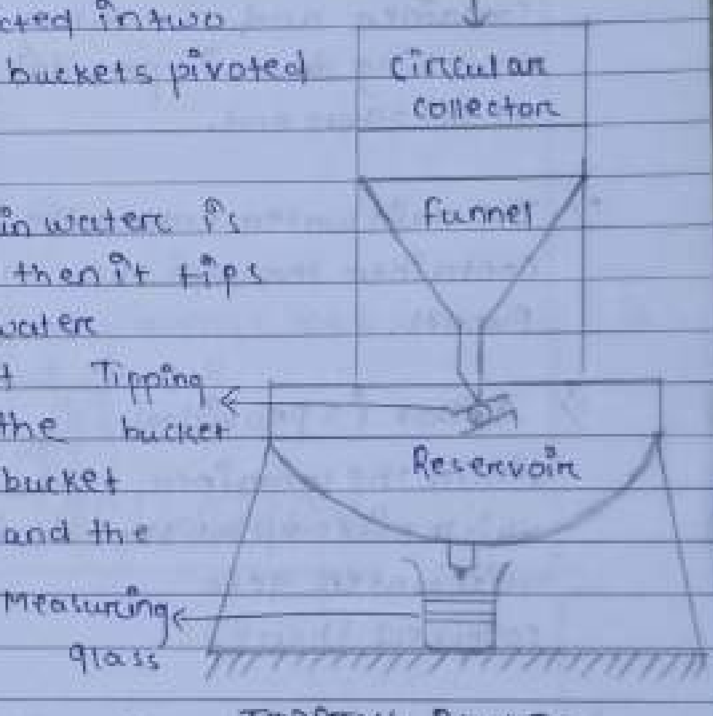
WEIGHING BUCKET RAIN GAUGE

⇒ The raingauge produces a graph of cumulative rain-fall versus time and hence it is some times called integrating raingauge. the graph is known as the mass curve of rainfall.

(ii) Tipping Bucket Raingauge:-

⇒ 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 funne.

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



TIPPING BUCKET RAINGAUGE

⇒ When the requisite amount of rain water is collected it also tips and discharges the water in the reservoir.

⇒ In this way a circular motion is generated by the bukets This circular motion is transmitted to a pen or pencil which traces a wave like curve on the sheet mouted on a revolving drum. The total rainfall may be ascertained from the graph

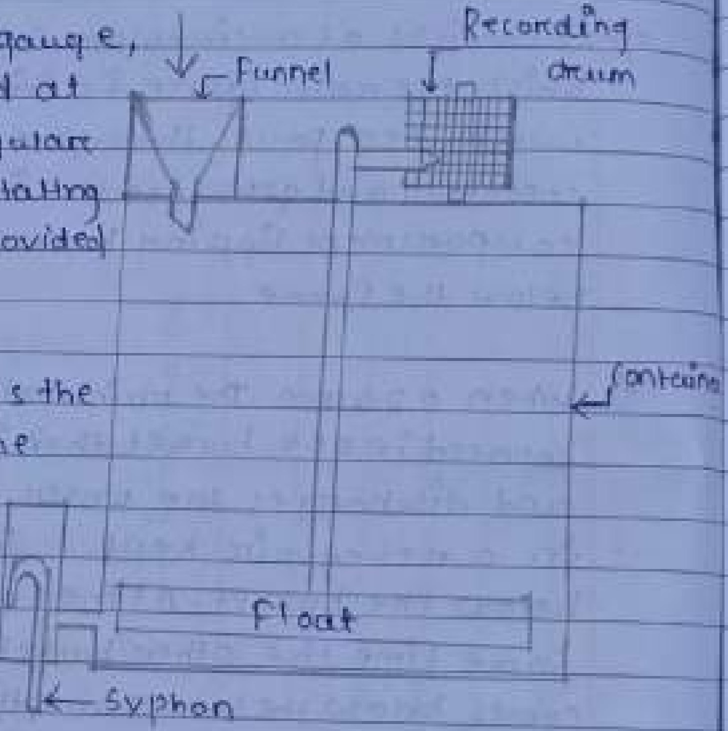
⇒ There is an opening with stopcock at the bottom of the reservoir for discharging the collected rainwater. Sometimes a measuring glass is provided to verify the results shown by the graph.

(iii) Float Type Raingauge :-

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

⇒ The rain water enters the container through the funnel.

⇒ A float is provided within the container which rises up as the rain water gets collected there.



FLOAT TYPE RAINGAUGE

⇒ 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 ~~float rises~~ container goes on emptying gradually.

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Empirical Formula

(a) involving Drainage Area Only

I) Dicken's formula :-

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

where, Q = Discharges in cumec,
A = catchman area in sq. km
C = A constant
depending upon the factors affecting the flood discharge. An average value of C is considered as 11.5

II) Ryve's Formula :-

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

where, Q = Discharge in cumec
A = catchment area in sq. km
C = A constant the averge ~~ofe~~ value of C in is consideredared as 6.8

FLOW IRRIGATION

31/5/21

Introduction :-

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

Type Of Canals :-

(1) => Based on purpose :- Based on the purpose of service the canals are designated as a) irrigation canal

b) Navigation canal
c) power canal
d) Feeder canal

Irrigation canal :-

The canal which is constructed to carry water from the Source to the agricultural land for the purpose of irrigation is known as irrigation canal such as Bhakra canal, Rajastan canal etc.

Navigation canal :-

The canal which is constructed for the purpose of inland navigation is known as navigation canal, this type of canal is also utilised for irrigation such as Ganga Brahmaputra navigation cum irrigation canal.

Power canal :-

tha canal which is constructed to feed another canal or to supply water with very high force to the hydroelectric power station for the purpose of moving turbine to generate electric power is known as power canal or hydel canal such as Nangal hydel canal.

Feeder canal :-

The canal which is constructed to feed another canal or river for the purpose of irrigation or navigation ~~or~~ is known as Feeder canal such as Farakka barrage Feeder canal.

(2) Based on Natural of Supply:-

Based on the natural of supply, the canals are designated as a) inundation canal
b) perennial canal

Inundation Canal:-

=> The canal which is excavated from the banks of the inundation river to carry water to the agricultural land in rainy season only when the river flows to its full capacity is known as inundation canal.

=> No regulator is provided at the head of such canal the flow of water through the canal depends on the fluctuation of water level in the river. When the water level rises above the bed level of the canal the water starts flowing through the canal. When the water level falls below the bed level of the canal, the flow of water through the canal stops.

