Lecture No. 01 - Irrigation Practice.

Topic(s) to be covered	Irrigation - Definition of Irrigation - Necessity of Irrigation. Scope of Irrigation - Quality of Irrigation Water. - Classification of Irrigation.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Define Irrigation	Remembering
LO2	Know Necessity & Scope of Irrigation	Remembering
LO3	Understand the quality of Irrigation water	Understanding.
LO4	adhere knowledge on Classification of Irrigation.	Understanding.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen / Discuss.

Lecture Notes

Irrigation:-

Defined as the Science of Artificial Application of Water to the land, in accordance with the Crop requirements throughout the Crop period for full-fledged Nourishment of the Crops.

NECESSITY OF IRRIGATION:

India is basically an Agricultural Country, & all its resources depend on the agricultural output. The Necessity of Irrigation Can be Summarised in the following points.

1. Less Rainfall - When the total rainfall is less than Needed for the Crop, Artificial Supply is Necessary.

2. Non-Uniform Rainfall
   - i) The rainfall in a particular area may not be Uniform Over the Crop period.
   ii) By the Collection of water during rainfall period, water may be Supplied to the Crop during Non rainfall period.

3. Growing perennial Crops
   - Perennial Crops, Such as Sugarcane which need water throughout the year, Can be grained only through the provision of Irrigation facilities in the area.

4. Commercial Crops with Additional Water:
   - The rainfall in a particular area may be Sufficient to raise the Crops, but more water may be required for raising Commercial & Cash Crops

5. Controlled Water Supply:
   - By the Construction of proper distribution System, the yield of Crop may be increased because of Controlled Supply of water.

SCOPE OF IRRIGATION :

Scope of Irrigation can be divided into Two Heads

(a) Engineering Aspect
(b) Agricultural Aspect.

Engineering Aspect :

- Engineering aspect of Irrigation deals with.

1. Storage, Diversion, or Lifting of water.
2. Conveyance of water to the Agricultural fields.
3. Application of water to Agricultural fields
4. Drainage & Relieving Water logging.
5. Development of Water Power.

Agricultural Aspect :-

- Deals with thorough study of following points.

1. Proper depth of water necessary in single application of water for Various Crops.
2. Distribution of water uniformly & periodically
3. Capacities of different soils for Irrigation Water, & the flow of water in soils.

Lecture No.02 - IRRIGATION DEVELOPMENTS.

Topic(s) to be covered	History of Irrigation developments in India - Irrigation Schemes before & after 1914 - Multipurpose river Valley project - Benefits & ill effects of Irrigation.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
LO1	Understand the Irrigation developments in India	Understanding
LO2	acquire knowledge on Multipurpose river valley projects	Understanding
LO3	know the benefits & ill effects of Irrigation.	Remembering.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

HISTORICAL DEVELOPMENT OF IRRIGATION IN INDIA

- Irrigation Practices in India can be traced to prehistoric times.
- Earliest reference to Irrigation is given by the great Sage, Narada around 3150 B.C.
- Chola rulers of South India also constructed necessary for Irrigation works.

- State Controlled Irrigation Works have begun to play a major role in the last about 150 - 200 years.
Three Important Irrigation Works such as
a) Iklestern Yamuna Canal
b) Eastern Yamuna Canal
c) Cauvery Delta System were remodelled & opened.

- Major Irrigation Works Completed from 1820 - 1930.

Project	Year of Completion	Area Irrigated in thousand Hectares.
Iklestern Yamuna Canal	1820	431
Ganga Canal	1856	655
Cauvery Delta System	1889	434
Godavari Delta System	1898	497
Sarda Canal	1930	525

- The first Hydro electric work in India was undertaken in 1897 Near Darjeeling.
- During period between two World war Mettur Hydro electric Scheme, Pykara hydro electric scheme were taken up by States.
- After World war & before Independance papanasam & Jog plants were made.

Major Irrigation Schemes After Independance.

Project	Area to be Irrigated (million Hectares)	Total Cost in Crore Rupees.
Bhakra Nangal	1.46	101.9
Gandak	1.35	49.5
Hirakud	0.84	93.3
Nagarjuna Sagar	0.43	91.1
Mahi	0.30	41.0
Rajasthan Canal	1.41	206.0.

The above table gives the plan wise Irrigation potential Created, Irrigation potential utilized & Approximate Experditure Incurred in India.

PLAN WISE IRRIGATION POTENTIAL

S.NO	Plan	potential Created (Mha)	potential utilized (Mha)	Expenditure (Rs Crores)
1.	1st plan (1951-56)	26.25	22.85	1423
2.	2nd (1956-1961)	29.07	27.78	542.
3.	3rd (1961-1966)	33.57	32.18	1019
4.	4th (1966-1969)	37.12	35.77	991
5.	5th (1969-1974)	44.20	42.09	2415
6.	5th (1974-1978)	52.02	48.26	3926
7.	Annual plan (1978-80)	56.61	52.65	3061
8.	6th (1980-1985)	65.22	58.82	10786
9.	7th (1985-1990)	76.53	68.59	17387
10.	Annual plan (1990-92)	81.09	72.86	} 27000
11.	8th (1992-1997)	95.43	80.37	
12.	9th (1997-2002)	101.33	83.91	47000.

• MULTIPURPOSE RIVER VALLEY PROJECT

a) A Multipurpose river Valley projects Includes the following aspects.

1. Irrigation 2. Water Supply for Public Health & Sanitation.
3. Generation of Hydroelectric power 4. Flood Control & river-training.
5. Erosion & Sediment Control 6. Inland Navigation 7. Fish culture
8. Recreation 9. Drainage.

b) A Multipurpose river Valley Scheme embodies the study of following science.

1. Agronomy & Animal Husbandry 2. Soil science & Mechanics.
3. Engineering (Civil, Electrical, Mechanical & Agricultural)
4. Hydrology 5. Hydraulics 6. Geology 7 Economics. etc.

• BENEFITS OF IRRIGATION

1. Increase in Food production
2. protection from famine
3. Cultivation of Cash Crops.
4. Generation of Hydro Electric power
5. Domestic & Industrial water Supply
6. Inland Navigation
7. Canal plantations
8. Improvement in the Ground water Storage.
9. Addition to wealth of the Country.
10. Increase in prosperity of people.

• ILL EFFECTS

1. Breeding places for Musquitoes
2. Water logging
3. Damp Climate.
4. Water pollution
5. Procuring & Supplying Irrigation water is Complex & expensive in itself.

Lecture No. 03 - CROPS

Topic(s) to be covered	PRINCIPAL CROPS - CROP SEASON - Kharif Season - Rabi season - perennial Crops - Soil Moisture Irrigation relationship.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	know the principle crops of India.	Remembering
LO2	understand the Crop Seasons	Understanding
LO3	gain knowledge on Soil Moisture Irrigation relationship	Understanding

Teaching Learning Material	Student Activity
Chalk & Talk	Listen. / Discussion

Lecture Notes

PRINCIPAL CROPS AND CROP SEASONS.

Crops can be classified in the following ways.

a) Agricultural Classification

b) Classification based on Crop Season

c) Classification based on Irrigation requirement.

1. Agricultural Classifications:
   (a) Field Crops : Such as Wheat, Rice, maize, barley, Oats etc.
   (b) Commercial Crops: Such as Sugar Cane, Cotton, tobacco, Hemp.
   (c) Oil Seed Crops: Such as Mustard, Ground Nut, linseed, etc.
   (d) Horticultural Crops: Consisting of Various fruits crops, & flower Crops.
   (e) plantation Crops: Such as Tea, Coffee, Coconut, Rubber etc.
   (f) Miscellaneous Crops: Such as Medicinal Crops, Aromatic Crops, Spices etc.

2. Based on Crop Season:
   (a) Rabi Crops
   (b) Kharif Crops
   (c) perennial Crops
   (d) Eight month Crops.
   (e) Winter Crops
   (f) Monsoon Crops

3. Based on Irrigation Requirement.
   (a) Dry Crops - Rain water is sufficient for growth.
   (b) Wet Crops - Which cannot grow without Irrigation.
   (c) Garden Crops - Requires Irrigation throughout the year.

CROP SEASON (பயிரின் பருவம்).

Based on Crop season Crops are classified as Rabi, Kharif, perennial & eight months Crops.

Rabi Crops:-

- Season starts from 1st October to 31st March.
- These Crops are sown in Autumn & are harvested in Spring.

Example:-	Crop	Sowing time	Harvesting time.
	Gram,	Sep - Oct	March - April
	Wheat	Oct - Nov	"
	Barley	Oct - Nov	"
	Peas	Oct - Nov	"
	Potato	Oct	February.

Kharif Crops:-

- Crops are sown by the beginning of the Southwest Monsoon & are harvested in Autumn.
- Starts from 1st April to 30th September.

Example:

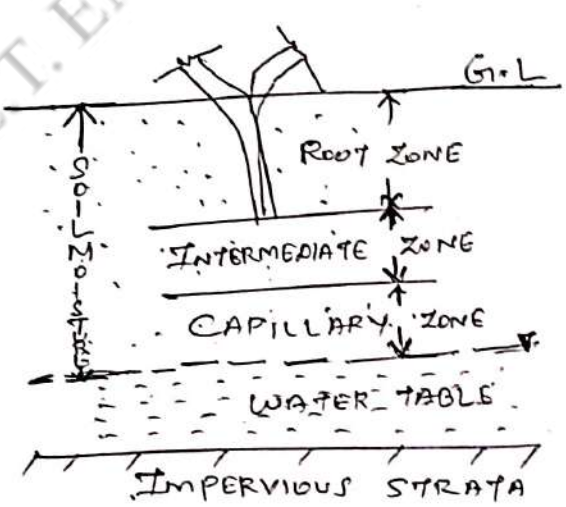
Rice	June - July	Oct - Nov
Maize	"	Sep - Oct
Pulses	"	Nov - Dec.
Ground Nut	May.	-

(iii) Eight month Crops:-
- These Crops, Such as Cotton,.
- It requires Irrigation water for 8 months.
- Season starts May/June to Dec/April.

iv) Perennial Crops:-
- These are the Crops that require water for Irrigation throughout the year.
- Example Sugar Cane, fruits, Vegetables.

• Soil Moisture - Irrigation Relationship.

. The water below the water table - Ground water
. The water above the water table - Soil Moisture.



• GRAVITY WATER:-

When water falls over the Ground, a part of it gets absorbed in the root zone, & the rest flows downward Under the action of gravity it is Called Gravity water.

Field capacity:-

* Immediately after a rain or Irrigation water application, when all the gravity water has drained down to the water table. A certain amount of water is retained on the surfaces of soil grains (by Molecular attraction & by loose Chemical bonds ie, Adsorption) This water Cannot be easily drained under the action of gravity and is called the Field Capacity (F).

$$F = \frac{\text{Weight of water retained in unit area of soil}}{\text{Dry Wt } (\gamma_d) \times \text{Volume of soil } (d)}$$

Capillary water:-

. The water which is attached to the soil Molecules by Surface tension against gravitational forces (gravity an external force, due to capillary nature) and can be extracted by plants by Capillarity.

Hygroscopic water:-

. The water which is attached to the soil Molecules by loose Chemical bond.

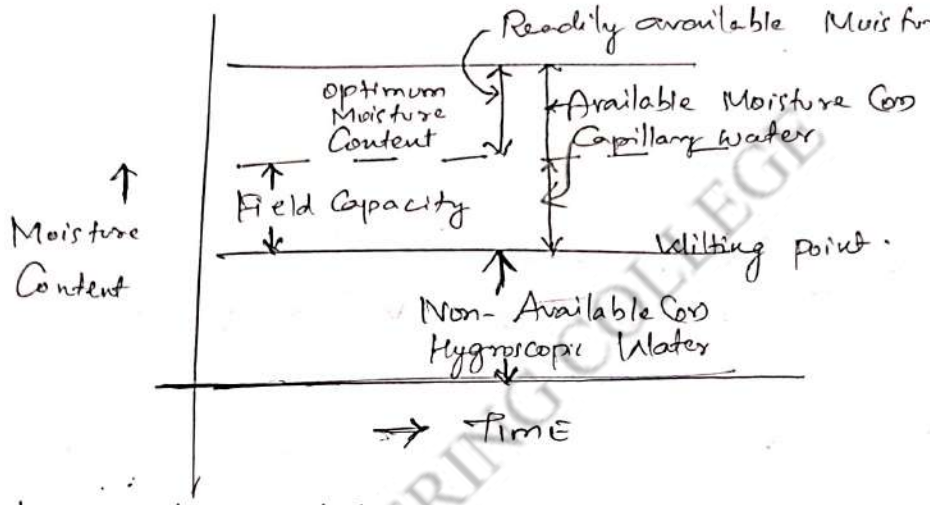
. This water which Cannot be removed by Capillarity is not available to the plants.

* Permanent Wilting point:-

Permanent wilting point is that water Content at which plant can no longer extract sufficient water for its full growth, & wilts up.

- **Available water (moisture) :-**

  - Water Available to plant is the difference between field capacity to permanent wilting point is known as available moisture



- **Readily available water:-**

  - It is the portion of available moisture which is most easily extracted by plants and is approximately 75-80% of the available moisture.

- **Soil Moisture Deficiency:-**

  - The water required to bring the soil moisture content of a given soil to its field capacity, is called field moisture cons soil moisture-deficiency.

Lecture No.4: DUTY, DELTA & BASE PERIOD

ic(s) to overed	Duty - Delta - factors affecting Duty - Relation between Duty & Delta - Methods of Improving Duty - Base period . Crop period.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Understand Relation between duty & delta.	Understand.
LO2	Analyze Duty , Delta & Baseperiod for Crop	Apply & Analyze.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

DUTY:-

(D) - Relationship between Volume of Water & the area of Crop it Matures.

Definition:-

- No. of. Hectares of land irrigated for full growth of given Crop by Supply of $1 m^3/sec$ of Water Continuously during the entire Base period of that Crop. [Eg: D for Rice - 900 Hectors/Cumec]

• **Delta :-**

Total depth of water (cm) required by a crop to come to maturity is called Delta (Δ).

For example,

If Rice required about 10cm depth of water at an average interval of about 10 Days, and Crop period for the Rice is 120 days. Find out the Delta for Rice.

Solution:

i) No. of. times water required for Crops = $\frac{120 \text{ (Crop period)}}{10 \text{ (Interval)}}$

= 12 Nos.

ii) Delta for Rice Δ = No. of. watering × Depth of water

$\Delta = 12 \times 10$

$$\boxed{\Delta = 120\text{cm}}$$

Note:-

Average Values of Delta for Crops in India.

a) Rice - 120cm
b) Vegetables - 45cm
c) Cotton - 50cm
d) Barley - 30cm.
e) Wheat - 40cm.

Relation between Duty and Delta.

- Let there be a Crop of Base period 'B' Days
- Let One Cumec of water be applied to this Crop for 'B' Days.

Now,

Volume of water applied to this Crop during 'B' days

$$V = 1 \text{ Day} \cdot B$$

$$V = 1 \times (24 \times 60 \times 60)$$

$$V = 86400\,B \quad (m^3)$$

- By definition of Duty - $1\ m^3$ supplied for B Days Matures D Hectare of land

∴ This quantity of water (V) matures D Hectares of land (or) $10,000\ m^2$ of Area.

- Total Depth of water applied on this land

$$\Delta = \frac{\text{Volume}}{\text{Area}} = \frac{86400\,B}{10^4\,D} = \frac{8.64\,B}{D} \text{ Metres}$$

$$\boxed{\Delta = \frac{8.64\,B}{D} \text{ Cm}}$$

where,
D – Hectare / Cumec
B – Days
Δ – Cm

- **Factors Affecting Duty:-**

- The Duty of water of Canal System depends upon a variety of the factors. They are

a) Methods & System of Irrigation.
b) Mode of applying water to the Crops.
c) Method of Cultivation
d) Time & frequency of filling.
e) Type of Crop
f) Base period of Crop
g) Climatic Condition of the area.
h) Character of soil

- **Methods of Improving Duty:-**

i) Suitable Method of applying water to the Crop Should be used.
ii) Land should be ploughed & levelled.
iii) Land should be Cultivated frequently
iv) The Canal should be lined.
v) Rotation of Crops Must be practiced.
vi) The Source of Supply gives good quality of water.
vii) The farmer apply Correct quantity of water at Correct timing.
viii) The Idle length of the Canal should be Reduced.

• **Base period (or) Crop period:**

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

(or)

- The time between the first watering of a crop at the time of its sowing to its last watering before harvesting is called Base period of the crop (B).

- Crop period is generally more than the Base period, practically they are taken as one

- It is usually expressed in Days.

Problem 1:- Find the Delta for a crop if the duty for a Base period of 110 Days is 1400 Hectare/Cumec.

Solution:-

Given: B = 110 Days & D = 1400 Hectare/Cumec.

$$\boxed{\Delta = 8.64\frac{B}{D}} = \frac{8.64 \times 110}{1400}\ (m) = 0.68m.\ (or)\ 68cm.$$

Problem 2 - A crop requires a total depth (Δ) of 92cm of water for a Base period of 120days. Find the Duty of water.

Solution:-

Given: B = 120 Days & Δ = 92cm (or) 0.92m.

$$\boxed{D_{Ha/Cumec} = \frac{8.64B}{\Delta}} = \frac{8.64 \times 120}{0.92} = 1127\ Hectare/Cumec.$$

Lecture No. 05 - Discharge required for Crops.

Topic(s) to be covered	Duty - Discharge required & storage Capacity of Reservoir.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	(Analyze) Find the discharge required for Various Crops.	Apply & Analyze.
LO2	Analyze the storage Capacity of Reservoir for Crop Irrigation.	Apply & Analyze.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

1) Table gives the necessary data about the Crop, their duty and the Area Under each Crop, Commanded by a Canal taking off from a storage tank. Taking a time factor for the Canal to be 13/20. Calculate the discharge required at the Head of the Canal. If the Capacity factor is 0.8, Determine the Design Discharge.

Crop	Base period (Days)	Area (Hectares)	Duty at the Head of the Canal (Hect/Cumecs)
Sugar Cane	320	850	580
Overlap for Sugar Cane in Hot weather	90	120	580
Wheat	120	600	1600
Bajri	120	500	2000
Vegetable	120	360	600

Solution:-

Discharge required for Crops:-

a) Discharge for Sugar Cane $= \frac{850}{580} = 1.466$ Cumecs.

b) Discharge for Overlap Sugarcane $= \frac{120}{580} = 0.207$ Cumec

c) Discharge for Wheat (Rabi) $= \frac{600}{1600} = 0.375$ Cumec

d) Discharge for Bajri (Monsoon) $= \frac{500}{2000} = 0.25$ Cumec

e) Discharge for Vegetables (Hot Weather) $= \frac{360}{600} = 0.60$ Cumec.

Note:
Since Sugarcane has a base period of 320 Days it will require water in Monsoon & Hot weather.

i) Discharge required in Rabi : 1.466 + 0.375 = 1.841 Cumec

ii) Discharge required in Monsoon : 1.466 + 0.25 = 1.716 Cumec

iii) Discharge required in Hot weather : 1.466 + 0.207 + 0.6
= 2.273 Cumecs.

• The Maximum Demand of 2.273 Cumecs is in the Hot weather.

Time factor = 13/20 (Given) 0.65

∴ Full Supply discharge at the Head of Canal will be

= 2.273 × 20/13 (or) 2.273/0.65

= 3.497 Cumecs.

Results:
• Design Discharge = Full Supply Discharge / Capacity factor
= 3.497 / 0.8
= 4.372 Cumecs.

(2) The Base period, Intensity of Irrigation & Duty of Various Crops Under a Canal System are given in Table below. Find the reservoir Capacity if the Canal losses are 20% & reservoir losses are 12%.

Crop	Base period (Days)	Duty at the field (Hectares/Cumec)	Area Under the Crop (Hectares)
• Wheat	120	1800	4800
• Sugarcane	360	800	5600
• Cotton	200	1400	2400
• Rice	120	900	3200
• Vegetables	120	700	1400

Solution:-

(a) Wheat:-

- Discharge required = $\frac{4800}{1800}$ (Cumecs)

- Volume of water required = $\frac{4800}{1800} \times 120$

= 320 Cumec – Days.

(b) Sugar Cane:-

- Discharge required = $\frac{5600}{800}$ = 7 Cumecs.

Volume of water required = $7 \times 360 = 2520$ Cumec-Days.

3) Cotton:-

- Discharge required = 2400/1400
- Volume of water required = $(2400/1400) \times 200 = 343$ Cumec-Days

4) Rice:-

- Discharge required = 3200/900
- Volume of water required = $(3200/900) \times 120 = 427$ Cumec-Days

5) Vegetables:-

- Discharge required = 1400/700
- Volume of water required = $\left(\frac{1400}{700}\right) \times 120 = 240$ Cumec-Days.

Total Volume of water required on the field for all Crops

$= 320 + 2520 + 343 + 427 + 240$

$= 3850$ Cumec-Days.

Note:-

1 Cumec-Day = $1 \times 24 \times 60 \times 60\ m^3$

1 Hectare Metre = $1 \times 10^4\ m^2$

Hence 1 Cumec Day = $\frac{1 \times 24 \times 60 \times 60}{1 \times 10^4} = 8.64$ Hectare Metre.

∴ Total Volume of water required on the field = 3850×8.64

= 33264 Hect-metre.

∵ i) losses in the Canal System are 20% the Volume of water required at the Canal Head.

$= 33264 \times \frac{100}{80} = 41580$ Hec-metre

ii) Allowing 12% Reservoir losses, the Storage Capacity of reservoir

$= 41580 \times \frac{100}{88}$

= 47210 Hectare-Metres.

Lecture No. 06 EVAPOTRANSPIRATION

Topic(s) to be covered	Evaporation – Transpiration & Transpiration ratio – Factors affecting Consumptive Use of Water – Measurements – Direct Measurement – Determination by use of equation

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Understand the Consumptive Use of water	Understand.
LO2	Apply Methods for determining the Measurement of Consumptive Use.	Apply

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

EVAPO – TRANSPIRATION (Consumptive Use of Water)

Consumptive Use of water by a Crop is the depth of water Consumed by evaporation & transpiration during Crop growth, Including water Consumed by accompanying Weed growth.

Note:- When the Consumptive Use of Crop is known, the water use of large units can be Calculated.

Evaporation:-

- Evaporation is the transfer of liquid water from the liquid to the vapour state.
- Rate of evaporation from water surface is proportional to the difference between vapour pressure at the surface & the vapour pressure in the overlaying air.

Transpiration:-

- Transpiration is the process by which plants dissipate water from the surface of their leaves, stalks & trunks in the process of growth.
- 99% of water received by a plant through its roots is lost to the atmosphere by this process.

Transpiration ratio:-

- The transpiration ratio is the ratio of the weight of water transpired by the plant during its growth to the weight of dry matter produced by the plant exclusive of roots.

• Factors affecting Consumptive Use of water

a) Evaporation b) Temperature c) precipitation
d) Wind Velocity e) Growing season of crop
f) Soil & topography g) Irrigation Practices - A method of Irrigation

• Measurement of Consumptive Use

- Direct Measurement
  - Tank & Lysimeter
  - Field experimental plots
  - Soil Moisture Studies
  - Integration Methods
- By use of Equations
  - Blaney - Criddle
  - Penman
  - Hargreaves Class A
  - Pan evaporation method

a) Tank & lysimeter Method:-

- Tanks are Containers set flush with the ground level having an area of $1 m^2$ & 3m Deep.
- Tank is filled with soil & Crop is growing in it.
- In Lysimeter Bottom is pervious.

Consumptive Use is the difference of water applied and that draining through pervious bottom & Collected in a pan.

b) Field experimental plots:-

- In this Method Irrigation water is applied to the selected field experimental plots in such a way that neither Runoff Nor deep Percolation.

- Yield obtained from different field are plotted against the total water used.
- It is seen from observation that for every type of Crop, the yield increases rapidly with an increase of water used to a certain point, & then decreases with further increase in water.
- At the Break in Curve the amount of water used is the considered as the Consumptive Use.

(c) Soil Moisture Studies:-

- Soil Moisture Measurements are done before & after each Irrigation.
- The quantity of water extracted per day from soil is Computed for each period.
- A Curve is drawn by plotting the rate of use against time & from this Curve, Seasonal Use Can be determined.

(d) Integeration Method:-

- It is Necessary to know the division of total area under Irrigation Crops, Natural Vegetation, Water Surface area & Bare land Area.

The Integration Method is Summation of the products.

(i) Unit Consumptive Use of each Crop times its area.

(ii) Unit Consumptive Use of Native Vegetation times its Area.

iii) Water Surface evaporation times the water Surface Area. and

iv) Evaporation from base land times its area.

CONSUMPTIVE USE DETERMINATION BY USE OF EQUATIONS.

1. Blaney – Criddle Method.
2. Penman Method.
3. Hargreaves Class A Pan evaporation method.

• Blaney Criddle Method:-

- Blaney & Criddle (1962) proposed an Empirical relation which is largely used by Irrigation Engineers.

- Blaney Criddle equation Expresses Potential Evapo-transpiration in terms of temperature and day time Hours.

If C_u is Monthly Consumptive Use.

$$C_u = k \cdot f$$

k - Crop Coefficient

f - monthly Consumptive Use factor

$$f = \frac{P}{A_0}\left[1.8t + 32\right]$$

Where P - Monthly percentage of Hours

(b) C_u is the Seasonal Consumptive Use, $C_u = k.\Sigma f$

(c) C_u is the Total Consumptive Use $C_u = \Sigma k f$.

2. Penman Method:-

$$E_t = \frac{\Delta . H + \gamma E_a}{\Delta + \gamma}$$

Where

E_t - Evapo-transpiration

γ - Constant = 0.49 mm Hg/°C

Δ - Slope of Curve b/n e_s & temp.

H - Daily Net Radiation in mm.

E_a - Actual Vapour pressure

3. Hargreaves Class A Pan Evaporation Method:-

Evapo transpiration E_t (or) $C_u = k . E_p$.

Where k = Consumptive Use Coefficient

E_p: Class A Pan evaporation.

E_p can be determined by Christiansen formula.

$$E_p = 0.459 R_A . C_t . C_w . C_h . C_s . C_e \quad (cm)$$

Lecture No. 08 PAN Evaporation.

Topic(s) to be covered	Analysing the field Irrigation requirement & Consumptive Use of Crops using PAN Evaporation Method.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	**Bloom's Level**
LO1	Analyze the field Irrigation requirement & Consumptive Use of Crops	Analyze.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Using the data given in the first four columns of Table. for a given crop, Determine the field Irrigation requirement for each Month assuming Irrigation efficiency to be 60 percent.

