VTU Question Paper Solution

Scheme	2022
Month & Year	June/July 2025
Branch	CIVIL ENGINEERING
Semester	VI
Subject	Irrigation Engineering and Hydraulic Structures
Subject Code	BCV602
Max Marks	100
Faculty Name	Prof. Seema R Basarikatti

Modified

CBCS SCHEME

USN | | | | | | | | | | | **BCV602**

Sixth Semester B.E./B.Tech. Degree Examination, June/July 2025
Irrigation Engineering And Hydraulic Structures

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Define irrigation. Write the benefits and ill effects of irrigation.	10	L1	CO2
	b.	The base period, intensity of irrigation and duty of various crops under a canal system are given in the table below. Find the reservoir capacity if the canal losses are 20% and the reservoir losses are 15%.	10	L3	CO2

Crop	Base Period (days)	Area (hect)	Duty (hect/cumecs)
Wheat	120	4800	1800
Sugar-Cane	360	5600	800
Cotton	200	2400	1400
Rice	120	3200	900
Vegetables	120	1400	700

OR

			M	L	C
Q.2	a.	Write a note on i) Bandhara irrigation ii)Frequency of irrigation.	10	L2	CO2
	b.	Define duty, delta and Base period and derive relationship between them.	05	L2	CO2
	c.	A canal has a discharge of 20 cumecs. It irrigates 25,920 hectare of land during a base period of 120 days. Find the duty and delta of the canal.	05	L3	CO3

Module – 2

			M	L	C
Q.3	a.	Define canal and explain classification of canal based on canal alignment.	10	L2	CO3
	b.	Design an irrigation channel in alluvial soil from following data using Lacey's Theory. Discharge = $18 m^3/Sec$. Lacey's silt factor = 1 Side slope = ½ :1.	10	L4	CO3

OR

			M	L	C
Q.4	a.	Define reservoir and what are the investigations for the selection of a reservoir site.	10	L1	CO3
	b.	Design an irrigation channel on Kennedy's Theory to carry a discharge of $45 m^3/sec$. Take N = 0.0225 and m=1.05. The channel has a bed slope of 1 in 5000. Assume Trail depth 2m, side slope 0.5:1.	10	L4	CO3

Module – 3

Q.5	a.	Define gravity dam and briefly explain the forces acting on a gravity dam.	10	L2	CO1
	b.	Determine the uplift force at the base of a gravity dam as shown in Fig.Q.5(b) for the following Three cases. a) No drains b) with drain and grout curtain at a distance of 5 m from U/S end c) Tension cracks upto 2 m from U/S end.	10	L3	CO1

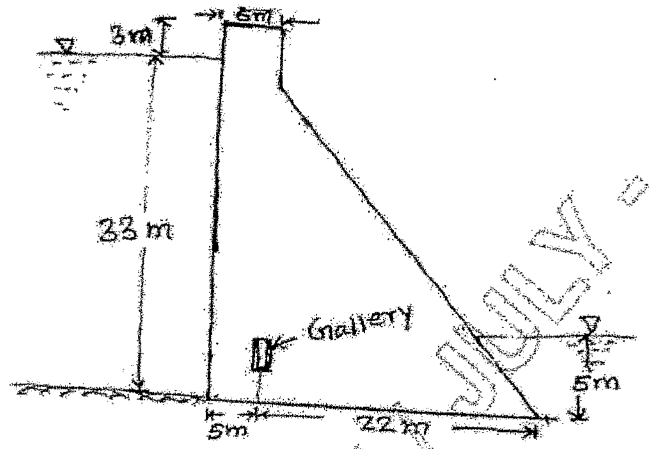


Fig. Q.5(b) Cross section of gravity dam

OR

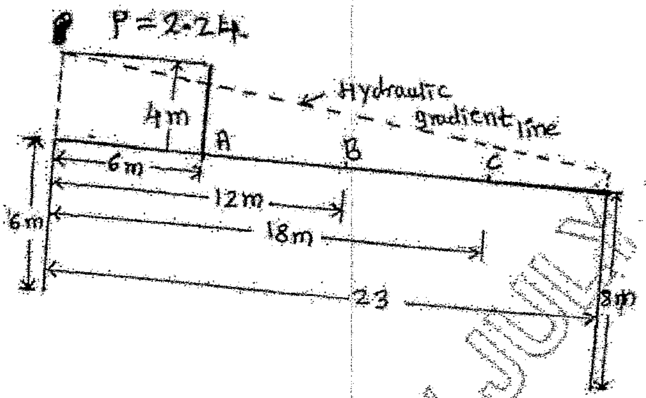
Q.6	a.	Write a note on : i) Practical Profile of a gravity dam ii) Drainage and inspection galleries.	10	L2	CO1
	b.	Following data were obtained from the stability analysis of concrete gravity dam : i) Total overturning moment about toe = 1.5×10^6 KN – m ii) Total resisting moment about toe = 2.5×10^6 KN – m iii) Total vertical force above base = 60,000 KN iv) Base width of the dam = 48 m v) Slope of D/S face = 0.8(H) : 1(V). Calculate the maximum and minimum vertical stress to which the foundation will be subjected to, what is the maximum principal stress at toe ? Assume there is no tail water.	10	L4	CO1