Perennial Canal:-

The canal which can supply water to the agricultural land throughout the year is known as perennial canal. This type of canal is taken from the up stream side of the diversion head works (weir or barrage) or from the storage reservoir with regulator at the head of the canal.

(3) Based on Discharge:-

According to the discharge capacity, the canals are designated as a) main canal
b) Branch canal
c) Distributory canal
d) Field channel

Main canal:-

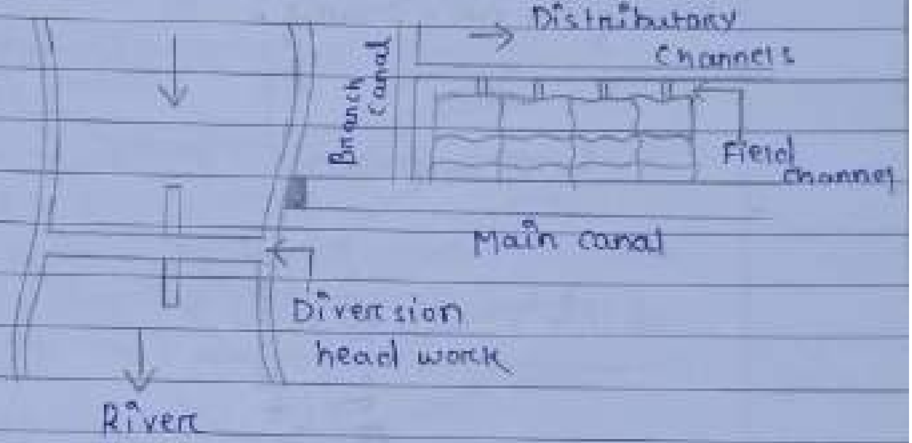
The large canal which is taken directly from the diversion head work or from storage reservoir to supply water to the network of other small canals is known as main canal. The irrigation water is not directly supplied to the field from the main canal. The water is taken to the field through the branch canal, distibutory channel and field channel. So the main canal is the backbone of the canal system.

Branch Canals:-

The branch canals are taken from either side of the main canal at suitable points so that the whole command area can be covered by the network. The discharge capacity of the branch canal is smaller than that of the main canal. The discharge varies from 5 to 10 cumec

Distributory channels:-

The distributory channels are taken from the branch canals to supply water to different sectors. The discharge capacity of these channels varies from 0.25 to 3 cumec. Again, these are designated as major distributory and minor distributory according to their function in the total network.



CANAL SYSTEM

Field channels:-

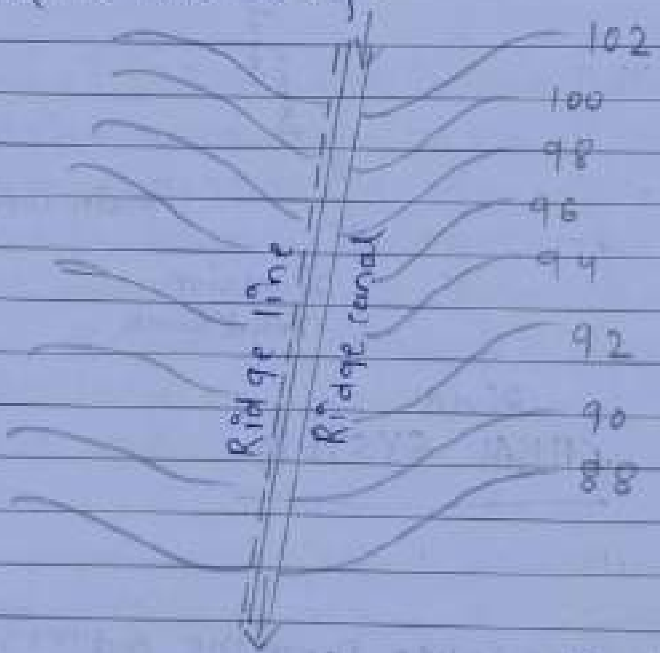
The channels are taken from the outlets of distributory channels by the cultivators to supply water to their own lands. These channels are maintained by the cultivators.

(4) Based on Alignment:-

Depending upon the alignment, the chanals are designated as a) Ridge or watershed canal
b) contour canal
c) side slope canal.

Ridge or watershed canal :-

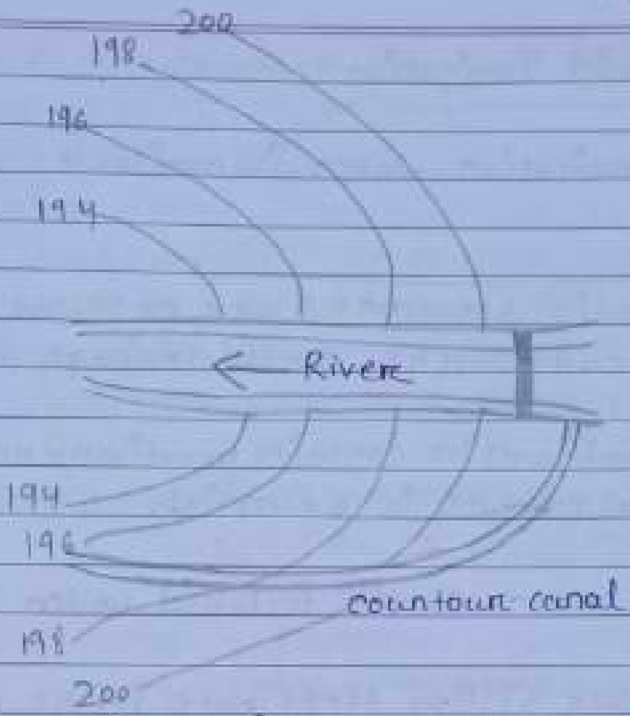
The canal which is aligned along the ridge line (water shed line) is known as ridge canal or water shed canal. the advantage of this type of canal is that it can irrigate the areas on both sides. Again there is no possibility of crossing any natural drainge and hence no cross-drainage work is necessary.



RIDGE CANAL

Contour Canal :-

The canal which is aligned approximately parallel to the countour line is known as countour canal. The canal can irrigate the areas on one side only. This canal may cross natural drainage and hence cross-drainage works are necessary.



COUNTOUR CANAL

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Side slope canal:-

The canal which is aligned approximately at right angle to the contour lines is known as side slope canal. It can irrigate the areas on one side only. Again, it does not cross any natural drainage and hence the cross drainage works are not neccessary.