Month	Crop factor (Kc)	Pan Evaporation Ep (mm)	Effective Rainfall (Pe)
Nov	0.20	118	6
Dec	0.36	96	16
Jan	0.75	90	20
Feb	0.90	105	15
March.	0.80	140	2

Solution:-

Step 1:-

To find potential Evapotranspiration D_{et} for each Month.

$$D_{et} = k \cdot E_p$$

Where

D_{et} = Potential Evapotranspiration (mm)

k = Crop factor

E_p = Pan Evaporation. (mm).

a) D_{et} for the month of November

$$D_{et} = k \cdot E_p$$

$k = 0.20$

$E_p = 118.0\text{mm}$

$D_{et} = 0.20 \times 118$

$$D_{et} = 23.60\text{mm}$$

b) D_{et} for the month of December

$$D_{et} = k \cdot E_p$$

Where $K = 0.36$

$E_p = 96.0$

$D_{et} = 0.36 \times 96$

$D_{et} = 34.56\text{mm}$.

(c) D_{et} for the Month of January

$K = 0.75$

$E_p = 90$

$D_{et} = 0.75 \times 90$

$D_{et} = 67.50\text{mm}$

(d) D_{et} for the Month of February

$K = 0.90$

$E_p = 105$

$D_{et} = 0.90 \times 105$

$D_{et} = 94.50\text{mm}$.

(e) D_{et} for the Month of March.

$K = 0.80$ & $D_{ei} = 0.80 \times 140$

$E_p = 140$. $D_{et} = 112.00\text{mm}$.

Step ii NIR = $C_u - R_e$ & FIR = $\frac{NIR}{E_a}$

To find Field Irrigation Requirement. (FIR) for each month

$$FIR = \frac{D_{et} - (D_p - D_{pl})}{E_a}$$

where

FIR = Field Irrigation Requirement

D_{et} = Consumptive Use (mm)

$D_p - D_{pl}$ = Effective Rain fall (mm)

E_a = Irrigation efficiency

(a)

FIR for the Month of November

$$FIR = \frac{D_{et} - (D_p - D_{pl})}{E_a}$$

D_{et} = 23.60mm

$D_p - D_{pl}$ = 6.0 mm.

E_a = 0.6 (Ci, 60 percent - Given).

$$FIR = \frac{23.60 - (6)}{0.6} = 29.33mm.$$

b. FIR for December

$$FIR = \frac{D_{et} - (D_p - D_{PL})}{E_a}$$

$D_{et} = 34.56mm$

$D_p - D_{PL} = 16.0mm$

$E_a = 0.6$.

$$FIR = \frac{34.56 - 16}{0.6}$$

$FIR = 30.93mm$.

c. FIR for January.

$D_{et} = 67.50$

$D_p - D_{PL} = 20mm$

$E_a = 0.6$

$$FIR = \frac{67.50 - 20}{0.6}$$

$FIR = 79.17mm$.

d. FIR for February

$D_{et} = 94.50mm$

$D_p - D_{PL} = 15mm$

$E_a = 0.6$

$$FIR = \frac{94.50 - 15}{0.6}$$

$FIR = 132.50mm$.

e. FIR for March.

$D_{et} = 112.00mm$

$D_p - D_{PL} = 2.0mm$

$E_a = 0.6$

$$FIR = \frac{112 - 2.0}{0.6}$$

$FIR = 183.33$.

- Result:

Month	(mm) Det (Ca) ①	F.I.R.	② N.I.R. (mm)	P2a
Nov	23.60	29.33	17.6	0.6
Dec	34.56	30.93	18.56	0.6
Jan	67.50	79.17	47.5	0.6
Feb	94.50	132.50	79.5	0.6
March	112.00	183.33	110	0.6

Lecture No 10 :- TANK IRRIGATION.

Topic(s) to be covered	Tank Irrigation - Classification - Tank Irrigation System - Merits & demerits of Tank Irrigation.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO_1	Understand the Importance of Tanks for Irrigation & their system with merits & demerits.	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

Tank Irrigation:-

- Tanks are small sized reservoirs formed by small earthern embankments to store runoff for irrigation.
- A Tank is formed by earth dams or Earthern bunds only.

These earthern Bunds spanning across the Streams are called Tank Bunds.

- Most of the existing tanks in India possess a Maximum depth of 4.5m while few are as deep as 9m.

Classification of Tanks.

According to Nature of Supply

1. System Tank
2. Non-System Tank
3. Ground Tank.

According to Size.

1. Small Tank
2. Medium Tank
3. Large Tank.

- **System Tank:-**
  - It gets assured supply from Nearby Rivers / Canals
  - They may not have their own Catchment.

- **Non-System Tank:-**
  - These Tanks depend on the runoff from their own Catchment.
  - They are not connected to any other Tank

- Grouped Tank :-
  - It Consists of a series of tanks Connected together.
  - These tanks either receives the surplus water of the upper tank & send its own to lower tank or do both.

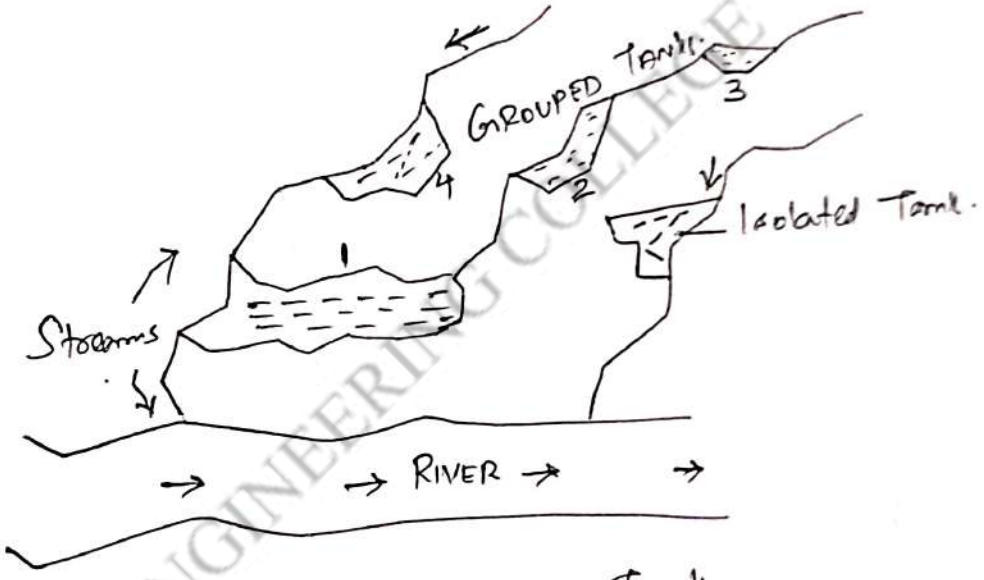


Fig. Isolated and Grouped Tank.

- Tank Irrigation System :-
  - It Consists of (a) Earthern Bund
    (b) A Surplus weir
    (c) Sluice to feed the channels
    (d) Channels from the sluices.

1. Earthern Bund:-

- It is a small sized Earth Dam
- Its design & Construction should be Carried out with principles applicable to Earth dams.

Types of Tank Bunds

(a) Homogeneous Embankment type
(b) Zoned Embankment type
(c) Diaphragm Type.

(a) Homogeneous Embankment

- Made up of single material
- It is Homogeneous throughout the section.
- The U/s face of the tank bund is protected with stone Apron.

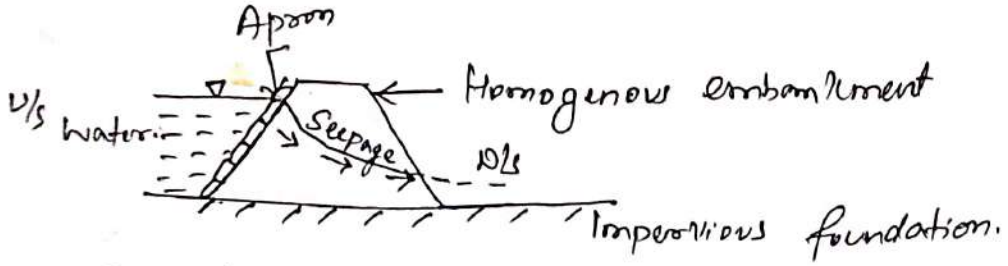
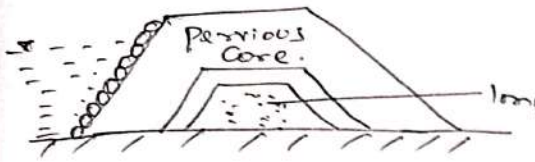


Fig: Homogenous Type

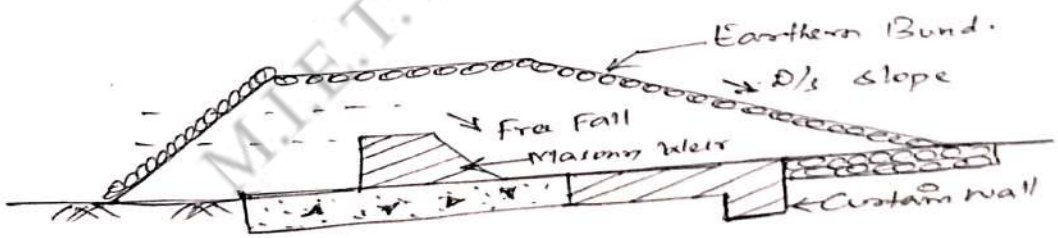
b) Zoned Embankment:-

Usually provided with a central impervious core made up of clay & covered by a pervious outer zone.



2. Tank weir:-

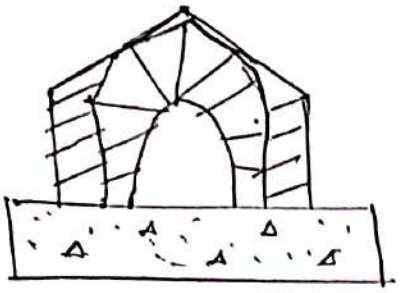
- Tanks are provided with arrangements for spilling away the excess surplus water.
- It may be provided in the body / end of tank bund.
- Is a Masonry weir.
- When the tank is full upto F.T.L & extra water comes in, then discharged over the surplus escape weir.



3. Tank Sluice cum Tank Outlet:-

- It is an opening in the form of a culvert or a pipe running through cum under the tank bund.
- Wing walls & other tank connections are provided at the Head & tail end of the culvert.

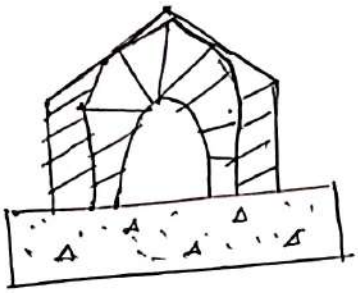
- Size of the Culvert depends upon the maximum quantity of water required to convey.



C/S

- Merits of Tank Irrigation:-
  1. Most of the tanks are Natural. It do not involve Heavy Cost for their Construction.
  2. Longer life Span.
  3. Fishing is Carried on many tanks
- Demerits of Tank Irrigation:-
  1. Many tanks dry up during the dry season.
  2. Silting of the tank bed is a Serious problem
  3. More water is evaporated from the water.

- Size of the Culvert depends upon the maximum quantity of water required to convey.



C/S

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Topic(s) to be covered	Well Irrigation - Types of well Irrigation - shallow, Deep open well. - Methods of lifting water - Merits & Demerits.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	**Bloom's Level**
LO_1	Understand what is well & its classification.	Understand
LO_2	Understand Methods of lifting water from well	Understand

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

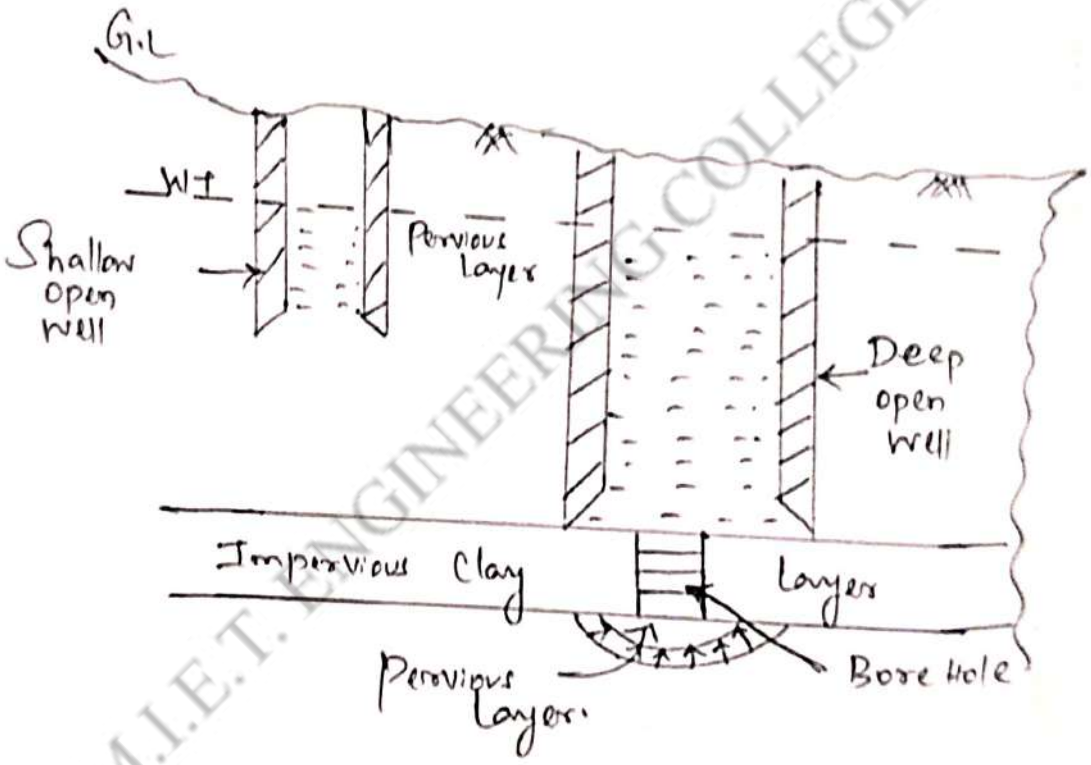
Well Irrigation:-

- It is a type of lift Irrigation detailing water from well.

Types:-

1. Shallow open wells
2. Deep open wells.

- Shallow well exists in a pervious stratum, and draws in supply from the surrounding materials.
- Deep well rest on a Impervious Clay layer, through a bore Hole made into it.
- pervious formation below the Clay layer. Contain greater quantities of ground water & greater discharge Can be obtained from deep open well.



SHALLOW & DEEP OPEN WELLS.

- Methods of lifting Water from Wells.
  - a) Lifting water from open well
  - b) Lifting of water from shallow tube well
  - c) Lifting of water from deep Tube well.

(a) Lifting of water from open well:-

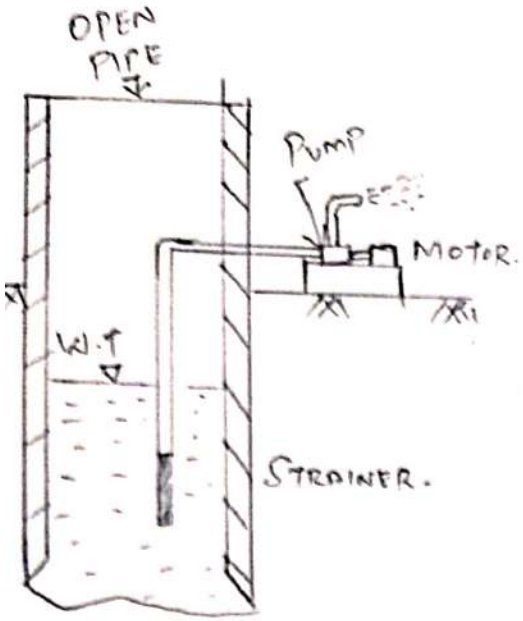
- The pump set is installed at the G.L of the strainer is provided sufficiently below the static water level of the open well.
- The supply of water may not be available through the year as the well may be dried up in summer or the water table may go below the suction Head.

(b) Lifting of water from shallow Tube well.

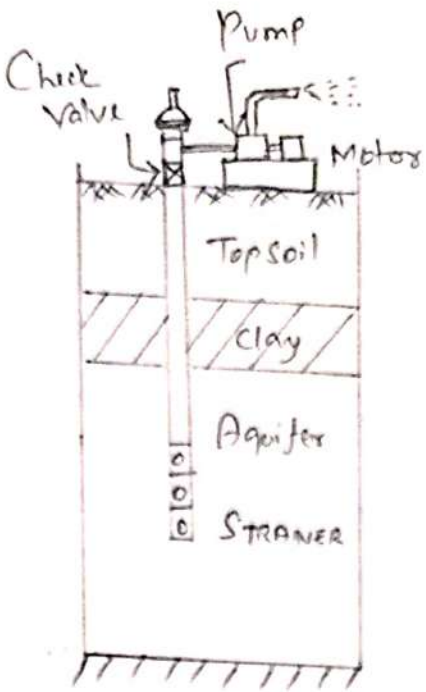
- The pumpset is installed at the G.L of a cap is provided on the well top. A check valve is provided just below the pipe connecting the pump with a tube well.
- The supply of the water may be stopped if the static water level goes below the such as Head.

(c) Lifting of water from Deep Tube well.

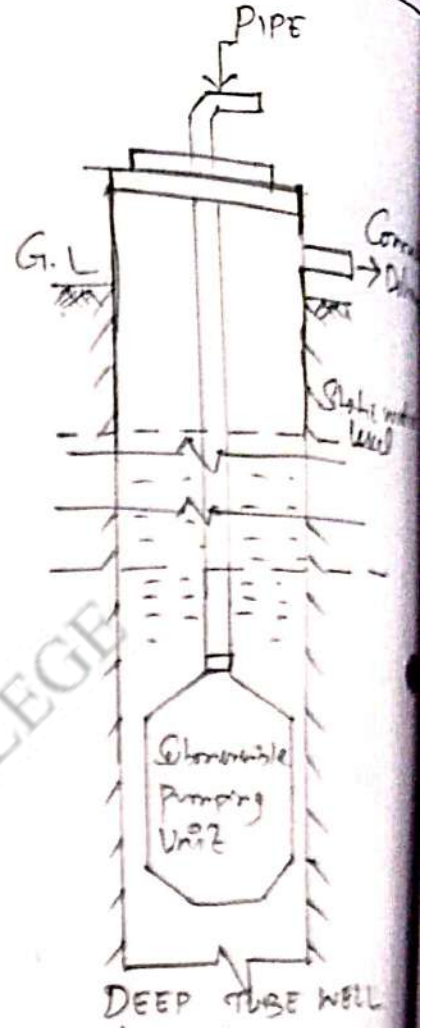
- In this system, a submersible pumpset consists of electric motor & a centrifugal turbine pump is lowered into the tube well by suspended cable.
- It is placed sufficiently below the lowest static level, water is available throughout year.



OPEN WELL PUMPING.



SHALLOW TUBE WELL



DEEP TUBE WELL

Merits of well Irrigation:-

1. Simplest & Cheapest source of Irrigation
2. It can be dug at any Convenient place
3. Is an Independent source of Irrigation.

Demerits of well Irrigation:-

1. Only limited area can be Irrigated.
2. well Irrigation is not possible when an Area Contains salty ground water.
3. Well may Dry up when excess water is taken out.

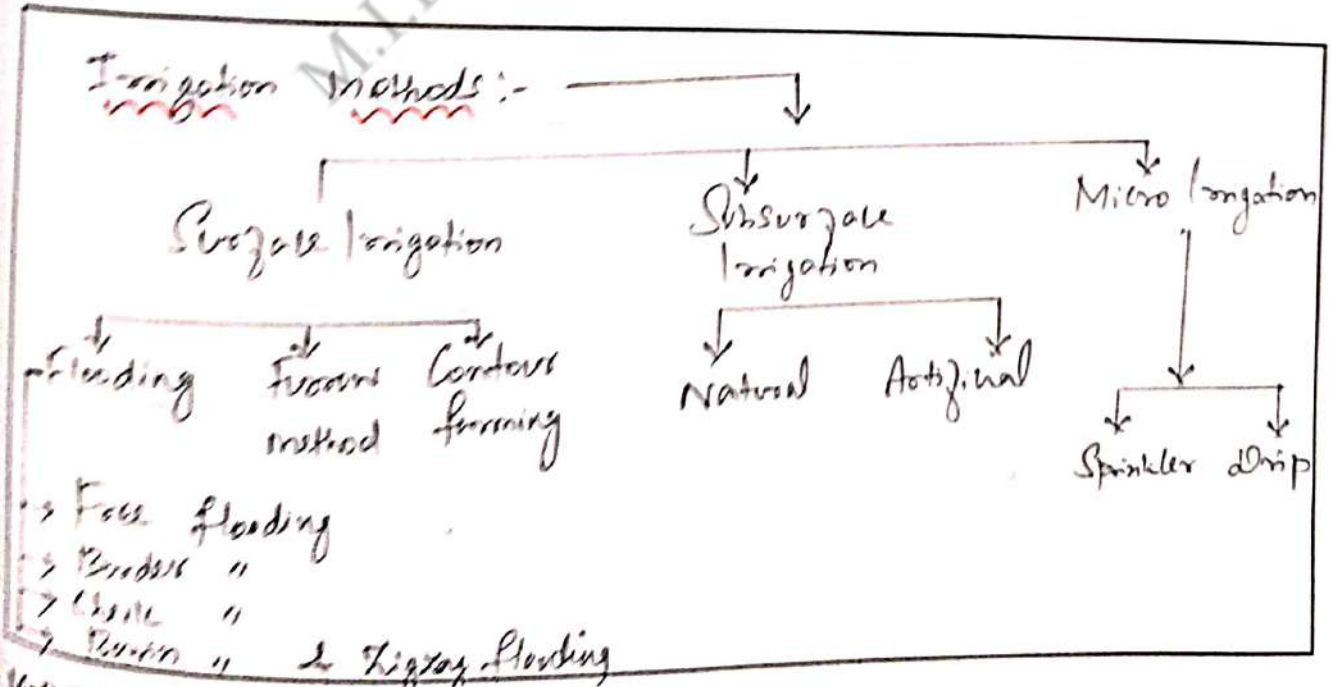
Lecture No.: 1 IRRIGATION METHODS [Flood Irrigation]

Topic(s) to be covered	Irrigation methods – Surface Irrigation – Subsurface – Micro Irrigation – Flooding – Controlled & Uncontrolled – Free, Border, Check, Basin & Zigzag flooding.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	**Bloom's Level**
LO_1	Understand Various Classification of Irrigation	Understand
LO_2	judge which Irrigation is suitable	Apply.

Teaching Learning Material	**Student Activity**
Chalk & Talk	Listen.

Lecture Notes



Surface Irrigation:-

- In this method, the irrigation water is distributed to the agricultural land or field through small Channels which flood the area up to the required depth.
- Surface Irrigation method may be further Classified as:

(a) Flooding Method
(b) Furrow Method
(c) Contour farming Method.

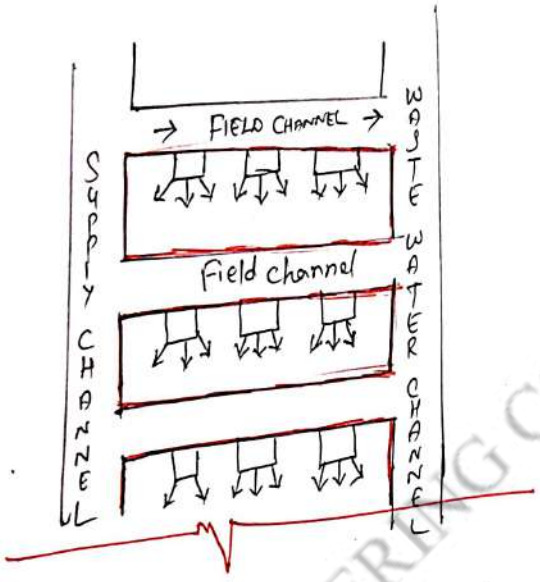
Flooding Method:-

(a) Free flooding:-

i) The Agricultural field is divided into small strips of land
ii) A series of field channel is connected to the supply channel.
iii) The strips of water the land are flooded with water
iv) The flow is stopped when the lower end of the field has received the desired depth of water.
v) It is suitable for close growing crops pastures etc.

Merits:-

1. Water application is quiet easy
2. Cheap
3. Does not require any skill
4. Minimum preparation & investment.



Free Flooding (Top View).

De-merits:-

1. Inefficient method & flooding is uncontrolled.
2. Result is uneven stand of crop & low yield.
3. More wastage of water due to runoff.
4. Crops may get damaged by excess water application.
5. Water Application efficiency is low.

b. Border flooding: -

i) The field is divided into series of long narrow strips. known as border strips. by Levees on sides.

ii) It is formed by levelling & grading the land between the levees.

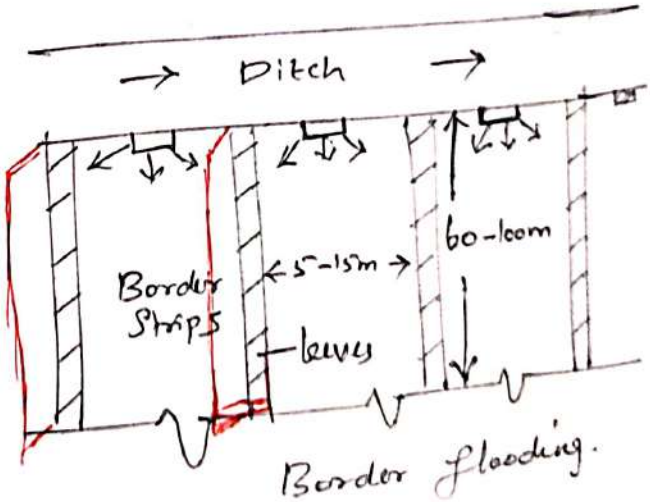
iii) width of strip varies from 5 - 15m and length varies from 60 - 100m. for sandy loam soil.

iv) A longitudinal gradient of 0.25 - 0.6% is provided in each strip.

v) water enters along the upper end of the border & flows down the slope along the length of strip

Merits: -

1. Provides Uniform Wetting.
2. Efficiency is high
3. Require less labour
4. Low Maintenance Cost.



Border flooding.

De Merits: -

1. Requires proper levelling
2. Chances of excess water accumulates in tail end of strip
3. Large Supply of water is needed.
4. Unsuitable for uneven & undulating land.