Module – 4

Q.7	a.	Explain the causes of failure of earthen dams.	10	L2	CO1
	b.	Briefly explain the methods of seepage control through foundation and body of earthen dams.	10	L2	CO1

OR

Q.8	a.	Define earthen dam and explain the design criteria for earthen dams.	10	L2	CO1
	b.	Write a note on : i) Ogee spillways ii) Stilling Basins.	10	L2	CO1

		Module – 5			
Q.9	**a.**	Explain the types of diversion head works and causes of their failure.	10	L2	CO1
	b.	Fig.Q.9(b), shows the section of hydraulic structure founded on sand. Calculate the average hydraulic gradient. Also find the uplift pressure at point 6,12 and 18 m from the U/S ends of the floor and find the thickness of the floor at these points taking P = 2.24.  Fig. Q.9(b) Hydraulic Structure	10	L3	CO1
		OR			
Q.10	**a.**	Describe with neat sketches, the working of a silt excluders and silt ejectors.	10	L2	CO1
	b.	Explain the following : i) Draw a layout of headwork, label the component and describe the function of each component. ii) Explain the Lane's weighted creep theory.	10	L2	CO1

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Sixth Semester B.E Degree Examination, June/July 2025
IRRIGATION ENGINEERING AND HYDRAULICS STRUCTURES

Q.NO.	SOLUTION	MARKS
1a.	**Irrigation :-** Irrigation may be defined as the process of artificially supplying water to the soil raising crops.	01
	Benefits of irrigation :-	
	1) **Increase in food production :-** Crops need optimum quantity of water at required intervals assured and timely supply of water helps in achieving good yield & also superior crops can be grown & thus, the value of the crops increases.	
	2) **Protection from famine :-** Irrigation work can be constructed during famine (drought). This helps in employment generation & people also get protection from famine.	
	3) **Cultivation of cash crops :-** with the availability of continous water supply, cash crops such as sugarcane, indigo, tobacco, cotton etc can be grown.	
	4). **Increase in prosperity of people :-** Due to assured water supply can get good yield and returned for their crops.	
	5). **Generation of hydroelectric power :-** major river valley projects are designed to provide power generation facilities also apart from irrigation needs.	
	6) **Domestic & Industrial water supply :-** water stored in reservoirs can also be used to serve other purposes like domestic water supply to towns and cities and also for industrial use canals can also be effectively used to serve these purposes.	

7) Inland Navigation :- In some cases, the canals are very large enough to be used as channels for inland navigation as water ways are the cheapest means of transportation.

8) Canal plantation :- Due to continuous flow of water adjoining areas of a canal are always saturated with water

9) Aid in Civilization :- Due to introduction of river valley projects, tribal people can adopt agriculture as their profession which helps in improving the standards of living. 06

Ill effects of irrigation :-

1) water logging :- Excess water applied to the fields allows water to percolate below and ground water table rise

2) Breeding places for mosquitoes :- Excess application of water for irrigation leads to water logging & formation of stagnant water pools. 03

3) Unhealthy climate :- Due to intense irrigation the climate becomes damp during summer due to humidity,

1b Discharge $q = \frac{A}{D}$ (cumecs)

wheat = q = 4800/1800 = 2.67 cumecs

Sugarcane = q = 5600/800 = 7.00 cumecs

Cotton : q = 2400/1400 = 1.71 cumecs

Rise = q = 3200/900 = 3.56 cumecs 03

Vegetable = q = 1400/700 = 2.00 cumecs

Volume = $V = Q \times B \times 86400$ (m^3)

Wheat = $2.67 \times 120 \times 86400 = 27.68 \times 10^6 \ m^3$

Sugar cane = $7.00 \times 360 \times 86400 = 217.73 \times 10^6 \ m^3$

Cotton = $1.71 \times 200 \times 86400 = 29.55 \times 10^6 \ m^3$

Rice = $3.56 \times 120 \times 86400 = 36.89 \times 10^6 \ m^3$ 04

Vegetable = $2.00 \times 120 \times 86400 = 20.74 \times 10^6 \ m^3$

Total field required $V_f = 332.59 \times 10^6 \ m^3$

Canal losses (20%)

$$V_c = \frac{V_f}{1-0.20} = \frac{332.59 \times 10^6}{1-0.20} = 415.74 \times 10^6 \ m^3$$

Reservoir losses (15%) $V_c = \frac{V_c}{1-0.15} = \frac{415.74}{0.85} = 489 \times 10^6 \ m^3$ 03

Reservoir capacity ≃ 489 Million cubic metres (Mm^3)

2a. i) Bandhara irrigation :- It is special irrigation scheme adopted across small perennial rivers. This system lies somewhere between inundation type and permanent type of irrigation. A bandhara is a low masonry weir of height 1.2m to 4.5m constructed across the stream to divert water into a small canal. The canal usually takes off from one side and the flow into the canal is controlled by a head regulator to about 8km. 05

ii) Frequency of irrigation :- Irrigation frequency refers to the number of day between irrigation during periods without rainfall. It depends on consumptive use of rate of a crop and on the amount of available moisture in the crop-root zone. It is function of crop, soil and climate. 05

Sandy soil must be irrigated more often than fine texture deep Soils. A moisture use ratio varies with the kind of crop and climate conditions and increase as crop grows. larges and days become longer and hotter.