SIDE SLOPE CANAL

Perennial Irrigation :-

⇒ The irrigation water is available through out the year.

⇒ Hydraulic structures are necessary (such as diversion headhead works cross-drainage works. etc)

⇒ The canal water contain practically no silt and hence chemical manure is essential.

⇒ Large area can be included under this system.

⇒ Negligible silting takes place in the canal bed.

⇒ Water tax can be imposed.

⇒ Initial cost is high.

⇒ Technical persons are always required for the operation of the irrigation system.

⇒ The main canal is provided with head regulator and hence there is no possibility of over irrigation.

Terms Relating to Canal Section :-

The canal section may be in fully cutting or fully banking or partial cutting and partial banking according to the natural ground surface and the permissible bed slope of the canal. But there are several terms in the canal section with which

a civil engineer should be acquinted to design the section and to execute the work.
the following are the diffrent terms related to the canal section.

- ⇒ canal bank
- ⇒ Berm
- ⇒ Hydraulic berm
- ⇒ counter berm
- ⇒ free board
- ⇒ side slope
- ⇒ service road or inspection road
- ⇒ Dowel or Dowla
- ⇒ Burrow pit
- ⇒ spoil Bank
- ⇒ Land width

F.S.L = Full supply level
D = Full supply depth

CANAL SECTION

Canal Bank:-

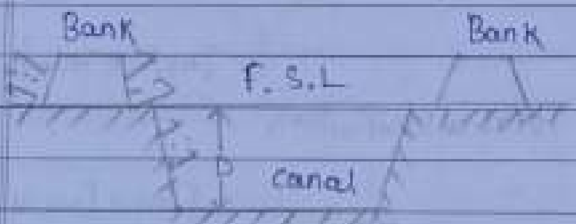
The canal bank is necessary to retain water in the canal to the full supply level But the section of the canal bank is diffrent for diffrent site conditions. The following are the diffrent forms for diffrent condition.

When the canal fully in cutting:-

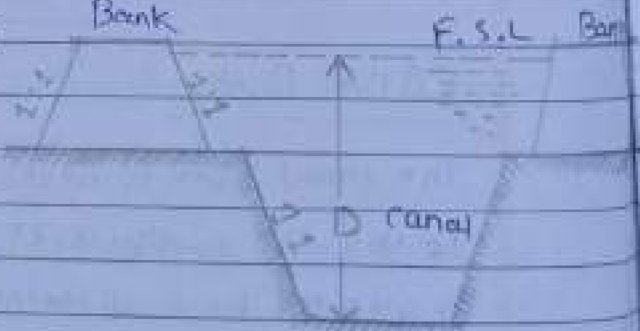
In this case, the banks are constructed on both sides of the canal to provide only a inspection road. Here the hydraulic gradient has no function, so, the height of the bank will be low and the top width will be minimum but to provide the road way. The side slope will be 1 ½ : 1 or 2 : 1 according to the nature of the soil.

When the canal in partial cutting and Banking:-

In this case, the banks are constructed on sides of the canal to retain water. The height of the banks depend on the Fully supply level of the canal. Again, the section of the canal depends on the hydraulic gradiant. The top width and the side slope of the bank should be such that the hydraulic gradiant should have a minimum cover of 0.5m.



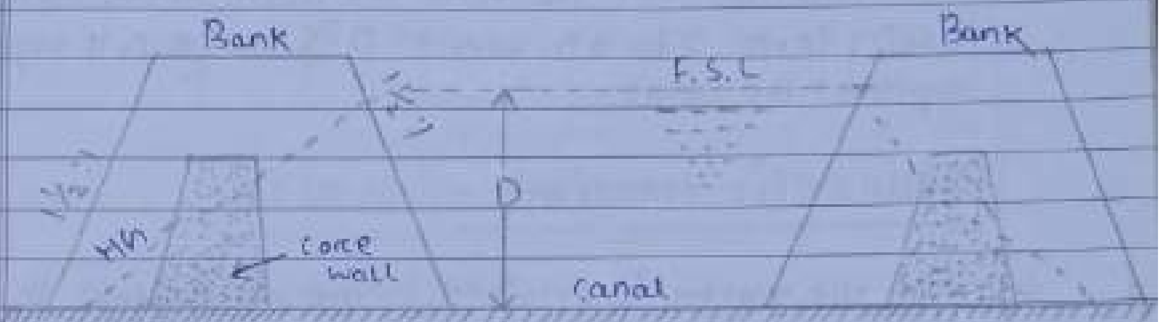
CANAL IN FULL CUTTING



CANAL IN PARTIAL CUTTING AND PARTIAL BANKING

When the canal in Full Banking :-

In this case, the canal and both 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 the hydraulic gradient. But to minimise the cross section of the bank a core wall of puddle cly is provided which deflects the hydraulic gradient downwards.



CANAL IN FULL BANKINH

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Berm :-

The distance between the toe of the bank and the top edge of cutting is termed as berm. The berm is provided for the following reasons.

=> To protect the bank from errosion.

=> To provide a space for widening the canal section in future if necessary

=> To protect the bank from sliding down towards the canal section.

⇒ The silt deposition on the berm makes an impervious lining.

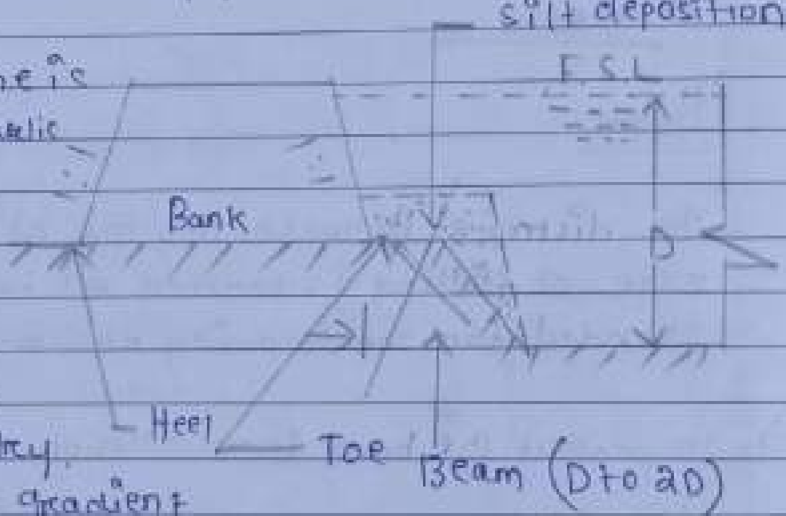
⇒ If necessary borrowpit can be excavated on the berm.

