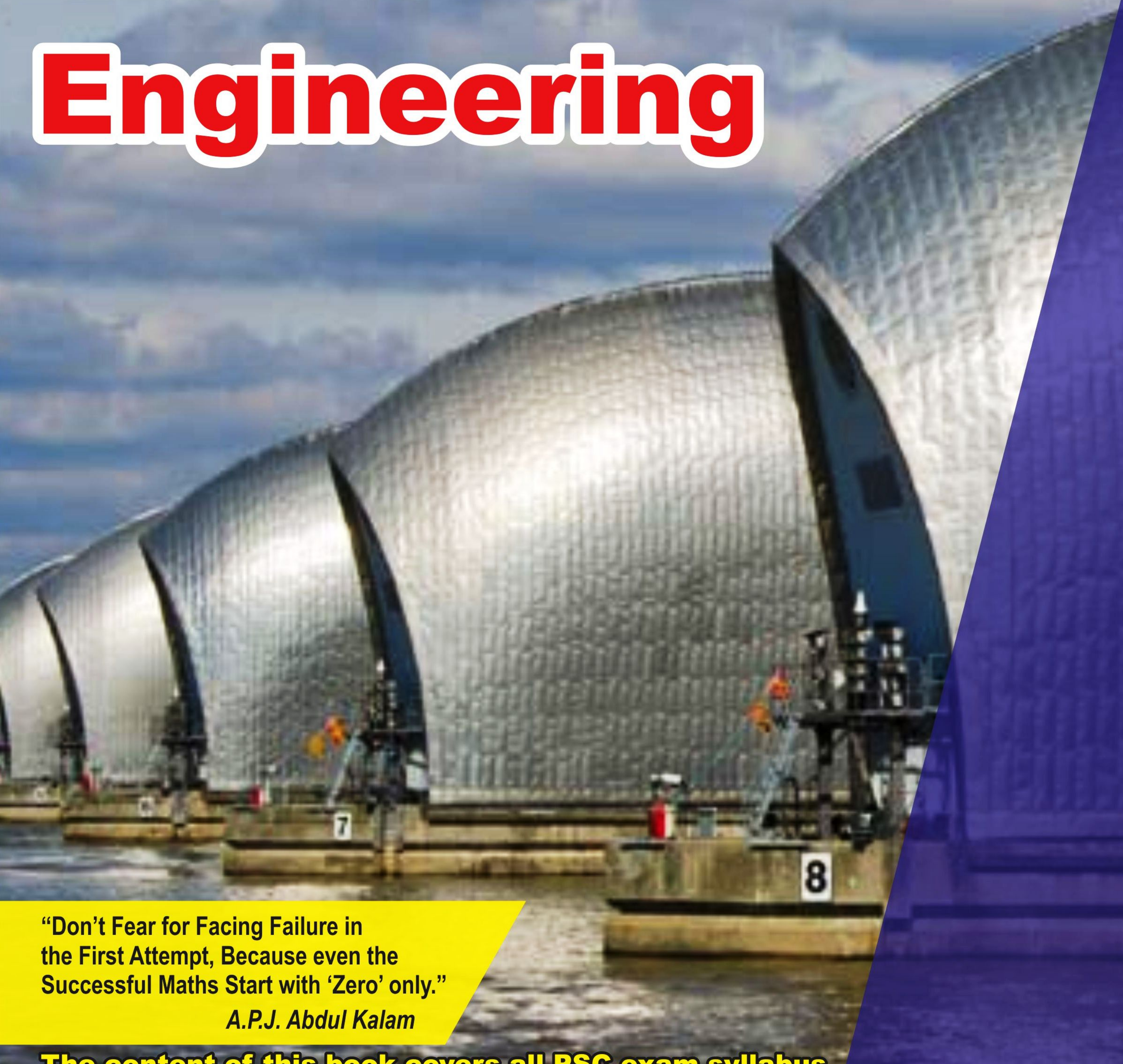
EXAM ACHARYA
EDUCATION REDEFINED

GPSC - CIVIL

Water Resource Engineering



"Don't Fear for Facing Failure in the First Attempt, Because even the Successful Maths Start with 'Zero' only."

A.P.J. Abdul Kalam

The content of this book covers all PSC exam syllabus such as MPSC, RPSC, UPPSC, MPPSC, OPSC etc.

INDEX

CHAPTER - 1

IRRIGATION & METHODS OF IRRIGATION

DEFINITION OF IRRIGATION

Irrigation may be 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.

NEED OF IRRIGATION

(i) Inadequate rainfall

(ii) Uneven distribution of rainfall

(iii) Increase in crop yield

(iv) Growing perrinial crops (eg-sugarcane)

(v) Growing multiple crops (2 — 3 crops in an year)

(vi) Insurance against drought

ADVANTAGES & DISADVANTAGES OF IRRIGATION

Advantages of Irrigation

Direct Advantages

(i) **Increase in food production:** Increase in crop yield due to irrigation leads to increase in food production, to attain self-sufficiency.

(ii) **Protection against drought:** The provision of adequate irrigation facilities in any region ensures protection against failure of crops from famine or droughts.

(iii) **Revenue generation:** When regular supply of water is assured for irrigation the cultivators can grow certain superior or high priced crops (like cash crops). Thus revenue is generated.

(iv) **Mixed cropping:** Means sowing of two or more crops together in the same field. This practice is followed so that if weather conditions are not favourable for one crop it may be suitable for another crop. But if irrigation facilities are made available, the need of mixed cropping is eliminated.

> **Note:**
> - **Mixed cropping-** By mixed cropping, we mean sowing together two or more crops in the same field. Advantage of mixed cropping is that, even when one crops fails, then also there is no loss in terms of revenue.

Indirect Advantages

(i) **Power generation:** Major river valleys projects are usually planned to provide hydroelectric power together with irrigation. However relatively small quantity of hydroelectric power may also be generated at a small cost on projects which are primarily planned for irrigation.

(ii) **Transportation:** Most of the irrigation canals are provided with unsurfaced roads primarily for purposes of inspection and maintenance. These roads provide a good pathway to the local people.

(iii) **Employment:** During the constructions of irrigation works, employment is provided.

Disadvantages of Irrigation

- Abundant supply of irrigation water tempts the cultivators to use more water than required, which would ground water table would be raised and will lead to water logging.
- The ground water can get polluted due to seepage of the nitrates into the ground water (applied to the soil as fertilizers).
- Intensive irrigation results in cold and damp climate, which causes spreading of disease such as dengue and malaria.

> **Note:**
> - If irrigation water is used judiciously with proper scientific consideration then there won't be ill effects of irrigation.

TYPES OF IRRIGATION PROJECTS

- In this system of irrigation, water is supplied through canal distribution system taking-off from above a weir or a reservoir.
- When irrigation is done by diverting the river runoff into the main canal by constructing a diversion weir or a barrage across the river, then it is called as direct irrigation. But if a dam is constructed across a river to store water during monsoons, so as to supply water in the off-taking channel during periods of low flow, then it is termed as storage irrigation.

Flood Irrigation

- In this method of irrigation, soil is kept submerged and thoroughly flooded with water, so as to cause thorough saturation of the land.
- It is usually practiced in delta regions where the river water level during flood is sufficiently high to supply water to the land by flow, or partly by flow and partly by lift.
- This system of irrigation is also called uncontrolled irrigation or inundation irrigation.

Sub-Surface Irrigation

In this type of irrigation, water does not actually wet the soil surface rather it flows underground and nourishes the plant roots by capillarity.

It may be divided into the following two types

(i) Natural sub-irrigation (ii) Artificial sub-irrigation.

Natural Sub-Irrigation

- Leakage water from channels, goes underground and during passage through the sub-soil, leakage causes the water-table to rise up, which helps in irrigation of crops by capillarity, called natural sub-surface irrigation.

Artificial Sub-Irrigation

(1) Free flooding
(2) Border flooding
(3) Check flooding
(4) Basin flooding
(5) Furrow method or furrow irrigation
(6) Sprinkler irrigation method
(7) Drip irrigation method

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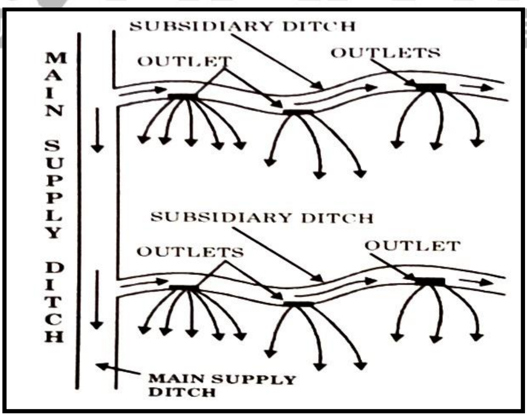
Free Flooding or Ordinary Flooding

- In this method, ditches are excavated in the field.
- Water from these ditches, flows across the field.
- After the water leaves the ditches, no attempt is made to control the flow by means of levees, also known as an wild flooding
- Water application efficiency is also low.
- Wild flooding is most suitable for close growing crops, pastures, etc., particularly where the land is steep.
- This method may be used on rolling land (topography irregular) where borders, checks, basins and furrows are not feasible.



Border Flooding

- In this method, the land is divided into a no. of strips, separated by low levees called borders.
- The land areas confined in each strip is of the order of 10 to 20 metres in width, and 100 to 400 metres in length.

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Building Material and Construction

Dream is not that which you see while sleeping it is something that does not let you sleep.

A.P.J. Abdul Kalam

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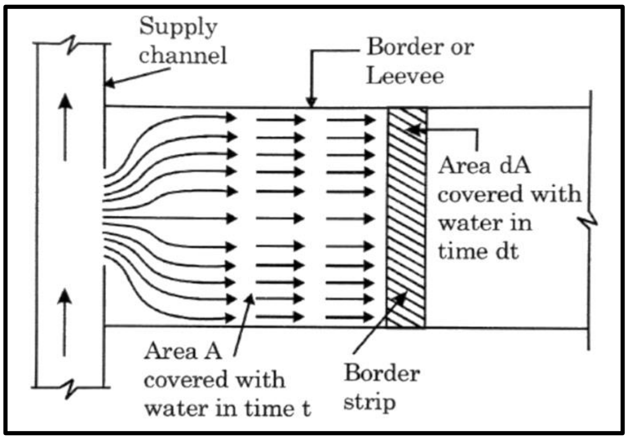
would be f.A dt. The total quantity of water supplied to the strip during time dt would be Q. dt. and also equal to y. dA + f . A dt.

$$\mathbf{Q.dt = y . d A + f . A . dt}$$



$$\mathbf{dt} = \left(\frac{y \cdot dA}{Q - f \cdot A}\right)$$

Considering y, f, and Q as constants, and integrating the above equation, we get

$$\int dt = y \int \frac{dA}{Q - fA}$$

$$t = -\frac{y}{f} \ln (Q - fA) + C$$

$$t = 0, A = 0$$

$$C = \frac{y}{f} \ln Q$$

$$t = -\frac{y}{f} \ln (Q\text{-}fA) + \frac{y}{f} \ln Q$$

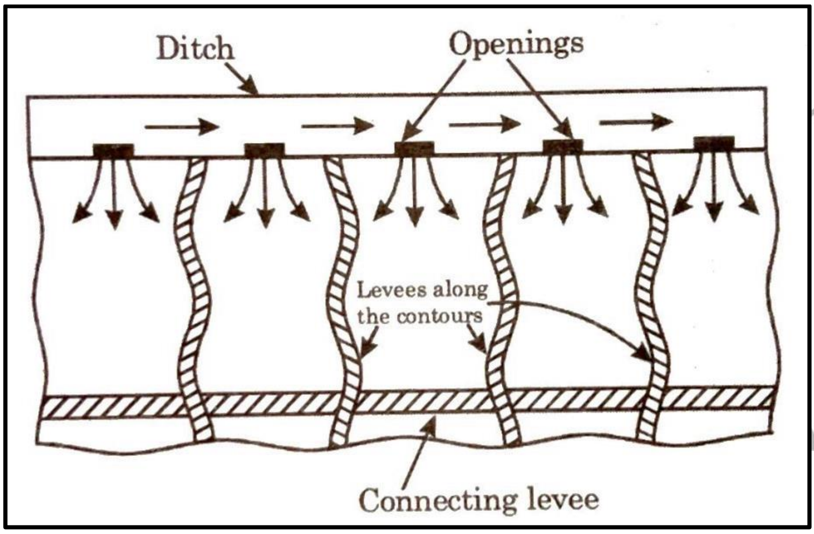
$$t = \frac{y}{f} \ln \left(\frac{Q}{Q - fA}\right)$$

$$\mathbf{t = 2.303\, \frac{y}{f} \log_{10} \left(\frac{Q}{Q - fA}\right)}$$

This equation can be further written as

Check flooding

- Check flooding is similar to ordinary flooding except that the water is controlled by surrounding the check area with low and flat levees.
- Close growing crops such as jowar or paddy are preferred for this method of irrigation.
- Deep homogenous loam or clay soils with medium infiltration rates are preferred for this method.
- This method is suitable for both more permeable and less permeable soils.



Basin Flooding

- This method is a special type of check flooding & adopted specially for orchard trees.
- Shape of the basin can be square, rectangular, circular or it may be irregular.
- Flatter the land surface, easier it is to construct the basins
- Coarse sands are not suitable for basin irrigation because of high percolation losses

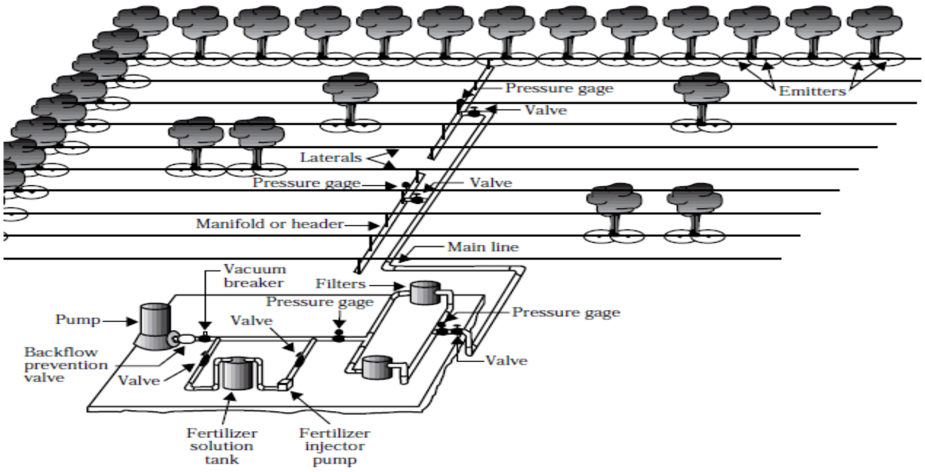
- In this method, the irrigation water is applied to the land in the form of spray, somewhat as in ordinary rain through a network of pipes and pumps.
- The sprinkler irrigation can be used for all the crops except rice and jute and for almost all the soils except very heavy soils with very low infiltration rates.
- Best suited for very light soils as deep percolation losses are avoided.
- This system is flexible to suit undulating topography and hence land levelling is not necessary.
- This method is used mainly by cultivators of tea, coffee and vegetables in our country.

Note
- For rice and jute, standing water is required.
- Light soils are sandy & silty with very little clay. Generally easy to work, warm up quickly, dry out rapidly.

Advantages of Sprinkler Irrigation

- It can be efficiently used for a wide range of topographic conditions, soils and crops.
- With use of sprinkler irrigation, erosion of soil can be controlled (as surface runoff is eliminated)
- Uniform application of water is possible with sprinkler irrigation.
- In this method, a better control on irrigation can be enforced and also light irrigation is possible which is required for seedlings and plants which are very young.
- Labour cost is reduced as no land preparations are required.
- Does not require borders, field channels etc. and hence more land is available for cropping.