Zig Zag Method:-

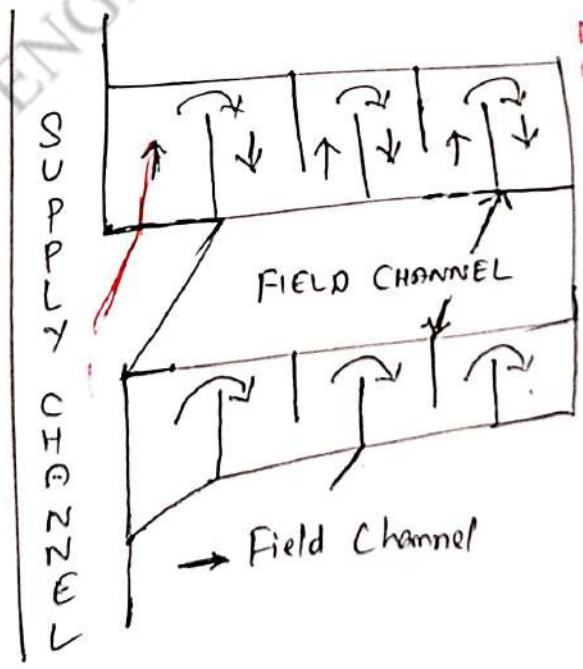
i) It is a special Method of Controlled flooding.

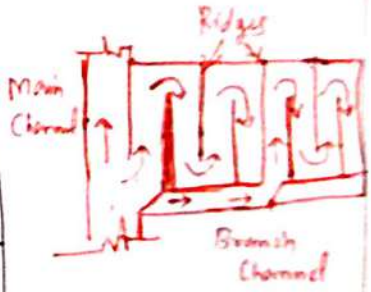
ii) Field is divided into square (or) rectangular plots. is further subdivided with the help of low bunds or levees in a Zig-Zag manner.

iii) Water enters at the upper end of plot and follows Circuitous Route or in a Zigzag way to reach the lower end of the plot.

iv) The water is applied to the plots from the field Channel through the openings.

v) When the desired depth is Obtained, the openings are Closed.





Merits:-

Suitable for gulatively level plots

Demerits:- Not suitable when the farming operations are to be done with modern farm machinary.

Lecture No: 13/ Furrow - Contour farming.

Topic(s) to be covered	Furrow - merits - demerits, Contour farming - merits -demerits - Check, Basin Irrigation system.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	**Bloom's Level**
CO1	gain knowledge on furrow Irrigation system	Understand
CO2	Gain knowledge on Contour farming	Understand

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

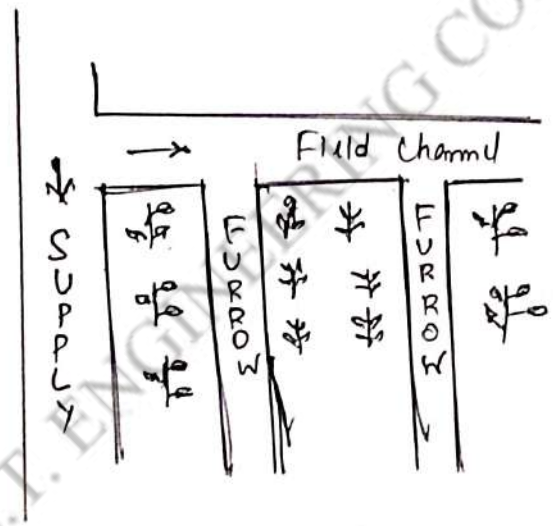
Furrow:-

- The furrow method is a method of surface Irrigation. in which the entire plot is not flooded.
- The water is applied to the field through a series of long, narrow channels called furrow.
- Furrows are dug at regular intervals

at right angles to the field channels.

- The water flowing in the furrows infiltrates the soil & spreads laterally & reaches the roots of the plants between the furrows.

- In this method a part of land is wetted.
- It helps in reducing evaporation losses
- Suitable for the Crops which are sown in rows.



Top view.

Merits:-

1. Less evaporative losses
2. Great saving of water
3. water application efficiency is high.

Demerits:-

1. Skilled labour is necessary
2. Adequate drainage need to be provided.

Check flooding :-

i) field is divided into small plots known as check basin enclosed by small bunds.

ii) Size of Basin may gauge from 3×2m to 30 × 30m.

iii) water is supplied to the check basin through the field channel which are connected with the supply channel.

iv) Each basin is flooded with water to the desired depth & the water is retained for some hours.

v) Suitable for permeable soils.

Merits :-

i) High Irrigation efficiency can be achieved.

ii) No loss of water by Runoff

iii) Unskilled labour can be employed

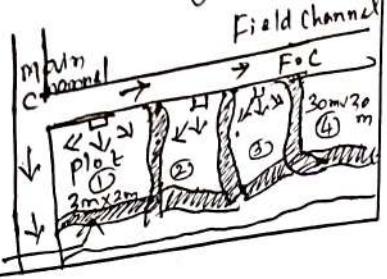
iv) provision of drainage of water is not necessary.

Demerits :-

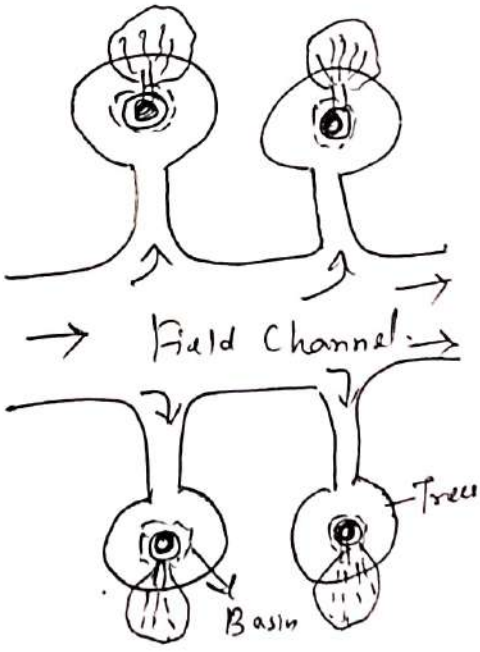
i) High labour requirement

ii) precise land levelling is necessary.

iii) Considerable land is wasted by Bunds & Channels.



- Basin flooding :-
  - i) Is a special type of check flooding & is adopted specially for orchard trees.
  - ii) There is a ring basin of Circular shape for each tree.
  - iii) If soil conditions & surface slopes are favourable even 2 to 5 trees are generally placed in one large basin.
  - iv) From supply channel water is taken to small field channel & supplied into individual basin.
  - v) Only a part of the total land area surface is flooded.



Merits:-

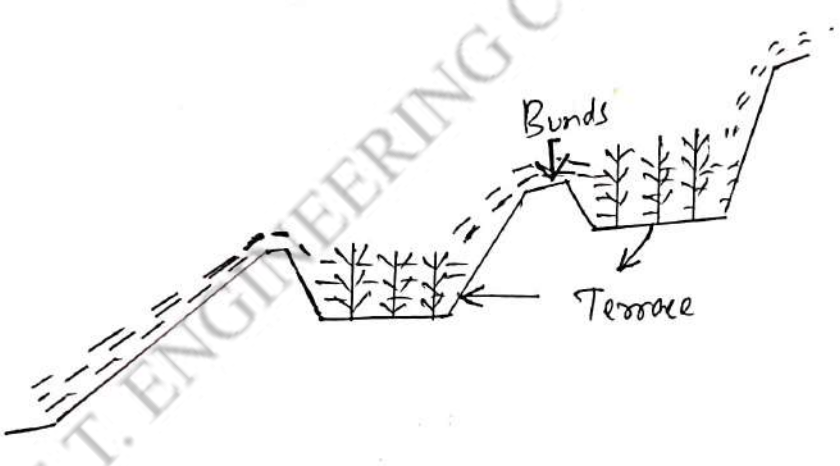
- i) No land is wasted
- ii) Labour requirement & cost of making basins are low.
- iii) No provision for drainage water.

Demerits:-

- i) Suitable for fruit trees or shrubs in orchards & plantations.

Contour Farming:-

1. Adopted in Hilly areas where the land has steep slope.
2. Land is divided into series of Horizontal strips aligned along the Contours of land (terraces)
3. Small bunds are provided at the end of each terrace to hold water upto the required depth.
4. This method also serves the propose of flood Control & Soil erosion.



Merits:-

i) Reduced runoff & flooding
ii) Increased moisture retention
iii) Create a Visually attractive landscape.

Demerits:-

i) Labour requirement is high & difficult.
ii) Not suitable for land with heavy overland flows Unless these flows can be diverted into safe outlet.

Lecture No. 15 MICRO IRRIGATION

Topic(s) to be covered	MICRO IRRIGATION – Definition – Types – Benefits – Sprinkler Irrigation – Types of Sprinkler – Merits & Demerits of Sprinkler Irrigation.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO_1	Understand the Concept of Micro Irrigation	Understand
LO_2	gain knowledge on Sprinkler Irrigation & its merits with demerits.	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

MICRO IRRIGATION:-

It is defined as the frequent application of small quantities of water directly above or below the soil surface through sprinklers placed along a water delivery line.

Types:-

1. Sprinkler Irrigation
2. Drip "

Benefits of Micro Irrigation:-

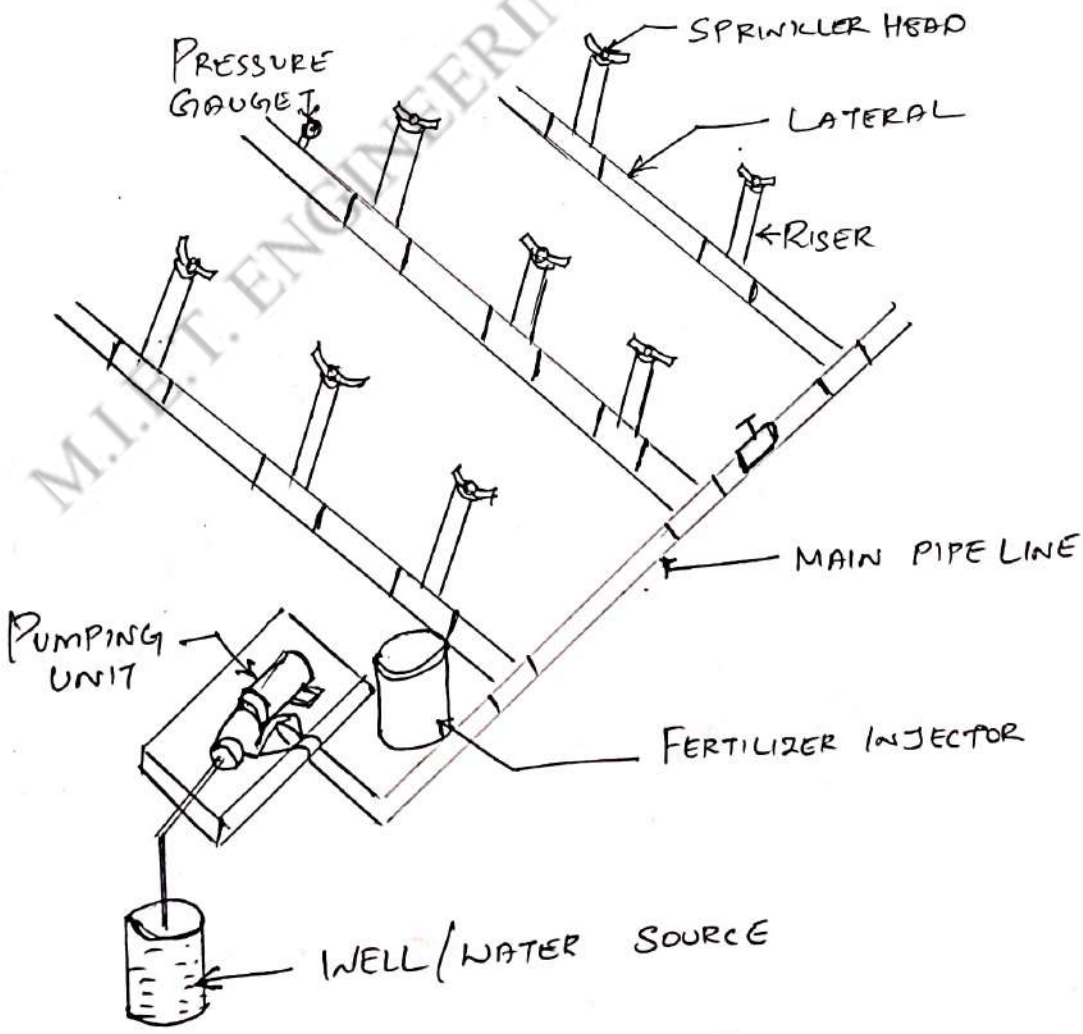
1. It enables farmers to grow crops which would not be possible under conventional system since it can irrigate adequately with lower water quantities.
2. It saves cost of hired labour & other inputs like fertilizers.
3. It reduces the energy needs for pumping because of its reduced water needs.

(a) Sprinkler Irrigation:-

- Is a method of applying water in the form of spray through networks of pipes & pumps.
- It is a kind of artificial rain
- It gives very good results, but it is a costly process.
- It can be advantageously used for many crops because it fulfills the normal requirement of uniform distribution of water.

Components :-

1. Pumping unit
2. Mainline & submainlines
3. Laterals
4. Risers
5. Sprinklers
6. Fertilizer injector



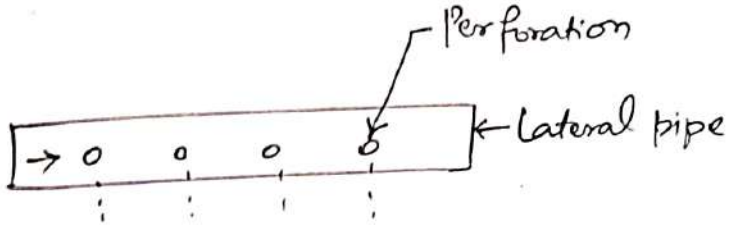
SPRINKLER IRRIGATION SYSTEM

Working Principle :-

- The pump unit is usually a Centrifugal pump
- It takes water from well & provides adequ pressure for delivery into the pipe System.
- The Mainline & Submain pipelines are pipes which deliver water from the pump to the latera
- The laterals deliver water from the mainlines usually movable.
- The Risers deliver the water from lateral line to the sprinkler.
- Sprinklers are used to spray the pressurize water through an Orifice & Rotates to distribute water on to the field.
- Fertilizer Injector is attached to the Sprinkler System to inject any chemical into Irrigation mainline & applied to the land using the Irrigation System.
- In addition to that Valves are fixed to Control the flow of water & flow meters & pressure gauges are provided to monitor System performance.

Classification of Sprinkler System.

1. perforated pipes Sprinkler System
2. Fixed Nozzle Sprinkler "
3. Rotating Sprinkler System



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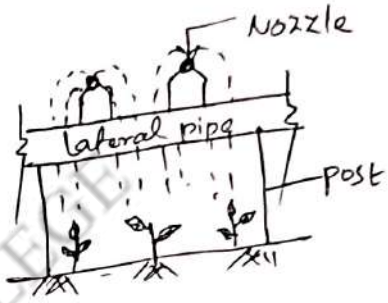

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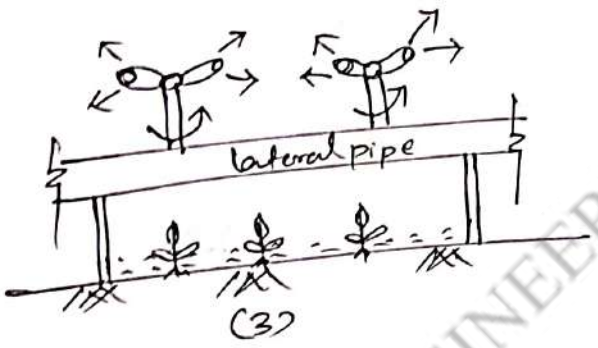


(3)

Merits:-

1. High Efficiency
2. Land levelling is not necessary
3. Drainage problem Eliminated
4. Low water loss.
5. Erosion of soil is avoided.

Demerits:-

1. High Initial Cost
2. Higher evaporation losses
3. Mechanical difficulties are expected.
4. Clean water is needed to avoid clogging of nozzles.

Lecture No.16 DRIP IRRIGATION

Topic(s) to be covered	Drip Irrigation - Definition - Composed parts - Working principle - Advantages & Demerits of Drip Irrigation.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Gain knowledge on working principle & usage of drip Irrigation	Understand

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Drip Irrigation:-

Drip Irrigation also Called trickle Irrigation is the latest Irrigation technique used at places where there is accurate Scarcity of Irrigation water & other soil problems.

- This Method Involves dipping water onto the soil at very low rate from a system of small diameter plastic pipes fitted with outlets Called Emitters or drippers.

Water is applied Closed to the plants so that only part of the soil in which roots grow is wetted thereby minimizing the losses by evaporation & percolation.

Drip Irrigation is most Suitable for row Crops Such as Vegetables & Soft fruit, tree & Vine Crops.

Drip Irrigation is suitable for most soils.

i) On Clay soil water must be applied Slowly to avoid Surface water ponding & runoff.

ii) On Sandy soil higher emitter discharge rates will be needed to ensure adequate lateral wetting of soil.

One of the main problem with drip Irrigation is the blockage of the emitters.

Component Parts:-

(i) Pumping Unit.
(ii) Control Head
(iii) Main & Submain lines
(iv) Laterals
(v) Emitters or Dippers.

Working Principle:-

- The pump unit takes water from the source and provides the right pressure for delivery into the pipe system.
- The Control Head Consists of Valves to Control the discharge and pressure in the entire System. It may also have filters to Clean the water.
- This also Contains a fertilizer tank. These slowly add a measured dose of fertilizer into the water during Irrigation.
- Main line & Submain lines & laterals Supply water from the Control Head into the field.

- They are usually made from PVC Hose and should be buried below ground.

- Emitters are devices used to control the discharge of water from the lateral to the plants & placed at about 0.5m to 1m.

- They are usually spaced more than 1 metre apart with one or more emitter used for a single plant such as a tree.

- Discharging of water at a slow rate of 2–10 L/Hr.
  - Used for small nursery orchards & Garden.

Types of Emitters:-

(a) porous pipe

(b) Multi - outlet distributors

(c) Sub lateral loop.

- Merits:-

(i) Saves 40-70% water

ii) Minimum loss of water

iii) No soil erosion

iv) field levelling is not necessary.

De Merits: -

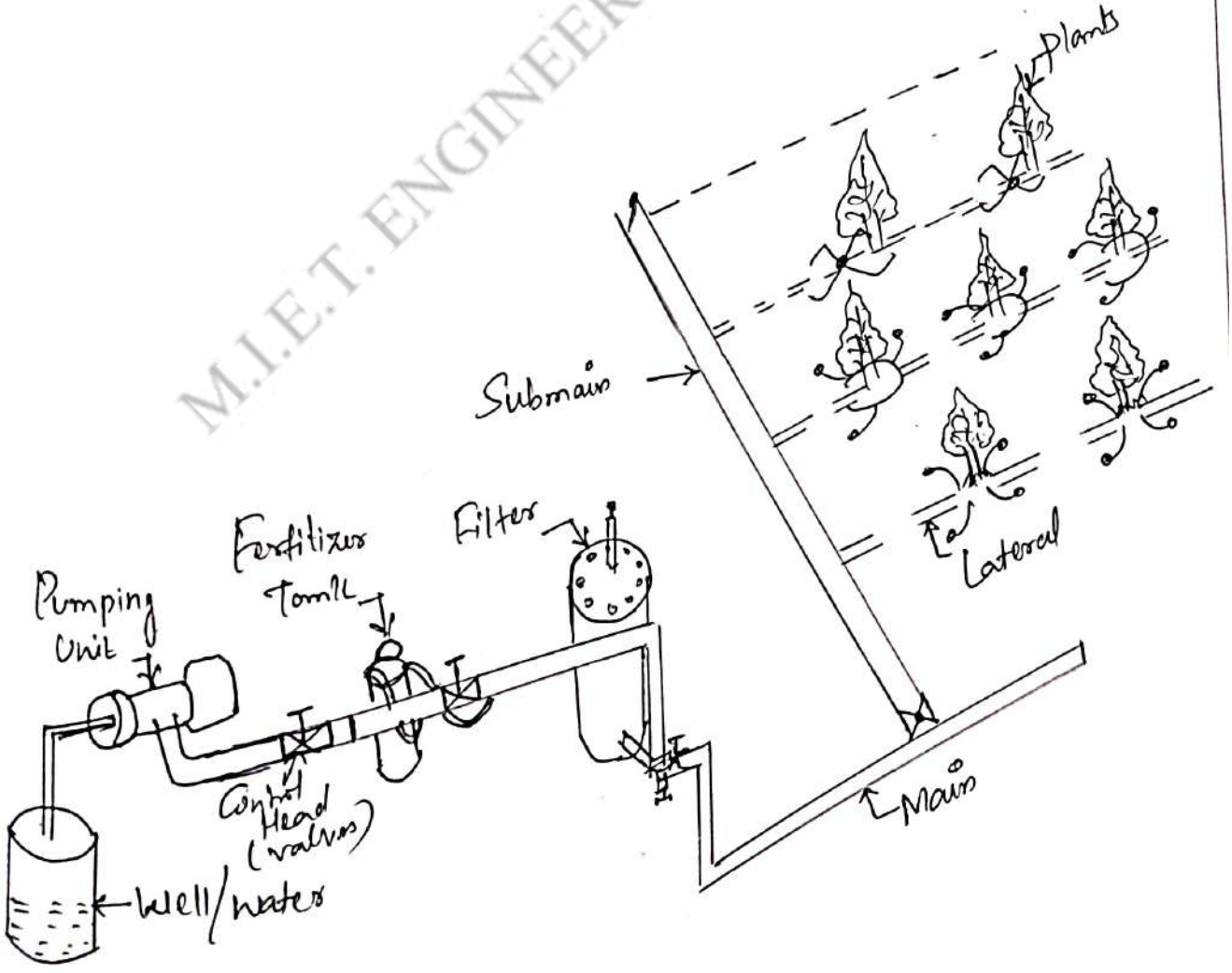
(i) High Initial Cost

ii) Dippers are susceptible to blockade.

iii) High skill is required for design.

iv) The sun can affect the tubes used for drip Irrigation

v) Root growth is sometimes inhibited because only a part of soil is wetted.



be covered	- water application efficiency - water conveyance efficiency - water storage & water distribution efficiency - water use efficiency

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
Lo1	determine the Irrigation efficiency of agricultural land.	Understand

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Irrigation Efficiencies -

. Efficiency is ratio of the water output to the water input and is expressed as %.

Input minus output is nothing but losses.

If losses are more, output is less & therefore efficiency is less.

- **Water Conveyance efficiency (η_c)**

It is a measure of efficiency of water conveyance system from canal network to field channels. It is the ratio of amount of water delivered into the field s to the amount of water diverted into the canal system from the river.

$$\eta_c = \frac{W_f}{W_r} \times 100$$

W_f - Amount of water delivered into the field

W_r = Amount of water diverted from diversion

- **Water Application Efficiency (η_a)**

It is measuring efficiency of water application in the field. It is the ratio of amount of water stored in the root zone of the crops to the amount of water actually delivered into the field.

$$\eta_a = \frac{W_s}{W_f} \times 100$$

W_s - Amount of water stored in root zone

W_f - Amount of water delivered into the field.

Water Use efficiency :-

- It is a Measure of efficiency of water use.
- It is the ratio of amount of water beneficially used to the amount of water delivered into the field.

$$\eta_u = \frac{W_{used}}{W_{field}} \times 100$$

Where

η_u = Water use efficiency

W_u = Amount of water used

W_f = Amount of water delivered into the field.

Water Storage efficiency :-

- It is the ratio of Amount of water stored in the root zone during Irrigation to the amount of water needed in the root zone prior to Irrigation.
- It is obtained by the expression

$$\eta_s = \frac{W_s}{W_n} \times 100$$

Where

η_s = Water storage efficiency

W_s = Amount of water stored in the root zone

W_n = Amount of water needed in the root zone prior to Irrigation.

- Water distribution efficiency :-

The water distribution efficiency represents the extent to which the water is uniformly distributed.

It is obtained by the expression

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

Where

η_d = Water distribution efficiency

D = Avg. Depth of water stored during Irrigation.

d = Avg of the absolute values of deviations from the mean.

1. 10 Cumec of water is delivered to a 30 Hectare field, for 5 Hours. Soil testing after the irrigation indicates that 0.3m of water has been stored in the root zone. Compute water application efficiency.

Given:-

Amount of water delivered to field = 10 Cumec

Duration of water applied = 5 Hrs

Area of field = 30 Hectares

Depth of water stored in the root zone } = 0.3m.

Solution:-

Volume of water supplied by 10 Cumec of water applied for 5 Hours.

$= 10 \times 5 \times 60 \times 60$

$= 1,80,000 m^3$

$= 18 \times 10^4 m^3 = 18m \times 10^4 m^2$

$= 18$ hectare Metre. $\left[\because 10^4 m^2 = 1 \text{ Hectare}\right]$

∴ Input = Amount of water delivered into field

= 18 Ha.Metre

Output = Amount of water stored in the root zone

= 30 hectares field is storing water upto 0.3m depth.

= 30 × 0.3

= 9 ha.metre.

- Water application efficiency (η_a)

$$= \frac{\text{Output}}{\text{Input}} \times 100$$

$$= \frac{\text{Amount of water stored in root zone}}{\text{Amount of water delivered into field}} \times 100$$

$$= \frac{9}{18} \times 100 \qquad = 50\%$$

Result:-

$$\eta_a = 50\%$$

Lecture No. 18 - Irrigation Efficiency (Problem)

Topic(s) to be covered	problem - Irrigation efficiency determination in the agricultural field.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Apply solve Irrigation efficiency problems.	Apply.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

Problem.

1. A Stream of 130 L/sec was diverted from a Canal & 100 L/sec were delivered to the fields. An Area of 1.6 Hectare was delivered Irrigated in 8 Hours. Effective depth of Root Zone was 1.7m. The depth of water penetration varied linearly from 1.7m at the Head end of the field to 1.1m at the tail end. Available Moisture Holding Capacity of the soil is 20cm/metre depth of soil. Irrigation was started at a Moisture extraction level of 50% of the available Moisture. Take Runoff loss in the field was 42m^3. Determine 1. Water Conveyance efficiency 2. Water Application efficiency 3. Water storage 4. Water Distribution efficiency.