The width of the berm depends on various factors such as capacity of the canal, the nature of the soil, the site condition etc. However the width of the berm varies from D to 2D, where D is the Full supply depth of the canal.

Hydraulic Gradient :-

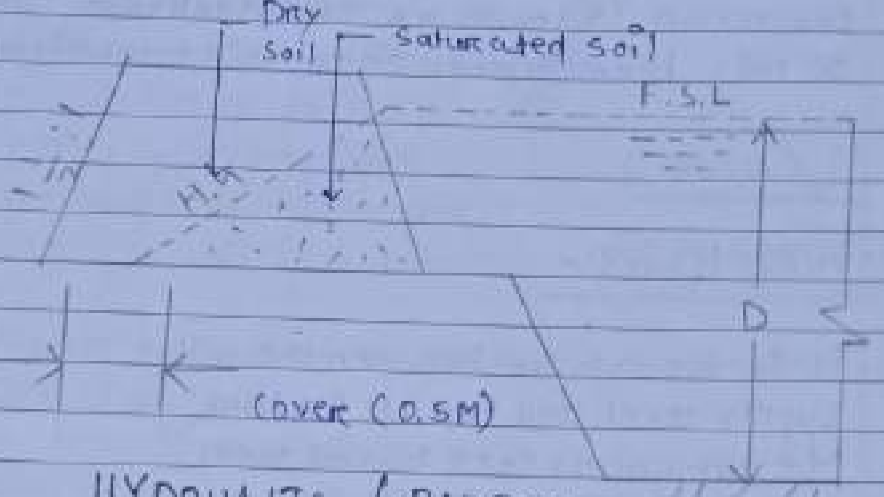
⇒ When the water is retained by the canal bank the seepage occurs through the body of the Bank. Due to the resistance of the soil the saturation line forms a sloping line which may pass through country side of the bank.

This sloping line is known as hydraulic gradient or saturation gradient.



⇒ The soil below this line is dry. The hydraulic gradient depends on the permeability of the soil.

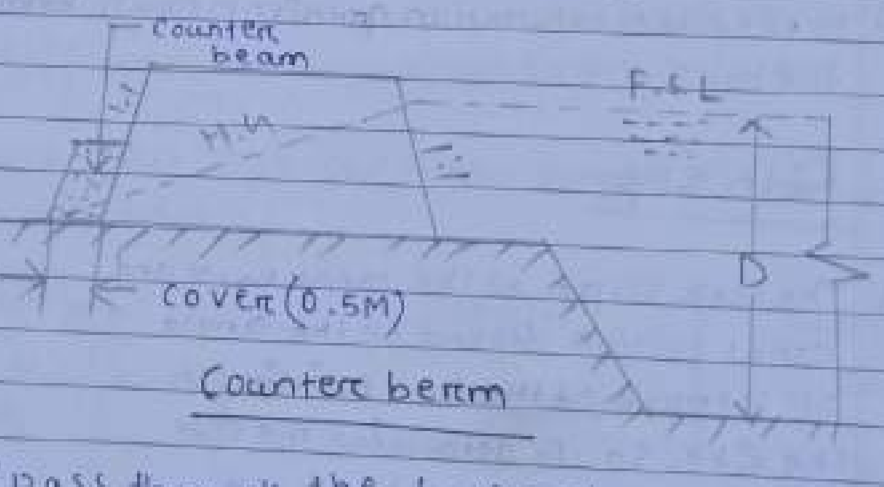
⇒ So, while constructing the bank, the soil should be tested in soil testing laboratory and the nature of the hydraulic gradient should be ascertained.



HYDRUALIC GRADIENT

Counter Berm:-

When the water is retained by a canal bank the hydraulic gradient line passes through the body of the bank. for stability of the bank, this gradient should not intersect the outer side of the bank.



Counter berm

It should pass through the base and a minimum cover of 0.5 m should always be maintained. sometimes it may occur that the hydraulic gradient line intersects the outer side of the bank. in that case, a projection is provided on the bank to obtain minimum cover. This projection is known as counterberm. The width of this berm depends on the site condition.

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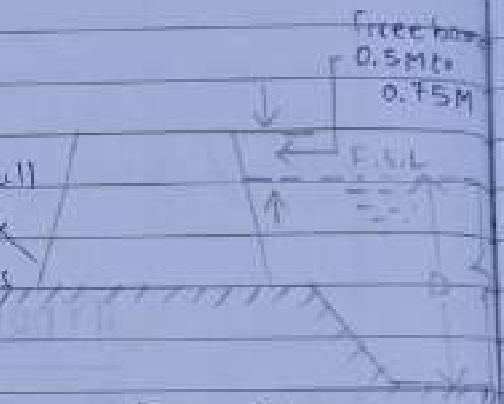
Free Board :-



It is the distance between the full supply level and top of the bank the amount of free board varies from 0.6m to 0.75m

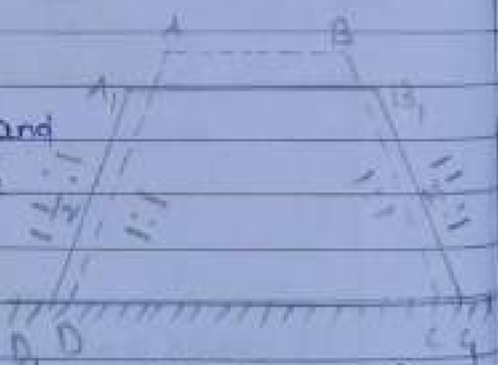
FREE BOARD

It's provided for the following reasons.

=> To keep a sufficient margin so that the canal water does not overtop the bank in case of heavy rainfall or fluctuation in water supply

=> To keep the saturation gradient much below the top of the bank

Side Slope :-



SLIDING OF BANK

=> The side slope of the canal bank and canal section depend on the angle of repose of the soil existing on the site. So, to determine the side slopes of different sections. The soil samples should be collected from the site and should be tested in the soil testing laboratory.

→ The necessity of such test is that if the permissible slope (to maintain angle of repose) is not provided in an embankment or cutting then the soil in that place will go on sliding gradually until the angle of repose for that particular soil is attained.