- The time and amount of application of fertilizer can be better controlled in sprinkler irrigation.
- About 80% water application efficiency is possible (water application efficiency is high).



Advantages of drip irrigation

- Water requirement is very less (since water is delivered directly to the plant).
- Evaporation loss and wind loss are almost negligible.
- There is least wetting of soil surface due to direct water supply to the plants.
- Suitable for all types of soils, especially for coarse textured soil.
- Highest rate of vegetative growth.
- Land levelling is not required.
- Roots stay within the moist zone.
- Reduction of deleterious effects of salts.
- Low labour requirements, as most drip systems are permanent setups.
- Field operations are easier to manage.
- There is no loss at the edge of the fields as can occur through wind drift of sprinkler systems or runoff from surface system.

New Batches are going to start.....

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Test Series Available..

Total weekly test	: 35
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Methods of Assessment

There are five methods of assessment:

(i) Assessment on area basis or crop rate basis

(ii) Volumetric assessment

(iii) Assessment on seasonal basis

(iv) Composite rate basis

(v) Permanent assessment

Assessment on Area Basis or Crop Rate Basis

Under this system of assessment of irrigation, area sowing crops is recorded by a 'patrol' both at the time of sowing and maturity. At the end of the crop period a 'demand statement' for each irrigator is prepared. The measurements are checked by various officials including Zilledar, Deputy Collector, Sub-Divisional Officer and the Divisional Canal Officer. Checking of irrigated area is an important part of Canal Officers duty at all levels upto Divisional Officer. For failure of crops for reasons beyond the control of the irrigator or for shortage of water supply, remission may be given to the farmers.

Special charges are levied in addition to the usual charges under the Canal Act for the following:

(a) Unauthorised irrigation comprising use of unanuthorised water course

(b) Cuts in channel banks

(c) Damaging the outlets

(d) Opening outlets at unanuthorised time

(e) Irrigation out of sanctioned turn

(f) Wasting water

Special charges may go up 6 times the normal charges.

In addition to the cost, the method has the following short comings:

1. A whole time staff is needed to keep records of the meters.
2. The meters may not work on small heads at the outlet.
3. Silt and debris may obstruct the flow through the metered oultlet.
4. The cultivators may pilfer water by unauthorised methods.
5. The internal distribution of volumetric supplies and apportionment of dues between petty shareholders may be difficult.

The only possible place for such assessment is tube-well, where water is sold out on a volumetric basis by litres per rupee or by units rate of electric power consumed, as a tube well operator is there to keep the full record. The only other feasible proposal is to sell out water on volumetric basis to co-operative societies or panchayats of irrigation who should be responsible both for internal distribution as well as collection and payment of canal dues for the same.

Assessment on Seasonal Basis

In this method the rate of assessment is based on the type of crop grown in a particular tract during certain crop season. This method is not in vogue in India.

Composite Rate Basis

Composite rate is a combination of water charges and the land revenue. Some states prefer to collect both the revenues together and hence the name.

Permanent Assessment or Betterment Levy Basis

The cultivators in a particular area may have their own source of water supply under ordinary conditions and may not use water from a canal which has been aligned in that area only to protect it in drought period. The farmers of that area are levied at a fixed rate every year due to such provisions. Such a levy is known as betterment levy. During the drought periods, the farmer will be authorised to use water from such a canal without paying extra charges above the betterment levy.

CLEAR YOUR CONCEPT:

Qu 1 Consider the following statements-

1 Irrigation helps avoiding mixed cropping

2. Irrigated land area generated more revenue than non-irrigated land area.

3. Over irrigation is uneconomical and causes kidney damage due fertilizer percolation.

4. Irrigation facility provides excellent transportation facility for local people.

Which of the following statements are correct

(a) 1. 2. 3 are correct

(b) 1, 3, 4 are correct

(c) 2. 3. 4 are correct

(d) 1. 2. 4 are correct

Qu 2 A sprinkler irrigation system is suitable when

(a) The land gradient is steep and the soil is easily erodible

(b) The soil is having low permeability

(c) The water table is low

(d) The crops to be grown have deep roots

Qu 3 The method of growing crops on ridges. running on the sides of water ditches is known as

(a) Flood irrigation

(b) Furrow irrigation

(c) Check irrigation

(d) None of them

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Construction, Planning and Management

"All Birds find shelter during a rain.
But Eagle avoids rain by flying above
the Clouds."

A.P.J. Abdul Kalam

The content of this book covers all PSC exam syllabus such as MPSC, RPSC, UPPSC, MPPSC, OPSC etc.

Qu 8 **In an irrigation system, water was delivered to the field in ditches spaced about 30 m apart, and was allowed to seep into the ground to maintain the water table at such a height that the water is available to the crops through the capillary fringe. This method of irrigation is called**

(a) Trickle irrigation
(b) Furrow irrigation
(c) Border irrigation
(d) Sub irrigation

Qu 9 **In border method of irrigation the flow along the border is a case of**

(a) Spatially varied, unsteady, open channel flow with decreasing discharges
(b) Steady, spatially varied open channel flow with decreasing discharges
(c) Unsteady, gradually varied open channel flow
(d) Unsteady, uniform, open channel flow.

Qu 10 **In an irrigation system, land was divided into a large no. of smaller size unit areas, having fairly level surface, by bunds & cross ridges. The basins thus created were filled with water to the desired depth & the water was retained for some time. This method of irrigation is known as**

(a) Border method
(b) Check basin method
(c) Sub-irrigation
(d) Contour irrigation

Answers:

1-(a), 2-(a), 3-(b), 4-(b), 5-(d), 6-(a), 7-(d), 8-(d), 9-(a), 10-(b)

Type	Sown time	Harvested time
Rabi Kharif	October April	March (next year) September (same year)
Hot weather Kharif Rabi	Feb. June Oct	May (same year) Sept. (same year) Feb. (same year)
Sugarcane Cotton	Feb. to march May to june	Nov. to mar. (next year) Dec. to jan. (next year)

Note
- Season from March to June is called Zaid.
- Sugarcane, tobacco, potato, jute, tea, coffee etc. are plantation crops.
- Main Kharif cereals are Jowar, soyabean, rice, bajra, cotton, maize, tobacco and groundnut.
- Main Rabi crops: Potato, wheat, pulse, gram, mustard, barley, linseed etc.

CROP PERIOD AND BASE PERIOD

- Crop period is defined as total time that elapses b/w the sowing of the crop and its harvesting. Thus, crop period represents the total time during which the crop remains in the field.
- Base period is defined as the total time between the first watering done for the preparation of the land for sowing of a crop and the last watering done before its harvesting.
- Crop period is slightly more than the base period for any crop but for calculation purpose they are taken same.
- Both the crop period and the base period are expressed in days.
- Consideration of base period is essential for determining the total water requirement of a crop.

Note
- The terms like growth period, crop period, base period, etc., can be used as synonyms, each representing crop period, and will be represented by B (in days).

RELATIONSHIP BETWEEN DUTY & DELTA

If D is the duty of water on the field in hectares per cumec, Δ, the total depth of water in metres supplied to a crop growing on the field during the entire base period and B, the base period of the crop in days.

Then, for a field of area D hectares corresponding to the depth of water Δ metres,

The total quantity of water supplied for growing a crop on the field = D × Δ ha-m = D × Δ x 10^4 cubic metre

Further, for the same field of area D hectares for growing a crop, if water is supplied at the rate of 1 cumec for the entire base period of B days,

The total quantity of water supplied to the field = 1 × B × 24 × 60 × 60 cubic metre

Hence, $D \times \Delta \times 10^4 = 8.64 \times 10^4 \times B$

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

FACTORS AFFECTING DUTY OF WATER

The duty of water mainly depends on the following factors.

(1) Types of crop

Duty of water varies from crop to crop. The crops which require large quantity of water have lower duty of water than for the crops which requires less quantity of water.

(2) Climatic condition of the area

The climatic conditions which affect the duty of water are (i) temperature, (ii) wind velocity, (iii) humidity and (iv) rainfall.

- Higher is the temperature, lesser is the duty of water (the loss of water due to evapotranspiration will be more)

- In the initial stages, the land to be cultivated may not be properly levelled and hence more than the required quantity of water may be applied, which will result in a lower duty of water.

- Frequent cultivation of land reduces the loss of moisture through weeds and evaporation from soil and hence results in as higher duty of water.

(8) Type of soil and sub-soil of the area through which canal passes

- If the canal is unlined and it passes through coarse grained soil then since there will be greater percolation, loss the duty of water will be low.
- On the other hand, if an unlined canal is passing through fine grained soil then the percolation loss will be less and hence the duty of water will he high.

(9) Canal conditions

In an earthen canal, the percolation loss is high which will result in a low duty of water. But if the canal is lined, the percolation loss will be less and the duty of water will be high.

(10) Base period of crop

In general when the base period of a crop is long, more water may be required thus resulting in a lower duty of water.

- It includes culturable as well as unculturable area for example ponds, residential area, roads, forest etc.

Culturable Commanded Area (CCA)

- The culturable commanded area is that portion of the gross commanded area which is culturable or cultivable.

- Thus culturable commanded area may be obtained by subtracting the unculturable area from the gross commanded area.

C.C.A = G.C.A. — unculturable area (area not fit for cultivation)

- The culturable commanded area may be subdivided into the following two categories.

  (a) Culturable cultivated area: It is that portion of the culturable commanded area which is actually cultivated during a crop season.

  (b) Culturable uncultivated area: It is that portion of the culturable commanded area which is not cultivated during a crop season.

Intensity of Irrigation

- The intensity of irrigation is defined as the percentage of the culturable commanded area proposed to be irrigated annually.

- The yearly intensity of irrigation may be obtained by adding the intensities of irrigation for all the crop seasons. **e.g.,** If the intensity of irrigation for Rabi is 50% and that for Kharif is 60% then the yearly intensity of irrigation will be 110%.

Test Series Available..

Total weekly test	: 35
Total mid subject test	: 16
Total full length test	: 13
Mock test	: 16
Total test	: 80

Note

- Since during kor watering certain quantity of water is required to be applied in a relatively short duration, the discharge capacity of the canal supplying irrigation water has to be maximum during this period.

Outlet Factor

The irrigation water is supplied to the land to be irrigated by field channels (or water courses) which in the case of a flow irrigation system are supplied water from canals through the outlets. The duty of water at the outlet is known as the outlet factor.

In other words, outlet factor is the duty of water at the head of a field channel. (Also called outlet discharge factor)

Capacity Factor

- A canal is designed for a certain maximum discharge capacity, but it need not carry the same discharge at all the time.
- Hence, ratio of the mean supply discharge of a canal for a certain duration to its maximum discharge capacity is defined as capacity factor.
- For example if during kharif season area sown is such that discharge required is 0.95 Q_{max}, then capacity factor = 0.95, where Q_{max} = maximum capacity of canal.
- During Rabi it will be say 0.67 Q_{max}. But to improve the capacity factor more area can be sown in Rabi.

Duty on Capacity (Full Supply Coefficient)

- It is design duty at the head of canal.

$$\textbf{full supply coefficient} = \frac{\textbf{Area estimated to be irrigated during base period}}{\textbf{Design full supply discharge at the head of canal}}$$

Crop Calendar

- It gives us the information about various agronomic practices of the crops grown by farmers.
- Crop calendar is a tool that provides information about planting, sowing and harvesting period of locally adopted crops in an area.

Crop Factor

Ratio between crop evapotranspiration and reference crop evapotranspiration.

Carry-Over Storage

The storage of water (say, about 5% of live storage) required for the next crop-year as a protection against the late monsoon break is called carry-over storage.

Live Storage

Live storage (LS) is defined as the water stored in a tank or reservoir between full-tank level (FTL) or full reservoir level (FRL) (i.e. RL of weir or spillway crest) and the lowest supply level (LSL) (sill level of sluice or dead storage level DSL).

Dead Storage

The dead storage (DS) is defined as the water stored between the LSL and the deepest river bed level (RBL) in a reservoir or of feeder nallah in a tank. This space is to allow for silting up and is about 10% of the gross storage.

Gross Storage

The gross storage (GS) is defined as the storage capacity, or the volume of water, between FTL or FRL and RBL. Mathematically,

$$\mathbf{GS = LS + DS = LS + 0.1\,GS \text{ or } GS = \frac{\mathit{LS}}{0.9}}$$

GPSC - CIVIL

Design of Steel Structures

"Shoot for the Moon. Even if you miss, you will land among the Stars."

Les Brown

The content of this book covers all PSC exam syllabus such as MPSC, RPSC, UPPSC, MPPSC, OPSC etc.

Thus, if R_f is the quantity of water lost as surface runoff from the field and D_f is the quantity of water lost due to deep percolation to a level far below the root zone, then

$$\mathbf{W_f = W_s + R_f + D_f}$$

$$\eta_a = \frac{W_f - (R_f + D_f)}{W_f} \times 100$$

e.g., In the case of sprinkler irrigation method the water application efficiency may be as high as 80% while in the case of a surface irrigation method it may not exceed 60%.

Water Use Efficiency (η_u)

It is defined as the quantity of water used beneficially including the water required for leaching to the quantity of water delivered.

Thus, if W_u is the quantity of water used beneficially and W_f is the quantity of water delivered to the field then

$$\eta_u = \frac{W_u}{W_f} \times 100$$

Water storage Efficiency (η_s)

It is defined as the ratio of the quantity of water stored in the root zone during irrigation to the quantity of water needed to bring the moisture content of the soil to the field capacity. Thus, if W_s is the quantity of water stored in the root zone during irrigation and W_n is the quantity of water needed to bring the moisture content of the soil to the field capacity (i.e., W_n = Field capacity - Available moisture in the soil prior to irrigation), then

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

Note

- The presence of excess salts in the soil would require that water storage efficiency should be high in order to keep the salts washed out of the soil.

water requirements that are not provided by water stored in the soil and precipitation that enters the soil.

Consumptive Irrigation Requirement (CIR)

It is defined as the amount of irrigation water that is required to meet the evapotranspiration needs of a crop during its full growth. If during the growth period of a crop rain occurs then since a part of it will be retained by the soil in the root zone and the same will be available to meet a part of the evapotranspiration requirements of the crop, the quantity of irrigation water required to be applied will be correspondingly reduced. This part of the rainfall is known as effective rainfall. Thus if E_{t_c} or C_u is the evapotranspiration or consumptive use of water for a crop and R_e is the effective rainfall during the growth period of the crop then

$$\mathbf{CIR} = E_{t_c} - R_e \text{ (or } C_u - R_e)$$

Net Irrigation Requirement (NIR)

It is defined as the amount of irrigation water required to be delivered at the field to meet the evapotranspiration needs of a crop as well as the other needs such as leaching, presowing requirement and nursery water requirement.

$$\mathbf{NIR = CIR + LR + PSR + NWR}$$

Where,

LR = Leaching requirement

PSR = Presowing requirement;

NWR = Nursery water requirement

Note

- Presowing requirement (PSR): Presowing irrigation is important for field preparation as availability of moisture is essential for good germination of seeds.
- Nursery Water Requirement (NWR): The water requirement for nursery is required to be considered in the case of those crops which are sown on nursery beds and are transplanted within few days after sowing when the plants are a few cm tall.