2b. **Delta:-** The total quantity supplied were to stand above the surface without percolation or evaporation. this total depth of water (in cm) required by a crop to come to maturity. is called its delta (Δ). 01

Duty:- Duty is the area of land irrigated by a unit discharge of water flowing continuously during the base period. 01

D = Area irrigated (hectares) per cumec.

Base period:- Base period is the time between the first watering of a crop and its last watering before harvest 01

B = time duration in days.

Relation between duty and delta:-

The volume of water applied to this crop during B days.

$$V = (1 \times 60 \times 60 \times 24 \times B)\ m^3$$

$$\boxed{V = 86400B\ m^3}$$

Total depth of water applied on this land.

$$= \frac{\text{Volume}}{\text{Area}} = \frac{86{,}400B}{10^4 D} = \frac{8.64B}{D} \text{ metres.}$$ 02

By definition, this total depth of water is called delta(Δ)

$$\therefore \quad \Delta = \frac{8.64B}{D} \text{ metres}$$

or

$$\boxed{\Delta = \frac{864B}{D}\ cm}$$

2c. Given:-

Discharge $Q = 20$ cumecs

Area irrigated $A = 25920$ hectares

Base period $B = 120$ days. 01

Duty of the Canal Duty (D) $= \frac{A}{Q}$

$$D = \frac{25920}{20} = 1296 \text{ ha/cumec}.$$ 02

Delta of the canal $\Delta = \frac{8.64B}{D}$ m

$$\Delta = \frac{8.64 \times 120}{1296}.$$ 02

$$\Delta = \frac{1036.8}{1296} = 0.80\text{m}$$

3a. Canal :- A canal is an artificial channel, generally trapezoidal in shape, constructed on the ground to carry water to the fields either from a river or tank or reservoir. 02

Classification based on Canal alignment :-

a) Ridge Canal or watershed canal

b) Contour canal

c) Side slope canal

a) Ridge Canal or watershed canal :- A Ridge canal or watershed canal is one which runs along the ridge or watershed line. It can irrigate the fields on both sides. In case of ridge canals the necessity of cross drainage works does not arise as the canal is not intercepted by natural streams or drains.

A contour canal is one which is aligned nearly parallel to the contours of the country area. these canals can irrigate the lands on only one side. The ground level on one side is higher and hence bank on the higher side may not be necessary. The contour canal may be intercepted by natural stream/drains and hence cross drainage works may be essential.

Side slope canal :- It is one which is aligned at right angle to the contour of the area. It is a canal running between a ridge and a valley. this canal is not intercepted by streams and hence no cross drainage works may be essential. this canal has steep bed slope since the ground has steep slope in a direction perpendicular to the contours of the area. 08

3b Given! -

Discharge $Q = 18\ m^3/s$

Lacey's factor $f = 1$

Side slope $z = \frac{1}{2} : 1 \quad (z = 0.5)$

1) wetted perimeter $P = 4.75\sqrt{Q}$

2) Hydraulic radius $R = 0.47\left(\frac{Q}{f}\right)^{1/3}$

3) Area $A = P \times R$

4) Area of trapezoidal channel $A = y(b + zy)$

5) wetted perimeter $P = b + 2y\sqrt{1 + z^2}$

4a **Reservoir :-** A water supply scheme drawing water direfly from a river or a stream may fail to satisfy the consumer demands during extremely low flows, while during high flood flows it may become difficult to carry out its operations due to devastating floods. 02

Selection of reservoir site :-

1) **Large storage capacity :-** The topography of the proposed site should be such that the reservoir has a large capacity for storing the water.

2) **Suitable site for the dam :-** A suitable site for the proposed dam should be available on the downstream side of the reservoir, with very good foundation, narrow opening in the valley to provide minimum length of the dam and also the cost of construction should be minimum.

3) **Water tightness of the reservoir :-** Geology at the proposed reservoir site should be such that the entire reservoir basin is water tight. They should have granite, gneiss, schists slates or shales etc. 08

4) **Good hydrological conditions :-** The hydrological conditions of the river at the reservoir should give high yield. evaporation, transpiration & percolation losses should be minimum.