EXTRA EARTH FILLING

For instance, suppose an embankment was constructed with with side slope 1:1 but

according to the nature of the soil, the side slope should be $1\frac{1}{2}$:1. Then the initial shape ABCD will automatically take the final shape A_1, B_1, C_1, D_1 after slide in the due course

Again, an opposite incident may occur, suppose an embankment was constructed with side 2:1, but later it was found that the side slope of 1:1 was sufficient to maintain the angle of repose for that soil. In this case an unnecessary earthwork was done.

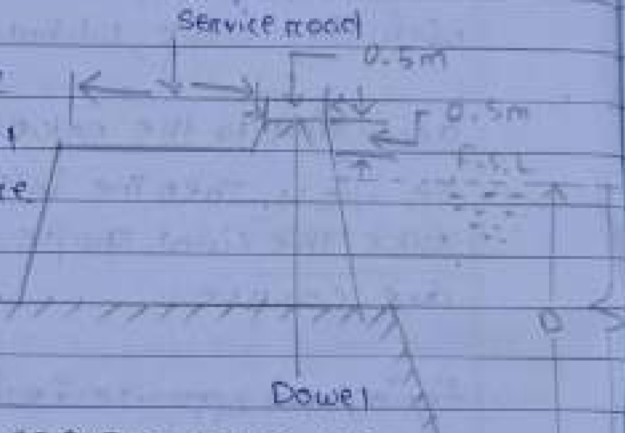
The permissible side slopes for some soil are given in the following table.

Type of soil	Side slope in cutting	Side slope in banking
Clayey soil	1:1	$1\frac{1}{2}$: 1
Alluvial soil	1:1	2:1
Sandy loam	$1\frac{1}{2}$:1	2:1
Sandy soil	2:1	3:1

Service Road:-

The road way which is provided on the top of the canal bank for inspection and maintenance works is known as service road or inspection road. for main canal the service roads are provided on both the banks. But for branch canals, the road is provided on one bank only. The width of the service roads for main canal varies from 4 to 6m. The width of the road for the branch canal varies from 3 to 4m.

The initial purpose of the service road is to conduct inspection and maintenance works. But finally these roads serve the purpose of communication between the different villages and for transporting agricultural goods. There fore it becomes necessary to construct metalled road to serve these purpose



SERVICE ROAD AND DOWEL

Dowel or Dowla :-

The protective small embankment which is provided on the canal side of the service road for the safety of the vehicles plying on it is known as dowel or dowel bank practically it acts as a curb on the canal side of the road. it is provided above the F.S.L with a provision of freeboard. The top width is generally 0.5m and the height above the road level is about 0.5m. The side slope is similar to the side slope of the bank.

Spoil Bank:-

When the canal is constructed in full cutting, the excavated earth may be not be completely required for forming the bank. In such a case, the extra earth is deposited in the form of small banks which are known as spoil banks. The spoil banks are provided on one side or both sides of the canal bank depending on the quantity of excess earth and the available space. The spoil banks run parallel to the main bank. But are not continous sufficient spaces are left between the adjacent spoil banks for proper drainage.

SPOIL BANK

Borrowpit:-

When the canal is constructed in partial cutting and partial banking, the excavated earth may not be sufficient for forming the required bank. in such a case the extra earth required for the construction of banks is taken from some pits. which are know borrowpits The borrowpits may be inside or outside. the canal

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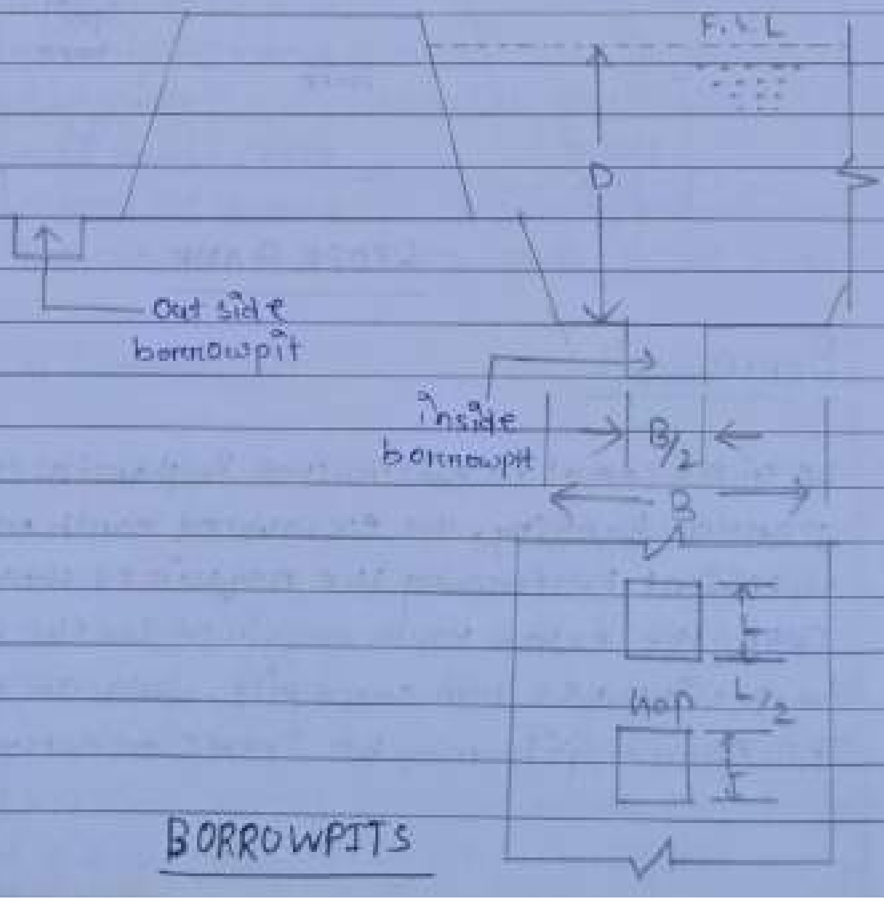
=> The inside borrowpit may be located at the centre of the canal. The width of the borrowpit should be half of the base width of canal. The maximum depth should be 1m. The excavation is done in a number of borrowpits leaving a gap between them.

=> The gap is generally half of the length of each borrowpit. The idea behind this is that the borrowpits will act as water pockets where the silt will be deposited and ultimately the canal bed will get levelled up.