CLASSIFICATION OF IRRIGATION CANALS

The irrigation canals can be classified in different ways on the basis of various considerations as follows:

Classification based on the Nature of Source of Supply

(i) Permanent canals (ii) Inundation canals

Permanent Canals

A permanent canal is the one which is fed by a permanent source of supply. It is a well graded channel and is provided with permanent regulation and distribution works. The permanent canals may be further classified as:

(a) Perennial canals: Canals which get continuous supplies from the source throughout the year.

(b) Non-perennial canals: Canals which get supplies only for a part of the year.

Inundation Canals

An inundation canal is a canal which gets its supplies only when the water level in the river, from which it takes off, rises during floods. These canals are not provided with any headworks for diversion of river water to the canal but obtain their supplies through open cuts in the bank of the river. The inundation canals are therefore non-perennial and the flow in these canals depend on the periodical rise of water level in the river.

Classification Based on the Function of the Canal

(i) Feeder canals (ii) Carrier canals

Feeder Canals

A feeder canal is a canal which is constructed only to feed another canal. No direct irrigation is carried out from a feeder canal. e.g., Indira Gandhi feeder canal.

Major Distributary

- Major distributaries are the irrigation canals which take off from the branch canals and sometimes from the main canal.
- The major distributaries are generally used for direct irrigation and hence they supply water through outlets to water courses.
- They carry a discharge varying from 0.25 to 5 cumec.

Minor Distributary

- Minor distributaries are the irrigation canals which take off from major distributaries and branch canals.
- They carry discharge less than 0.25 cumec.

Water Courses or Field Channels

- Water courses are small channels which carry water from the outlets of a major or minor distributary or a branch canal to the fields to be irrigated.
- Outlets are provided in the irrigation canal at appropriate places.
- Beyond the outlet, water is handled by the individual cultivators who directs it to various parts of its command.
- These are owned, constructed, controlled and maintained by the cultivators.

Classification Based on Canal Alignment

(i) Ridge canal or Watershed canal (ii) Contour canal

(iii) Side slope canal

Ridge canal or Watershed canal

- A ridge or watershed canal is a canal which is aligned along the ridge or the natural watershed line.

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Test Series Available..

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A canal which when fully developed yields enough revenue to cover up its running cost and a net saving at the rate of more than six percent of the capital invested initially for its construction.

Protective Canals

A canal which is constructed as a relief work during famine to provide employment to the inhabitants of the famine affected area and to protect that area against famine in future.

Classification Based on the Soil Through which Constructed

(i) Alluvial canals (ii) Non-alluvial canals

Alluvial Canals

Canals flowing through alluvium i.e. ground formations consisting of non-cohesive sediments like sand, silt and gravel. These soils are readily scoured and deposited.

Non-Alluvial Canals (NAC)

Canals that have been lined with some suitable material to provide a rigid bed and banks so as to avoid the problem associated with alluvial boundaries.

Classification Based on the Lining

Unlined Canals

Canals which has its bed and banks made up of natural soil through which it is constructed and it is not provided with a lining of impervious material. The bed and banks of the canal may not be scoured.

Lined Canals

Canals which are provided with a lining of impervious material on its bed and banks to prevent the seepage of water.

CLEAR YOUR CONCEPT:

Qu 5 What is the first step in soil preparation before sowing of seeds?

a) Levelling

b) Ploughing

c) Manuring

d) Pre-watering

<u>TEST YOUR SELF:</u>

Qu 6 Determine the Gross irrigation requirement for an irrigation system if consumptive use of crop is 200 cm in terms of depth and the rainfall excess is 30 cm. Assume water application efficiency = 50% and conveyance efficiency = 90%.

a) 370 cm

b) 380.79 cm

c) 355.56 cm

d) 377.77 cm

Qu 7 An outlet irrigates an area of 40 ha. The discharge required at this outlet to meet the evapotranspiration requirement of 40 mm occurring uniformly in 40 days neglecting other field losses is _________

a) 4.52 litres / sec

b) 2.31 litres / sec

c) 4.01 litres / sec

d) 1.52 litres / sec

Answer:

1-(a), 2-(c), 3-(b), 4-(a), 5-(b), 6-(d), 7-(a)

Note
- Whenever there is water logging, there is salinity.

CAUSES OF WATER LOGGING

Over and Intensive Irrigation

When a policy of intensive irrigation is adopted, then the maximum irrigable area of a small region is irrigated. This leads to heavy irrigation in that region resulting in heavy percolation and subsequent rise of water table. Hence, policy of extensive irrigation should be preferred, to avoid water logging.

Seepage of water from the Adjoining High Lands

Water from the adjoining high lands may seep into the sub-soil of the affected land and may raise the water table.

Seepage of Water Through the Canals

Water may seep through the beds and sides of the adjoining canals, reservoirs, etc., situated at a higher level than the affected land resulting in high water table. This seepage is excessive, when soil at the site of canals, reservoirs, etc., is very pervious.

Impervious Obstruction

Water seepage below the soil moves horizontally but may find an impervious obstruction causing the rise of water table on the u/s side of the obstruction. Similarly, an impervious stratum may occur below the top layers of pervious soils. In such cases, water seepage through the pervious soils will not be able to go deep, and hence, quickly resulting in high water table.

Inadequate Surface Drainage

If proper drainage is not provided, the storm water falling over the land and the excess irrigation water will constantly percolate and will raise the level of the underground reservoir.

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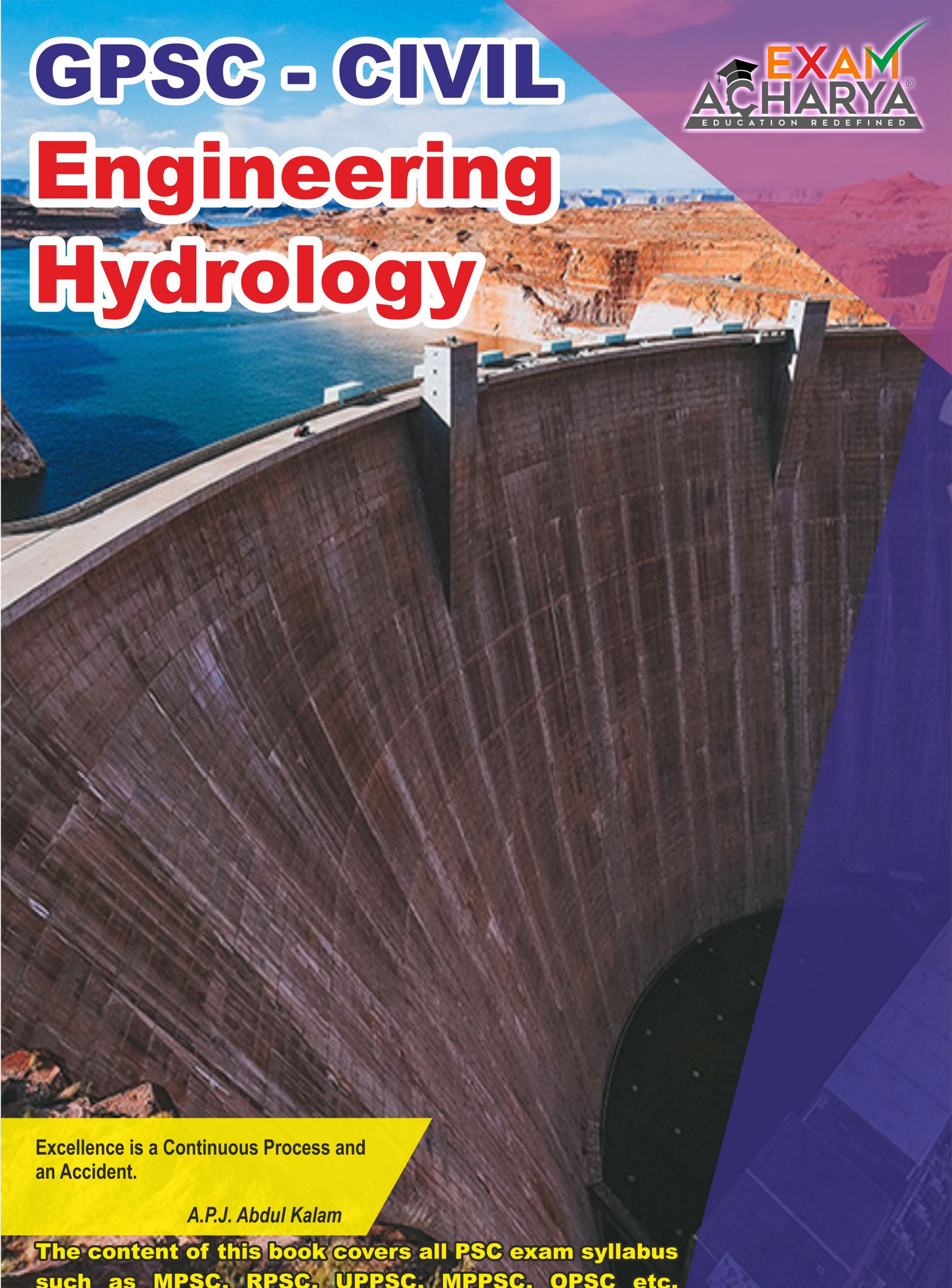
Engineering Hydrology



Excellence is a Continuous Process and an Accident.

A.P.J. Abdul Kalam

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By Optimum Use of Water

Only a certain fixed amount of irrigation water gives best productivity. The unaware cultivators should be made aware about this technicality. Moreover, the revenue should not be charged on the basis of irrigated area but should be charged on the basis of the quantity of water utilised.

By Providing Intercepting Drainage

Intercepting drains along the canals should be constructed, wherever necessary. These drains can intercept and prevent the seeping canal water from reaching the area likely to be water logged.

By Provision of an Efficient Drainage System

An efficient drainage system should be provided in order to drain away the storm water and the excess irrigation water. A good drainage system consists of surface drains as well as sub surface drains.

RECLAMATION OF SALINE AND ALKALINE LANDS

- Land reclamation is a process by which an uncultivable land is made fit for cultivation. Saline and water-logged lands give very less crop yields, and are therefore, almost unfit for cultivation, unless they are reclaimed.
- Every agricultural soil contains certain mineral salts in it. Some of these salts are beneficial for plants as they provide the plant foods, while others prove injurious to plant growth. These injurious salts are called alkali salts and their common examples are Na_2CO_3, Na_2SO4, and NaCl. Na_2CO_3 is the most harmful; and NaCl is the least harmful. These salts are soluble in water.
- If the water table rises up, or if the plants roots happen to come within the capillary fringe, water from the water table starts flowing upward. The soluble alkali salts also move up with water and get deposited in the soil within the plant roots as well as on the surface of the land. This phenomenon of salts coming up

Leaching

- In this process, land is flooded with adequate depth of water. The alkali salts present in the soil gets dissolved in this water which percolate down to join the water table. The process is repeated till the salts in the top layer of the land are reduced to such an extent that some salt resistant crop can be grown. This process is known as leaching.

Leaching Requirement (LR) of a Soil

- In order to avoid further increase in salinity, of a given soil after the land has been reclaimed it is necessary to apply water to the soil in excess of the consumptive use.
- This excess water will flow down beyond the root zone of the crop to the underground drainage system or to the underground reservoir, washing down the excess salts, which otherwise would have been deposited in the soil to further increase the salinity of the soil.
- This excess water, which is required to meet the leaching needs, is generally expressed as the percentage of the total irrigation water applied to the soil (field) to meet the consumptive use as well as the leaching needs.

$$\textbf{LR (Leaching Requirement)} = \frac{D_d}{D_i}$$

$$\textbf{LR} = \frac{\textit{Depth of water drained out per unit area}}{\textit{Depth of irrigation water applied per unit of area}}$$

where, D_i = Total irrigation water depth applied. = $C_u + D_d$

where, C_u = Consumptive use + Drained out water depth

$$\textbf{L.R} = \frac{D_d}{D_i} = \frac{D_i - C_u}{D_i}$$

For salt equilibrium, the ratio D_d/D_i is found to be equal to C_i/C_d

(i) Investigations such as topographical, geological and soil surveys should be carried out.

(ii) The nature of soil from the point of view of permeability should be studied.

(iii) A knowledge of water table and its fluctuations and the quality of ground in the area proposed for irrigation.

Two types of drainage can be provided, i.e., (i) Surface drainage, (ii) Sub-surface drainage.

Surface Drainage or Open Drainage

- Surface drainage is the removal of excess rain water falling on the fields or the excess irrigation water applied to the fields, by constructing open ditches, field drains etc. Land is sloped towards these ditches or drains so as to make the excess water flow into these drains.
- In arid regions, drainage ditches become necessary to remove water required for leaching undesirable salts from the soil, and to dispose off the excess rainfall.
- The open drains, which are constructed to remove the excess irrigation water collected in the depressions on the fields, as well as the storm water, are broad and shallow, and are called shallow surface drains.
- These drains carry the runoff to the outlet drains, which are large enough to carry the flood water of the catchment area from the shallow surface drains, and are of sufficient depths to provide outlets even for the underground tile drains, if provided. These outlet drains may be called deep surface drains.
- Surface drains constructed for removing excess irrigation water applied to the farms and the storm water, should not be deep enough, as to interfere with the agricultural operations. They are, therefore, designed as shallow surface drains.
- The shallow surface drain are trapezoidal in cross-section. They should be strictly designed to carry the normal storm water into the fields, plus the excess irrigation water.

- They are economical to be installed and do not interfere with the farming operations.

SUB-SURFACE DRAINAGE OR TILE DRAINAGE

VC: AgPhD

- Sub surface drains are required for soils with poor internal drainage and a high water table.
- Tile drains are usually pipe drains made up of porous earthenware and are circular in section.
- The diameters may vary from 10 to 30 cm.
- The trenches in which they are laid are back filled with sand and excavated material.
- The tile drains should not be placed below less pervious strata.
- If no impervious layer occurs below the land and the water table is low (lower than about 3 m from the ground), internal soil drainage may be sufficient and no tile drains needed.
- For maximum productivity of most of the crops, both surface as well as sub surface drains may sometimes however become, essential, particularly in areas of higher water tables.

Advantage of Tile Drains

(i) Removes the free gravity water that is not directly available to the plants.

(ii) Increases the volume of soil from which roots can obtain food.

(iii) Increases air circulation.

(iv) Permit deep roots development by lowering the water table especially during spring months.

(v) Increases bacterial activity in the soil, thus improving soil structure and making the plant food more readily available.

(vi) Lesser time and labour is required for tilling and harvesting.

CLEAR YOUR CONCEPT:

Qu 1 Which one of the following is not a remedial measure for water logging?

a) Good drainage for irrigated land

b) Conjunctive use of water in the basin

c) The lining of canals and watercourses

d) Contour bunding

Qu 2 Which of the following factor do not contribute to water-logging?

a) Inadequate drainage

b) Seepage from unlined canals

c) Frequent flooding

d) Excessive tapping of groundwater

Qu 3 Which of the following is a remedial measure for water-logging?

a) Controlling seepage from the canals

b) By lowering the F.S.L of the canals

c) Quick disposal of rainwater

d) Installation of lift irrigation systems

Qu 4 Swampy land is ________

a) Ill-aerated land

b) The land where cultivation operations are impossible

c) Land having deposition of alkali salts in the root zone of the crops

d) Saline land

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Chapter – 4

CANAL DESIGN

SEDIMENT TRANSPORT

Water flowing in a channel has a tendency to scour its surface. Silt, gravel or even large boulders are detached from the bed or sides of the channel and moved d/s by the moving water. This phenomenon is known as Sediment transport.