5) **Deep reservoir :-** The proposed site should be such that a deep reservoir is formed after the dam construction. The reason being evaporation losses would be minimum in addition to low cost of land aquisition. and less weed growth.

wetted perimeter $P = 4.75 \times 4.232$

$$P = 20.16m$$

Hydraulic radius $R = 0.47 \times 2.62$

$$R = 1.23m$$

Area of flow $A = 20.16 \times 1.23$

$$A = 24.8\ m^2$$

Area

$A = y(b+0.5y)$

$24.8 = y(b+0.5y)$ —— (1)

wetted perimeter.

$20.16 = b + 2y\sqrt{1+0.5^2}$

$20.16 = b + 2y(1.118)$

$20.16 = b + 2.23y$ —— (2)

Solving (1) & (2) we have

$b = 20.16 - 2.236y$.

Substituting in eq (1)

$24.8 = y(20.16 - 2.236y + 0.5y)$

$1.736y^2 - 20.16y + 24.8 = 0$

$\therefore$ $y = 1.40m$

Now, $b = 20.16 - 2.236(1.4)$

$$b = 17.0m$$

10

4b. Given:-

Discharge $Q = 45\ m^3/s$

Kennedy's constant $N = 0.0225$

Critical Velocity ratio $= m = 1.05$

Bed Slope $S = 1/5000$

Trial depth $y = 2\ m$

Side Slope $z = 0.5 : 1$

Critical velocity $V_c = 0.55\, m y^{0.64}$

$$= 0.55 \times 1.05 \times (2)^{0.64}$$

$$V_c = 0.90\ m/s.$$

Area of flow $A = \frac{Q}{V}$

$$A = \frac{45}{0.90} = 50\ m^2$$

Bed width (b)

$$A = y(b + zy)$$

$$50 = 2(b + 0.5 \times 2)$$

$$b = 24\ m$$

Wetted perimeter $P = b + 2y\sqrt{1 + z^2}$

$$P = 24 + 2(2)\sqrt{1 + (0.5)^2}$$

$$P = 28.47\ m$$

Hydraulic radius $R = \frac{A}{P} = \frac{50}{28.47}$

$$R = 1.76\ m$$

Velocity from Chezy's formula. $C = \frac{1}{N} R^{1/6}$

$$C = \frac{1}{0.0225} (1.76)^{1/6}$$

$C = 44.44 \times 1.10$

$C = 48.9$

Velocity $V = C\sqrt{RS}$

$V = 48.9 \sqrt{1.76 \times \frac{1}{5000}}$

$V = 48.9 \times 0.0188$

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

5a. Gravity dam :- A gravity dam has been defined as a structure which is designed in such a way that its own weight resists the external forces. 02

Forces acting on a gravity dam :-

1) water pressure :- water pressure (p) is the most major external force acting on such a dam. The horizontal water pressure External by the weight of the water stored on the upstream side on the dam

The resultant force due to this external water $= \frac{1}{2}\gamma_w H^2$ acting at H/3 from base.

2) Uplift pressure :- water seeping through the pores, cracks. & fissures of the foundation materials. & water seeping through dam body and then to the bottom through the joints between the body of the dam. 08

3) Earthquake forces :- If the dam to be designed, is to be located in a region which is susceptible to earthquake, allowance must be made for the stresses generated by the earthquake.

4) Silt pressure :- If "h" is the height of the silt deposited then the force. Exerted by this silt in addition to External water pressure, can be represented by rankines formula. as.

$P_{silt} = \frac{1}{2}\gamma_{sub} \cdot h^2 \cdot K_a$ and it acts at $\frac{h}{3}$ from base.

5b. Given:-

upstream water head = 33m

Tail water head = 5m

Base width = 5+22 = 27m

Drain/grout curtain location = 5m from u/s end

unit weight of water = $\gamma_w = 9.81 \, kN/m^2$

Average uplift head $h_{avg} = \frac{33+5}{2} = 19m$

i) Case i) no drain.

uplift force $U = \gamma_w + h_{avg} + $ base width

$U = 9.81 + 19 \times 27$

U = 5035 kN per m length. 03

ii) Case II Drain + grout curtain at 5m from u/s.

Head reduced from 33m to 5m

$h_1 = \frac{33+5}{2} = 19m$

$U_1 = 9.81 \times 19 \times 5 = 932$ kN

Head remains constant at 5m

$U_2 = 9.81 \times 5 \times 22 = 1079$ kN 04

Total uplift force $U = U_1 + U_2$

U = 2011 kN per m length

iii) case III Tension cracks up to 2m from u/s.

Cracked portion (0-2m) $U_1 = 9.81 \times 33 \times 2 = 647$ kN.

Remaining base (2-27m) $h_2 = \frac{33+5}{2} = 19m$ 03

length = 25m $U_2 = 9.81 \times 19 \times 25 = 4660$ kN.

Total uplift force **U = 5307 kN** per m length

6a. i) Practical profile of a gravity dam :-

The elementary profile of a gravity dam is only a theoretical profile. Certain changes will have to be made in this profile in order to cater to the practical needs. these needs are :-

i) providing a straight top width, for a road construction, over the top of the dam.

ii) providing a free board above the top water surface, so that water may not spill over the top of the dam due to wave action etc.