=> The outer borrowpit may be adjacent to the heel of bank with a clearance of 1m between the heel and edge of borrow pit. But the outer borrowpit may create some inconvenience. So, it is better to borrow earth from the barren lands far away from the canal.



BORROWPITS

Land Width:-

The total land width required for the construction of a canal depends on the nature of the site condition, such as fully in cutting or fully in banking or partly in cutting and partly in banking. These condition arise according to the designed bed level of the canal and the natural ground surface. So, total land width differs with the site condition. However, to determine the total land width the following dimensions should be added.

- Top width of the canal
- Twice the berm width
- Twice the bottom width of banks.
- A margin of one metre from the heel of the bank on both sides.
- width of external borrowpit if any.
- A margin of 0.5m from the outer edge of borrowpit on both sides, if external borrowpit becomes necessary.

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Types of Lining:-

The following are the different types of linings which are generally recommended according to the various site conditions.

- cement concrete lining
- pre-cast concrete lining
- cement mortar lining
- Lime concrete lining
- Brick lining

- Boulder lining
- Short crete lining
- Asphalt lining
- Bentonite and clay lining
- Soil-cement lining

Cement concrete lining:-

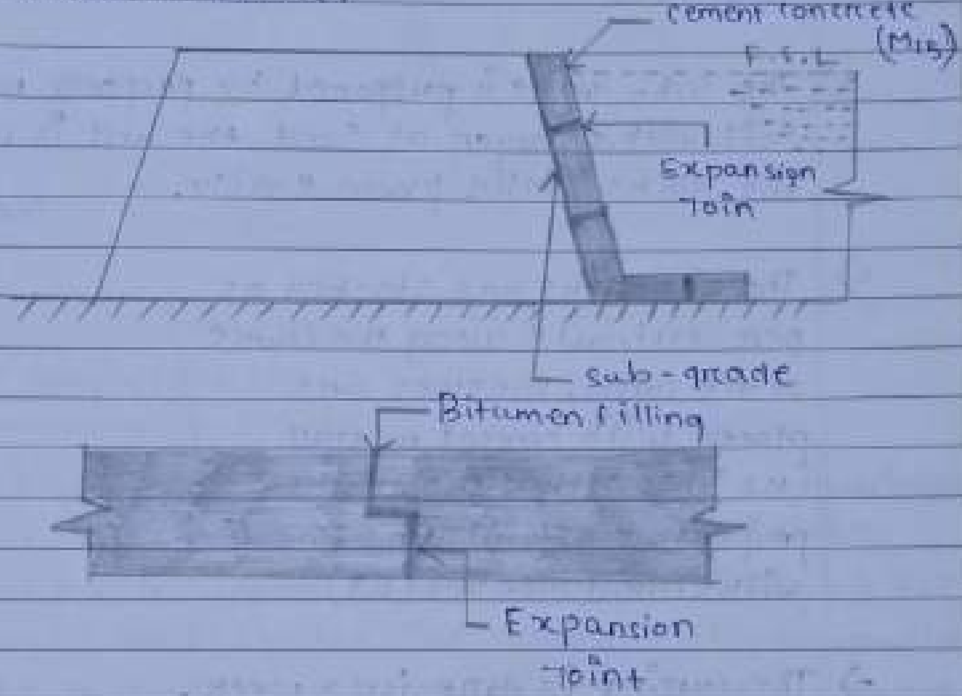
This lining is recommended for the canal in full banking. The cement concrete lining (cast-in-situ) is widly accepted as the best impervious lining. It can resist the effect of scouring and erosion very efficiently. The velocity of flow may be kept above 2.5 m/sec. It can eliminate completely growth of weeds. the lining is done by following steps.

Preparation of sub-grade:-

The sub-grade is prepared by ramming 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.

Laying of concrete:-

The cement concrete of grade M_{15} is spread uniformly according to the desired thickness (generally, the thickness varies from 100mm to 150mm). After lying the concrete is tapped gently until the slurry comes on the top. The curing is done for two weeks. As the concrete is liable to get damaged by the change of temperature, the expansion joints are provided at appropriate places. Normally no re-inforcement is required for this cement concrete. But in special cases, a network of 6mm diameter rods may be provided with spacing 10cm centre to centre.



Cement concrete lining

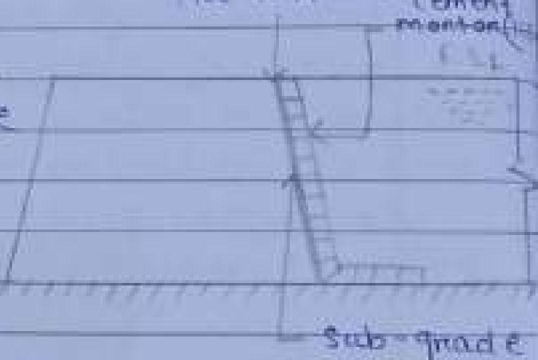
Pre-Cast Concrete Lining:-

=> This lining is recommended for the canal in full banking. It consists of pre-cast concrete slabs of size 60cm x 60cm x 5cm which are set along the canal bank and bed with cement mortar (1:6). A network of 6mm diameter rod is provided in the slab with spacing 10 cm centre of centre.

=> The proportion of the concrete is recommended as 1:2:4 rebates are provided on all the four sides of the slab so that proper Joints maybe Obtained when they are placed side by side. The Joints are finished with cement mortar (1:3). Expansion Joints are provided at a suitable interval. the slabs are set in the following sequence.

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

=> The ~~sed~~ slabs are stocked as per estimate along the course of the canal. The slabs are placed with cement mortar (1:6) by setting the rebates properly. the Joints are finised 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 the cement mortar (1:4) is generally 2.5cm. The sub-grade is prepared by ramming the soil after cutting. Then, over the compacted sub-grade the cement mortar is laid uniformly and the surface is finished with neat cement polish. This lining is Impervious, but is not durable The curing should be done properly.

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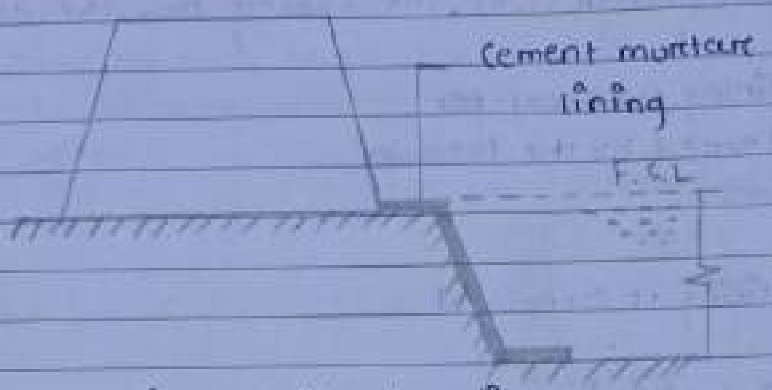


Cement Mortar ~~ling~~ lining.