IMPORTANCE OF SEDIMENT TRANSPORT

- Sediment transport phenomena causes large scale scouring and siltation of irrigation canals.
- Bed levels may change by direct scouring or deposition of sediment, and thereby leading to change in flood levels.
- Scouring & silting of the river banks may create sharp and irregular curves, which increases the flow resistance of the channel, thereby, flood levels gets raised for the same discharge.
- Silting of reservoir and rivers is an important aspect of sediment transport. The storage capacity of the reservoir is reduced by silting, thereby, reducing use and life of the reservoir. Natural rivers used for navigation are frequently silted up. This leads to drastic reduction in the clear depth for navigation, thus, requiring costly dredgings.

SEDIMENT LOAD

Sediment load is the burden of sediment carried by the flowing water in a canal. The sediment moving in water has been classified as:

(1) Bed load (2) Suspended load.

Bed Load

- When the velocity is increased beyond formation of dunes, the dunes are erased by the flow, leaving very small undulations or virtually a flat surface with sediment particles in motion.
- Now, increase in velocity results in formation of sand waves in association with surface waves.
- As velocity is further increased, Froude no. $\left(i.e \frac{V}{\sqrt{gy}}\right)$ exceeds unity, the flow becomes super-critical, and the surface waves become so steep that they break intermittently and move u/s, although the sediment particles keep on moving d/s only. Sand Waves are then called antidunes, since direction of movement of bed forms in this regime is opposite to that of the dunes.

Note
- Dunes may form in any grain size of sediment, but ripples do not occur if the size of the bed particles is coarser than 0.6 mm.
- In case of canals and natural streams, anti-dunes rarely occur.
- Dunes are much larger and more rounded than ripples.

MECHANICS OF SEDIMENT TRANSPORT

- We assume the soil to be incoherent and study each soil grain individually.
- We confine ourselves to the mechanism of movement of sands and gravels only as most of our river beds are made up of sands and gravels.
- **Basic mechanics involved:** Drag force exerted by water in direction of flow on channel bed.
- This force is known as Tractive Force or Shear Force or Drag Force

Let us consider a channel of length L and cross-sectional area A.

The volume of water stored in this channel reach = AL

Wt. of water stored = γ_wAL

where, γ_w = unit weight of water = $\rho_w g$ (ρ_w, is the density of water).

Horizontal component of this weight = γ_wAL = γ_wALS ($\because$ sin $\theta \approx$ tan θ; for small values of θ)

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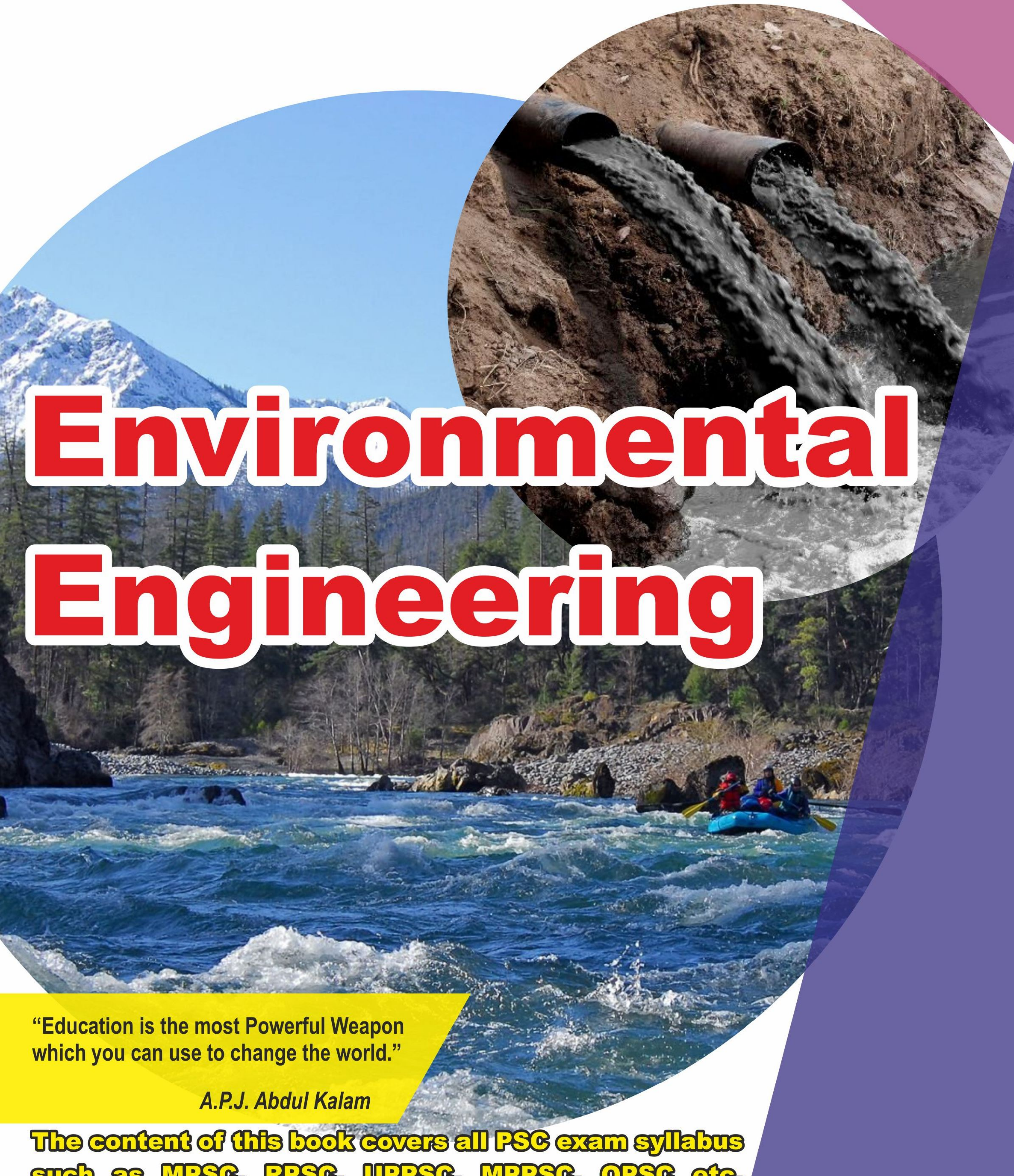

Environmental Engineering

"Education is the most Powerful Weapon which you can use to change the world."

A.P.J. Abdul Kalam

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This horizontal force exerted by the water is the tractive force.

Average Tractive force per unit of wetted area

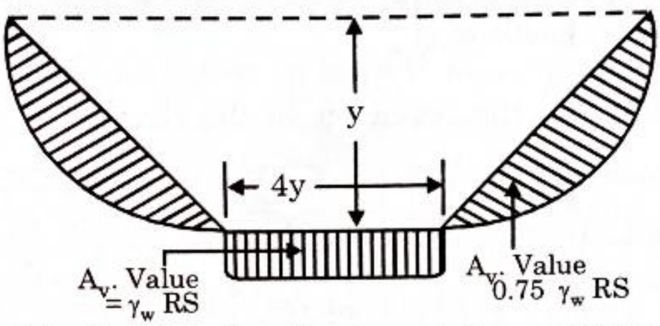
= Unit Tractive Force (τ_0) = $\frac{\gamma_w ALS}{Wetted\ area} = \frac{\gamma_w ALS}{Wetted\ perimeter \times Length} = \frac{\gamma_w ALS}{P.L}$

= $\gamma_w \left(\frac{A}{P}\right)$ S = $\gamma_w RS$

where, $\frac{A}{P}$ = R = the hydraulic mean depth of channel; S = channel bed slope

γ_w = unit weight of water; P = wetted perimeter

Shear stress, τ_0 = γ_wRS, here τ_0 is average drag.



Actual distribution of tractive force in trapezoidal channel

Note
- Incoherent soil are cohesionless soils such as sands or gravels.
- The unit tractive force in channels is not uniformly distributed along the wetted perimeter (except for wide open channels).

Threshold Motion of the Sediment (For Non-Scouring Channels)

- When velocity of flow through a channel is very small, the channel bed does not move at all, and the channel behaves as a rigid boundary channel.
- As the flow velocity increases steadily, a stage is reached when the shear force exerted by the flowing water on the bed particles will just exceed the force opposing their movement leading to intermittent movement of few particles on the bed. This condition is called the incipient motion condition or simply the critical condition or the threshold point.

The basis for designing an ideal, non-silting, non-scouring channel is that whatever silt has entered the channel at its head is kept in suspension. so that it does not settle down and deposit at any point of the channel. Moreover, the velocity of the water should be such that it does not produce local silt by erosion of channel bed and slopes.

Regime conditions

Following conditions should be established for a channel to be in regime.

(i) The channel should flow uniformly in unlimited incoherent alluvium of the same character as that transported by the channel.

(ii) Silt grade and silt charge should be constant.

(iii) Discharge should be constant.

KENNEDY'S THEORY

- R.G. Kennedy (an Executive Engineer of Punjab P.W.D.) in 1895 carried out extensive investigations on some of the canal reaches in the Upper Bari Doab Canal System.
- He selected some straight reaches of the canal section, which had not posed any silting and scouring problems for a long time in the past.
- On basis of these observations, he concluded that the silt supporting power in a channel cross-section was mainly dependent upon the generation of the eddies, rising to the surface.
- These eddies are generated due to the friction of the flowing water with the channel surface. The vertical component of these eddies try to move the sediment up, while the weight of the sediment tries to bring it down, thus keeping the sediment in suspension. So, silting will be avoided if the velocity is sufficient to generate these eddies, so as to keep the sediment just in suspension.

Kennedy defined the critical velocity (V_0) in a channel as the mean velocity (across the section) which will just keep the channel free from silting or scouring, and related it to the depth of flow by the equation

Determine the critical velocity V_0 by the above equation by assuming a trial depth, and then determine area by dividing discharge by velocity (V), for this area determine channel dimensions.

Velocity is calculated by using Kutter's formula, Manning's formula, etc. If the two velocities V_0 and V are same, then the assumed depth is all right, otherwise change it and repeat the procedure, till V and V_0 become equal.

The items which must be known are:

(1) Discharge, Q (2) Rugosity coefficient, n

(3) C.V.R, m (4) Bed slope S or B/D ratio

Kutter's Formula

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

Manning's Formula

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

where V = Velocity of flow in metres/sec; R = Hydraulic mean depth in metres.

S = Bed slope of the channel; n = Rugosity coefficient

Note

- The values of n in both these equations depend upon channel condition and also upon the discharge.
- Generally Kutter's equation is used with Kennedy's theory.

Step 3 : Determine channel dimension

Area (A) = (B + m'y) y [For trapezoidal SK]

Perimeter (P) = (B + 2y$\sqrt{1 + m'^2}$) [For trapezoidal s/c]

m' = Side slope of channel section

Step 4 : Calculate actual mean velocity by Kutter's equation or Manning's equation.

Kuttey's Equation:

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

Maning's Equation

$$V = \frac{1}{n}R^{2/3}S_0^{1/2}$$

Kennedy has suggested use of Kuttey's equation

Step 5 : If 'V' calculate din step 4 and step 1 are same, then correct otherwise redesign the section with other trial depth.

> **Note**
> - V_0 and V are not same. V_0 is critical flow velocity and V is mean flow velocity.

LACEY'S THEORY

Lacey (an eminent civil engineer of U.P. Irrigation Department), in 1939, carried out extensive investigation on the design of stable channels in alluviums. He found many drawbacks in Kennedy's Theory and he put forward his new theory.

Lacey's Regime Channels

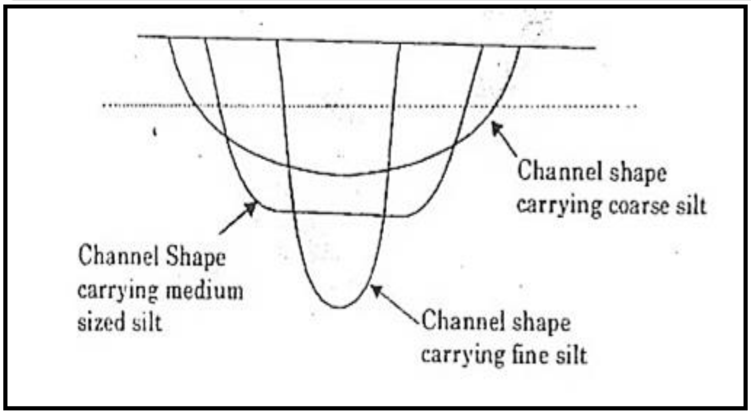
It was stated by Kennedy that a channel is said to be in a state of 'regime' if there is either silting nor scouring in the channel. But Lacey came out with the statement that velocity. Hence, the given discharge is allowed to flow through the channel of smaller width.

- With increase in the bed slope, the depth may also vary but the width of the channel does not change because the sides of the channel are usually cohesive and hence they resist erosion.

So, keeping the discharge, silt grade, silt charge and width fixed and only by varying bed slope and depth, the channel attains stability. This condition is known as initial regime.

Final Regime

- It is the ultimate state of regime attained by a channel when in addition to bed slope and depth, the width of the channel is also adjusted as per requirement.
- In this condition, the resistance of the sides of the channel is ultimately over come due to continuous action of water.
- So, the channel adjust its width, depth and bedslope in order to obtain a stable channel. This condition is known as final regime.



- Such a channel in which all variables are equally free to vary, has a tendency to assume a semi-elliptical section. The coarser the silt, the flatter is the semi-ellipse, i.e. greater is the width of the water-surface. The finer the silt, the more nearly the section attains a semicircle.

Note
➢ The various equations developed by Lacey are applicable to channels which has attained final regime.

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- Lacey's regime width & scous depth for alluvial river regime width = $4.75\sqrt{Q}$, for such stream, Lacey's regime scour depth in m = $0.48\left(\frac{Q}{f}\right)^{1/3}$, Q in m/sec.
- Above scour depth formula is applicable only when river width equals regime width. For any other river width normal scour depth is given by $1.35\left(\frac{q^2}{f}\right)^{\frac{1}{3}}$, $q = \frac{Q}{B} = \frac{discharge}{width}$

Drawbacks in Lacey's Theory

The various drawbacks in Lacey's theory are as follows:

(1) The characteristics of a regime channel are not precisely defined.

(2) The true regime conditions defined by Lacey are only theoretical and may not be achieved in actual practice.

(3) The derivation of various equations by considering a single factor called silt factor f is not satisfactory as there can be different value of f for the bed and the sides.

(4) Silt charge and silt grade have not been defined properly by Lacey.

(5) Lacey indicated that a true regime channel has a semi-elliptical section but the same is not supported by any of his equations

(6) The actual dimensions of stable channels are often found to be vastly different from those given by Lacey's equations with f based on the size of the bed material only. Moreover, the values of f obtained from various equations of Lacey are often quite divergent.

(7) Lacey's equations are highly empirical and it is based on the data obtained from channels flowing in a particular type of material. So before these equations can be applied in general it would be necessary to determine the values of the constants by making observations on existing stable channels flowing in other types of material.

(3) The capacity of a chosen canal section can be considerably increased by lining it. The lining presents a smooth surface and causes less resistance to the flow of water. The water flows faster by carrying more of it per second than that in an unlined canal. And since capacity is a function of velocity, the higher the velocity, the greater is the capacity of the channel.

(4) A lined canal can be designed not only smaller in cross-section but also shorter in length. The steeper gradients can be provided because higher velocities are permissible and a shorter alignment can, therefore, be selected. On the other hand, flatter slopes can be provided without silting on a lined channel compared to these on an unlined channel.

(5) Maintenance of unlined canals involve huge expenditure. This expenditure may be required on.

(i) periodical removal of silt deposited on the bed and sides of the canal section;

(ii) minor repairs like plugging of cracks, cuts and uneven settlements of banks; and

(iii)removal of weeds and water plants.