The additions of these two provisions, will cause the resultant force to shift towards the heel. the resultant force, when the reservoir is empty, was earlier passing through the inner middle third point. This will therefore shift more towards the heel crossing the inner middle third point and consequently, tension will be developed at the toe. 05

ii) Drainage and inspection gallaries :- A gallery provided in a dam may serve one particular purpose or more than one purpose. This gallery is called foundation gallery or a drainage gallery. It runs longitudinally and is quite near to the upstream face of the dam. Its size usually varies from 1.5m x 2.2m to 1.8m x 2.4m. Drain holes are drilled from the floor of this gallery after the foundation grouting has been completed. Seepage is collected through these drain holes.

05

Inspection gallaries :- The water which seeps through the body of the dam is collected by means of a system of gallaries provided at various elevations and interconnected, by vertical shafts etc. All these gallaries, besides draining off seepage water. Serve inspection purposes. They provide access to the interior of the dam and are, therefore called inspection gallaries.

6b Given:-

Overturning moment about toe $M_o = 1.5 \times 10^6$ KN

Resisting moment about toe $M_r = 2.5 \times 10^6$ KN

Total Vertical load $W = 60,000$ KN

Base width $B = 48$m

Downstream face slope $= 0.8(H) : 1(V)$

No tail water.

1) Resultant moment about the toe

$$M = M_r - M_o = (2.5 - 1.5) \times 10^6 = 1.0 \times 10^6 \text{ KN}$$

2) Eccentricity of resultant

Distance of resultant from toe

$$x = \frac{M}{W} = \frac{1.0 \times 10^6}{60000} = 16.67\text{m}$$

Centre of base $= B/2 = 24$m

$$e = 24 - 16.67 = 7.33\text{m}$$

Since $e < B/6 = 8$m, no tension develops.

3) Vertical stresses at the base — 03

Average stress:

$$\sigma_0 = \frac{W}{B} = \frac{60000}{48} = 1250 \text{ KN/m}^2$$

Maximum stress (at toe)

$$\sigma_{max} = \sigma_0\left(1 + \frac{6e}{B}\right)$$

$$= 1250\left(1 + \frac{6 \times 7.33}{48}\right)$$

$$= 1250(1.9167) = 2396 \text{ KN/m}^2$$

Minimum stress (at heel)

$$\sigma_{min} = \sigma_0\left(1 - \frac{6e}{B}\right)$$

$$= 1250(0.0833) \approx 104 \text{ KN/m}^2$$

4. Maximum Principal stress at the toe.

Slope of downstream face :-

$$\tan\theta = \frac{1}{0.8} = 1.25$$ 03

Principal stress at toe for a sloping face.

$$\sigma_1 = \frac{\sigma_V}{2}\left[1 + \sqrt{1+4\tan^2\theta}\right]$$

$$= \frac{2396}{2}\left[1+\sqrt{1+4(1.25)^2}\right]$$

$$= 1198\left[1+\sqrt{7.25}\right]$$

$$= 1198(3.69) \simeq 442\times10^3\ KN/m^2$$ 03

Maximum Vertical Stress

$$\sigma_{VD} = \frac{\Sigma V}{b}\left(1+\frac{6e}{B}\right) = \frac{60000}{48}\left(1+\frac{6(7.34)}{48}\right) = 2386\ KN/m^2\ (comp)$$

Minimum Vertical Stress

$$\sigma_{YD} = \frac{60000}{48}\left(1-\frac{6\times7.34}{48}\right) = 103\ KN/m^2$$

Maximum Principal Stress

$$\boxed{\sigma_{ID} = \sigma_{YD}\sec^2\phi_D = 3930\ KN/m^2}$$ 01

7a. **Causes of failure of Earthern dams :-**

1) Hydraulic failures

2) Seepage failures

3) Structural failures.

1) Hydraulic failures :- About 40% of earth dam failures have been attributed to these causes.

a) By over topping :- The water may overtop the dam, if the design flood is under-estimated or if the spillway is of insufficient capacity or if the spillway gates are not properly operated.

b) Erosion of upstream face :- The waves developed near the top water surface due to the winds, try to notch-out the soil from the upstream face and may even, sometimes, cause the slip of the upstream slope.

c) Cracking due to frost action :- Frost in the upper portion of the dam may cause heaving and cracking of the soil with dangerous seepage and consequent failure.

2) Seepage failures :- Controlled seepage or limited uniform seepage is inevitable in all earth dams & ordinarily it does not produce any harm. However, uncontrolled or concentrated seepage through the dam body or through its foundation may lead to piping or sloughing and the subsequent failure of the dam. More than 1/3rd of the earth dams have failed because of these reasons :-

a) piping through foundations.

b) Piping through dam body

c) Sloughing of D/S Toe.