Solution:-

1. Water Conveyance Efficiency (η_c)

$$= \frac{\text{Water Delievered to the field}}{\text{Water Supplied into the Canal at the Head}} \times 100$$

$$= \frac{100 (l/s)}{130 (l/s)} \times 100$$

$$= 77\%$$

2. Water Application Efficiency

$$= \frac{\text{Water Stored in the Root Zone during Irrigation.}}{\text{Water Delievered to the field.}} \times 100$$

i) Water Supplied to the field during 8 Hours at 100 l/sec

$$= 100 \text{ (l/sec)} \times 8 \times 60 \times 60 \text{ (sec)} = 2880000 \text{ l}$$

$$= 2880 \text{ m}^3$$

ii) Runoff loss in the field = 420 m^3 (Given)

∴ The water stored in the Root Zone = $2880 - 420$

$$= 2460 \text{ m}^3$$

∴ Water Application Efficiency = $\frac{2460}{2880} \times 100$

$$= 85.4\%$$

3. Water Storage Efficiency

= Water Stored in the root zone during Irrigation.

Water Needed in Root Zone prior to Irrigation

- Moisture Holding Capacity of soil = $\frac{20\text{cm}}{\text{Moisture depth}} \times 1.7\text{m Depth of root Zone.}$ (Effective)

∴ for 1.7m depth moisture holding capacity =

$= 20 \times 1.7$

$= 34\text{ cm}.$

- Moisture Already available in the root zone at the time of start of Irrigation } = $\frac{50}{100} \times 34$ (50% of available moisture (Given))

$= 17\text{cm}.$

- Actual Storage in root zone = 246m^3.

- Additional Water required in Root Zone

$= 34 - 17$

$= 17\text{cm (Depth)}$ or $0.17\text{m}.$

- Water Needed in Root Zone prior to Irrigation

$= \frac{17}{100}\text{ (m)} \times (1.6 \times 10^4)\text{ (m}^2\text{)}$ (plot Area)

Note:
plot Area = 1.6 Hectare.
$1.6 \times 10^4\text{m}^2$

$= 2720 m^3$

- Water storage efficiency $\eta_s = \frac{2460}{2720} \times 100$

$$\boxed{\eta_s = 90\%}$$

4. Water Distribution $\eta = 1 - \frac{d}{D}$

i) D = Mean Depth of water stored in root zone
(Head) (Tail)

$$D = \frac{1.7 + 1.1}{2} = 1.4m.$$

ii) d = Average Absolute value of deviation from Mean

a) - Deviation from the Mean at upper end (Absolute Value)

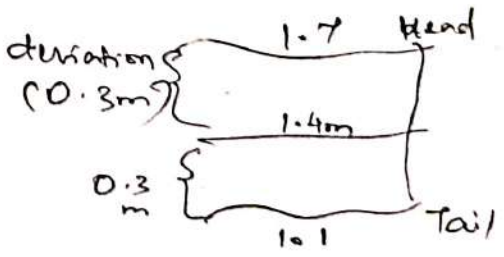
$= |1.7 - 1.4|$

$= 0.3$

b) - Deviation from the Mean at lower end

$= |1.1 - 1.4|$

$= 0.3$



$$d = \frac{0.3 + 0.3}{2} = 0.3$$

$$\eta = 1 - \frac{d}{D} \times 100$$

$$\eta = 1 - \frac{0.30}{1.4} = 0.786 \times 100$$

$$\boxed{\eta = 78.6\%}$$

Lecture No. 19 Unit-II.

DIVERSION & IMPOUNDING STRUCTURES

Topic(s) to be covered	Types of Impounding structures - site selection for a dam. - Types of Dams.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Understand what is Impounding structure & its types.	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

- Types of Impounding Structures:-

1. Impounding Structures:-
   - Are Man made Hydraulic structures
   - Constructed to store water for the purpose of long time, diversion for Irrigation.
   - eg- Dams, Weirs & Barrages.

- **Dam:-**
  - A Dam is an obstruction or a Barrier built across a stream or river.
  - The pond of water which is formed on the U/s side is called Reservoir.

- **Weir & Barrage:-**
  - Are also Impervious barriers across the river
  - Suitable in plain terrain
  - Purpose of weir is only to raise the water level to some desired height.
  - Purpose of Barrage is to adjust the water level at different levels when required.

- **Selection of site for a Dam:-**
  - Width of the River is minimum
  - Impervious Stratum at reasonable depth
  - Adequate Catchment area.
  - To be Constructed on a High ground.

- Materials available easily
- Silting is minimum
- Suitable for locating spillways.
- Easy diversion of river water

- Classification or Types of Dams:

I. Based on purpose or Function.

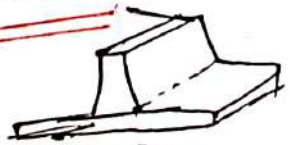
a) Storage Dam
b) Detention Dam
c) Diversion Dam
d) Coffer Dam.

II. Based on Hydraulic Design.

a) Over flow Dam
b) Non Over flow Dam.

III. Based on Structural behaviour.

a) Gravity Dam
b) Arch Dam
c) Buttress Dam



1. Storage Dam:-

It is Constructed to Create a Reservoir to store water in the Reservoir is used for Irrigation, power generation etc.

2. Detention Dam:-

It is primarily Constructed to temporarily detain all or part of the flood water in a river & to gradually release the stored water later at Controlled rate. so that the entire region on the d/s side of the dam is protected from floods.

3. Diversion Dam:-

It is Constructed to divert part of or all the water from a river into a Conduit.

4. Cofferdam:-

. It is a temporary dam Constructed to exclude water from a specific area.

. It is Constructed on the U/s side of the site where a dam is to be Constructed so that the site is dry. In this case, it behaves like a diversion Dam.

5. Over fall Dam:-

It is constructed with a crest to permit overflow of surplus weir that cannot be retained in the reservoir. Diversion weirs of small height may be designed to permit overflow over its entire length.

6. Non. Over flow Dam:-

. It is constructed such that water is not allowed to overflow over its crests.

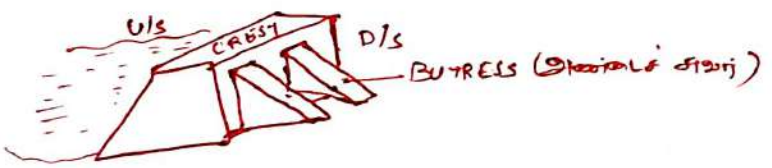
. In most cases dams are so designed that part of its length is designed as an overflow dam & rest of its length is designed as a non overflow dam.

7. Arch Dam:-

It is a curved masonry / concrete dam convex u/s, which resist the forces acting on it by arch action.

8. Buttress Dam:-

It consists of water outlaining sloping membrane which is supported by a series of buttresses. Buttress are in the form of equally spaced triangular masonry or reinforced concrete walls or counterforts.



Lecture No. 20. GRAVITY DAM.

Topic(s) to be covered	Definition - Requirement - Merits & Demerits - Working principle - C/s details of gravity dam.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
Lo_1	gain knowledge on Gravity dam	Understand
Lo_2	Understand forces acting on gravity dam	〃

Teaching Learning Material	Student Activity
Chalk / Talk	Listen.

Lecture Notes

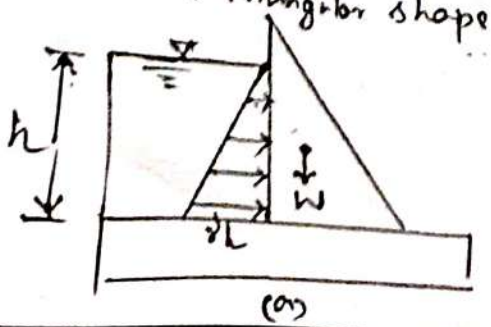
- Definition:-

A Gravity Dam is a Dam Constructed from Concrete / stone Masonry & Designed to hold back water by primarily utilizing the weight of the material alone to resist the Horizontal pressure of water pushing against it.

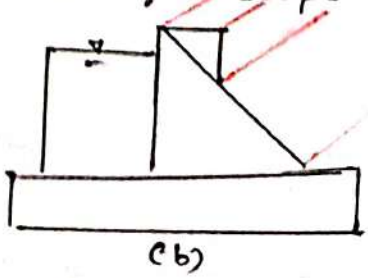
Working Principle:-

- Gravity Dams generally require stiff rock foundations
- The Bearing strength of the foundation limits the allowable position of the resultant which influences the overall stability.
- Dams Constructed out of Masonry or Concrete which rely solely on its self weight for stability fall under the nomenclature of gravity Dams.
- Coursed Rubble Masonry was used which was bonded together by lime Concrete / Cement Concrete.
- Masonry Dam is no longer being designed in our Country.
- Gravity Dams are now being built of mass Concrete.
- The basic shape of a Concrete gravity dam is triangular in Section, with a top Crest often widened to provide a roadway as shown in figure.

• Triangular shape.



• Modified Shape



The Increasing width of the section towards the base is logical since the water pressure also Increases linearly with depth as shown in fig.

In the figure

h - is assumed as the depth of water

γh - is the pressure at base

γ - is the Unit weight of water ($9810 N/m^3$)

W - is the weight of Dam body.

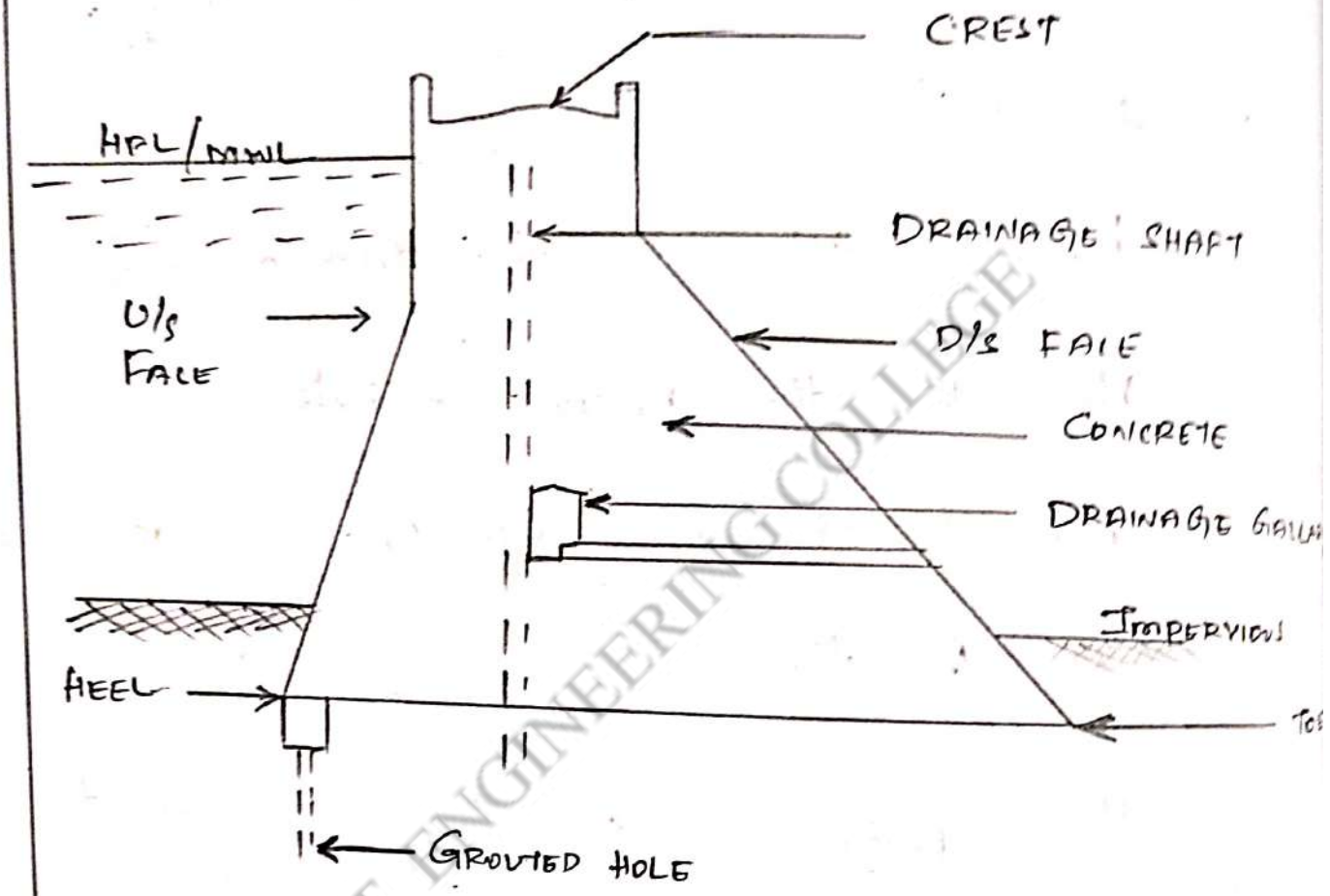
The Top portion of the Dam is widened to provide space for Vehicle movement.

- **Merits:-**
  1. They Can tolerate minor over topping flows as the Concrete is resistant to scouring.
  2. This reduces the size of spillway.

- **Demerits:-**
  1. They are susceptible to uplift pressure. which act as a distabilising force.

Cross sectional details of gravity Dam.

Fig shows the C/s details of gravity Dam.



U/s : Side on which water is retained.

D/s : Side on which water is released

Heel : U/s end of base of the dam.

Toe : D/s end of the base of the dam.

Crest : Top surface of the Dam

Galleries : Small room like structures left within dam for Checking operations.

Lecture No. 32 SPILL WAY

Topic(s) to be covered	Definition - Components of spillway - Types of spill way - Straight Drop - Chute - Ogee - Tunnel spillway.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	. Understand the need & necessity & types of spillways.	Understand

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

• SPILL WAY :-

- A spillway is the overflow portion of Dam over which surplus discharge flows from the reservoir to the down stream side.
- It is designed to carry this flood water not required to be stored in the reservoir, safely to the river lower dam.

- Components of Spillway :-
  1. Control Structure
  2. Conveyance Structure
  3. Terminal Structure
  4. Entrance & exit Channel.

- Control structure :-
  - It regulates and Controls the outflow from reservoir.
  - Located at the U/s end of the spillway.
  - It consists of Orifice or overflow Crest.

- Conveyance Structure :-
  - The outflow released through the Control structure is Conveyed to the d/s river channel through a discharge channel
  - Located at d/s end of the dam.

- Entrance & exit Channel :-
  - Entrance Channel :-
    It Conveys water from the reservoir to the Control structure.

- Exit Channel Conveys flow from the terminal structure to the Stream Channel d/s of dam.

Types of Spillway:-

(i) Straight Drop Spillway (Free Fall)
(ii) Ogee (Overflow) Spillway
(iii) Chute spill way (open channel)
(iv) Shaft spillway
(v) Tunnel spill way.
(vi) Side Channel spillway.

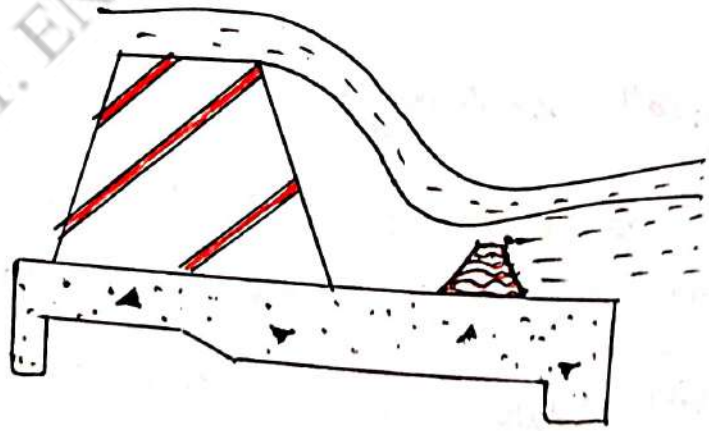
a) Free Overfall spillway:-

(i) Simplest type of spillway
(ii) Constructed in the form of a low height weir.
(iii) Water Drops freely from the crest of a free Overfall spillway.
(iv) At times, the crest is extended in the form of an overhanging lip.

(a) with out d/s portion

(b) overhanging lip.

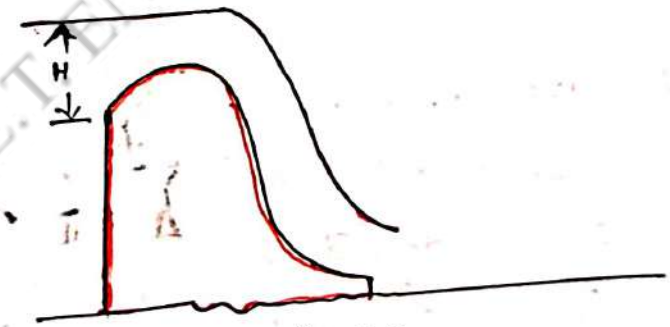
- The flowing water usually drops into the stream bed, objectionable scour may occur.
- In some cases a deep plunge pool may be formed.
- If erosion can't be tolerated, plunge pool is created by constructing an auxillary dam down stream of the Main Dam.



(c) Spill way Downstream protection work.

- Ogee Spillway:-
  - Most common type of spillway provided on gravity Dam.

- The overflowing water is guided smoothly over the Crest so that it doesn't break Contact with spillway Surface.
- A smooth gradual reverse curvature on the d/s face of the spillway is provided.
- This reverse Curve turns the flow on the Apron of a stilling basin or into the spillway discharge Channel.

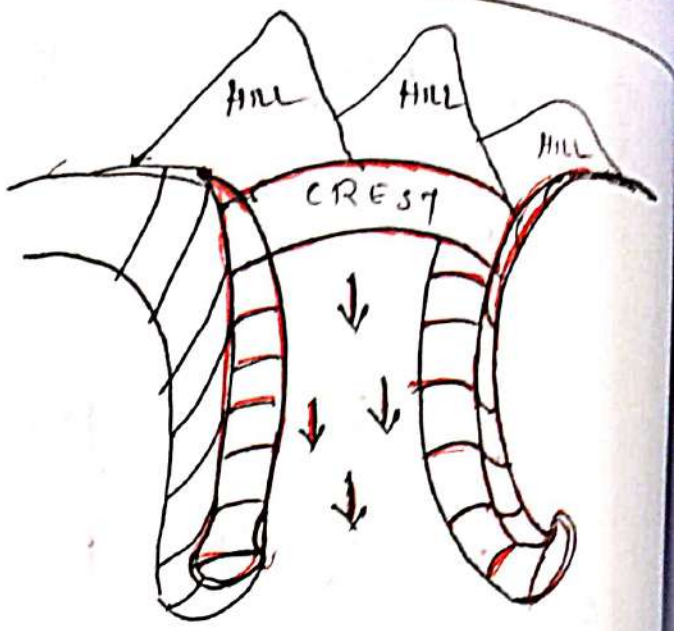


. ogee spill way.

• TROUGH SPILLWAY:-

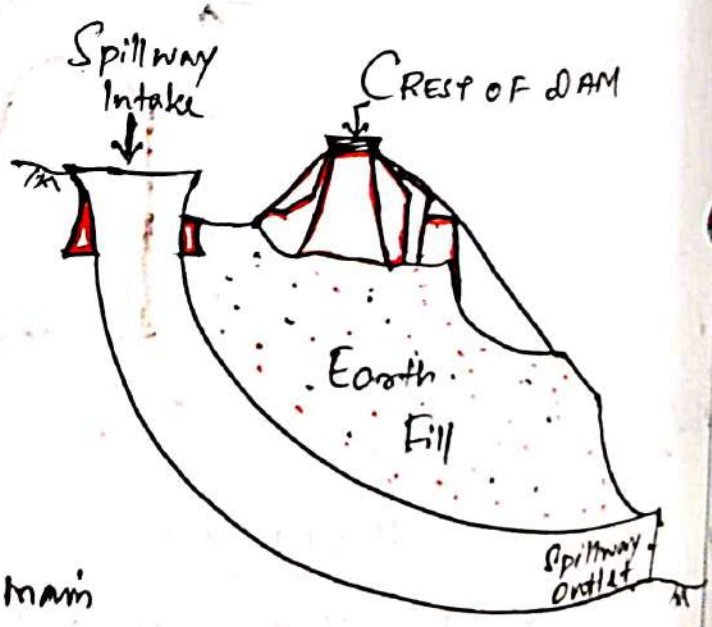
- A Chute spillway passes the surplus discharge through a steep sloped open Channel, called trough, placed either along a dam through a saddle.
- It is provided on Earth / rock fill dam.

- It Crest is kept normal to its Centre line.
- It Consists of discharge Channel to the river in an excavated Trench.
- It is suitable for Concrete dams Constructed in a narrow Valley across a river.



SCHEMATIC VIEW

- Shaft spillway:-
  - In a shaft spillway Water enters a Horizontal Crest drop through a Vertical shaft and then flows to the down Stream River Channel through a Horizontal Conduit.



  - In a shaft spillway, main Components are
    a) Overflow Control weir
    b) Vertical Control
    c) Closed discharge Channel.
  - Small spillway may be Constructed either Metal/Concrete pipe
  - Large Spillway made up of R.C.C.

Lecture No. 23 Forces acting on Concrete Gravity Dam

Topic(s) to be covered	Design of Concrete gravity dam – Forces – Dead load – Water pressure – Uplift pressure – Silt pressure – Seismic forces – Wave pressure.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO_1	Understand the various forces acting on Concrete gravity dam.	Understand

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

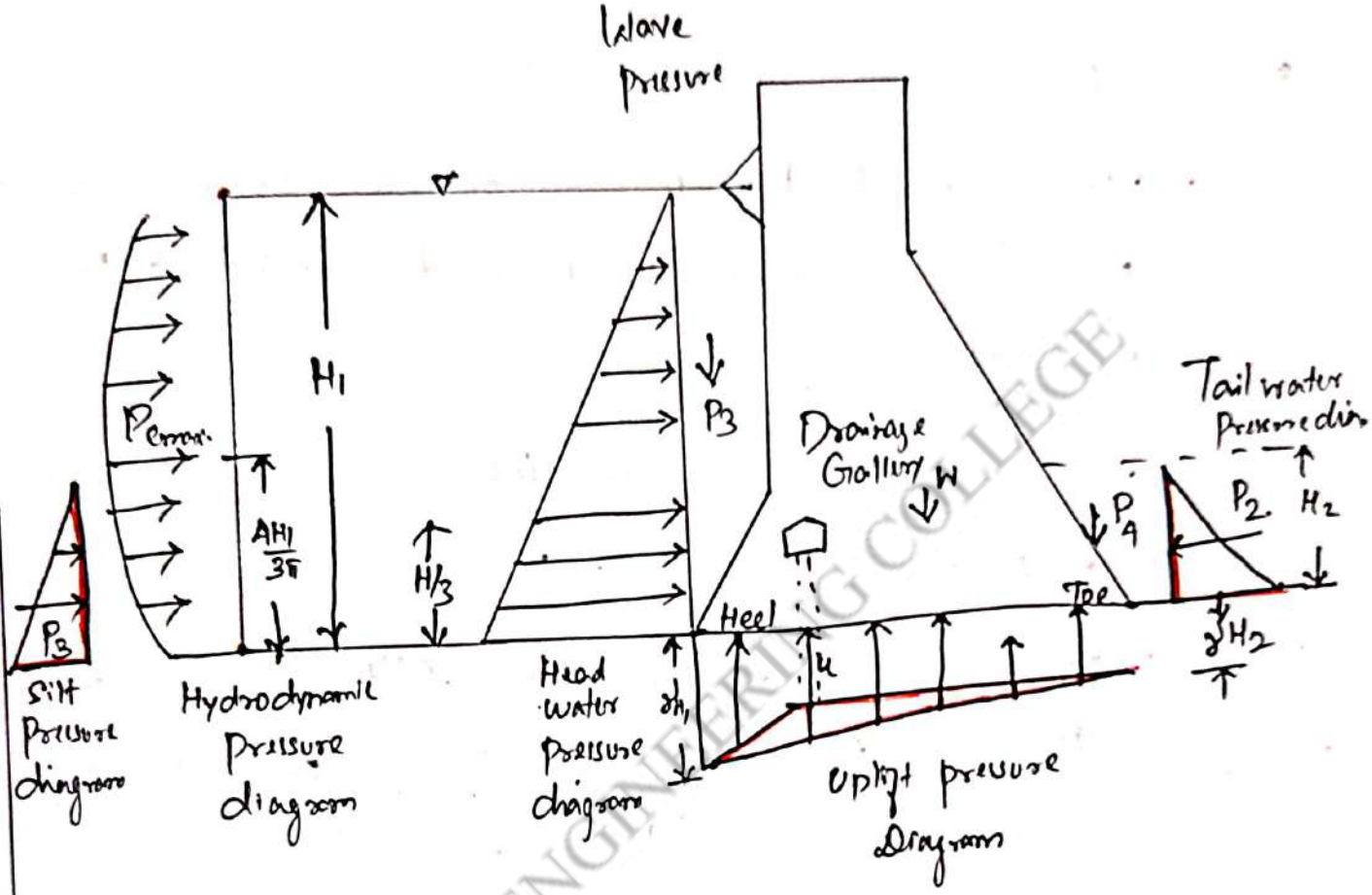
Lecture Notes

- **Loading (or) Forces acting for Concrete gravity Dam**

The significant loadings on a Concrete gravity dam include the dead weight of the dam, the water pressure from the reservoir, & the uplift Pressure from foundation.

- **Dead load:-**
  - It Comprises of the weight of the Concrete Structure of the dam body. Density of Concrete may be Considered as 2400 kg/m^3.
  - The Analysis of Dam may be Carried out by dividing the section into Several triangles & rectangles
  - The moment of the dead load required for Calculating stresses, the moments due to the respective Sub parts may be Calculated Individually & then Summed up.

- **Water pressure on Dam:-**
  - Force due to Hydrostatic water Pressure is the major external force on a gravity Dam.
  - The Intensity of pressure from Zero at the water surface to the maximum at the base. (Δ'le)
  - P_1 & P_2 are due to Hydrostatic pressure acting on U/s & D/s.
  - P_3 & P_4 are the weight of water held over the Inclined faces of the dam on U/s slope & D/s slope respectively



FORCES ON GRAVITY DAM

- Uplift pressure! —

Water that seeps through the pores, cracks, & fissures of the foundation material & water that seeps through the body of the dam to the bottom through the joints b/n the body of the dam & the foundation at the base, exert an uplift pressure on the base of the dam.

- According to U.S. Bureau of Reclamation, the uplift pressure intensities at the heel & the toe are

- **Silt pressure:-**

  - The weight & the pressure of the submerged silt are to be considered in addition to weight & pressure of waters.

  - The weight of silt acts vertically on the slope & pressure horizontally.

  - The submerged density of silt for calculating Horizontal pressure 1360 kg/m³. for calculating Vertical force 1925 kg/m³.

$P_{silt} = \frac{1}{2} \gamma_s h_s^2 K_a$ acting at $\frac{h_s}{3}$ from base.