Lining reduces these charges considerably

(6) An unlined canal founded on weaker foundations is always in danger, and a breach may occur at any time. Small breaches in unlined canals can result in washing away of considerable length of embankment, leading to flooding of certain areas and causing scarcity of irrigation water in other areas. A strong concrete lining eliminates all such dangers.

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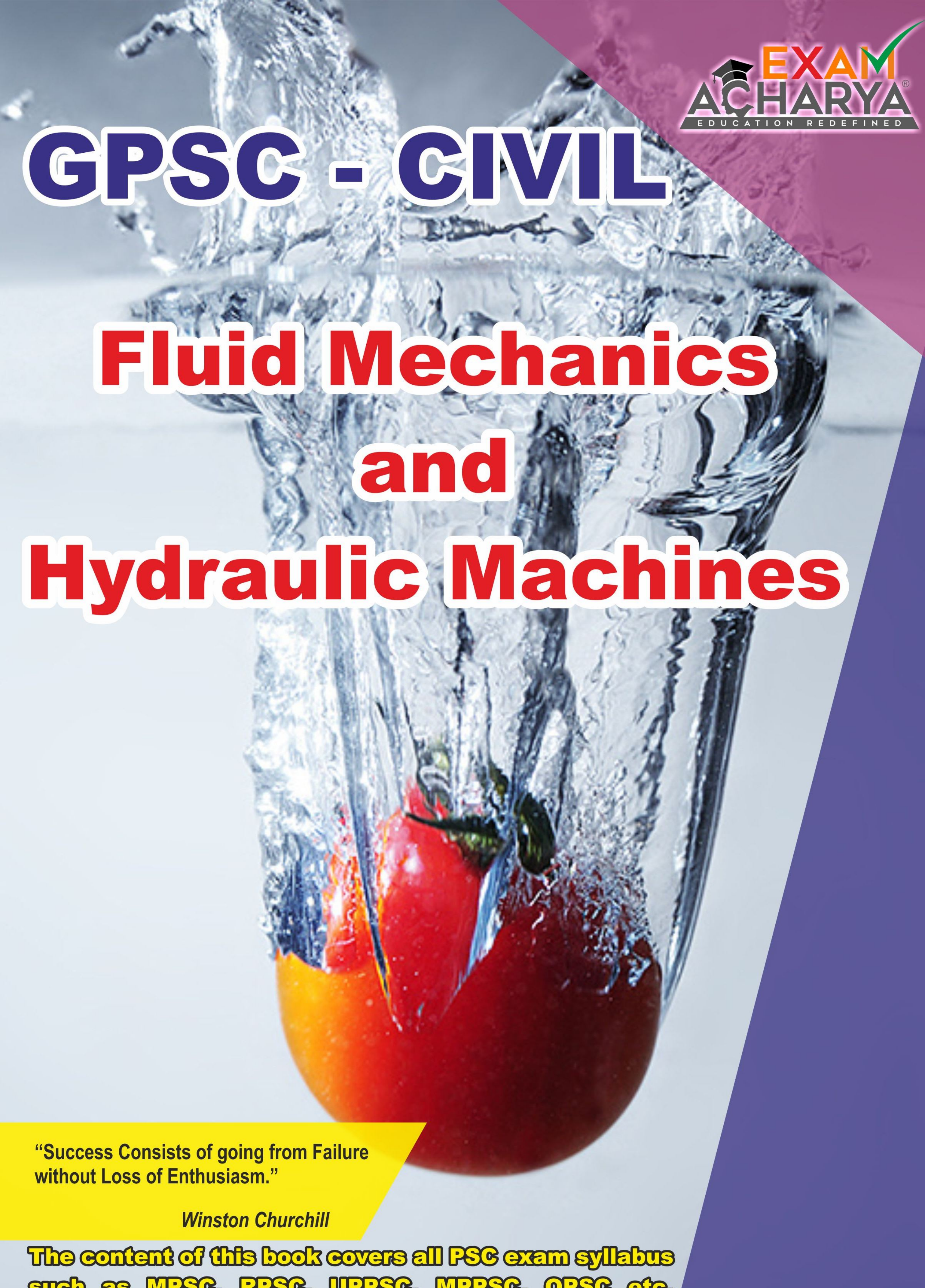

"Success Consists of going from Failure without Loss of Enthusiasm."

Winston Churchill

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also be able to withstand the damaging effects caused by cattle traffic weed and rodent growth, etc.

Repairability

Since the lining will get damaged with its use over a period of time, it should be such that it can be repaired easily and economically. Brick tile or concrete tile or stone boulder linings, or precast slab lining can be easily repaired, as compared to cast in situ concrete lining.

Impermeability

The permeability of lining may decide the quantum of seepage loss from a canal, which also is governed by the depth of water in the canal, and the type of subgrade soil. the permissible values of seepage losses from a canal for a particular area will depend upon the local conditions, such as the values of land and water, population intensity, etc.

Hydraulic Efficiency

The hydraulic efficiency of a canal, generally reduces with time, since the surface of lining gets eroded, increasing the friction factor (n), and thereby reducing its carrying capacity.

Resistance to Erosion

Sometimes, a canal may have to transport a considerable amount of sediment load, which may damage the lining by abrasion. Hence, in such a canal, the lining chosen should be able to withstand such abrasion. Cement concrete and stone boulder linings may provide better abrasion resistance, as compared to brick tile lining.

Berms

Berm is the horizontal distance left at ground level between the toe of the bank and the top edge of cutting.

The Berms serve the following purposes:

(i) The silt deposited on the sides is very fine and impervious. It, therefore, serves as a good lining for reducing losses, leakage and consequent breaches, etc.

(ii) They help the channel to attain regime conditions, as they help in providing a wider water, if required.

(iii) They give additional strength to the banks & provide protection against erosion and breaches.

(iv) They protect the banks from erosion due to wave action.

(v) They provide a scope for future widening of the canal.

(vi) Berms can be used as borrow pits for excavating soil to be used for filling.

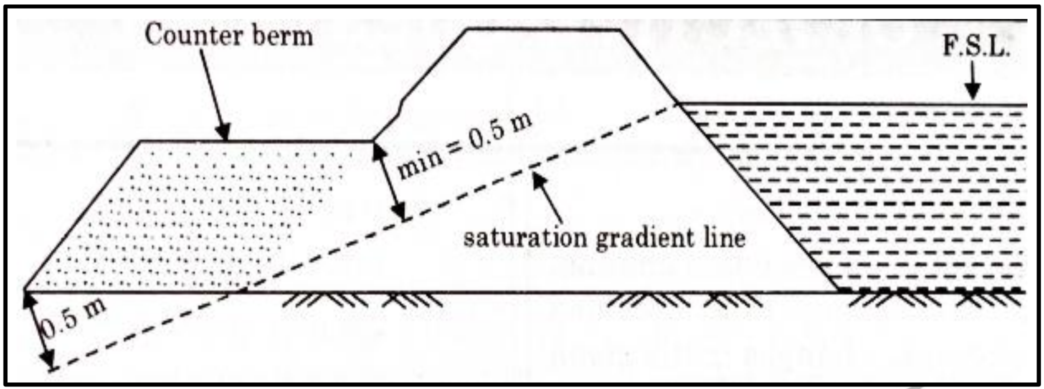
Freeboard

The margin between FSL and bank level is known as freeboard. The amount of freeboard depends upon the size of the channel. The generally provided values of freeboard are given in Table.

Discharge (in cumecs)	Extent of freeboard (in metres)
1 to 5	0.50
5 to 10	0.60
10 to 30	0.75
30 to 150	0.90

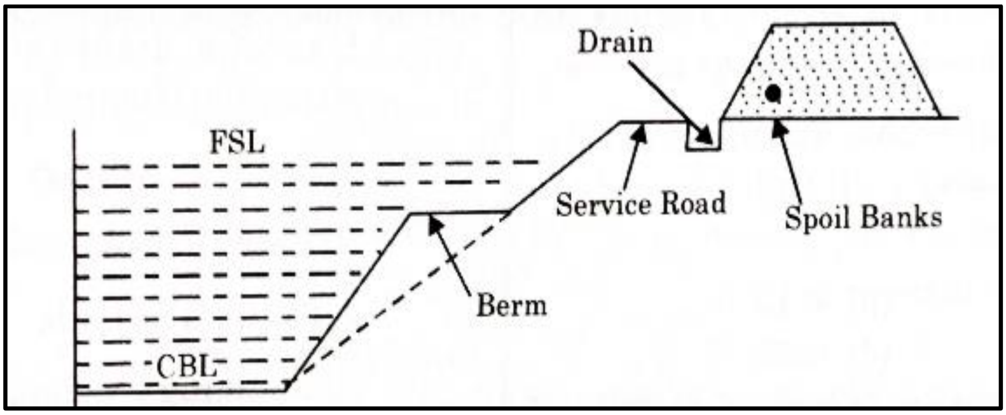
Back Berm or Counter Berms

Even after providing sufficient section for bank embankment, the saturation gradient line may cut the d/s end of the bank. In such a case, the saturation line can be kept covered at least by 0.5 metre with the help of counter berms.



Spoil Banks

When the earthwork in excavation exceeds earthwork in filling, even after providing maximum width of bank embankments, the extra earth has to be disposed off economically. To dispose of this earth by mechanical transport, etc, may become very costly, and an economical mode of its disposal may be found in the form of collecting this soil on the edge of the bank embankment itself. The soil is, therefore, deposited in such a case, in the form of heaps on both banks or only on one bank. These heaps of soil are discontinued at suitable intervals and longitudinal drains running by their sides are excavated for the disposal of rain water.



Borrow Pits

a) A.R and M.O Costs

b) Irrigation Water Costs

c) Construction Costs

d) Transportation Costs

Qu 2 What type of major dangers can the lining of canals extinguish?

a) Leakages

b) Floods

c) Water-logging

d) Seepage Losses

Qu 3 Mathematically, depending on what factor we can say velocity increases the capacity of the canal?

a) Coefficient of Viscosity

b) Coefficient of Capillarity

c) Coefficient of Roughness

d) Coefficient of Resistance

Qu 4 Depending on what factor does the lining of a canal can increase the capacity of the canal?

a) Width of the Canal

b) Type of Flow

c) Velocity

d) Side Slope

CHAPTER – 5

DAMS AND RESERVOIRS

INTRODUCTION

A dam is a barrier constructed across a river in order to create a reservoir for impounding water or to provide the facility of diverting water from the river or to retain debris flowing in the river along with water.

CLASSIFICATION OF DAMS

Dams may be classified in different ways on the basis of their function, hydraulic design, material of construction, structural design and size.

Classification Based on Function

Storage Dam or Impounding Dam

A storage dam is constructed to create a reservoir to store water during the period when the flow in the river is in excess of the demand, and utilising it later during the period when the demand exceeds the flow in the river. The water stored in the reservoir so created may be used for various purposes such as irrigation, hydroelectric power generation, water supply etc.

Detention Dam

A detention dam is constructed to temporarily detain all or part of the flood waters of a river and to gradually release the stored water at controlled rates so that the entire region on the d/s side of the dam may be safeguarded against the possible damage due to floods.

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A rigid dam is a type of darn which is constructed with rigid material such as masonry, concrete, steel or timber. Earlier stone masonry was commonly used for the construction of dams, but now a days it is almost totally replaced by concrete.

> **Note**
> ➢ Bhakra dam (a concrete dam) a Rana Pratapsagar dam (a stone masonry dam), are rigid dams in India.

Non-Rigid Dam

A non-rigid dam is a type of dam which is constructed with non-rigid material such as earth, rockfill etc. e.g., earth dam, rockfill dam and rockfill composite dam.

- An earth dam is constructed with gravel, sand, silt and clay.
- A rockfill dam consists of fragmental rock material supporting a water tight membrane on the u/s face.
- A rockfill composite dam consists of a rockfill on the d/s side and an earth fill on the u/s side.

> **Note**
> ➢ In most of the cases an earth dam is provided with a concrete or stone masonry overflow or spillway section. Such as a dam is known as composite dam.

Classification Based on Structural Behavior

Gravity Dam

A gravity dam is a masonry or concrete dam which resists the forces exerted upon it by its own weight. Its cross-section is approximately triangular in shape. If a gravity dam is straight in plan it is known as straight gravity dam, while if it is curved in plan it is known as curved gravity dam. A curved gravity dam resists the forces exerted upon it both by gravity action and arch action. Further a gravity dam is also classified as solid gravity dam and hollow gravity dam.

> **Note**
> ➢ Most of the gravity dams constructed in India are straight solid gravity dams and e.g., Bhakra dam

Arch Dam

The various external forces acting on a gravity dam may be :

(1) Water Pressure (2) Uplift Pressure

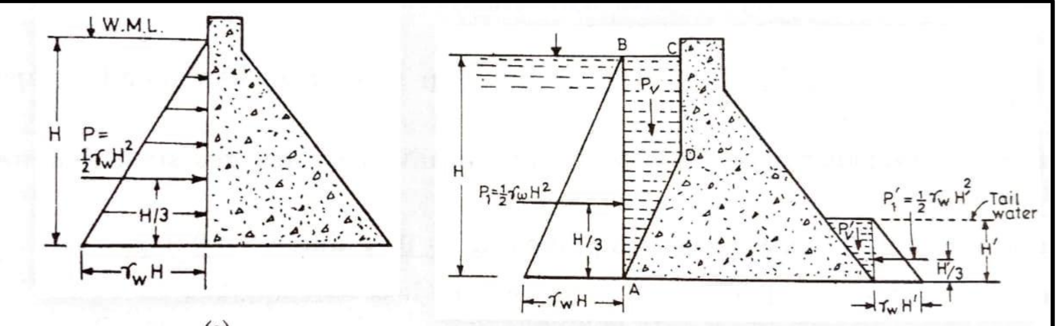
(3) Pressure due to earthquake forces (4) Silt Pressure

(5) Wave Pressure (6) Ice Pressure

(7) Weight of the dam

Water Pressure

- Water pressure (p) is the major external force acting on a dam. The horizontal water pressure, exerted by the weight of water stored on the u/s side on the dam can be estimated from rules of hydrostatic pressure distribution.
- When the u/s face is vertical, the intensity is zero at the water surface and equal to γ_w H at the base where, γ_w = unit weight of water and H = depth of water.
- The resultant force due to this external water, P = $\frac{1}{2}\gamma_w H^2$, acting at H/3 from base.



(a) (b)

- When the u/s face is partly vertical and partly inclined, the resulting water force can be resolved into horizontal component (P_h) and vertical component (p_v).
- If there is tail water on the d/s side, it will have horizontal and vertical components.

Uplift Pressure

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All of us do not have Equal talent.
But, all of us have an Equal Opportunity
to Develop our Talents.

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Earthquake Forces

- The effect of an earthquake is equivalent to imparting an acceleration to the foundations of the dam in the direction in which the wave is travelling.
- Earthquake wave may move in any direction.
- Both horizontal acceleration (α_h) and vertical acceleration (α_v) are induced by an earthquake. The values of these acceleration are generally expressed as percentage of the acceleration due to gravity (g), i.e., α = 0.1 g or 0.2 g, etc.
- In India, the entire country has been divided into four seismic zones depending upon the severity of the earthquakes.
- Zone V is the most serious zones. (Now zone i and ii have been merged such that we have now only four zones).
- For areas not subjected to extreme earthquakes, $\alpha_h = 0.1g$ and $\alpha_v = 0.05g$.
- These forces may be neglected in areas of no or very less earthquakes.
- In extremely seismic regions and in conservative design, even a value up to 0.3 g may sometimes be adopted.

Effect of Vertical Acceleration (a_v)

- When the vertical acceleration is acting in the upward direction, the effective weight of the dam will increase and hence, the stress developed will increase.