3) Structural failure :- About 25% of the dam failures have been attributed to structural failures. Structural failures are generally caused by shear failures, causing slides.

a) Foundation slide (i.e overall stability of the dam).

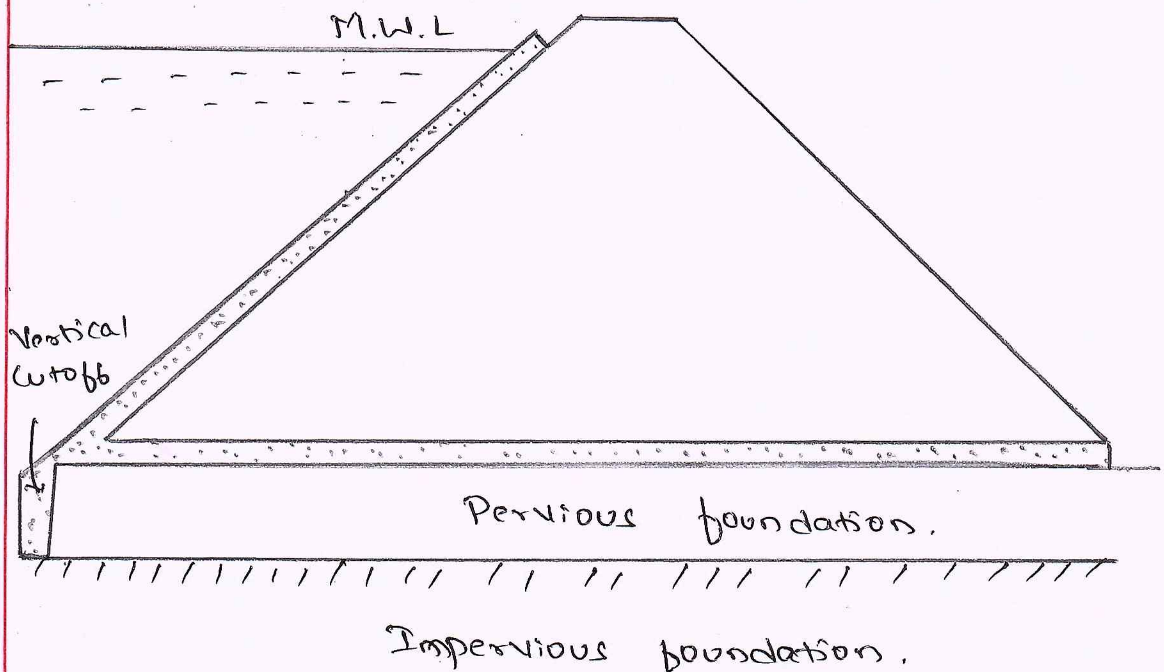
b) Slide in Embankments.

Q12 Methods of Seepage control through foundation & body of earthern dam

1) Impervious cutoffs.

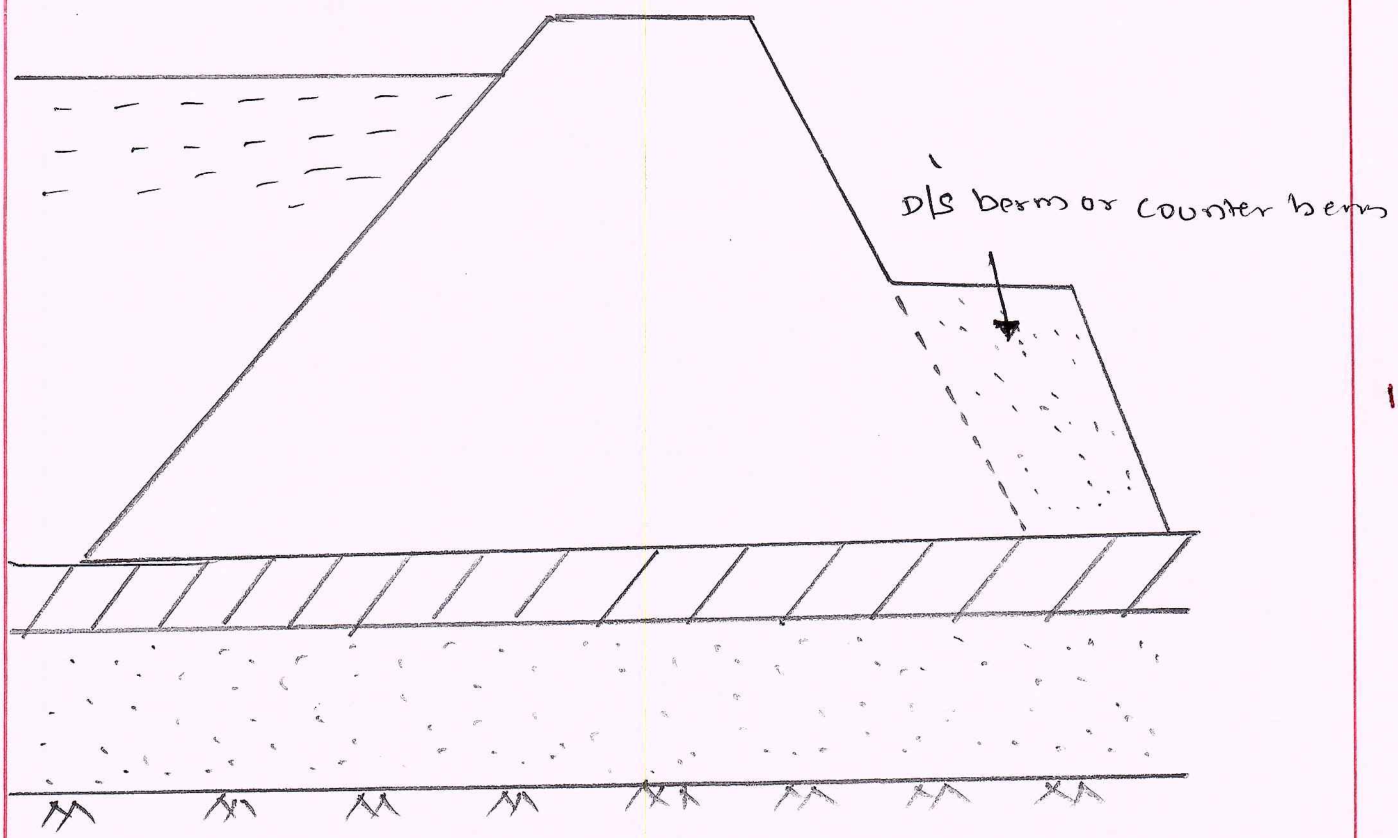
2) Relief wells & drain trenches.