K_a = Coefficient of Active Earth pressure of silt

$$K_a = \frac{1 - \sin\phi}{1 + \sin\phi}$$

γ_s = Submerged unit weight of silt

ϕ = Angle of internal friction of soil.

- **Earthquake forces:-**

- The Earth quake is associated with Complex Oscillating pattern of acceleration & ground motions, which Generate transient dynamic loads due to inertia of the dam & the retained body of water.

- It is usually designated as a fraction of the acceleration due to gravity & is expressed as $\sigma.g$, where

σ is the Seismic Coefficient.

- Horizontal Acceleration (α_h) is $0.1g - 0.2g$
- Vertical Acceleration α_v is $0.1g$

Hydrodynamic force assumed to be parabolic $M_c = P_e * (2H_1/3)$

Vertical Acceleration α_v exerts a downward force on the dam which is given by

$$\frac{W}{g}\alpha_v$$

Hence,

The Net effective weight of the Dam

$$W_f = W - \frac{W}{g}(\alpha_v)$$

- **Wave Pressure** -

- Waves are generated on the reservoir surface because of the wind blowing over it.
- Wave height calculated from D.F method

a) For $F < 32$ km

$$h_w = 0.032 \sqrt{V.F} + 0.763 - 0.271 \sqrt[4]{F}$$

b) For $F > 32$ km

$$h_w = 0.032 \sqrt{V.F}$$

h_w - height of wave

V - wind velocity

- Pressure intensity due to wave is given by

$$P_w = 2.4 \gamma h_w \ (t/m^2)$$

Total force due to the wave pressure P_w is given by

$$P_w = \frac{1}{2} \times 2.4 h_w \times \frac{5}{3} h_w = 2 \gamma h_w^2 \ (t/m)$$

and this act at a distance of $(3/8)^{th} h_w$ above the reservoir surface.

Lecture No. 24 Failure & Profile of Dams

Topic(s) to be covered	Causes of failure of dam - Precaution against failure of Dam - Elementary profile of the Gravity dam.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
CO1	Gain knowledge on failure of dam & how to prevent it	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listening.

Lecture Notes

- Causes of failure of Gravity Dams:-

1. By Over Turning
2. By sliding
3. By Overstressing
4. By Cracking.

- Over Turning:-
  - The solid gravity dam may fail by over turning at its toe when the total Horizontal forces acting on dam are greater than the total Vertical forces.
  - The overturning caused at d/s edge of horizontal section.
- Sliding:-
  - The total Horizontal forces acting on a dam tend to slide the entire dam at its base
  - Sliding take place when the total Horizontal forces are greater than Shearing resistance of the joint & the static friction.
- Over Stressing:-

  If the permissible working Compressive stress of Concrete exceeds due to adverse Condition Dam may fail by Crushing due to overstress of Concrete / masonry.
- Cracking:-

  If Tension is developed in the dam section Crack will form in the body of the dam & Ultimately this will Cause failure of the dam.

• Precaution against failure of Gravity Dams.

1. To avoid overturning, the resultant of all forces acting on the dam should remain within the middle third of the base width of the dam.

2. In the dam, the sliding should be fully resisted When the Condition for no sliding exists in the dam Section.

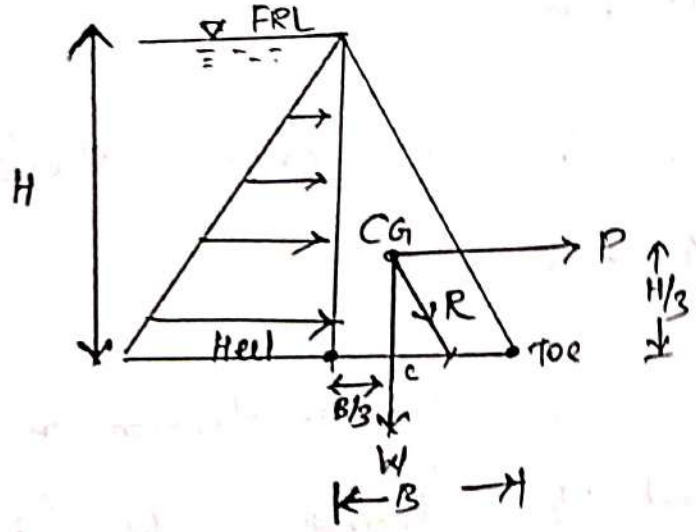
$$\tan\phi = P/W \text{ (or) } \tan\phi < 1/\mu$$

3. In the dam section, the Compressive Stresses of Masonry or Concrete should not exceed the permissible working Stresses to avoid failure due to Crushing.

4. The factor of sagety should be taken to 4 to 5.

5. There should be no tension in the dam section to avoid the formation of Cracks.

- Elementary profile of the Gravity Dam.
  - When the water is stored against any Vertical face, then it exerts pressure perpendicular to
  - The pressure is Zero at top & maximum at the
  - Thickness required at top is Zero & bottom - m thickness
  - Let H be the Height of water stored
  - Let B Base width of dam
  - Resultant force should remain within the middle third



Elementary Profile.

When Full : When the reservoir is full, the resultant F should pass through the point D, the extreme rigid end of middle third.

For Stability, Base width B is to be determined in terms of H.

Taking moment about D

$$W \times \frac{B}{3} = P \times \frac{H}{3}$$

$$\frac{W}{P} = \frac{H}{B}$$

WKT

$$P = \frac{1}{2} \gamma_w H^2$$

$$W = \gamma_{max} \times \frac{1}{2} BH$$

$$\frac{W}{P} = \frac{\gamma_{max}}{\gamma_w} \times \frac{B}{H} \quad (\text{or}) \quad \frac{W}{P} = \text{Specific gravity of material of Dam} \times \frac{B}{H}$$

Substitute the above value W/P,

$$\frac{H}{B} = \text{Sp.gr} \times \frac{B}{H} = \text{Sp.gr} \times B^2 = H^2$$

$$B^2 = \frac{H^2}{\text{sp.gravity}}$$

$$B = \frac{H}{\sqrt{\text{sp.gravity of material}}}.$$

So to keep the resultant force in the middle in the Base width B should be equal to $\frac{H}{\sqrt{\text{Sp.gr.of material}}}$.

Thus elementary profile of a gravity dam is a right angle triangle with base width equal to $H/\sqrt{\text{sp.gr. material}}$

Lecture No. 26. Diversion Head Works.

Topic(s) to be covered	Diversion Head work - Objectives - site selection - Components - Weir - Barrage. - Difference between weir and Barrage.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	**Bloom's Level**
LO1	Gain knowledge on Diversion Head Works.	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

- **Diversion Head work:-**

The Works, which are Constructed at the Head of the Canal Inorder to divert the River water ~~from~~ towards the Canal. are known as diversion Head works.

- **Objectives:-**

1. To raise the water level at the Head of the Canal.
2. to form a storage by Constructing dykes or embankment on both the banks of the river to that water is available throughout the years.
3. to Control the entry of silt into the Canal
4. To Control the fluctuation of water level in the river during different seasons.

- **Site Selection:-**

1. The River should be straight & Narrow
2. The River Banks should be well defined.
2. The elevation of the site should be much higher than the area to be irrigated.
4. The site should be easily accessible by roads or railways.
5. The Material of Construction should be available in vicinity of the site.

- Components of a Diversion Head works.

(a) Weir

(b) Barrage

(c) Under Sluices (or) Scouring Sluices.

(d) Divide wall

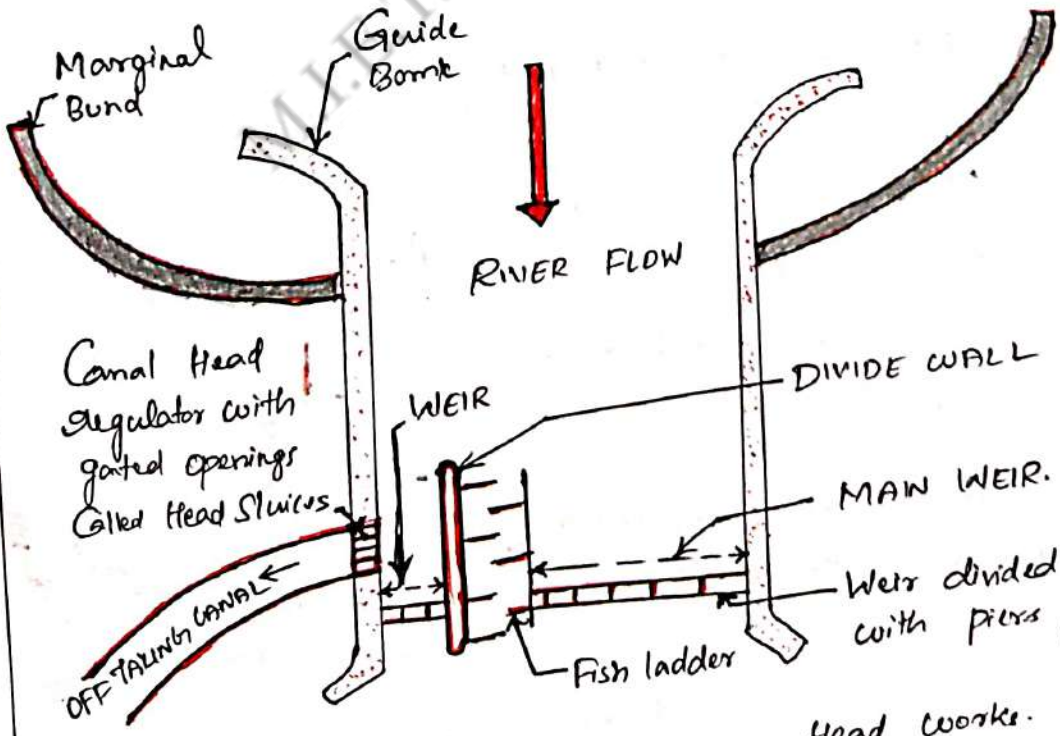
(e) Fish ladder

(f) Canal Head Regulator

(g) River Training works.

(h) Shutters & Gates

(i) Silt Regulation works.

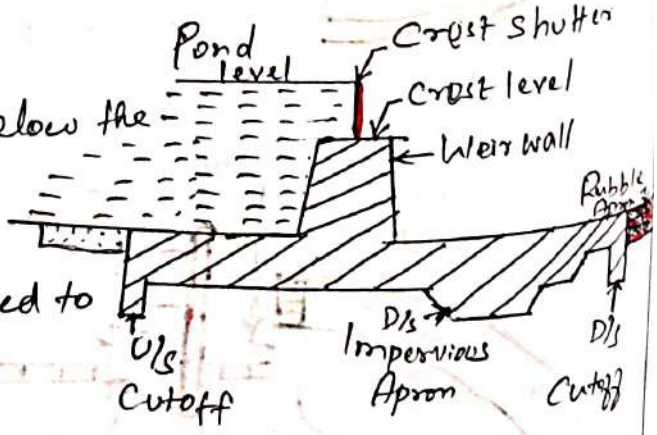


• Layout of Diversion Head works.

- **Weir :-**
  - It is a Barrier Constructed across the river to raise the water level on the U/s of the obstruction inorder to feed the main Canal.
  - The Major part of entire ponding of water is achieved by a raised Crest.

- **Types of Weir :-**
  (a) Masonry weir with Vertical drop
  (b) Rock fill weirs with sloping Aprons
  (c) Concrete weir with sloping glacis.

- **Masonry weir :-**
  - Masonry weir wall is Constructed over the Impervious floor.
  - Cut off Walls are provided at the both ends of the floor
  - Sheet piles are provided below the Cut off walls.
  - Crest shutters are provided to raise the water level.



Masonry Weir.

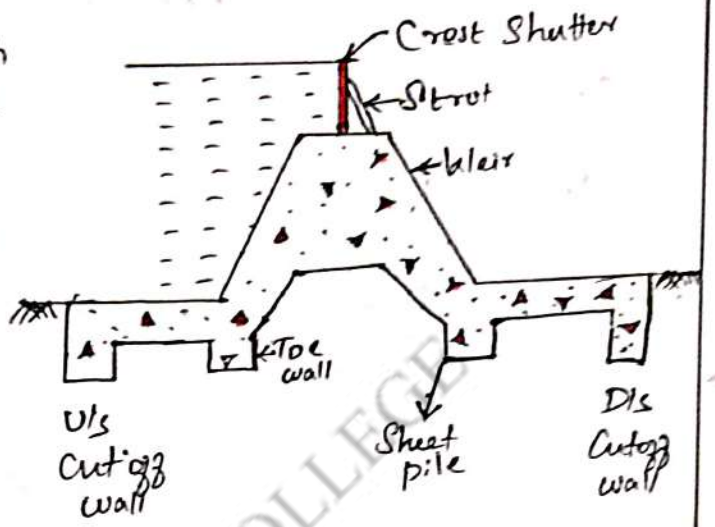
- **Concrete weir:-**

. Weir is Constructed with R.C.C. The Impervious floor & the weir are made monolithic.

. Cut off walls are provided at the U/s & D/s end of the floor and at the toe of the weir.

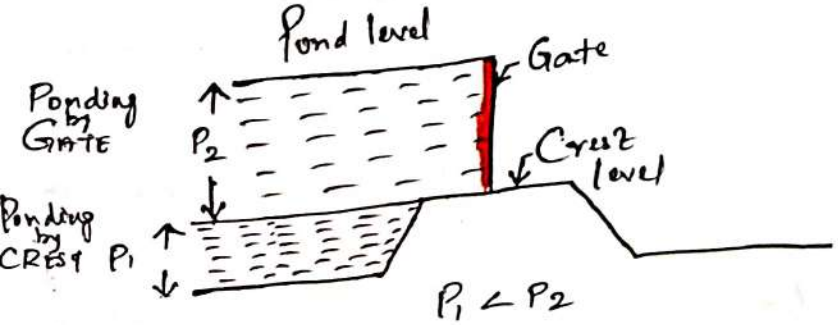
. Sheet piles are provided below the Cutoff walls.

. Crest shutters are provided

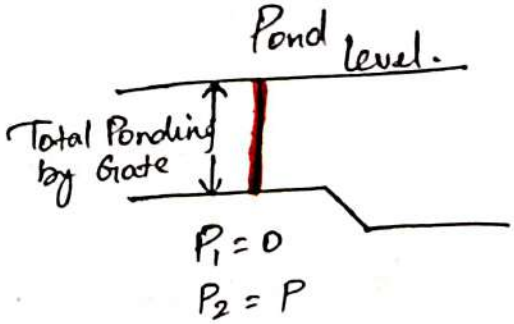


- **Barrage:-**

- If Most of the ponding is done by gates and a smaller or nil part of its done by the raised crest then the barrier is known as a barrage or river regulator.



(a) Barrage with a small raised Crest



(b) Barrage without any raised Crest.

- Difference between Barrage and Weir.

S.NO	Barrage	Weir.
1.	Low Set Crest	High Set Crest
2.	Ponding is done by means of Gates.	Ponding is done against Raised Crest by Shutters
3.	Gated over entire length	Shutters in Part length.
4.	Gates are of greater Height.	Shutters are of Smaller Height, 2m.
5.	Perfect Control on river flow	No Control of river in low floods.
6.	Gates Convenient to operate	operation of Shutters is slow
7.	Longer Construction period	Shorter Construction per
8.	Road and/or Rail bridge Can be	Not possible to provide Road-rail Constructed at low Cost bridge.
9.	Costly structure	Relatively Cheaper Struct
10.	Silt removal is done through Under	NO means for silt disposa sluices.

Lecture No. 27, Diversion Head work.

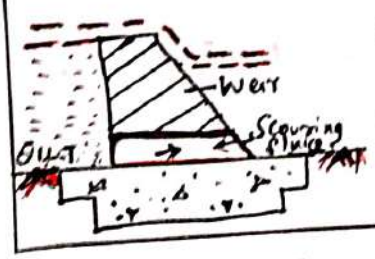
Topic(s) to be covered	Under sluice - Divide wall - Fish ladder - Canal Head regulator - River Training works.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
LO_1	Understand the Various components & its working principle for diversion Head work.	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

- Under sluice:-
  - Are openings provided at the base of weir
  - These openings are provided with adjustable gates.
  - The Crest of sluice portion of weir is kept at a lower level than the Crest of normal portion of a weir.



- The suspended silt goes on depositing in front of the Canal Head regulator.

- The functions of Under sluice are

(i) To maintain well defined deep channel approaching the Canal Head regulator.

(ii) To ensure easy diversion of water into the Canal

(iii) To Control the entry of Silt into the Canal.

- **The Divide Wall:-**

- Is a Masonry / Concrete wall Constructed at right angle to the axis of the weir.

- The Divide wall extends on the U/s side beyond the beginning of the Canal Head regulator.

- The divide wall is a long wall constructed with Stone masonry / Concrete.

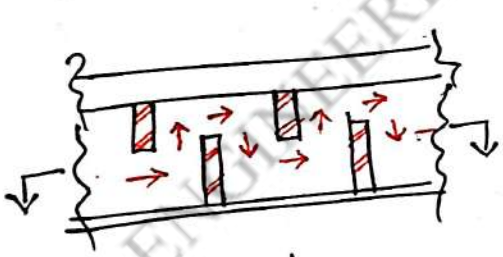
- **Functions:-**

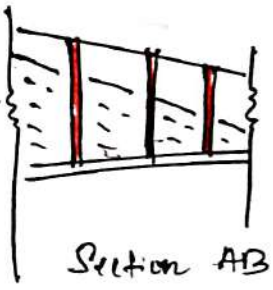
(i) It separates the Under sluices with lower crest level from the 'weir proper' with higher crest level

(ii) It helps to keep Cross. Current, if any, away from the weir.

(iii) It separates the turbulent flood waters from the pocket in front of the Canal Head.

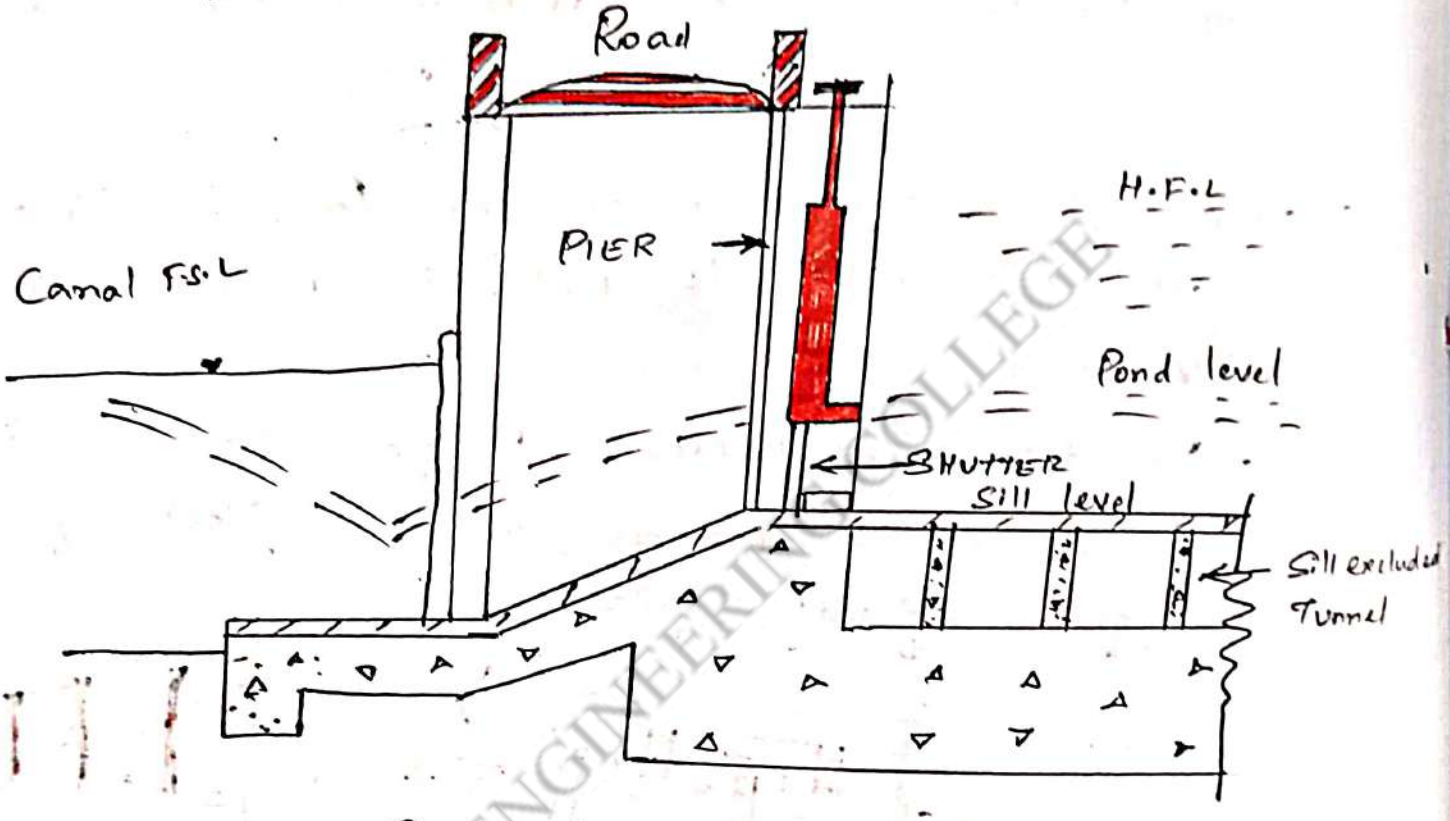
- **Fish ladder:-**
  - It is provided just by the side of the divide wall for the free movement of fishes.
  - The tendency of fish is to move from U/s to d/s in winter & D/s to U/s in Monsoon.
  - Due to Construction of weir / Barrage, this Movement gets obstructed. In order to prevent it fish ladder is Essential.
  - In the fish ladder, Baffle walls are Constructed in a Zig Zag manner so, the Velocity of flow doesn't exceed 3m/sec.





- **Canal Head Regulator:-**
  - A Structure which is Constructed at the Head of the Canal to regulate flow of water is known as Canal Head Regulator.
  - It Consists of No. of. piers which divide the total width of Canal into a no. of. Span which are known as Bay.
  - A pier Consists of No. of. tiers on which the adjustable gates are placed.

- Gates are operated from the top by suitable mechanical device.
- A platform is provided on the top of the pier

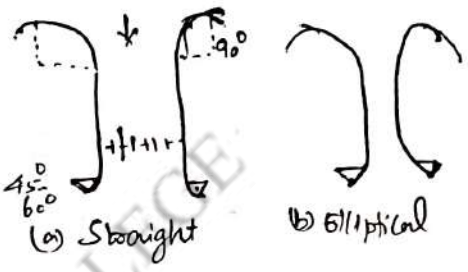


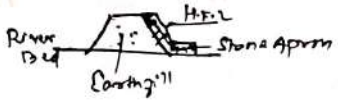
Canal Head Regulator.

- River training works:-
  - River training works are required near the weir site inorder to ensure a smooth and an axial flow of water, & thus to prevent the river from outflanking the works due to a change in its course.

The River Training works required on a Canal Head work are

(a) Guide Banks
(b) Marginal Bunds
(c) Spur or Groynes.

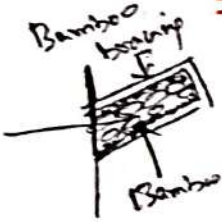




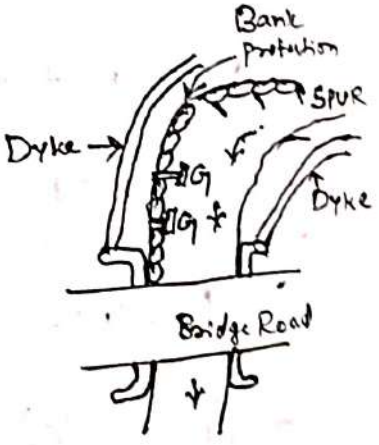
- **Guide Banks:-**
  - When a Barrage is Constructed across a river which flows through the alluvial soil, the guide banks must be Constructed on both the approaches to protect the Structure from Erosion.
  - It protect the barrage from the effect of Scouring & Erosion.
  - Guiding & Confining the flow in a reasonable water way at the site of Structure.
- **Marginal Bunds:-**
  - The Marginal bunds are (flood) a Earthern Embankment
  - Constructed parallel to the River bank
  - Top width is 3-4m
  - Side slope 1.5:1 to 2:1.
  - It retain the flood water or storage water within a specified section. (flood plain of the river)
  - They are not provided with stone pitching & fully Cover the back water length.

- **Spurs :-**
  - These are temporary structures permeable in nature
  - provided on the Curve of a river to protect the river bank from erosion.
  - These are projected ~~towards~~ from the river bank towards the bed making angles 60° to 75°. with the bank of the river.
  - The function of spur is to break the velocity of flow and to form a water pocket on the U/s side where the sediment gets deposited

Types of Spurs:-



1. Bamboo Spur
2. Timber Spur
3. Boulder Spur.



- **Groynes :-**
  - Are Impervious Structure (permanent) Constructed on the Curve of a river bank, Interrupting water flow & limiting the movement of sediment
  - The function of groynes is similar to that of spur.
  - Groynes are Constructed with rubble masonry in Trapezoidal section

Lecture No. 28 CANAL IRRIGATION.

Topic(s) to be covered	Introduction - Networks of Canal - Classification of Canals. - Nature of Source of supply - Functions - Discharge

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Gain knowledge on Networks & classification of Canals.	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listening.

Lecture Notes

Introduction:-

- A Direct Irrigation scheme & storage Irrigation scheme requires the Construction of a Network of Canals.

Canal:-

Canal is an Artificial channel trapezoidal c/s. Constructed on the ground to Carry water from a river to the fields.

- Water from a river is diverted to flow through a main Canal by Constructing diversion Headwork structures across the river.
- The Main Canal further divides into branches and distributaries from the distributaries is let Off through gated outlets into the fields with the help of a field channel.