- When the vertical acceleration is acting downward, the foundation shall try to move downward away from the dam body and thus the effective weight and the stability of the dam will decrease. This is the worst case for designs.

Such acceleration will exert an inertia force $\frac{w}{g}\alpha_v$ (W is total wt. of the dam)

∵ The net effective weight of the dam = W - $\frac{w}{g}\alpha_v$

Silt Pressure

Silt gets deposited against the u/s face of the dam. If h is the height of silt deposited, then the force exerted by this silt in addition to external water pressure, can be represented by Rankine's formula as :

$$\mathbf{P_{silt} = \frac{1}{2}. \gamma_{sub}. h^2 K_a} \qquad \text{(it acts at } \frac{h}{3}\text{ . from base)}$$

where, $K_a = \frac{1-\sin\phi}{1+\sin\phi}$ = coefficient of active earth pressure of silt

(ϕ = angle of internal friction of soil, and cohesion is neglected).

γ_{sub} = submerged unit weight of silt material ; h = height of silt deposited.

> **Note**
> - If the u/s face is inclined, the vertical weight of the silt supported on the slope also acts as vertical force.

Wave Pressure

Waves are generated on the surface of the reservoir due to blowing winds, which causes a pressure towards the d/s side. Wave pressure depends upon the wave height. Wave height may be given by the equation,

$$\mathbf{h_w = 0.032\sqrt{V.F} + 0.763 - 0.271\,(F)^{3/4} \text{ for } F < 32 \text{ km,}}$$

$$\mathbf{h_w = 0.032\sqrt{V.F} \text{ for } F > 32 \text{ km}}$$

where h_w = height of water from top of crest to bottom of trough (in metres).

V = wind velocity (in km/hr); F = Fetch or straight length of water expense (in km)

The maximum pressure intensity due to wave action may be given by

$$P_w = 2.4\,\gamma_w \cdot h_w \qquad \text{(acts at } \frac{h_w}{2} \text{ metres above the still water surface).}$$

- The minor forces are : silt pressure, ice. pressure and wave pressure.
- A situation will never arise when all the forces are taken together. USBR has classified the normal load combinations and extreme load combinations.

Normal Load Combinations

- Water pressure up to normal pool level, normal uplift, silt pressure and ice pressure. This class of loading is taken when ice force is serious.
- Water up to normal pool level, normal uplift, earthquake forces, and silt pressure
- Water pressure upto maximum reservoir level (maximum pool level), normal uplift, and silt pressure.

Extreme Load Combinations

Water pressure due to maximum pool level, extreme uplift pressure without any reduction due to drainage and silt pressure.

Reservoir Empty Case

- Empty reservoir without earthquake forces are computed for determining bending diagrams, etc. for reinforcement design, for grouting studies or other purposes.
- Empty reservoir with a horizontal earthquake force produced towards the u/s has to be checked for non-development of tension at toe.

MODES OF FAILURE AND CRITERIA FOR STRUCTURAL STABILITY OF GRAVITY DAMS

A gravity dam may fail in the following ways:

(1) By overturning about the toe (2) By crushing

(3) By development of tension (4) By shear failure called sliding

Note

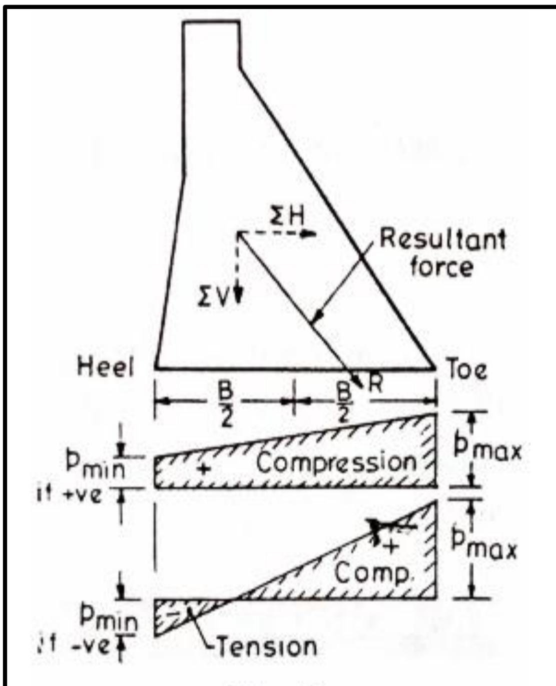


Fig. (a)

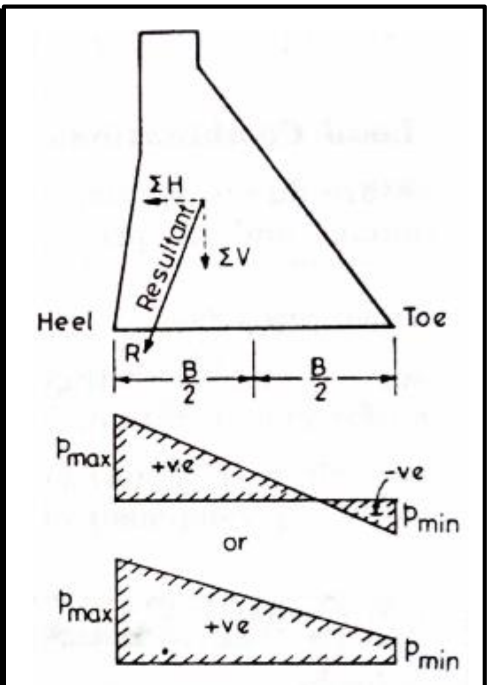


Fig. (b)

- The maximum stress i.e., P_{max}, will be produced on the end which is nearer to the resultant, as shown in figure (a) and (b).

- If P_{min} comes out to be negative, it means that tension shall be produced at the appropriate end.

- If P_{max} exceeds the allowable compressive stress of dam material [generally taken as 3000 kN/m² for concrete], the dam may crush and fail by crushing.

Tension

- Masonry and concrete gravity dams are usually designed in such a way that no tension is developed anywhere, because these materials cannot withstand sustained tensile stresses. If subjected to such stresses, these materials may finally crack.

- However, for achieving economy, certain amount of tension may be permitted under worst loading condition. This may be permitted because of the fact that such worst loading conditions shall occur only momentarily for a little time.

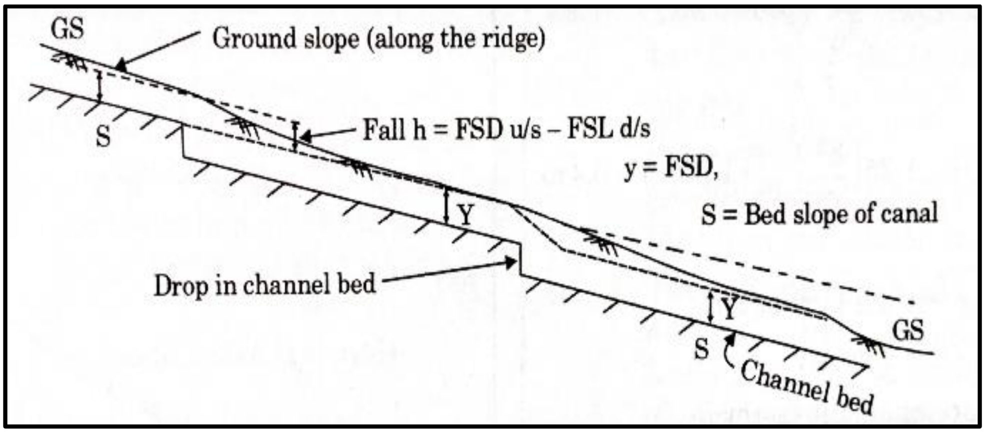
Note

- In low dam, the safety against sliding should be checked only for friction, but in high dams, for economical designs, the shear strength of the joint, which is an additional shear resistance, must also be considered. If this shear resistance of the joint is also considered, then the equation for factor of safety against sliding which is measured by shear friction factor (S.F F)

$$\text{S.F.F} = \frac{\mu \sum V + B.q}{\sum H}$$

where, B = width of the dam at the joint ; q = Average shear of the joint which varies from about 1400 kN/m^2 for poor rocks to about 4000 kN/m^2 for good rocks. The value of μ generally varies from 0.65 to 0.75.

CANAL FALLS



- A fall is a structure constructed across a channel to permit lowering down of water level in order to dissipate the surplus energy possessed by the falling water which may other wise scour the bed and banks of the channel.

- When the available natural ground slope is steeper then the designed bed slope of the channel, the difference is adjusted by constructing vertical falls or drops in the canal bed at suitable intervals. Such a drop in a natural canal bed will not be stable and therefore, in order to retain this drop we have to construct these falls.

New Batches are going to start.....

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Total test : 80

The performance of an Ogee fall had few major defects such as

(i) There was heavy draw-down on the u/s side, resulting in lower depth, higher velocities and consequent bed erosion.

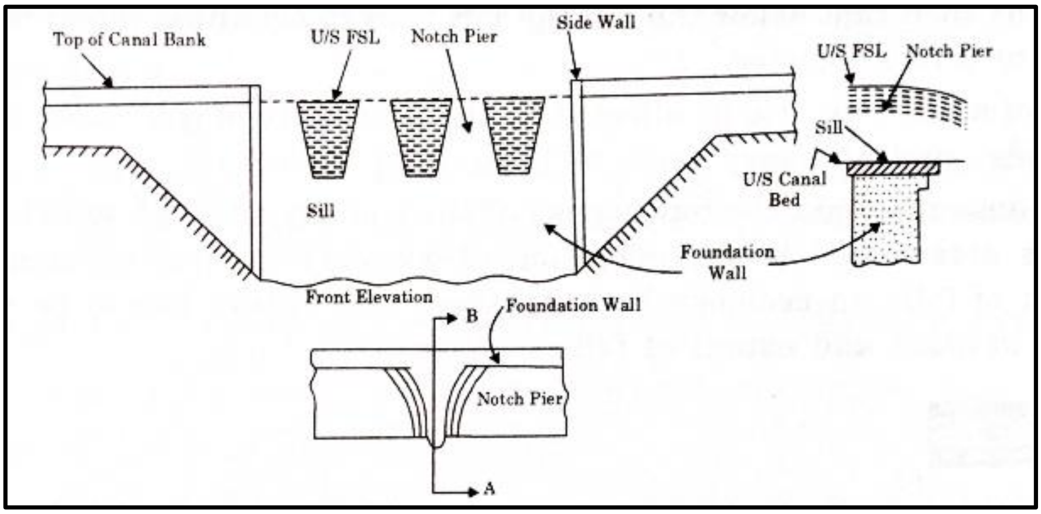
(ii) Due to smooth transition, K.E. of the flow was not dissipated, causing erosion of d/s bed and banks.

Rapids

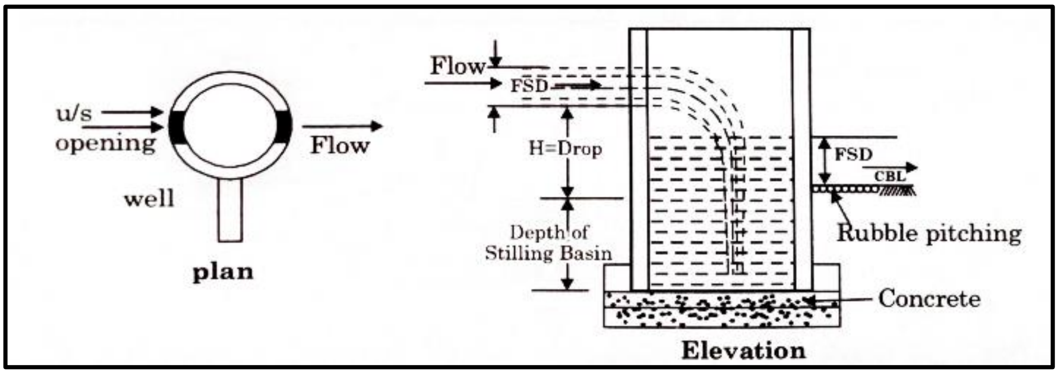
- Long rapids at slopes of 1 : 15 to 1 : 20 with boulder facings, were provided in Western Yamuna Canal.
- These falls were very expensive, and hence became obsolete.
- The long glacis assured the formation of hydraulic jump.
- These falls were quite satisfactory.

Trapezoidal Notch Falls

- It consists of a number of trapezoidal notches constructed in a high crested wall across the channel with a smooth entrance and a flat circular lip projecting d/s from each notch to spread out the falling jet.
- In these falls, energy is dissipated by turbulent diffusion.



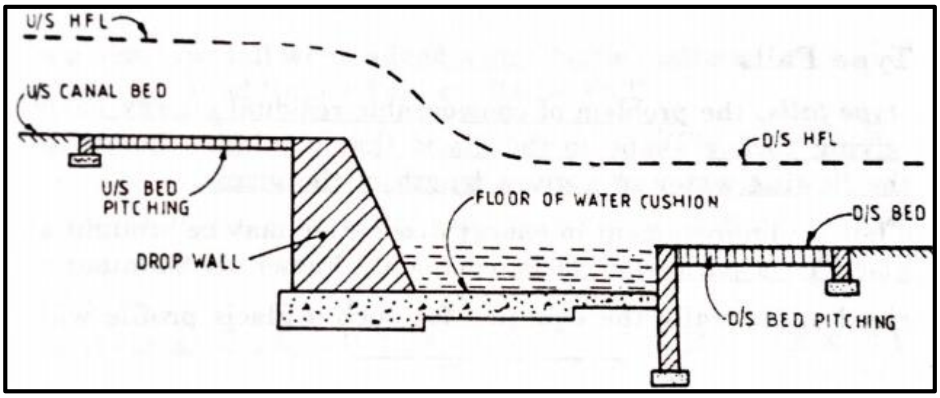
- In case of falls greater than 1.8 m and discharges greater than 0.29 cumecs, this type of d/s well is necessary.



- This type of falls are very useful for affecting larger drops for smaller discharges.
- They are commonly used as tail escapes for small canals.

Simple Vertical Drop Type and Sarda Type Falls

- A raised crest fall with a vertical impact was first of all introduced on Sarda Canal System in U.P.
- It was simple and quite economical.



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Education's purpose is to replace an empty mind with an open one.

Malcolm Forbes

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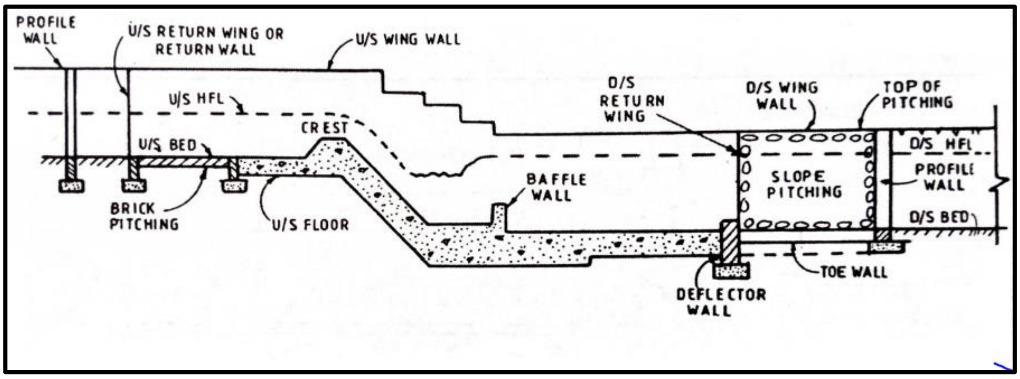
Inglis Falls or Baffle Falls

- A straight glacis type fall when added with a baffle platform and a baffle wall was developed by Inglis, and is called 'Inglis Fall' or 'Baffle Fall'.