1) **Impervious Cutoffs :-** Vertical impervious cutoffs made of concrete or sheet piles may be provided at the upstream end of the earthen dam, these cutoffs should, generally, extend through the entire depth of the pervious foundation, so as to achieve effective control on the seeping water. when the depth of the pervious foundation strata is very large, a cutoff, up to a lesser depth, called a partial cutoff may be provided. Such a cutoff reduces the seepage discharge by smaller amoun So much so, that a 50% depth reduces the discharge by 25% & 90% depth reduces the discharge by 65% or so.



Relief wells and drain trenches :- when large scale seepage tak place through the pervious foundation, overlain by a thin less pervious layer, there is a possibility that the water may boi up near the toe of the dam.

Such a possibility, can be controlled by constructing relief wells or drain trenches through the upper impervious layer, so as to permit escape of seeping water. the possibilit of sand boiling may also be controlled by providing d/s berm beyond the toe of the dam.



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8a **Earthen dam :-** Earthen dams & earthen levees are the most ancient type of embankments, as they can be built with the natural materials with a minimum of processing and primitive equipment. 02

Design criteria for earth dams :-

1) A fill of sufficiently low permeability should be developed out of the available materials, so as to best serve the intended purpose with minimum cost.

2). Sufficient spillway and outlets capacities should be provided so as to avoid the possibility of overtopping during design flood.

3). Sufficient freeboard must be provided for wind setup wave action, frost action & earthquake motions.

4) the seepage line should remain well within the downstream face of the dam, so that no sloughing of the

of the face occurs.

5) There is little harm in Seepage through a flood control dam. If the Stability of foundation & embankments is not impaired, by piping, sloughing etc.

6) There should be no possibility of free flow of water from the upstream to downstream face.

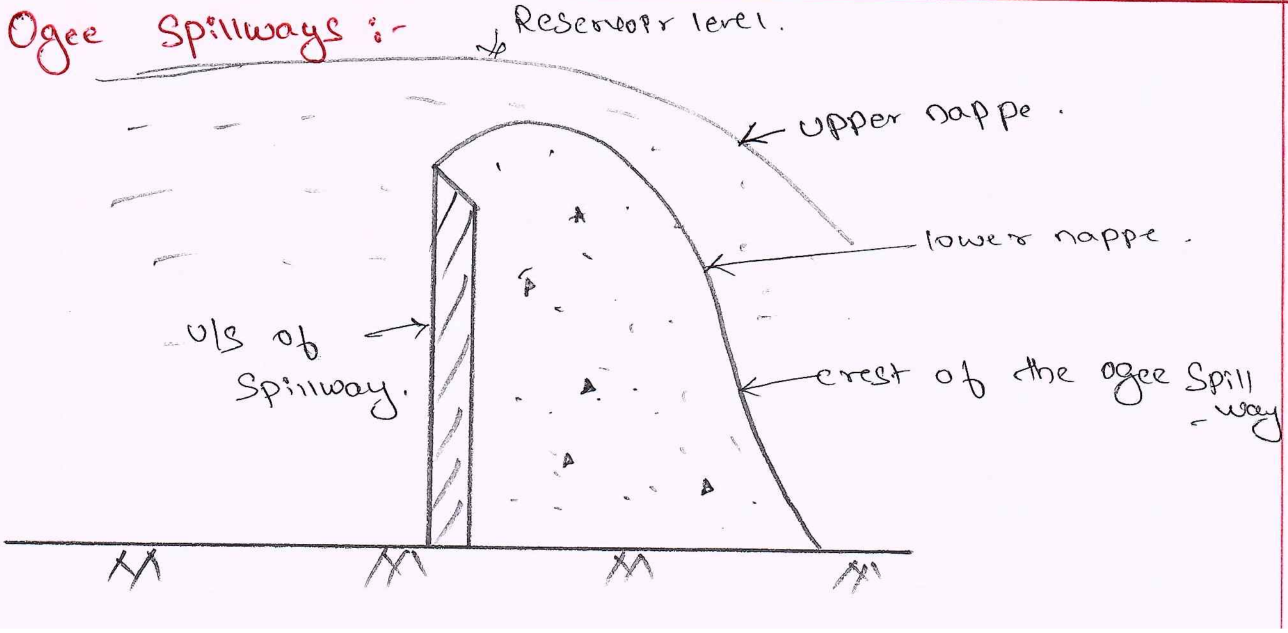
7) The upstream face should be properly protected against wave action, and the downstream face against rains & against waves upto tail water.