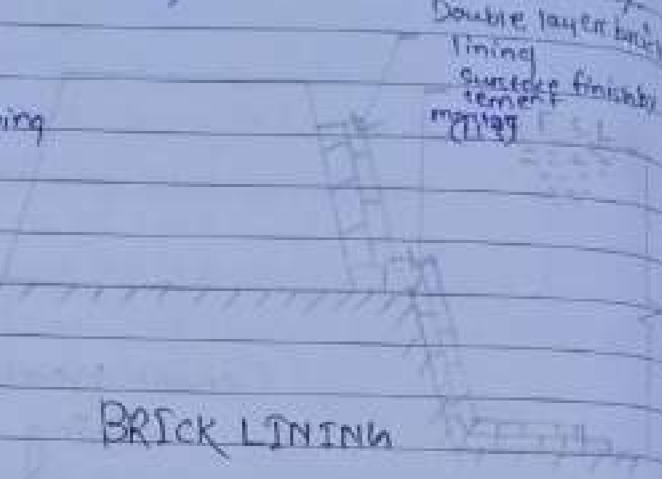
Lime Concrete Lining:-

When hydraulic lime, Surki and brick ballast are available in plenty along the course of the canal or in the vicinity of the irrigation project, then the lining of the canal may be made by the lime concrete of proportion 1:1:6. The producere of lying this concrete is same as that of the cement concrete lining. Here, the thickness of concrete varies from 150mm to 225mm and the curing should be done for longer period. This lining is less durable than the cement concrete lining. Howevere, it is recommended because of the availability of the materials and also because of the economics.

Brick Lining:-

This lining is prepared by the double layer brick flat soiling laid with cement motar (1:6) over the compacted sub-grade. The first class bricks should be recommanded for the work. The surface of thi lining is finised with cement plaster (1:3). The curing should be done perfectly.

The lining is always pre preferred by the following reasons,



BRICK LINING

=> This lining is economical

=> Work can be done very quickly,

=> Expansion joints are not required.

=> Repair works can be done easily.

=> Bricks can be manufactured from the excavated earth near the site.

However this lining has certain disadvantages,

=> it is not completely impervious.

=> it has low resistance against erosion,

=> it is not so much durable.

Boulder lining :-

In hilly areas where the boulders are available in plenty, this type of lining is generally recommanded. The boulders are laid in single or double layer maintaining the slope of the banks and the bed level of the canal. The joints of the boulders are grouted with cement mortar (1:6) The surface is finised with cement mortar (1:3) curing is necessary in this lining too.

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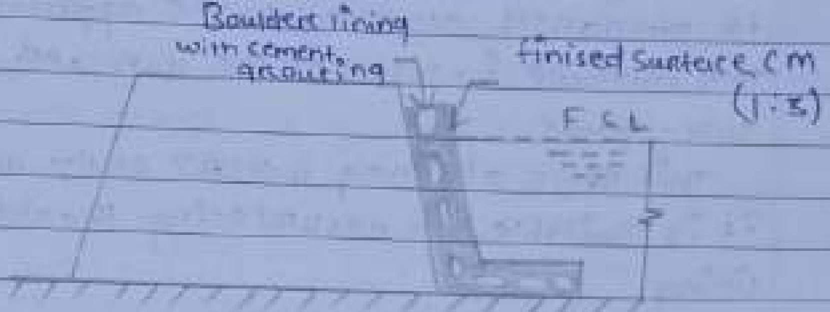
This lining is very durable and impervious. But the transporting cost of the material is very high. So it cannot be recommended for all cases.



BOULDER LINING

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SHOT 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 shot crete and the lining is known as shot crete lining. The process is also known as guniting. as a gun is used for laying the mortar. sometimes this lining is known as gunited lining. The lining is done in two ways

=> By dry Mix:-

In this method, a mixture of cement and moist sand ~~and water~~, is prepared and loded in the cement gun. then it is forced through the nozzle of the gun with the help of compressed air. The mortar spread over the sub-grade to a thickness which varies from 2.5 cm to 5 cm.

By wet Mix :-

In this process, the mixture of cement, sand and water is prepared according to the approved consistency. The mixture is loded in the gun and forced on the sub-grade.

This type of lining is very costly and it is not durable. it is suitable for resurfacing the old cement concrete lining.

Asphalt Lining :-

This lining is prepared by spraying asphalt (i.e bitumen) at a very high temperature (about 150°c) on the subgrade to a thickness varies from 3mm to 6 mm. The hot asphalt when becomes cold forms a water proof membrane over the subgrade. This membrane is covered with a layer of earth and gravel. the lining is very cheap and can control the seepage of water very effectively but it cannot control the growth of weeds.

Bentonite and clay Lining :-

In this lining a mixture of bentonite and clay are mixed throughly to form a sticky mass. this mass is spread over the sub-grade to form an impervious membrance which is effective in controlling the seepage of water, but it cannot control the growth of weeds This lining is generally recommended for small channels.

Soil-cement lining:-

This lining is prepared with a mixture of soil and cement. The usual quantity of cement is 10 percent of the weight of dry soil. The soil and cement are throughly mixed to get an uniform texture. The mixture is laid on the sub-grade and it is made throughly compact. The lining is efficient to control the seepage of water, but it cannot control the growth of weeds. So, this is recommended for small channels only.

Advantages and Disadvantages of canal lining:-

Advantages:-

=> It reduces the loss of water due to seepage and hence the duty is enhanced.

=> It controls the water logging and hence the bad effects of water-logging are eliminated.

=> It provides smooth surface and hence the velocity of flow can be increased.

=> Due to the increased velocity the discharge capacity of a canal is also increased.

=> Due to the increased velocity, the evaporation loss also be reduced.

=> It eliminates the effect of scouring in the canal bed.

=> The increased velocity eliminates the possibility of silting in the canal bed.

=> It controls the growth of weeds along the canal side and bed.

=> It provides the stable section of the canal.