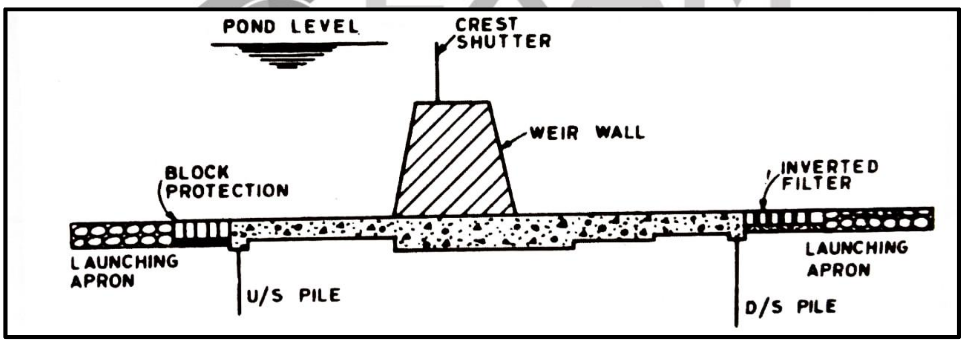
  They are quite suitable for all discharges and for drops of more than 1.5 m.

- It makes use of a horizontal impact for energy dissipation.
- The design consists of a standard long throated weir flume followed by a glacis and a horizontal platform or pavement on which a baffle is fixed to hold the hydraulic jump stable on the platform.
- On the d/s of the baffle, a cistern is provided and at the d/s end of the cistern, a deflector is provided. The impervious floor is provided only upto the end of the deflector.
- On the d/s of the deflector, often a second cistern is provided which is surfaced with stone or brick pitching only.
- The maximum dissipation of energy by a hydraulic jump occurs when the jump forms at the toe of the glacis. As such the horizontal platform is provided at such a level that for normal discharge conditions the jump forms at the toe of the glacis.
- The cistern and deflector d/s of the baffle are meant to restore normal distribution of velocities in the channel.
- They can be flumed easily.



Masonry weirs with vertical drop or vertical drop weirs

- This type of weir consists of an impervious horizontal floor or apron and a masonry weir wall with either both u/s and d/s faces vertical; or both faces inclined; or u/s face vertical and d/s face inclined.
- Curtain walls and cutoffs or piles are provided at the u/s and the d/s ends of the floor.
- Immediately at the u/s end of the floor a block protection and at the d/s end a graded inverted filter is provided.
- After the block protection and the inverted filter, launching aprons are provided.
- This type of weir is suitable for any type of foundation.
- This is an old type of weir for which floor design was usually based on Bligh's theory.



Rockfill Weirs with Sloping Aprons

- It consists of a masonry weir wall and dry packed boulders laid in the form of glacis or sloping aprons on the u/s and d/s sides of the wall with a few intervening core walls.
- It is the simplest type of construction.
- It requires a very large quantity of stone.

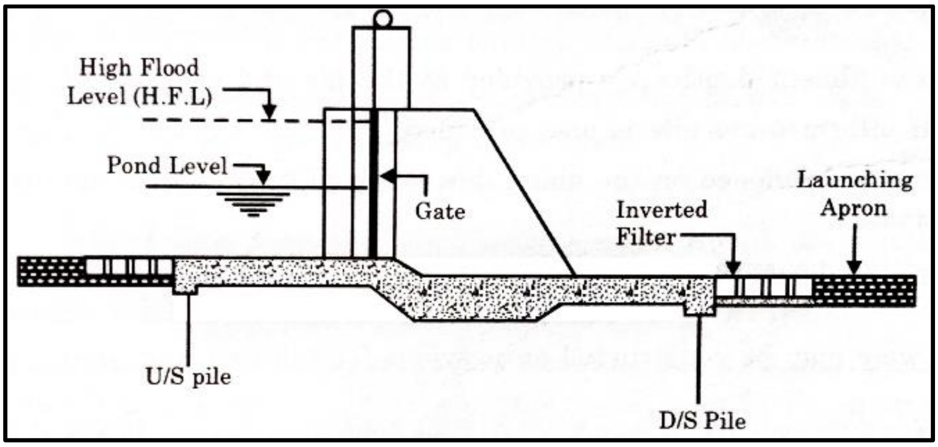
  e.g., Okhla weir across River Yamuna near Delhi.

Gravity and Non-Gravity Weirs

- When the weight of the weir balances the uplift pressure caused by the head of the water seeping below the weir, it is called a Gravity weir.
- If the weir floor is designed continuous with the divide piers as reinforced structure, such that the weight of concrete slab together with the weight of divide piers keep the structure safe against the uplift then the structure may be called as a Non-gravity Weir.

BARRAGE

- Barrage is a structure similar to weir with the only difference that the crest is kept at a low level and the ponding of water is accomplished mainly by means of gates. During floods these gates can be raised above the HFL. (high flood level) and thus enable the high flood to pass with minimum of afflux.
- A barrage provides better control on the water level in the river but it is comparatively more costly.
- It is also known as river regulator.
- The crest of undersluice portion of the weir is kept at a lower level than the crest of the normal portion of the weir.



- **Afflux :** The rise in the max. flood level u/s of the weir, caused due to construction of the weir across the river.

(a) Provide sufficient length of the impervious floor so that the path of percolation is increased and exit gradient is reduced.

(b) Provide piles at the u/s and the d/s ends of the impervious floor.

By Uplift Pressure

The water percolating through the foundation exerts an upward pressure on the impervious floor. This pressure is known as uplift pressure. If the uplift pressure is not counterbalanced by the weight of the floor, it may fail by rupture.

Remedies

(a) Provide sufficient thickness of the impervious floor.

(b) Provide pile at the u/s end of the impervious floor (uplift pressure is reduced on the d/s side).

Surface Flow

By Suction due to Standing Wave or Hydraulic Jump

The standing wave or hydraulic jump developed on the d/s side of the weir causes suction or negative pressure which also acts in the direction of uplift pressure. Suction happens due to the conversion of high pressure before jump to low pressure after jump.

Remedies

(a) Provide additional thickness of the impervious floor to counterbalance the suction pressure due to standing wave.

(b) Construct floor as monolithic concrete mass instead of in different layers of masonry.

By Scour on the U/S and D/S of the Weir

(iv) The scouring process takes about a day and the canal is closed during this period.

(v) The undersluices are closed as soon as the deposited silt gets washed away and the supply in the canal is restored.

- This is very useful method to control the amount of silt entering the canal.
- The main drawback of this method is that the supply in the canal has to be stopped during the cleaning operation of the undersluice pocket which leads to loss of irrigation during that period.
- This method is possible only when the crest of the canal head regulator is high above the u/s floor of the undersluices.
- The supply that is allowed to enter into the pocket is the same as the discharge into the canal. The discharge above that is moved d/s from other route.

Semi-Open Flow Regulation

Procedure

(i) In this method of regulation, the gates of the undersluices are always kept partially open so that water in excess of the canal requirement enters the undersluice pocket and the same is allowed to be discharged to the d/s side through the undersluices.

(ii) The water entering the pocket gets divided into two parts the top water (above the crest of the regulator) which is relatively clean enters the canal through the regulator, and the bottom silt laden water (below the crest of the regulator) escapes through the undersluices to the d/ s side.

(iii) Certain velocity is maintained in the pocket due to continuous flow through the undersluices which keeps silt in suspension and the same is discharged to the d/s side without being deposited in the pocket.

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- **For F_1 = 1.7 to 2.5**, a series of small rollers develop on the surface of the jump, but the d/s water surface remains smooth. The velocity throughout is uniform. The energy dissipation is also less being only about 20%. This jump is called a **weak jump.**
- **For F_1 = 2.5 to 4.5**, the entering jet oscillates back and forth from the bottom to the surface and back again without any periodicity. This jump is called an **oscillating jump.** The energy dissipation in this case ranges from 20 to 45%.
- **For F_1 = 4.5 to 9**, a stable and well balanced jump is developed. The action and position of this jump are least sensitive to variation in tail water depth. This jump has the best performance. The energy dissipation ranges from 45 to 70%. This jump is called a **steady jump.**
- **For F_1 = 9.0 and more**, the jump action is rough which results in a rough water surface with strong surface waves d/s from the jump. The jump action is however effective since the energy dissipation may reach 85%. This jump is called a **strong jump.**

Qu 4 The formation of hydraulic jump at the foot of a spillway is one of the common methods of energy dissipation because ______________________

a) It destroys more than 90% of total energy by the turbulence produced in the jump

b) It reduces the kinetic energy by increasing the depth of flow

c) Its action is not understood

d) It reduces the kinetic energy by decreasing the depth of flow

Qu 5 Which of the following stilling basin help in stabilizing the flow and improve the jump performance?

a) Dentated sills

b) Chute blocks

c) Baffle piers

d) Friction blocks

<u>TEST YOUR SELF:</u>

Qu 6 The maximum height of masonry dam of a triangular section whose base width is b and specific gravity is s

a) $bs^{1/2}$

b) b.s

c) $(bs)^{1/2}$

d) $sb^{1/2}$

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Solid Mechanics

"Education is the most Powerful Weapon which you can use to change the world."

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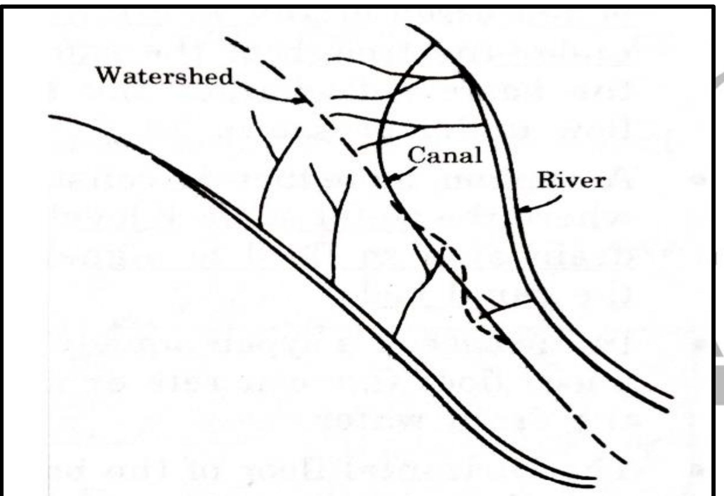
Solid Mechanics

CHAPTER – 6

CROSS DRAINAGE WORKS

INTRODUCTION

When a canal takes off from a river, it has to cross some streams or rivers before it can reach the top of the intended watershed for the purpose of irrigating an area. So. crossings are an important requirement on the canal alignment in the form of cross drainage works.



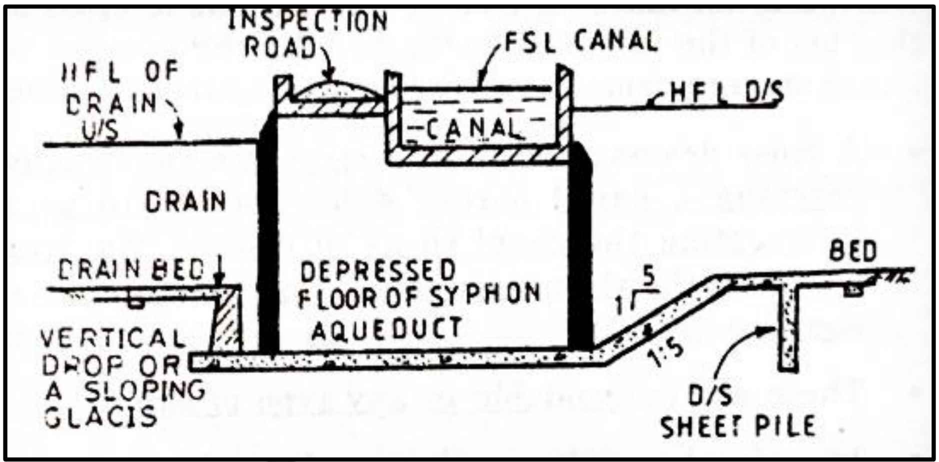
Canal crossing natural drains.

- A cross drainage work is a structure constructed for carrying a canal across a natural drain or river intercepting the canal so as to dispose the drainage water without interrupting the continuous canal supplies.
- These are unavoidable in any type of canal system.
- In order to minimise the number of cross drainage works, the alignment of canals should be generally along the watershed so that we have less number of natural drains.
- A canal taking off from a river has to travel a certain distance before it can mount the watershed. In this reach, the canal intercepts a number of natural drains from the watershed towards the river and it is necessary to carry the canal

- Generally an inspection road is provided along with the trough.

Syphon Aqueduct

- A syphon aqueduct is a cross drainage structure similar to an aqueduct except that the streambed is depressed locally where it passes under the trough of the canal and the barrels discharges the stream flow under pressure.
- A syphon aqueduct is constructed where the water surface level of the drain at high flood is higher than the canal bed.



Cross Drainage Works Carrying the Natural Drain Over the Canal

(i) Super passage (ii) Syphon (or canal syphon)

Super Passage

A super passage is also similar to a bridge in which the natural drain is carried over the canal.

- A super passage is reverse of an aqueduct.
- A super passage is constructed where the bed of the drain is well above the canal F.S.L.
- In this case, the drain water is taken across the canal in a trough supported on piers.

Cross Drainage Works Admitting the Drain Water into the Canal

In this type of cross drainage works, the canal water and the drain water are allowed to intermingle with each other. This may be achieved by the following two types of the cross drainage works.

(i) Level crossing (ii) Inlet and outlet.

Level crossing

A level crossing is a cross drainage work in which the drainage and the canal meet each other at approximately the same level. A level crossing is generally provided when a large canal and huge drainage (may be a stream or a river) approach each other at almost the same level.

A level crossing consists of:

(a) A crest with its top at the F.S.L. of the canal across the drain at its u/s junction with the canal

(b) A regu1ator with quick falling shutters across the drain at its d/s junction with the canal

(c) A cross regulator across the canal at its d/s junction with the drain.

- Such an arrangement is adopted when both canal and the drainage carry considerable discharge the latter during the high flood season when syphoning either the canal or the stream proves to be extremely costly or else the head loss through the syphon barrels is very high.
- Arrangement is practically similar to that provided on a canal head works.
- In this arrangement, the perennial discharge is used advantageously in order to increase the canal supplies.
- During dry season, regulator of the drain is generally kept closed and the outgoing canal regulator is kept fully open.

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Transportation Engineering

END is not the end if fact E.N.D. means
" Effort Never dies"

A.P.J. Abdul Kalam

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- Inlet is a non-regulating structure
- Outlet is another open cut in the canal bank with bed and sides of the cut properly pitched.
- The escaping water from the outlet is taken away by a lead channel to some nearby drain or outfall on the d/s side of the surface outlet.

SELECTION OF A SUITABLE TYPE OF CROSS-DRAINAGE WORK

The relative bed levels, water levels, and discharge of the canal and the drain are the primary factors on which the type of cross drainage work depends. In ideal cases, our choices will be the following:

(i) Aqueduct will be the first choice, if the bed level of the canal is significantly above the HFL of the drains.

(ii) Super passage will be the first choice if the bed level of the drain is significantly above the HFL of the canal.

(iii) On similar basis, we can make choices for canal syphon and syphon aqueduct according to their definition.

In actual field, we will not have such ideal conditions and our choice would depend upon various other factors, such as:

(i) Suitable canal alignment

(ii) Position of W.T. and availability of dewatering equipment.

(iii) Suitability of soil for embankment.

(iv) Permissible head loss in canal

(v) Nature of available foundation.