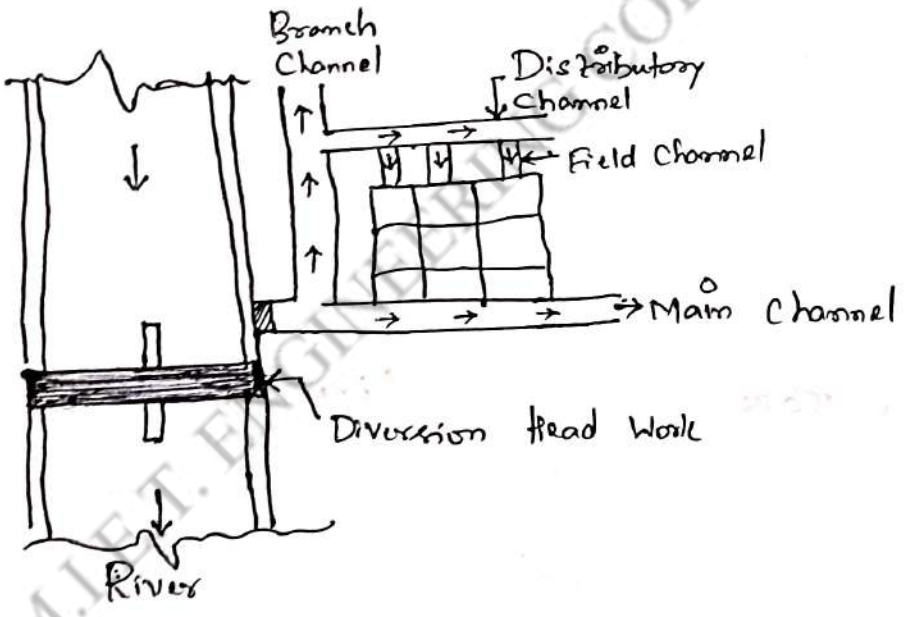


fig: Network of Canals.

Note:-

- Canal System has to be planned & designed for the maximum expected demand.
- Layout of Canal should ensure smooth flow by gravity in each Channel.

Classification of Canals:

Canals are classified based on different factors explained below.

1. Based on the Nature of Source of Supply

(a) Permanent Canal:-

- Is a Continuous Source of water supply
- Also Called as perennial Canals.

(b) Inundation Canal:-

- It draws it supplies from a river only during the high stages of the river.

2. Based on their function:-

(a) Irrigation Canals:-

- It Carries water from its source to agricultural fields.

(b) Navigation Canals:-

- Canals used for Transport of goods are known as Navigation Canals.

(c) Power Canals:-

- Used to Carry water for generation of Hydro electricity.

(d) Feeder Canals:-

- A feeder Canal feeds two or more Canals.

3. Based on Discharge:-

(a) Main Canal - (i) It takes its supplies from dam through Head regulator
(ii) Supply water to branch Canals & distributaries

(b) Branch Canal - (i) It takes their supply from main Canal
(ii) Carry a discharge from 1 - 8.5 m³/s.
(iii) Acts as a feeder Canals for distributaries.

(c) Major distributaries - (i) It Carry 0.75 - 5.5 m³/s of discharge.
(ii) It takes supply from branch Canal.

(d) Minor distributaries - (i) Are small Canals which Carry a discharge less than 0.75 m³/s & feed the water Course for Irrigation.

4. Based on Alignment:-

(a) Ridge Canal:- i) The Canal is aligned along the side line
ii) It Can Irrigate the areas on both side.

(b) Contour Canal - (i) The Canal is aligned parallel to the Contour line
(ii) It Can Irrigate the area on one side only.

(c) Side slope Canal - (i) The Canal is aligned right angles to the Contour line.
(ii) It Can Irrigate the areas on one side only

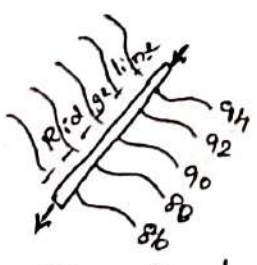


fig 1. Ridge Canal

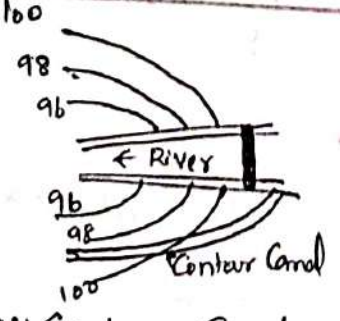


fig 2: Contour Canal

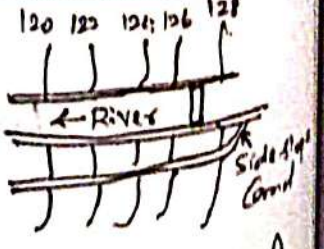


fig 3: Side slope Canal

Lecture No. 29. CANAL DROP

Topic(s) to be covered	Definition - Necessity of Canal Drop/Fall - Types of Falls / Drops.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Understand the Necessity, location and Types of Canal Drops	Understand

Teaching Learning Material	Student Activity
Chalk / Talk	Listening.

Lecture Notes

Canal Drop:-

A Canal Drop is an Irrigation structure Constructed across a Canal to lower down its water level and destroy the surplus energy liberated from the falling water which may otherwise Scour the bed & banks of the Canal.

- Necessity of Canal Drop :-

(i) When the slope of the ground suddenly changes to steeper slope, the permissible bed slope cannot be maintained. It requires earth work in filling to maintain slope. In such a case falls are provided to avoid excessive Earth Work in Filling.

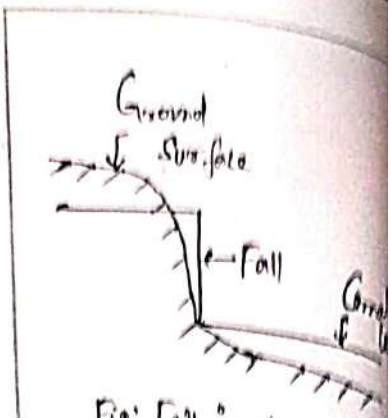


Fig: Fall in steep ground

(ii) When the slope of the ground is more/less uniform & the slope is greater than permissible bed slope of Canal, A Canal falls are Necessary.

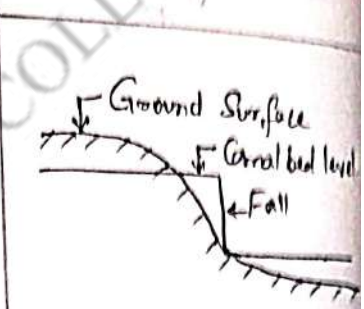


Fig: Fall in uniform Ground.

(iii) - In Cross-drainage works, when the difference b/n bed level of Canal & that of drainage is small then the Canal fall is necessary. It Carry the Canal water below the Stream / drainage.

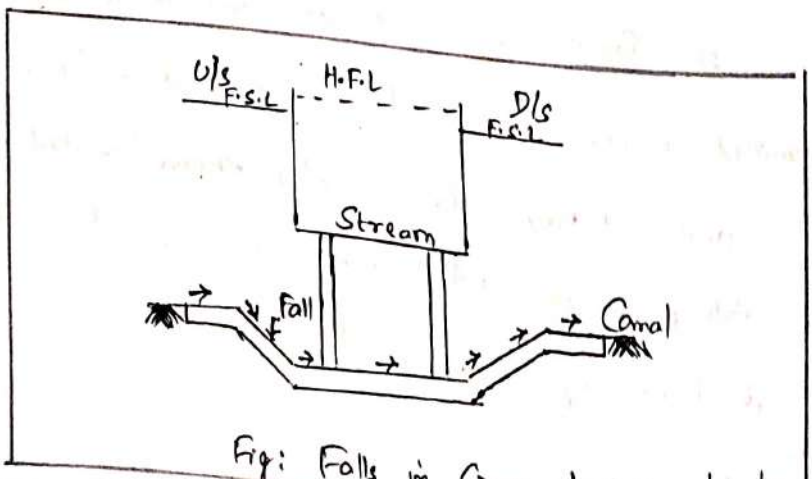


Fig: Falls in Cross drainage works.

- Types of falls / Drops

1. Ogee Fall :-

- In this type of fall an ogee curve which is a combination of convex and concave curve in the shape of elongated S is provided for conveying the canal water from higher level to lower level.
- This fall is recommended when the natural ground surface suddenly changes to steeper slope along the alignment of the canal.
- Stone pitching is provided on U/s & D/s of the fall.

2. Rapid Fall:-

- It is suitable when the slope of the natural ground surface is even and long.
- It consists of a long sloping glacis with longitudinal slope which varies from 1 in 10 - 1 in 20.
- Curtain walls are provided on the U/s & D/s side
- A bed of rubble masonry is provided & finished with cm!!3

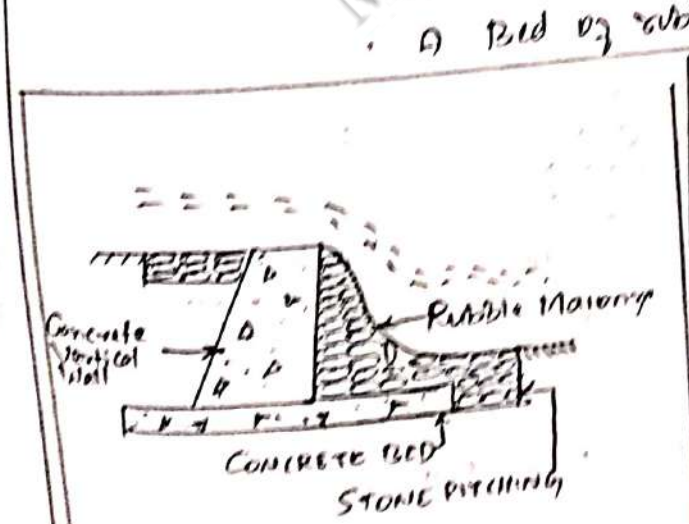


Fig: Ogee Fall

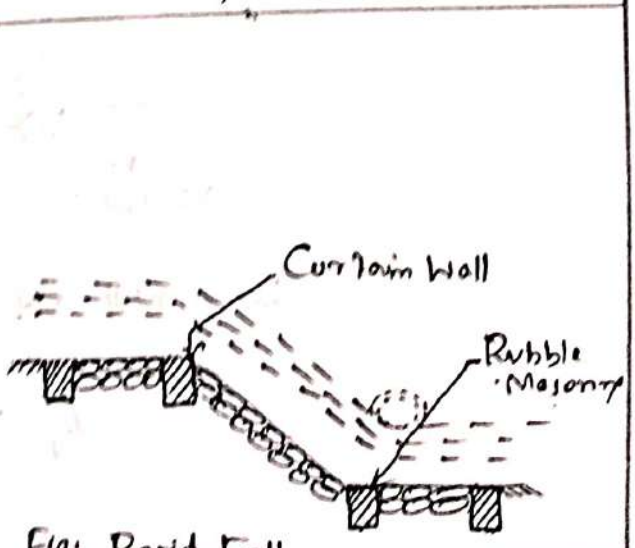


Fig: Rapid Fall

3. Stepped Fall :-

- It Consists of a series of Vertical drops in form of steps.
- This Fall is suitable in places where the sloping ground is Very long & requires long glacis to Connect Higher bed level to Lower bed Level.
- Sloping glacis is divided into a Number of drops
- Brick walls are provided at each of the drops.

1. Vertical Drop Fall:-

- Constructed with Masonry work the water flows over the crest of the wall. A water eastern is provided on the d/s side which acts as a water Cushion to dissipate energy of falling water.
- A Concrete floor is provided on D/s side and
- Curtain walls are provided on the U/s & D/s side.

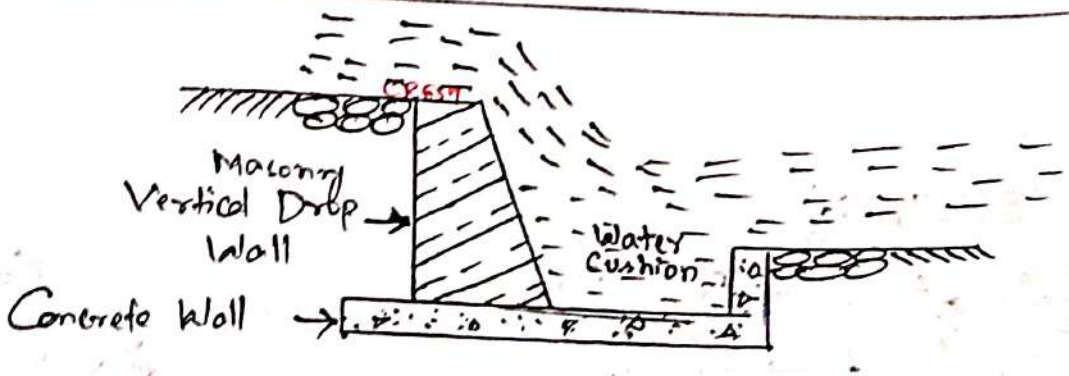


fig: Vertical Drop Fall.

5. Glacis Fall:-

- It Consists of a straight (slope) glacis provided with a Crest.
- A water Cushion is provided on the D/s side to dissipate the energy of flowing water.
- It is Constructed with Cement Concrete.
- Curtain wall & Toe walls are provided on the U/s & D/s side.
- Is a Modern type of Construction.

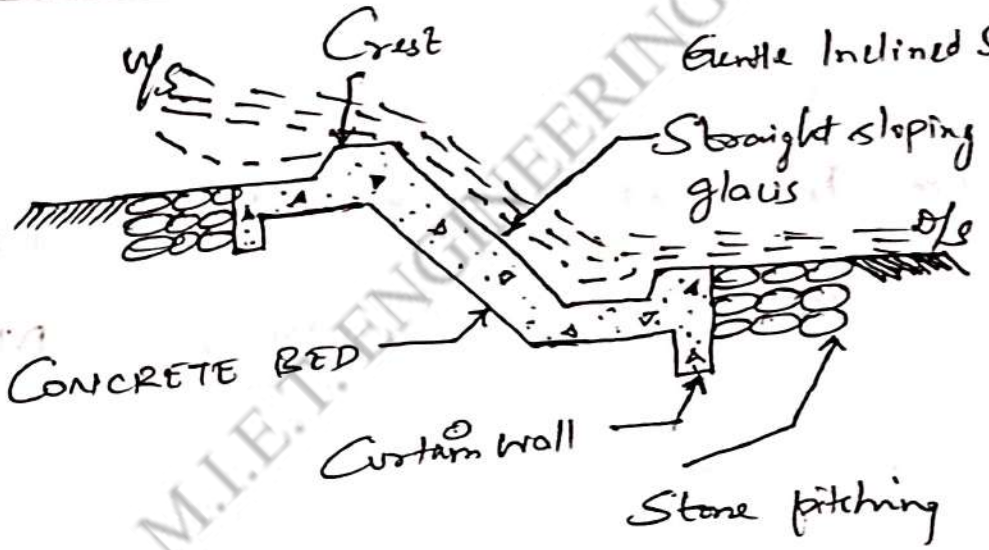


Fig: Glacis Fall

- This type of fall is suitable for drops upto 1.5m.

Lecture No. 30 CROSS DRAINAGE WORKS.

Topic(s) to be covered	Definition – Necessity of Cross drainage works - Types of Cross work drainage - Aqueduct - Siphon Aqueduct.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
Lo1	Gain knowledge on Cross drainage work	Understand.

Teaching Learning Material	Student Activity
Chalk / Talk	Listening.

Lecture Notes

Definition:-

- These are structures provided for Crossing Canals across Natural streams.
- A structure must be Constructed at the Crossing point for the easy flow of water of the Canal & drainage in the respective directions.

- Necessity of Cross drainage Works:

- The water shed Canals do not Cross natural drainage But in actual Orientation of the Canal Network, this Ideal Condition may not be available and the Obstacles like natural drainages may be present across the Canal. So, the Cross drainage works Must be provided for running the Irrigation Systems.

- Types of Cross Drainage works.

(a) Aqueduct

(b) Siphon Aqueduct

- Aqueduct:-

- When the High flood level of the Natural drainage like River & Stream is Sufficiently below the bottom of the Canal so that the drainage water flows freely under gravity, then the type of structure provided for Cross drainage work is known as aqueduct

- The aqueduct is just like a bridge where a Canal is taken over the deck supported by piers.

- The Canal is in the shape of a rectangular trough which is Constructed with R.C.C.

- The Height and section of piers are designed according to the Highest flood level and Velocity of flow of the drainage.

- The piers may be of brick Masonry, stone masonry. or Reinforced Cement Concrete.

- Deep foundation is not necessary for the piers.

- Concrete foundation may be provided for the required depth of foundation according to availability of Hard soil.

Advantages:-

(i) Canal is open for Inspection

(ii) Rare Chance of damage to the Canal due to floods in the drainage.

Dis-advantages:-

(i) More river training Works are required.

(ii) Foundations are susceptible for scouring during Heavy floods.

(iii) Waterway of the drainage may get Clocked with debris, trees etc.

- Some times, the Trough may be of Trapezoidal section.
- An inspection Road is provided along the side of the trough.

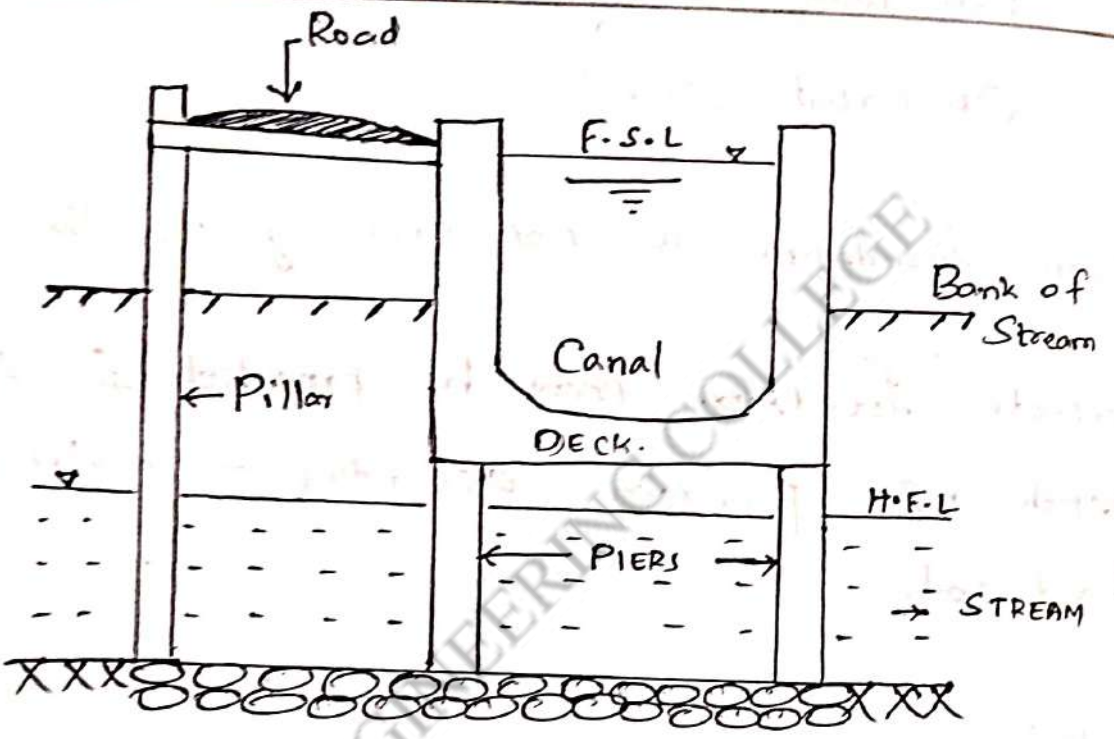


Fig: Aqueduct.

- The bed & Banks of the drainage below the trough is protected by boulder pitching with Cement grout.
- The section of the trough is designed according to the Full supply discharge of the Canal.
- A Free Board of about 0.5m should be provided.

31. Lecture No. SYPHON AQUEDUCT

Topic(s) to be covered	Definition – working principle - Merits & Demerits - Supper passage - working principle - Merits & Demerits.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
Lo_1	Understand the working principle & use of Syphon Aqueduct.	Understand

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

- Syphon Aqueduct:-

When the high flood level of the natural drainage like River & Stream is Higher than the Canal bed and the water passes through aqueduct Under Syphonic action, then the aqueduct is known as Syphon aqueduct.

- In a Syphon Aqueduct the bed of the drainage is depressed below the bottom level of the canal trough by providing sloping apron on both sides of the Crossing.
- In a Trough type, the Canal is carried the drainage through a trough supported on

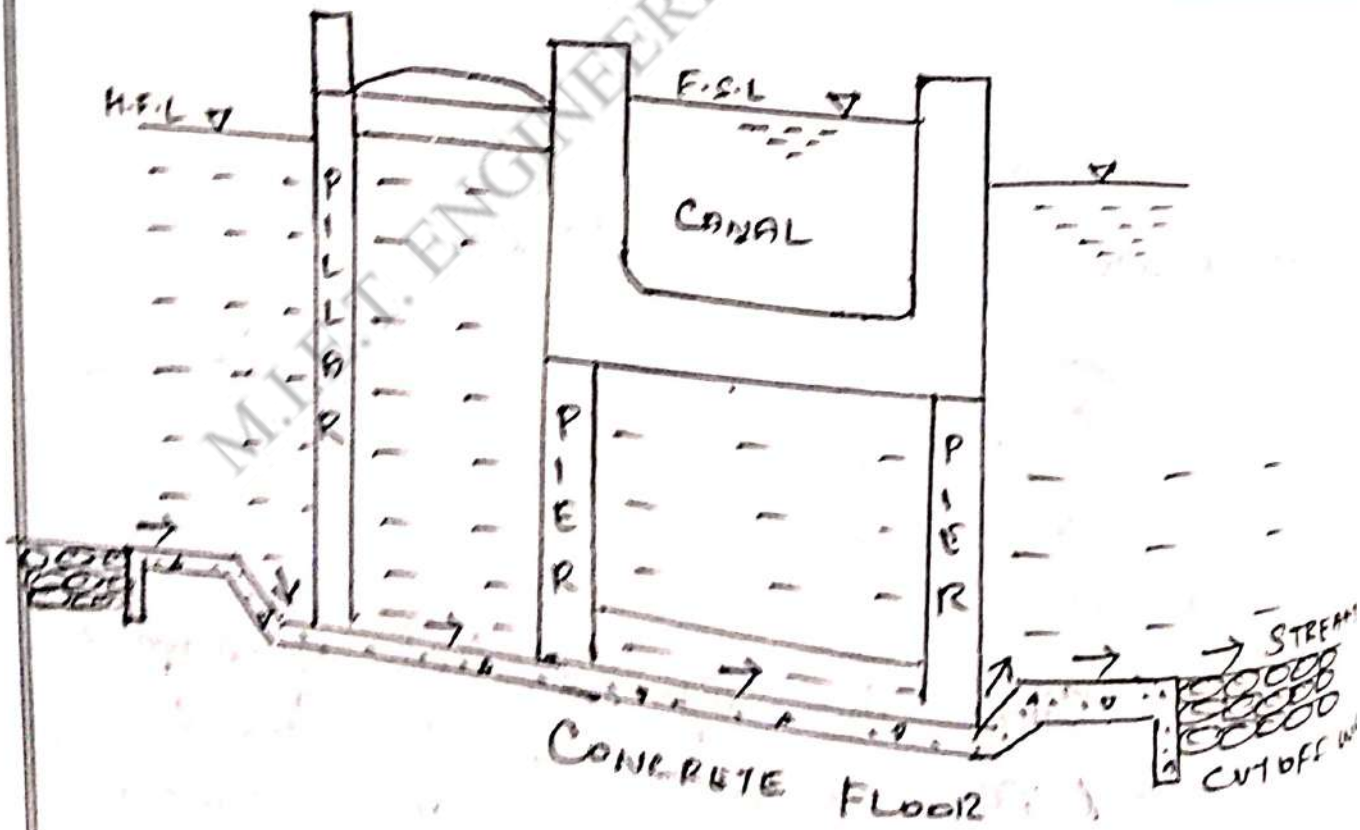


Fig: Syphon Aqueduct.

- Cut off walls are provided on both sides of the apron to prevent scouring.
- The sloping apron may be constructed by stone pitching or cement concrete.
- The section of the drainage below the canal trough is constructed with cement concrete in the form of tunnel. This tunnel act as a siphon.
- Boulder pitching should be provided on the U/S and d/s of the cut off walls.
- The other components like canal trough, piers, inspection road etc. should be designed according to the methods adopted in case of aqueduct.

Merits :-

1. Canal is open for inspection
2. Canal runs without disturbance with its designed levels.

- Rare Chance of damage to the Canal due to floods in the drainage.
- This is preferred when the drainage is small Compared to Canal Capacity.

De Merits :-

- Lowering of bed level is not economic in Case of large drainage.
- Fandations are susceptible for scouring during Heavy floods.
- High Cost during foundation due to large dewatering.

TYPE II : NATURAL DRAINAGE PASSES OVER THE IRRIGATION

- SUPER PASSAGE :-

The Super passage is the structure where waterway of the natural drainage is Carried above the water in the Canal and it is just opposite of the aqueduct.

- When the Full Supply level (F.S.L) of the Canal is sufficiently below the bottom of the natural drainage so that the Canal water flows freely under gravity, then the structure is known as Super passage.

- The drained trough is carried over the piers constructed in the bed of the Canal as shown in figure.

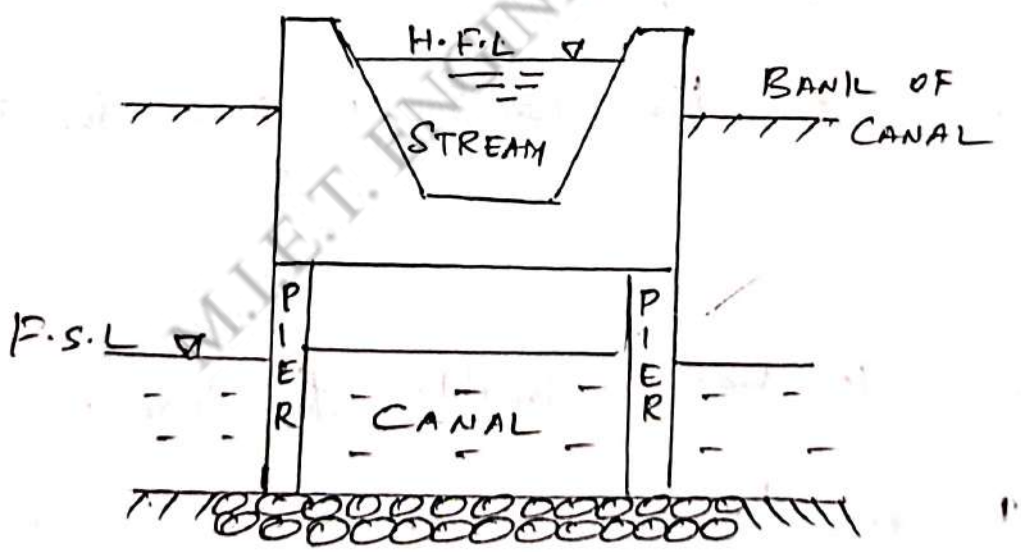


Fig: SUPER PASSAGE

- The Trough should be Constructed of R.C.C

- The Section of the drainage trough depends on the High flood discharge.
- A Free Board of abod 1.5m should be provided for safety.
- The Bed & Banks of the Canal below the drainage trough should be protected by boulder pitching.