=> It reduces the requirement of land width for the canal, because smaller section of the canal can produce greater discharge.

=> It prevents the sub-soil salt to come in contact with the canal water.

=> It reduces the maintanance cost for the canals

Disadvantages:-

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

=> It involves much difficulties for repairing the damaged section of lining.

=> It takes too much time to complete the project work

=> 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.

WATER LOGGING AND WATERSHE MANAGEMENT 16/8/21

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INTRODUCTION:-

In agricultural land, when the soil pores within the root zone of the crops get saturated with the subsoil water, the air circulation within the soil pores gets totally stopped. This phenomenon is termed as water logging. The water logging makes the soil alkaline in character and the fertility of the land is totally destroyed and the yield of crops is reduced.

Causes of water logging:-

The following are the main causes of water logging

① Over Irrigation:-

In inundation irrigation since there is no controlling system of water supply it may cause over irrigation. The excess water percolates and remains stored with in the root zone of the crops. Again, in perennial irrigation system if water is supplied more than ~~the~~ what is required. This excess water is responsible for the water logging.

② Seepage from canals:-

In unlined canal system, the water percolates through the bank of the canal and get collected in the low laying areas along the course of the canal and thus the water table gets raised the seepage is more in case of canal in banking.

(3) Inadequate Surface Drainage :-

When the rainfall is heavy and there is no proper provision for surface drainage the water gets collected and submerges vast area. when this condition for a long period, the water table is raised.

(4) Obstruction in Natural water course :-

If the bridge or culverts are constructed across a water cource with the opening with insufficient discharge capacity, the upstream area gets flooded and 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 subsoil water gets obstructed and causes water logging in the area.

(6) Nature of Soil :-

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

(7) Incorrect Method of Cultivation :-

If the agricultural land is not levelled properly and there is no arrangment 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, these may cause seepage of water. this sub-soil water will move towards the low-laying areas and cause water logging.

⑨ Poor Irrigation Management:-

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

⑩ Excessive Rainfall:-

If the rainfall is excessive and the water gets no time 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 agricultured land is flat, ie with no country slope and consists of depressions or undulations then this leads to 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:-

The following are the effects of water logging.

(1) Salinization of Soil:-

=> Due to water logging the dissolved salt like sodium carbonate, sodium chloride and sodium sulphate come to the surface of the soil. when the water evaporate from the surface, the salts are deposited there.

=> This process is known as 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 also known as salt efflorescence.

(2) Lack Of Aeration:-

=> The crops require some nutrients for their growth which are supplied by some bacteria or micro-organisms by breaking the complex nitrogeneous compounds into simple compounds which are consumed by the plants for their growth.

→ But the bacteria requires oxygen for their life and activity. when the aeration in the soil is stopped by water logging. these bacteria cannot survive without oxygen and the fertility of the land is lost which result in reduction of yeild.

③ Fall of Soil Temprature :-

Due to water logging the soil temprature is lowered At low temprature of the soil the activity of the bacteria becomes very slow and consequently the plants do not get the requisite amount of food in time Thus growth of the plants is hampered and the yield also is reduced.

④ Growth Of Weeds and Aquatic plants :-

Due to water logging, the agricultural land is converted is converted to marshy land and the weeds and aquatic plants are grown in plenty. These plants consume the soil Foods in advance and thus the crops are destroyed.

⑤ Diseases of Crops :-

Due to low temprature and poor Aeration. The crops get some diseases which may destroy the crops are reduce the yield.

⑥ Difficulty in cultivation :-

In water logged area it is very difficult to carry out the operation of cultivation Suchas tilling, ploughing etc.

(7) Restriction of Root growth:-

When the water table rises near to root zone the soil get saturated. The growth of the root is confined only to the top layer of the soil So the crops cannot be matured properly and the yield is reduced.

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(i) Detection of water logged area:-

=> The water logged area can be easily detected by Knowing the intensity of rainfall and the amount of runoff so to calculate the quantity of rain water which infiltrate into the Sub soil and help in raising the lvel of water table.

=> If the above information is no available then, a hole is made to be drilled to determine the level of underwater below the surface. if the water is available nearer to the root zone of the crops, then the area is called water logged area.

Preventive measure:-

Controlling Seepage From the canals:-

By following measures should be adopted to reduce Seepage From the canals.

⇒ By lowering the F.S.L of the canal:-

when the full supply level of canal is lowered than the loss of water's Seepage loss is reduced and hence water logging is also reduced

⇒ By lining of canal:-

The bed and sides of the canal should be lined by protective materials so that Seepage losses is reduced and hence water logging is also reduced.

Disposal of rain water:-

Rain water as soon as, it falls on the earth's Surface should be disposed of as soon as possible otherwise it will increase water logging.

Reducing the intensity of irrigation:-

The intensity should be reduced in this area where water logging occurred. irrigation should be done rotation wise in diffrent Seasons.

REMEDIAL MEASURES:-

The following methods are adopted to reclaim the water logged areas.

Installation of lift irrigation system:-

when a tube well systems are introduce, then the level of underground water goes down and hence water logging is reduced.

⇒ Implementation of drainage Scheme:-

Area in reclaimed by introducing overland and Subsurface drainge schames. Surface drainage maybe of:-

⇒ providing seepage drain

⇒ By providing strom water or surface drain

⇒ By providing lining of canal

⇒ implementation of tube well in fields or water logging area.

Surface drain:-

Surface drains are that construction may be natural or artificial which remove surplus water from any area and placed over the surface of the soil while aligning surface drains followings points which are given below should be considered.

⇒ Drain should flow lowest contouring natural drainage line.

⇒ The Total alignment of drain should be straight, so that length of the drain is reduced and all this reduces the cost of construction of that drain.

=> The drain should not pass through any ponds and it also should not cross irrigation canals.

Sub Surface drains:-

When the depth of the surface drain increases then the drain scheme becomes uneconomical. In this situation subsurface drain is used. Subsurface drain is pipe drain laid in permeable stratum below a ground water table. These drains are circular pipes made of ~~ver~~ vitrified clay. The trech is excavated in the ground up to the required depth and tile line is laid on 15cm sand bed.

Ground water recharge:-

It is a process where water moves downward from surface water to ground water. This process usually below plant root. The water table recharge occurs naturally or artificially, Natural Ground water is recharge by rain water by melting of snow, by river and lake through permeability of soil

Artificial ground water is recharge by makeing a pond, reservoirs and by storing rain watered.