- By changing the alignment in a proper way, the bed levels of the canal and the drainage can be changed and manipulated in order to provide best solution while designing a CD works.

CLEAR YOUR CONCEPT:

Qu 1 What is Lacey's equation for fixing the approximate value of the required waterway for the drain?

a) P = 4.75 Q

b) P = 4.57 Q

c) P = 4.75 Q1/2

d) P = 4.57 Q1/2

Qu 2 The maximum permissible reduction in the waterway from Lacey's perimeter is _______

a) 15%

b) 20%

c) 25%

d) 30%

Qu 3 The permissible velocity through the barrels is generally limited to _____________

a) 1.5 to 2 m/sec

b) 2 to 3 m/sec

c) 2.5 to 3 m/sec

d) 1 to 2 m/sec

Qu 7 A siphon aqueduct is constructed at a canal crossing site where drainage HFL was 212.2 m by allowing an afflux of 0.4 m at high flood discharge. At this site, the water level downstream of the crossing at the same high flood will be _________

a) 212.2 m

b) 212.6 m

c) 211.8 m

d) It cannot be predicted

Answer:

1-(c), 2(b), 3-(b), 4-(c), 5-(c), 6-(b), 7-(a)

TYPES OF DIVERSION HEADWORKS

The diversion headworks may be classified into the following types.

(i) Temporary diversion headworks (ii) Permanent diversion headworks.

- **Temporary diversion headworks** consist of a spur or bund constructed across the rivet to raise the water level in the river and divert it into the canal.
- These bunds are constructed almost every year after the floods, because they may be damaged by the floods.
- **Permanent diversion headworks** consists of a permanent structure such as weir or barrage constructed across the river to raise the water level in the river and divert it into the canal.
- In our country, most of the diversion head works for important canal system are permanent diversion headworks.

LOCATION OF CANAL HEADWORKS

The location of canal headworks depends on the stages of flow of river. Most of the large rivers in our country have the following four stages of flow.

Rocky Stage or Hilly Stage

- In this stage, the river is in the hills.
- The bed slope and velocities are high in this stage.
- The cross-section of the river is made up of rock or very large boulders.

Boulder Stage

- From the rocky stage, the river passes on to the boulder stage.
- In this stage, the bed and banks of the river are composed of boulder and gravel.
- The river cross-section is usually well defined and confined between non submersible banks on either side which are close to the main current of the river.

EXAM ACHARYA
EDUCATION REDEFINED

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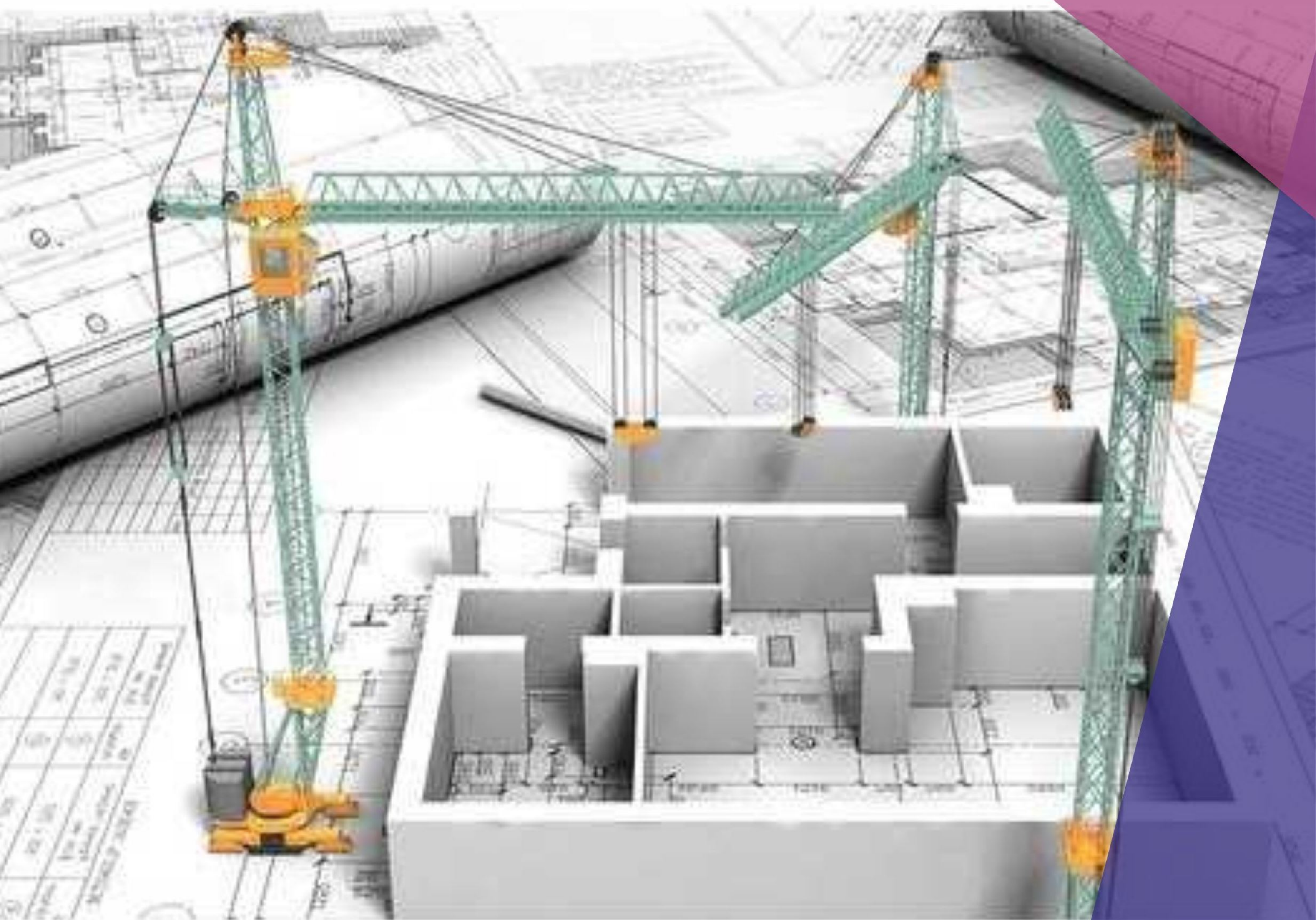
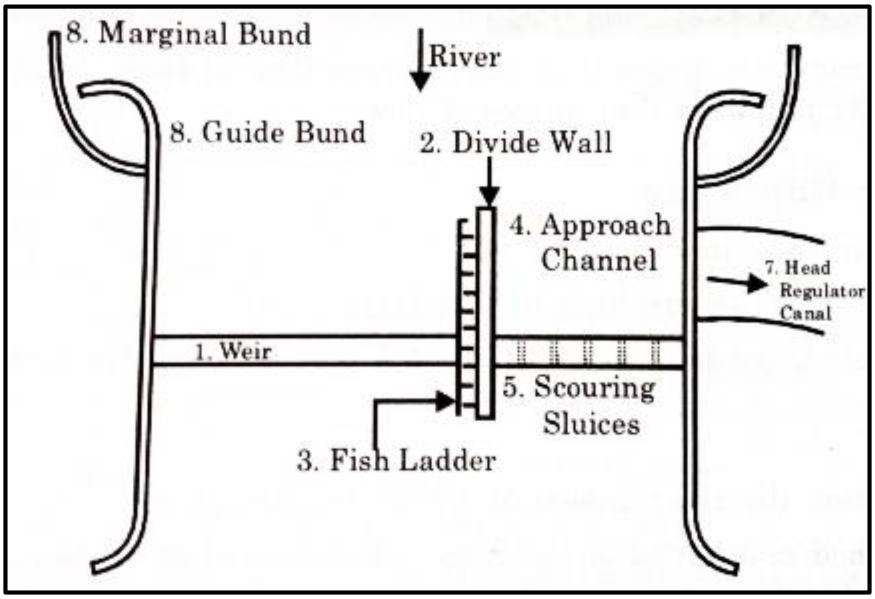


Structural Analysis

"All of us do not have Equal Talent.
But, all of us have an Equal Opportunity
to Develop our Talents."
A.P.J. Abdul Kalam

The content of this book covers all PSC exam syllabus such as MPSC, RPSC, UPPSC, MPPSC, OPSC etc.



RIVER TRAINING AND ITS OBJECTIVES

- By the term ricer training we mean various measures adopted on a river to stabilize the river channel along a certain alignment with a certain cross section.
- These measures are required to be adopted because river in alluvial plains, frequently alter their courses and cause damage to land and property adjacent to their banks.

The main objectives of river training are as follows

(1) Provide a safe passage to flood discharges without overflowing to the bank for protection of cultivated or inhabited area.

(2) Prevent outflanking of structures like a bridge, weir or aqueduct constructed across the river.

(3) Protect the banks from erosion and improve the alignment by stabilizing the river channel.

(4) Deflect the river away from the bank which it might be attacking.

(5) Provide minimum depth of flow and a good course for navigation purposes.

(6) Ensure effective disposal of sediment load.

Classification of River Training

METHODS FOR RIVER TRAINING

The various methods adopted for river training are as follows:

(1) Marginal embankments/levees

(2) Guide banks or Guide bunds

(3) Groynes or spurs

(4) Pitching of banks and provision of launching aprons.

(5) Pitched islands

(6) Miscellaneous methods

Marginal Embankments

- Marginal embankments are earthen embankment constructed parallel to the river to protect the area on one side of it from flooding.
- It is also termed as bund, dyke as levees.
- Marginal embankments are designed on the some principles as an earth dam.
- They may be constructed on both sides of the river or only on one side for some suitable length of the river where the river is passing through towns or cities on some important place.
- If the marginal embankments are likely to come in contact with high velocity flow then the waterside of the embankments should be provided with pitching protection.
- Launching apron may also be provided if the embankment is close to the main river channel.
- A levee or dyke is mainly used for flood protection by controlling the river and not by training the river.

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Surveying

The best Brains of the Nation may be found on the last Benches of the Classroom.

A.P.J. Abdul Kalam

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- It is uneconomical to span the entire width of the river and to expose the structure to vagaries of attack and deep scour. Hence, weir or a barrage or a bridge etc. is extended in a smaller width of the river, and river water is trained to flow almost axially through this trough without out-flanking the structure. The river is normally trained for this purpose with the help of a pair of guide banks.
- The guide banks are generally provided in pairs, symmetrical in plan and may either be kept parallel or may diverge slightly up-stream of the works.
- Before the water enters into the trough formed between these two guide banks, the flow may have to be partially controlled and directed with the help of marginal bunds or by groynes or both.
- The portion of the river between the normal river banks and the guide banks is closed by ordinary embankments.

Guide bank may be classified according to their layout u/s of the work as

(i) Divergent guide banks
(ii) Convergent guide banks
(iii) Parallel guide banks.

Divergent guide banks tend to attract the flow towards them and are suitable where the river current has been oblique to the structure or where the work is located at one edge of Khadir.

Convergent guide banks have the disadvantage of excessive attack and heavy scour at the u/s head and shoaling all along the bank thus rendering the end bays ineffective.

- Due to these drawbacks, divergent and convergent guide banks with excessive splay are rarely used.
- In most of the cases parallel guide banks or slightly convergent guide banks with a splay of 1 in 20 or 1 in 40 are used unless local conditions necessitate the other types.

CLEAR YOUR CONCEPT:

Qu 1 Into how many components the diversion headwork is divided?

a) 8

b) 5

c) 4

d) 7

Qu 2 In order to find the proper location for the head works on the river, the river is divided into how many stages?

a) 5

b) 2

c) 3

d) 4

Qu 3 By constructing which structure we can help the fish in their migration?

a) Scouring Sluices

b) Silt Excluder

c) Fish Ladder

d) Divide Wall

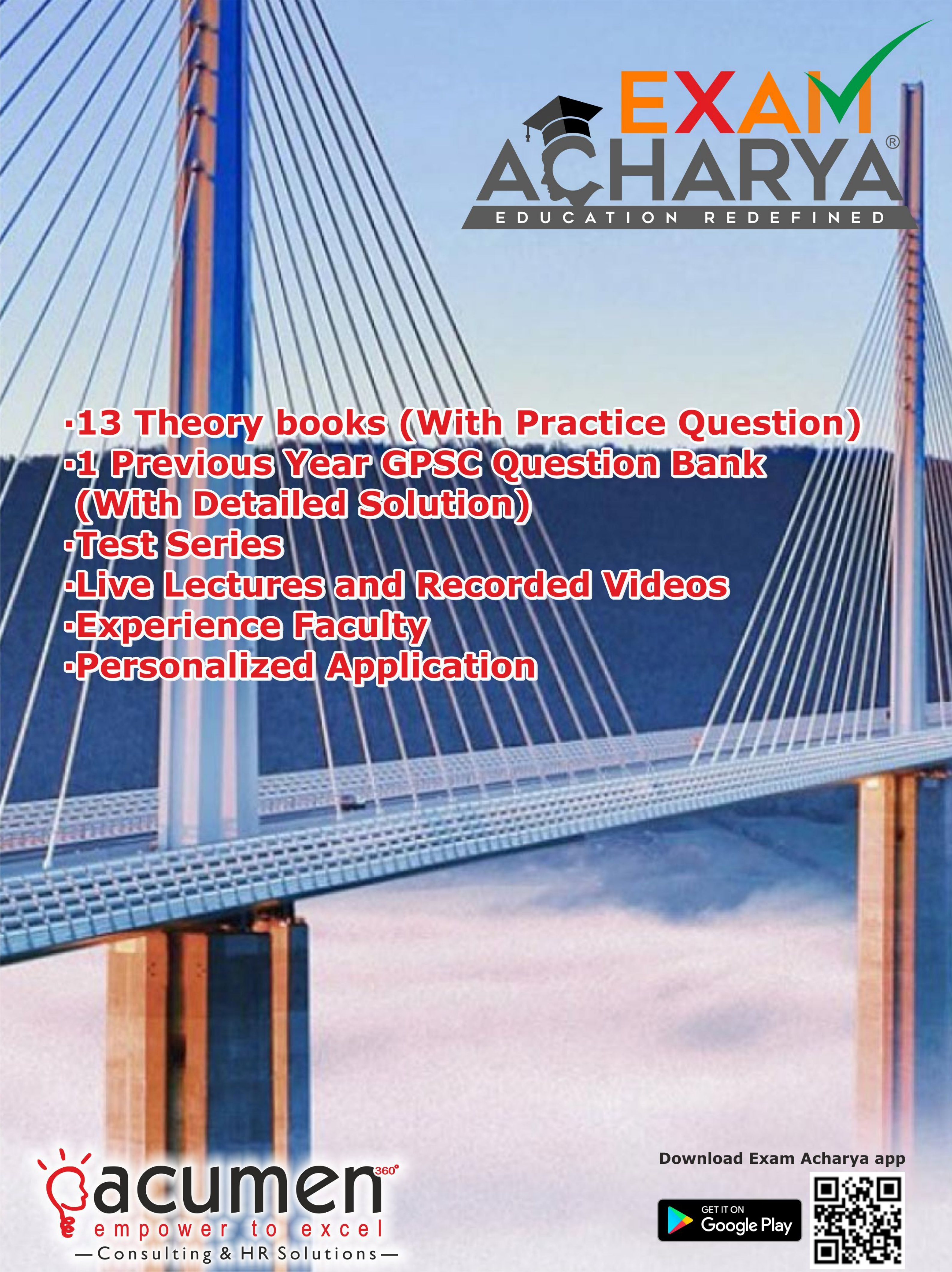
Qu 4 What device is placed in front of head regulator for silt removal?

a) Weir

b) Silt Extractor

c) Silt Excluder

d) Barrage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