Merits:-

- Used in large drainage cases
- Canal section can be economically designed.
- Damage of the Canal is more due to floods.

Demerits:-

- Canal is not available for inspection
- Designed levels of Canals are disturbed.
- Foundation Cost is More due to dewatering.

Lecture No. 32 Syphon Super Passage.

Topic(s) to be covered	Syphon super passage - definition - working principle - Merits - Demerits - Level Crossing.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	gain knowledge on Syphon super passage & level Crossing.	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Syphon Super Passage:-

- Syphon super passage is just reverse of an syphon aqueduct.
- If the F.S.L of the Canal is above the bed level of the natural drainage so that the Canal lower under syphonic action under the trough, then the structure is known as Syphon Super Passage.

- The Canal passes below the drainage trough with bed level depressed below its normal bed level and the trough bottom is below FSL of the Canal, such that Canal water flows under pressure.
- It is provided where Canal FSL is at or above the drainage bed.
- The Bed of the Canal is depressed below the bottom level of the drainage trough by providing sloping apron on both sides of the Crossing.
- The sloping apron may be Constructed with Stone pitching.
- The Section of the Canal below the trough is Constructed with Cement Concrete in the form of tunnel which acts as siphon.
- Cutoff walls are provided on U/s & d/s side of sloping apron.

- Other Components are same as in the case of siphon aqueduct.

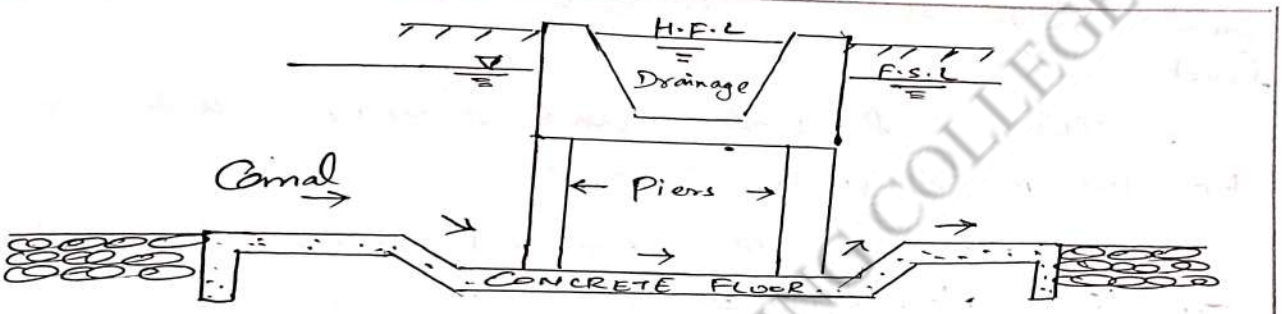


Fig : Syphon Super Passage.

Merits: -

- Used in larged drainage cases.
- Canal section can be economically designed.
- Damage to the Canal is more due to floods.

Demerits: -

- Inspection road cannot be provided along the Canal.
- Separate bridge is required for the roadway.
- Foundation cost is more due to dewatering.

Type - (ii) : Natural drainage & Canal intersection each other at the same level.

- **Level Crossing :-**

- Is an Arrangement provide to regulate the flow of water through the drainage and the Canal. When they Cross each other at the same bed level.

- The Canal water and drainage water allowed to Intermingle with each other.

- A Regulator is provided across the drainage on the d/s side of the Crossing.

- At the outgoing Canal, a Regulator is provided so as to Control the discharge into the Canal.

- A Regulator at the end of Incoming Canal is also Sometimes required.

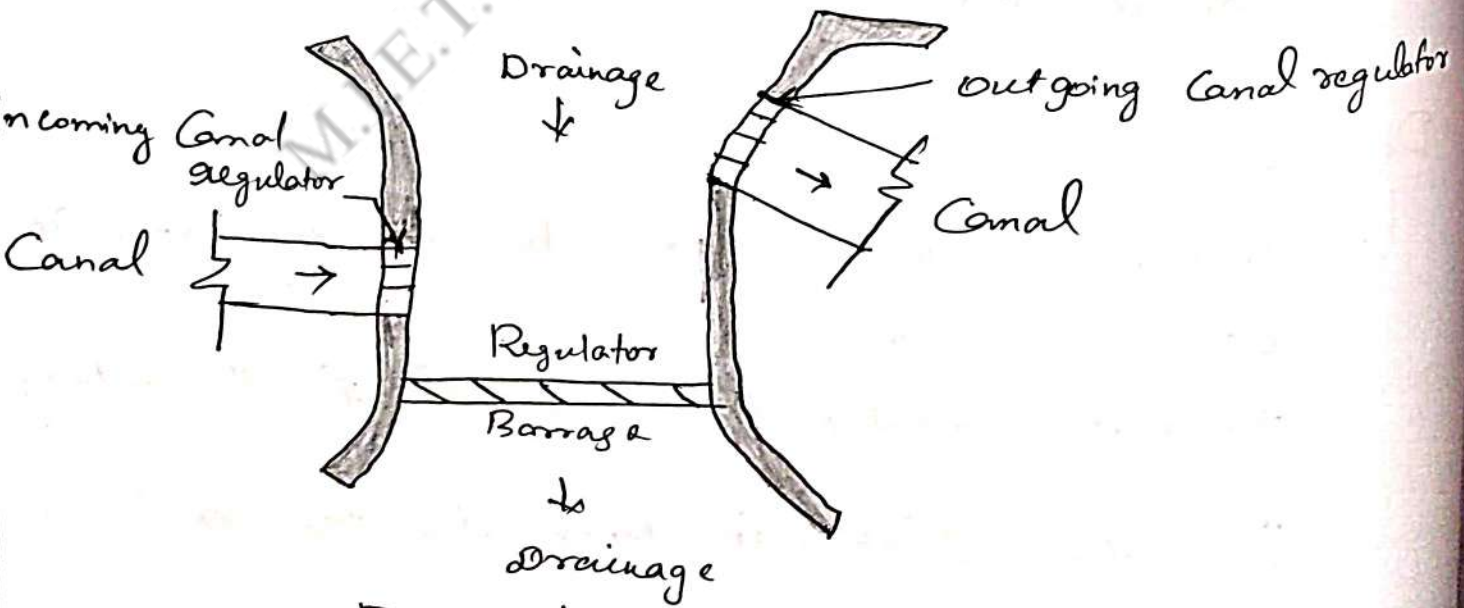


Fig : Layout of level Crossing.

33. Lecture No. CANAL OUTLET

Topic(s) to be covered	Canal outlet - Definition - Requirement - Types of outlets

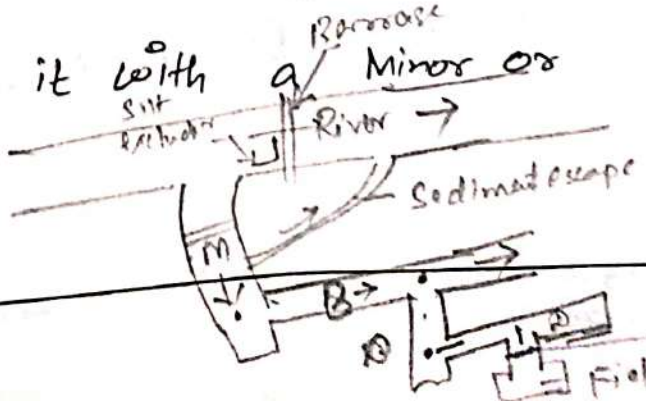
	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Gain knowledge on Canal outlets & its uses	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Canal Outlet:-

- A Canal outlet is a small hydraulic structure.
- It is built at the head of the water course
- Used to connect it with a Minor or distributary channel.



- The Control & Maintenance of the entire work of Canal falls under the jurisdiction of State govt.
- The Main Objective of providing an outlet is to provide ample supply of water to the channel Needed.

Requirements of a Good outlet :-

- It should be simple to Construct.
- It should be Cheaper
- It should work efficiently with a small working Head.
- It should be such as to avoid interference by Cultivators.
- It should draw its fair share of silt.

Types of Outlets:-

(a) Non Modular Outlet
(b) Flexible Module
(c) Rigid Module.

(a) Non- Modular outlet :-

- Non Modular outlets are those through which the discharge depends upon the Head difference between the distributary & the water Course.

- The Discharge through this Module depends upon either a Change in water level of the distributor or Head of the water Course.

Types of Non- Modular Outlet.

(i) Open sluice

(ii) Submerged pipe outlet.

(i) Open sluice :-

- An open sluice is like an Abridge. Opening Created across the bank of the distributary by raising two abutments at 2.5 - 3m apart with a Horizontal floor.

(ii) Submerged pipe outlet :-

- pipe diameter Varies from 10-30cm & generally embedded in Concrete.

- Pipe is fixed Horizontally at right angle to direction of flow.

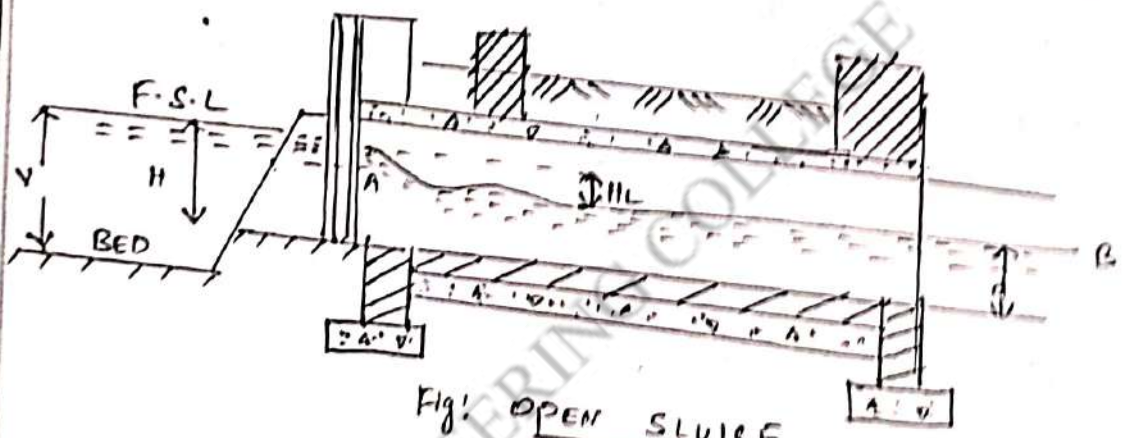


Fig: OPEN SLUICE

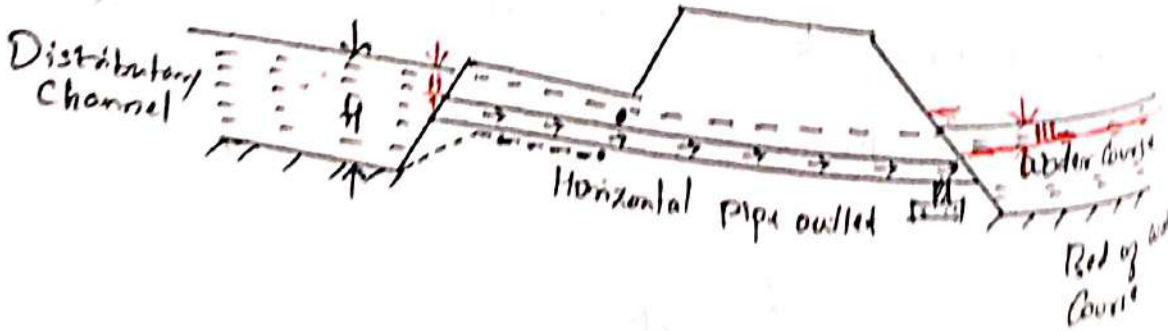


Fig: Submerged pipe outlet.

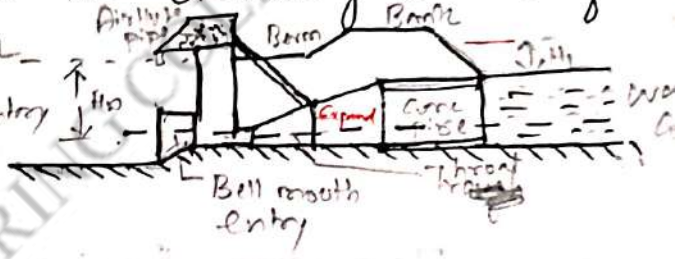
Due to Construction, a super critical Velocity is ensured in the throat & thus allowing the formation of a jump in the expanding flume. The jumps makes the outlet discharge Independent of water level in water course.

(b) Flexible Modules:-

- Flexible Modules are those which the discharge is Independent of the water level of the water Course. but depends only upon the water level of the distributary so long as a minimum working Head is available.

- the Discharge through such an outlet will Increase with a rise in the distributary water surface level.

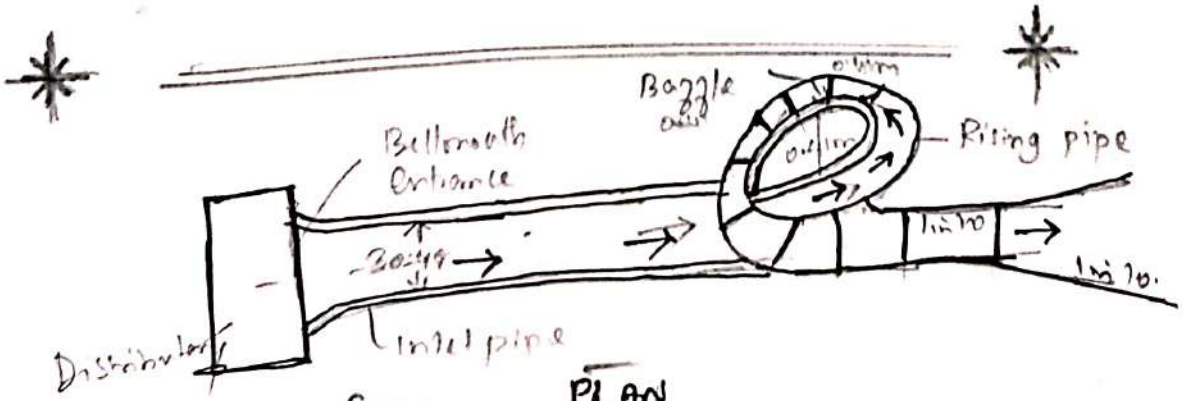
Ex- pipe outlet, open flume type.



(c) Rigid Modules:-

- Rigid Modules or Modular outlets are those through which discharge is Constant & flexible within limits, Irrespective of the fluctuations of the water levels of either the distributary or the water Course or both.

Example.- Gibb's module.



GIBB'S PLAN

Lecture No. 34. CANAL LINING.

Topic(s) to be covered	Canal lining - Definition - Need - Types of Canal lining - Earthern - Hard surface lining.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able ~~to~~	Bloom's Level
LO1	To gain knowledge on Canal lining	Understand

Teaching Learning Material	Student Activity
Chalk / Talk	Listen.

Lecture Notes

CANAL LINING :-

~~An~~ Impermeable layer is provided at the bed & sides of Canal to improve life & discharge capacity. Canal known as Canal lining

Though Irrigation Canals may be Constructed in natural or Compacted earth, these suffer from certain disadvantages such as Maximum Velocity limited to prevent erosion, Seepage of water into the ground, possibility of Vegetation growth in banks, All these reasons leads to adoption of lining of Canals.

- Types of Canal lining:
  a) Earthern Type
  b) Hard Surface Lining.

(a) Earthern Type Canal lining
  - (i) Compacted earth lining
  - (ii) Soil Cement lining.

(i) Compacted Earth lining:-
- It is suitable where earthern material is avail near the site.
- A lining of Compacted earth is inexpensive
- It is a way for efficient means of Controlling seep
- Compaction reduces soil pore size by displacing a water.
- Reduction in Voids size increases the density, Compressive Strength, shear strength & reduc permeability.

(ii) Soil Cement Lining:-
- These are Constructed with Mixtures of S soil, Cement & water, which harden to Concrete like Material.
- Cement Content should be 2-8% of the so Volume.
- For erosion protection & additional streng large Channels, the layer of soil-Cement is Covered with Coarse soil.

Hard Surface Canal lining

a) Brick Lining
b) plastic "
c) Boulder "
d) Cement Concrete lining.

Brick Lining:-

- The Canal is said to be lined with bricks when the sides & bed are protected with brick Surfacing laid in Cement Mortar.
- The lining may be Constructed of 2 layers.
- First layer is laid on 12mm layer of 1:6 Cement Mortar. is spread on Subgrade & on top of first layer 12mm layer of C.M 1:3 is given.
- Second layer of bricks in Mortar is laid on the top.
- Thus a 12mm layer of rich C.M 1:3 is Sandwiched b/n two brick layer & makes water tight.

plastic lining:-

- There are 3 types of plastic Membranes which are Used in Canal lining, namely;
  - Low density polyethylene
  - High Density "
  - polyvinyl Chloride.

- The plastic as a material for Canal lining offers Characteristics advantages like negligible weight, e for Handling, Spreading and transport, Immune Chemical action and speedy Construction.
- The plastic film is spread on the prepared Subg of the Canal.
- To anchor the Membrane on the banks 'V' tren are provided.
- The film is then Covered with protective soil Co

(c) Boulder lining:-

- Boulder lining is used for lining the earthen Canal Cross section, by proper placement and pa of stones, either after laying a filter layer o the soil surface.
- This type of lining is Constructed with dressed Stone blocks laid in Mortar.
- Irregular stone blocks are dressed and chipped off as per requirements.
- Stone lining is limited to situation where loss of he is not an important Consideration & where stones are available at Moderate Costs.

(d) Cement Concrete lining :-

- Concrete linings are widely used; with benefits justifying their relatively High Cost.
- They are tough, durable, relatively Impermeable and hydraulically efficient.
- Concrete linings are suitable for both small & large Channels and both High & low flow Velocities.
- They fulfill every purpose of lining.

Procedure :-

(i) - Cast in situ lining - This type of lining is widely accepted as best Impervious lining.
- It Can resist the effect of scouring & erosion very efficiently.
- The Velocity of flow may be kept above 2.5m/sec.

(ii) Preparation of Subgrade :

The subgrade is prepared by ramming the surface properly with a layer of sand (15cm). Then a slurry of Cement and sand (1:3) is spread uniformly over the prepared bed.

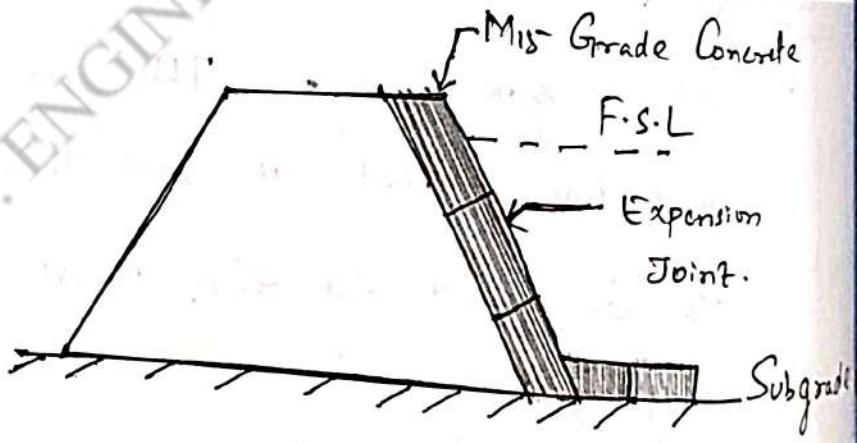
b. Laying of Concrete:-

(i) M15 grade of Cement Concrete is spread to desired thickness (100 - 150mm).

(ii) After laying, the Concrete is tapped gently until the slurry comes on top.

(iii) Curing is done for few weeks.

(iv) In special cases, a Network of 6mm dia rods may be provided with spacing 10cm c/c as shown in figure.



C/S

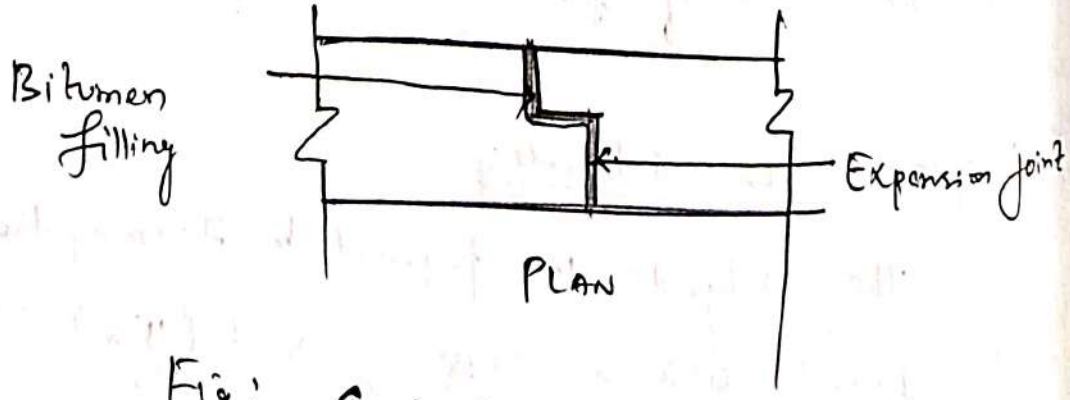


Fig: Cast in Situ Concrete lining

Lecture No. 35. CANAL DESIGN.

Topic(s) to be covered	Unlined Canal design on Alluvial soil by Kennedy's Theory.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO_1	Understand the design Concept of Kennedy theory for unlined Canal	Understand
LO_2	Analyse the design of canal	Apply.

Teaching Learning Material	Student Activity
Chalk / Talk	Listen.

Lecture Notes

KENNEDY'S THEORY :-

The silt Carried by flowing water in a Channel is kept in Suspension by the Vertical Component of Eddy Current. which is formed over the entire bed width of the Channel & the Suspended silt sits up gently towards the surface.

- The Relationship between the Critical Velocity and the full supply depth $\boxed{V_c = C \times y^n}$
- The Values of C & n where found out as 0.55 & 0.64

$$V_c = 0.55 \times y^{0.64}$$

- Critical Velocity ratio

$$\boxed{V_c = 0.55 \times m \times y^{0.64}}$$

Where m = Critical Velocity ratio

= 1.1 - 1.2 for Coarse sand

= 0.8 - 0.9 for fine sand.

Procedure:- [CHANNEL DESIGN]

(i) Q, & m are all initially known.

(ii) Assume a depth of flow y

(iii) Compute the Critical Velocity from Kennedy's formula $\boxed{V_c = 0.55 \times m \times y^{0.64}}$

(iv) Compute Area of Cross Section of flow

Area of $\boxed{C/s = \frac{Q}{V_c}}$

- Compute the bed width (Assume slope 0.5 : 1)
- Compute the Wetted perimeter for the assumed depth of Computed bed width.
- Calculate 'C' from Kutters formula.

$$C = \frac{\left[\frac{1}{n}\left(23 + \frac{0.00155}{S}\right)\right]}{\left[1 + \left[23 + \frac{0.00155}{S}\right]\cdot\frac{n}{\sqrt{R}}\right]}$$

- Compute the Velocity of flow by Chezy's Equations.

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

- If the Velocity Computed now is same as found by Kennedy's Method and Critical Velocity Ratio is equal to one. then, the design depth is Correct.
- Otherwise Repeat the above steps by assuming different depth of flow.

• Design an Irrigation Channel with the following data using Kennedy's theory.

Full supply discharge : 6 Cumec.
Rugosity Coefficient : 0.0225
C.V.R. (m) : 1
Bed slope : 1 in 5000

Solution:-

(i) Assume Full supply depth $Y = 1.5m.$

(ii) Critical Velocity, $V_c = 0.55 \times 1 \times 1.5^{0.64}$

$\boxed{V_c = 0.55 \times m \times y^{0.64}}$

$V_c = 0.707$

As $m = 1$, $V = V_c$

$$\text{Area} = \boxed{\frac{Q}{V_c}} = \frac{6}{0.707} = 8.49m^2$$

$$\text{Area} = (2b + 3)/2 \times 1.5$$

$$= 1.5b + 2.25$$

$$A = 8.49$$

$$b = 4.16m.$$

$$P = b + 2x\sqrt{2 \times 1.5} = b + 4.24 = 8.40$$

$$R = 4.16/8.40 = 1.0m.$$

Substituting $n = 0.0225$, $S = 1/1000 = 0.0002$ in Kutter formula.

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

$C = 44.49$.

By Chezys formula $V = C\sqrt{RS}$, $V = 44.49\sqrt{1 \times 0.0002} = 0.629$ (m/sec)

C.V.R $= 0.629 / 0.707 = 0.889 < 1$

As the C.V.R is < 1, the Channel will be in silting.

So the Design is Not satisfactory.

Trial - II.

$Y = 1.25m$

$V_c = 0.5 \cdot 4611 \times 1 \times 1.25^{0.64} = 0.629$ ∴

As $m = 1$, $V = V_c$

$A = b/0.629 = 9.53m$.

$A = 1.25b + 1.56 = 9.53$

$b = 6.38m$.

$P = b + 2x\sqrt{2x1.25^2} = 9.92m$.

$R = 0.96m$.

$C = 44.23$

$V = 44.23\sqrt{1 \times 0.0002} = 0.613$ m/sec.

$C.V.R = \frac{0.613}{0.629} = 0.97 < 1$ ∴ [CVR is close to 1]

Design is good. $Y = 1.20m$ & $b = 6.38m$.

Lecture No. 36 LACEY'S THEORY.

Topic(s) to be covered	Lacey's Method of Channel design - problem. Solving using Lacy's method for the design of Channel.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Understand the design procedure for Channel design by Lacey's theory.	Understand
LO2	Analyze the Channel design.	Apply

Teaching Learning Material	Student Activity
Chalk / Talk	Listen.

Lecture Notes

Lacey's Theory :-

1. Q and d^{mm} are initially known.
2. Calculate the silt factor f

$$f = 1.76\sqrt{m}$$

m = Mean particle size ; mm.

- Compute Velocity from Lacey's equation.

$$V = \left[\frac{Q.f^2}{140}\right]^{1/6}$$

- Calculate Hydraulic Mean depth R.

$$R = \frac{5}{2}\left[\frac{V^2}{f}\right]$$

- Compute Area of Channel Section from Continuity equation.

$$\text{Area} = \frac{Q}{V}$$

- Compute Wetted perimeter P from lacey's eq.

$$P = 4.75\sqrt{Q}$$

- Bed slope S from Lacey's equation

$$S = \frac{f^{5/3}}{3340.Q^{1/6}}$$

- Lacey's Regime width & flow depth for Alluvial Rivers.

For Alide Streams or rivers, Wetted perimeter approximately equals the River width

Regime width $W = P = 4.75\sqrt{Q}$

Regime Scour depth $R = 0.47 \times (Q/f)^{1/3}$

Regime flow equation $V = 10.8 \times R^{2/3} \times S^{1/3}$

$$S = \left[\frac{f^{5/3}}{3340\, Q^{1/6}}\right]$$

- Design an Irrigation Channel with the following data Using Lacey's theory.

Full supply discharge = 10 cumec.

Mean dia of silt particles = 0.33mm

Side Slope = 1/2 : 1

$f = 1.76\sqrt{m}$.

Find the Bed Slope of the Channel.

Solution:

(i) $f = 1.76\sqrt{m}$

$f = 1.76 \times \sqrt{0.33}$

$f = 1.0$.

(ii) $V = \left[\frac{Q.f^2}{140}\right]^{1/6}$

$$V = \left[\frac{16 \cdot 1^2}{140}\right]^{1/6}$$

$$\underline{V = 0.64 \text{ m/sec}}$$

(iii) $\underline{\text{Area}} = \frac{Q_1}{V} = \frac{10}{0.64} = \underline{15.62 m^2}$

(iv) Wetted perimeter $\underline{P} = 4.75\sqrt{Q_1} = 4.75\sqrt{10} = 15.02$

(v) Regime Scour depth $\underline{R} = 0.47 \times (Q/f)^{1/3}$

$$R = 0.47 \times (10/1)^{1/3}$$

$$\underline{R = 1.02 m}$$

(vi) Slope $\underline{S} = \frac{f^{5/3}}{3340 \cdot Q_1^{1/6}} = \frac{1^{5/3}}{3340 \cdot 10^{1/6}} = \underline{1/4401}$

But $\boxed{A = by + 0.5y^2}$

$$15.62 = by + 0.5y^2 \quad \text{— (i)}$$

$$\boxed{P = b + \sqrt{5}y}$$

$$15.02 = b + 2.24y \quad \text{— (ii)}$$

Solving eqn i & ii, we get.

$$\underline{y = 1.21 m.}$$

$$\underline{b = 12.30 m.}$$

LectureNo. 37

Water Management.

Topic(s) to be covered	General – Improved performance in Irrigation management – Modernization techniques.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
Lo1	Understand the use of modernization techniques in Irrigation water management	Understand

Teaching Learning Material	Student Activity
Chalk/Talk	Listen.

Result of Irrigmt – prevent excessive use of water for Irrig.
– Prevent Irrigation enduced erosion
– Reduced labour
– Minimizing pump cost
– Increase Crop biomass yield.

Lecture Notes

(நீர் மேலாண்மை)

Water Management:-

– It Helps determine future Irrigation expectations.

(Definition) – Water Management is the management of water resources under set polices & regulations. (Decisions) (Decisions)

– Efficient Irrigation system & water management practices can help maintain farm profitability in an era of limited, Higher cost water supplies.

– Efficient water management Reduce the Impact of Irrigated production on offsite water quantity & quality.

Activities focus of water use –

i) Water Use
1) Acquisition
2) Allocation
3) Distribution

ii) Water Control
1) Design
2) Construction
3) operation

iii) maintenance.

- Improved performance in Irrigation water manage achieved through three types of Interventions (The Action)

- Rehabilitation:-

Which Consists of re-engineering a deficient Infrastructure to Return it to the orginal des Although Rehabilitation Usually applies to the phys Infrastructure, it Can also Concern Institutional Arrangements.

- Process Improvement:-

Which Consists of Intervening in the process without Changing the Rules of the Water management.

Modernization:-

Which is a more Complex Intervention Implying fundamental Changes in the rules governing water Resource management. It may include Intervention in the physical Infrastructure as well as in its management

MODERNIZATION TECHNIQUES

- Definition:-

A process of technical and managerial upgrading of irrigation schemes combined with institutional reforms, with the objective to improve resource utilization such as labour, water, economic, environmental & water delivery service to farms.

For many decades, Modernization has been central to the concerns of the irrigation community; is a fundamental transformation of the management of water resources.

Modernizing water management in irrigation systems can be interpreted in different ways depending on the local circumstances.

One type of modernization is the term introduction of modern technologies, such as water application, and distribution. through pipes rather than open channels, & the use of computerized soil-water sensors to trigger water applications.

eg- Cloud Automated. & timed sprinkler & drip systems.

• A set of Conditions for the success of modernization can be drawn from an analysis of recent Irrigation Modernization.

- Modernization is More likely to succeed if the Idea Come from the farmers.
- Pressure Irrigation is "in" and gravity Irrigation is out Future Irrigation should be for pressurised Irrigation.
- Much attention Needs to be given to efficient Water distribution; Otherwise High water losses, water theft, & Unscheduled Irrigation will Continue
- payment of water service fees remains a problem Unless farmers are taught & accept that Water cannot be free.
- Providing farmers with appropriate technical assistance requires Considerable attention. Despite the training provided, there are still large gaps in knowledge about farming practices, water requirements & Irrigation scheduling.
- Each System requires tailor made Solutions; (Different Conditions)
Modernization always includes Improving the physical Infrastructure, but how this is done & all other Needs are site-specific.

LectureNo. 38

Topic(s) to be covered	Rehabilitation – Tank Rehabilitation. – optimization of water use.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	**Bloom's Level**
Lo1	gain knowledge on Rehabilitation & optimization of water use.	Understand.

Teaching Learning Material	Student Activity
Chalk Talk	Listen

Lecture Notes

Definition:-

- Rehabilitation is defined as bringing back to original / positive condition.

An irrigation Rehabilitation projects returns the level of Service (LOS) of the system essentially to the original design.

The LOS has six elements. These are critical factors in Crop planning & enterprise decision making to prepare for a move to Crops that are. Higher in Value with Higher cost.

6 Elements:-

1. Seasonal Supply Volume
2. Delivery or Service point Conditions
3. Scheduling & flexibility of Supply
4. Reliability
5. Equality (the quality of being fair & impartial)
6. Cost

Tank Rehabilitation:-

The rehabilitation of tank covers Strengthening Earth bunds, laying filter & rip rap (rock placed along shorelines structures to protect), Reconstruction of totally damaged sluices (loss), Repairing Surplus weir, Rehabilitation Supply Channels & drainage Channels, Repairing Conc Structures, and selective lining of Channels.

In View of the quantum (Bulk) & large Spread out of works, the implementation of the Specifications should have optimum Conformity (agreement).

- OPTIMIZATION OF WATER USE:-

It is defined as the process of making best or most effective use of water in the minimal situation

The optimization of water use & Crop production will therefore proceed sequentially through the three distinct but interrelated stages such as optimization of Nitrogen & seeding rate least limiting to yield, quantification of the relationship between yield & water supply, the optimal timing or sequencing the moisture sensitive stages of plant growth.

The Approach to optimize water use in the case of one or other the crop may be important in its own right.

optimising water usage and Improving Irrigation on farm land Helps to save money, increase yields and protect the environment at the same time as making farming more sustainable.

Key Elements of optimization are given below.

- Irrigation scheduling based on real time soil Moisture measurements & local weather forecasts & reports.

- Support from Commercial Servile providers on bo
  Soil moisture & fertiliser application.
- Selection of most efficient but affordable Irrigati
  System.
- Increased profit per unit Volume of water used
  through a Combination technology & Careful manag
- Member of an excellent water User association
  proving water on order as required.

Outcome of optimization:-

(i) Crop Yield per Unit of water withdrawn will be Increased.
(ii) Very high yield Compared to other farms.
(iii) Reduced fertilizer bill resulting from targetted application of fertiliser to the Crops.
(iv) Crop growth Increased the Consumptive use of the farm & thus Return flows to the basin will be reduced.

LectureNo. 39

Topic(s) to be covered	Water losses (minimizing) - Tactics for reducing overall water used by an Irrigation System.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO_1	gain knowledge on minimizing water losses in Irrigation System	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

General :- [WATER LOSSES]

Developed water resources have to be used sustainably, because the development of new water resources for Irrigation has become very difficult. At the same time, water use efficiency in Irrigation has to be increased.

The water use efficiency of existing Irrigation project is not high but low. Both Conveyance efficiency from the water source to field & application efficiency

on each field have to be increased to attain higher w
Use efficiency in Irrigation. On each field, a reduction in
Water loss & Irrigation water results in the attainment of hig
application efficiency.

Irrigation water losses include Air losses, Canopy los
Soil & water surface evaporation, Runoff, & deep
percolation. The Magnitude of each loss is dependi
on the design & operation of each type of Irrigation sy

Following are the few of tactics for reducing the overall
Water used by an Irrigation System:

(i) Reduce site water requirements:-

One of the simplest ways to decrease water used for Irrigation is to limit the (Manage
areas that require a high amount of water, along wit
plants that have Moderate to high water needs.
- Replace plants & turf areas with Hearty / native
plants that can survive with less water.

(ii) Improve Distribution Uniformity (DU)

Distribution Uniformity means placing the
Sprinkler Heads properly so that water will be distributed

evenly across the entire lawn. Using equipments that has a more consistent application rate in two areas to eliminate dry areas will also work to achieve even distribution of water.

(iii) Use Pressure Regulation:-

It helps ensure that sprinklers are opening at the optimal level. When pressure is too high, water droplets atomize, which results in significant amount of water being carried off site by wind drift. By reducing the operating pressure, the water drops are larger & heavier, and are more likely to land where intended.

(iv) Convert to Drip Irrigation:-

Convert Sprinklers (within plant beds) over to drip Irrigation so water has less of a chance to evaporate and/or runoff.

Drip Irrigation is about 90-95% efficient, while spray Head & Rotors are about 60-65% efficient.

(iv) Improved Management Practices:-

- Make Sure property Managers Remember Check the Sprinklers once a week.

- Sprinklers Usually Operate after work. Property managers may not know when a Sprinkler Head isn't operating properly.

- A Good Practice is Running the Zones Once a week to check that the whole System is working order.

Use Smart Controllers:-

- Smart Controllers determine the watering durations and frequencies on a daily basis based on the real time weather conditions. The Controller relies on you to Input the Correct soil & plant type. It is Important to remember that these Controllers are only as good as the information you input. While using a smart Controller, you must be able to assess & document the various site features present within each zone (plants, soil, exposure, shade, slope, Root depth).

LectureNo. 40.

Topic(s) to be covered	On farm Development Works - definition - Components - working principle.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to gain	Bloom's Level
LO_1	knowledge on on farm development works	Understand

Teaching Learning Material	Student Activity
Chalk / Talk	Listening.

Lecture Notes

Definition:- [OFD]

The items of works pertaining to on farm water management are termed as on farm development Works.

The on farm development work comprise the following

(a) field channel for conveyance of water.

(b) Control structures.

(c) Crossing

(d) Surface drainage System

(e) farm Roads

(f) field channel protection works

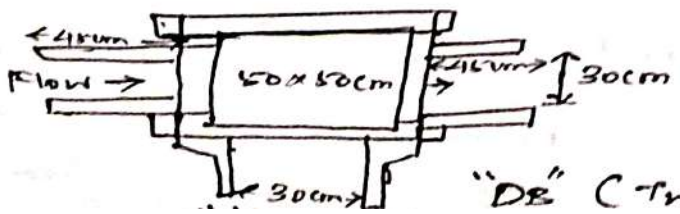
(g) Land farming.

Structure on field Channel - The structure on f Channel include measuring device, drop / falls, divers Boxes, Turnouts, Road Crossing etc.

- Flow Measuring devices is fixed in the Initial reach of field channel system of every chan The device should be located on straight reach.

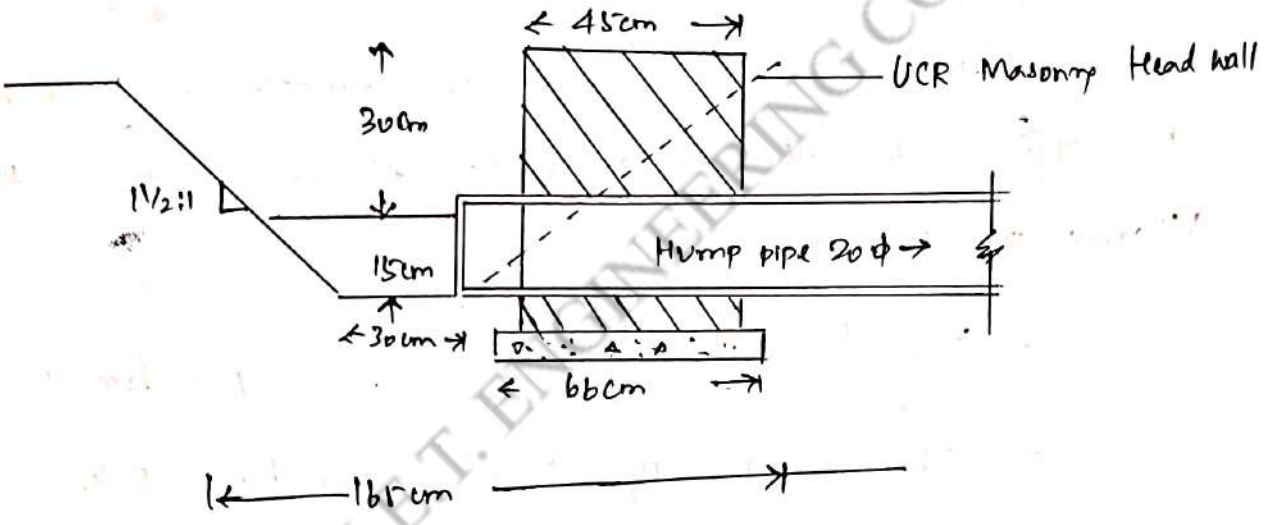
- Diversion Box to farm Roads - The Box is provided in the field Channel where it branches off in 2 or 3 directions. The purpose is to divert the flow into any 1 branch.

The structure consists of a rectangular bo with openings in Vertical side walls, & wing walls extr in the directions of the field Channel & branches.



"DB" (Two way)

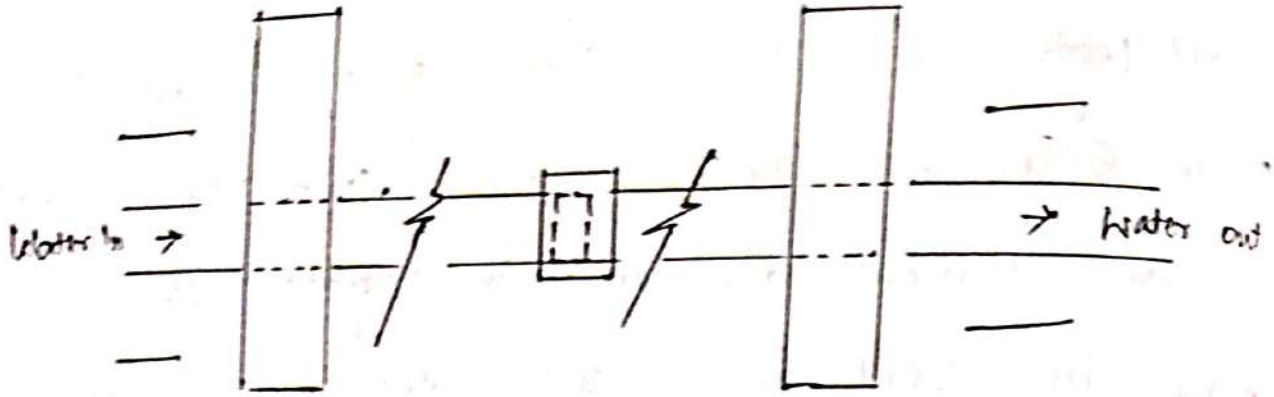
: Turn out - Is a structure on field Channel from where water is diverted from field Channel to the field. It is either in Clay or Cement spun pipe embed in masonry. If the turnout are more in number, Dry Gubble turnout may be used to reduce the cost. pipe turnout can also be used.



(SECTION TURNOUT)

• Crossings:-

Field Channel, Crossing the natural drain, A simple arrangement is to provide a spun pipe of 30cm dia as waterway to the field Channel, fixed in two masonry Head walls. The width of the Crossing is depends on the width of the Road.



Field Channel Crossing.

PLAN

- Farm Roads:-

- In a well laid out system every farm should have an approach to the link road, leading further to the village or market.

- The length of the farm road per ha is 50 m
- The Number of Crossing per ha is 0.4.

- Surface drainage:-

It the orderly removal of excess water from land surface through Constructed or Improved natural Channels & supplemented by proper grading of land surfaces. A field drain collects excess water from a field, A Collector drain collects water from field drains & carries it to main drain.

LectureNo. 41

Participatory Irrigation management.

Topic(s) to be covered	Introduction - objective - Necessity - provision in PIM Acts.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
L01	Gain knowledge on PIM.	Understand.

Teaching Learning Material	Student Activity
Chalk / Talk	Listening.

Lecture Notes

PIM

Introduction:-

Participatory Irrigation management (PIM) refers to the participation of Irrigation Users - the farmers - in the management of Irrigation system.

The Govt. of India took up initiative of PIM through the Command Area development (CAD) program in several states in 1985.

Objectives:-

1. To create sense of ownership of water resources and the Irrigation System among the users, so as to Improve promote economy in water use & preservation of the System.

2. To Improve service deliveries through better Operation & maintenance.

3. To achieve, optimum utilization of available resources through Sophisticated deliveries, precisely as per Crop needs.

4. To achieve equity in water distribution.

5. To Increase production per unit of water, where water is scarce & to Increase production per unit of land where water is adequate.

Necessity of PIM:-

It is Imperative to increase the agricultural production to keep pace with the requirement of Increasing human population.

- Irrigation being lifeline of agriculture, its development & meticulous management is the necessity of the day.
- Farmers are the real stake Holders, they have to come forward to actively participate in the management of the Irrigation Systems.
- PIM appears extremely Necessary and worthwhile.

- Provisions in PIM Acts

Recognizing the need for suval legal framework for PIM in the Country, the Ministry brought out a model act to be adopted by the state legislatures for enacting new Irrigation acts / amending the existing Irrigation acts for a facilitating PIM.

1. Water Users Association (WUA)

- will Have a delineated Command area on a Hydraulic basis, which shall be administratively Viable. Generally a WUA should Cover a group of Outlet or a minor.

2. Distributory Committee:-

will Comprise of 5 or more. WUA
All the presidents of WUAs will Comprise general
body of the distributory Committee.

3. Project Committee:-

will be an Apex Committee of an Irriga
System & presidents of the distributary Committee
the project area shall Constitute general body of
Committee.

The Association at different levels are expected to be
actively involved in:

i) maintenance of Irrigation System in their area of operation
ii) Distribution of Irrigation water to the beneficiary farmers
iii) Assisting the Irrigation department in the preparation
of water demand & Collection of water Charges.
iv) Resolve disputes among the member of WUA
v) Monitoring flow of water in the Irrigation System
etc

LectureNo. 42

Topic(s) to be covered	42. Water Users Association - PIM Women role in PIM - The Wayhad farmer managed Irrigation System.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
Co_1	Gain knowledge on PIM & Water User Association	Understand

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

- Water Users Association
  - shall perform the following functions

i) To prepare & implement a warabandi schedule for each Irrigation season, operational plan, Area, soil, & Cropping Pattern approved by the distributory Committee / project Committee.

ii) To promote economy in the use of water allocated.

iii) To raise resources

iv) To monitor flow of water for Irrigation

v) To encourage modernization of agriculture in its area of operation.

- Women's Role in PIM :-

It is realized that women should play an important role in the WUAs considering the importance of women in terms of their numerical strength & the significant contribution they make to the agricultural labour force.

Government of India has given special emphasis on involving women in the process. Ministry of Water Resources, while issuing guidelines in April, 199[illegible] specifically emphasized the states to consider representation of women in the WUAs at all levels.

- PIM in Tamil Nadu Case study: PIM in India.

(The Waghad Farmer Managed Irrigation System

Waghad Irrigation Scheme is located at Nashik district of Maharashtra, India, catering to irrigation needs of 15926 small farmers having Total Cultural Command Area of 9642 Ha. Water available for irrigation is 48 m^3/s, average land holding 0.80 - 1.0 Ha. Earlier to formation of 3 WUAs in tail reach, having CCA of 1151 Ha, there were Hardly 100 ha of irrigation & that too seasonal. Food Crops eg, Sorghum were taken.

The active participation of WUAs in Irrigation management resulted in assured Irrigation in tail reach & Irrigated area rose remarkably in a span of 3.5 years. With the Success of WUAs in tail reach, farmers in other parts of Command of the Scheme Came together to form WUAs & gradually 24 WUAs were formed on entire Command area of Waghad Scheme.

The WUAs had managed water efficiently & productively through Conjective Use of water, application of drip Irrigation Method & diversification to high Value Crops like grapes, Vegetables. WUAs (in 2003) form project level & taken over entire Irrigation management of Waghad Irrigation Scheme in 2005. Now water is Supplied in bulk, Volumetrically at the Canal Head & BLA equitably distribute water Volumetrically to all WUAs as per their water quota, WUAs then distribute among their members. The water use rights and Crop freedom to WUAs have resulted into transforming Waghad Irrigation Scheme from eight monthly to perennial Scheme & traditional Cropping pattern to high value and productive Cropping pattern.

The extensive use of drip Irrigation Method and Conjuctive Use of water has made it possible

To use water quota efficiently & productively. Canal rotations are planned such that water avai for Irrigation can be used throughout the year

The project represents a highly successf "bottom up" farmer taking over of the Irrigation syst & the huge prosperity it has brought to the reg What was. Once a decaying Irrigation System where fa received no water & the Irrigation department receive no revenue is now a thriving region where incomes have grown 50-fold & Irrigation department Revenues went upto 10 fold within 15 years.

The Success of this project in part resulted to the state government passing the maharashtra State farmer Managed Irrigation Act in 2005, in a bid to replica the Success elsewhere. The project Success has been recognized by many awards including one from the Confederation of Indian Industry (CII) which allowed the project to Compete for a water efficiency award as a private Company.

Lecture No. 44.

Performance Evaluation.

Topic(s) to be covered	General - Evaluation Studies - Tenth plan proposals.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
LO_1	Gain knowledge on performance evaluation	Understand.
	for Irrigation projects.	

Teaching Learning Material	Student Activity
Chalk / Talk	Listen.

Lecture Notes

The water resources sector in the country has developed since 1951 through successive five year Plans. A large number of major, medium and minor projects have already been implemented & more are under implementation all over the country.

As a result the irrigation potential has gone up from 23 million hectare in 1951 to about 90 million hectare at the beginning of the 9th five year plan. In the recent past it has been realised that reforming irrigation institutions is

essential for increasing Productivity & efficiency of the Irrigation System. The Concept of benchmarking the Irrigation System is now widely regarded as an Important Management tool for Improving efficiency.

The Central Water Commission has initiated Performance Evaluation Studies of some Selected Irrigation projects at the national level. During 1982 - 1999, CWC has completed Evaluation studies of the following projects through Consultants & the findings of these Studies have already been sent to the Concerned State govt for their Comments and follow up action. The projects are: Indira Gandhi Nahar project (Rajasthan), Dantiwada Irrigation Project (Gujarat), Sirhind feeder Canal (Punjab) Godavari Delta Region (AP), Sriram Sagar Project (AP) Nira Pavara project (Maharashtra), Eastern Kosi Canal Project (Bihar), Bhadar Irrigation project (Gujarat), and the Lower Bhavani project (Tamil Nadu).

Evaluation Studies:-

The following are some of the findings of the Studies:

- The Irrigation Canal is being being used as a

Source of drinking water and the people in the Command area are enjoying better facilities in respect of Health and Sanitation.

- Substantial Changes in the Cropping pattern. The Crop Intensity has also been higher. An overall Improvement in the availability of ground water.

- There is a Need for Increasing people's participation in the distribution of water on equitable basis, among the users so that they may have a sense of Involvement and belonging with the project.

- Introduction of Rotational water supply is Considered Very essential in order to Improve the efficiency of the Irrigation System & to promote better Management practices.

- Spurt in activities of Infrastructural development, poverty reduction, Social Consciousness, Overall development of Economic activities in the Commands & the Surrounding areas.

- Over all Important of the environment & the ecosystem.

Tenth Plan Proposals:

CWC has formulated a proposal for taking up to Completed Irrigation projects for evaluation studies. It about 20 Million. The working group of the planning Commission on major & medium projects for formulation in the 10th plan has suggested the following 2 ter of Reference related to performance of Completed Irrig Projects.

To review the performance of the projects Completed up to the end of the 9th plan with refe to the originally planned project objectives & environ Impacts & Suggests changes needed, if any, in the pla & Implementation of new projects. To evolve a su strategy & suggest measures to improve Irrigation effi of all the existing projects to ensure equitable, timely & optimal delivery of Irrigation water to the farm

LectureNo. 45 Economic Aspects of Irrigation.

Topic(s) to be covered	Purpose of Irrigated agriculture - Socio economic problems -

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
1.	Gain knowledge on economic Aspects of Irrigation.	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Economic Aspects of Irrigation:-

The Major purpose of Irrigated agriculture is to Increase agricultural production & Consequently Improve the economic & social well - being of the area of the project.

Irrigation schemes usually achieve this objective, they could often have been more

Successful in developing Countries if more attention had been paid to the Social & Economic Structure of the project area.

Socio Economic problems reducing the Income generating Capacity of Irrigation scheme are

(i) Social organization of Irrigation operation & Maintenance : Who will Carry out the work (Opeation & Maintenance); when will Irrigation take place ; how will far delivery be determined ? Poor O&M Contributes. Significantly to long term Salinity & water logging problems & Needs to be adequately planned at the design Stage.

(ii) Reducing farming flexibility, Irrigation many only be Viable with high Value Crops thus reducing activities Such as graging animals, operating woodlots etc.

(iii) Insufficient external Support Such as markets, agro Chemicals Inputs, extension & Credit facilities

Improved planning, with User Involvement, has the potential to reduce if not remove the above problems for both the New Rehabilitation projects. Extension Services, with T&E offer much Scope to Improve the Income & amenity of Irrigation Schemes.

Economic activity Increases resulting in more employment, Trade etc. & this is the Indirect primary benefit. When Some of the agri. produce begin to get processes in the area as for Instance oilseeds into oil cake by oil mills gives rise to further employment, trade, Income etc.. (Direct Secondary benefit).

Indirect Secondary benefit arise when the Increased Income arising from oil are Spent on goods & Services giving rise to further economic activity. When the oil produced in the oil mills begins to be used for making Soap etc; there is further rise in employment Income etc. There are the direct tertiary benefits.

The Measurement & evaluation of these benefits therefore it has been recognised that the Measurement of Secondary & tertiary benefits become progressively difficult. Hence, Direct benefits in these Categories again are easier to measure than Indirect