8) The portion of the dam, downstream of the impervious core, should be properly drained by providing suitable horizontal filter drain, or toe drain, or chimney drain etc.

9) The u/s and d/s slopes should be so designed as to be stable under worst conditions of loading.

10) The u/s & d/s slope should be flat enough, as to provide sufficient base width at the foundation level, such that the maximum shear stress developed remains well below the corresponding maximum shear strength of the soil, so as to provide a suitable factor of safety.

8b. i) Ogee Spillways :-



ogee Spillway is an improvement upon the "free overfall Spillway, and is widely used with Concrete, masonry, arch and buttress dams. Such a spillway can be easily used on valleys where the width of the river is sufficient to provide the required crest length & the river bed below can be protected from scour at moderate costs. The profile of this spillway is made in accordance with the shape of the lower nappe of a free falling jet, over a duely venti-lated sharp crested weir. 05

The shape of the lower nappe of freely falling jet over a sharp crested weir can be determined by the principle of projectile.

ii) Stilling basins :- when water flows over a spillway, it attains very high velocity. If this energy is not dissipated it can cause severe scouring and erosion of the downstream riverbed and foundation.

A stilling basin forces the formation of a hydraulic jump converting kinetic energy into turbulence & heat, thereby protecting the structure.

The hydraulic jump formation depends considerably upon the Froude number of the incoming flow (F_1). The pre-jump depth (y_1) & post-jump depth (y_2) are also governed by the equation 05

$$\frac{y_2}{y_1} = \frac{1}{2}\left[\sqrt{1+8F_1^2} - 1\right]$$

where $F_1 = \dfrac{V_1}{\sqrt{g \cdot y_1}}$

9a. Types of diversion head works :-

1) Weir

2) Barrage

1) weir :- The ponding of water can be achieved either only by a permanent pucca raised crest across the river or by a raised crest supplemented by falling counter-balanced gates or shutters, working over the crest. If the major part or the entire ponding of water is achieved by a raised crest & a smaller part or nil part of it is achieved by the shutters, then this barrier is known as a weir. on the other hand, if most of the ponding is done by gates & a smaller or nil part of it is done by the raised crest, then the barrier is known as barrage or a River Regulator. 05

weir cum-barrage combination of weir & gated structure used where partial regulation insufficient. 05

Permeable weir or submerged weir allows some water to pass through used mainly for groundwater recharge and minor diversion.

Given:-

9b: Hydraulic Structure founded on Sand

Total head causing Seepage (H).

= U/s water depth - D/s water depth

= 6 - 3 = 3m 01.

Length of impervious floor (L) = 23m

A = 6m

B = 12m

C = 18m.

Specific gravity of Concrete $\rho = 2.24$

i) Average hydraulic gradient

$$i = \frac{H}{L} = \frac{3}{23}$$ 02

$$i = 0.130$$

ii) uplift pressure at different points.

$$h_2 = H\left(1 - \frac{x}{L}\right)$$

$$u = \gamma_w h_2$$

a) At 6m from u/s end.

$$h_6 = 3\left(1 - \frac{6}{23}\right) = 3(0.739) = 2.22\,m.$$ 02

$$U_6 = 9.81 \times 2.2 = 21.8\ KN/m^2$$

b) At 12m from u/s end

$$h_{12} = 3\left(1 - \frac{12}{23}\right) = 3(0.478) = 1.43\,m$$

$$U_{12} = 9.81 \times 1.42 = 14.0\ KN/m^2$$ 02

c) At 18m from u/s end.

$$h_{18} = 3\left(1 - \frac{18}{23}\right) = 3(0.217) = 0.65\,m$$

$$U_{18} = 9.81 \times 0.65 = 6.4\ KN/m^2$$

3) Thickness of floor at these points. 03

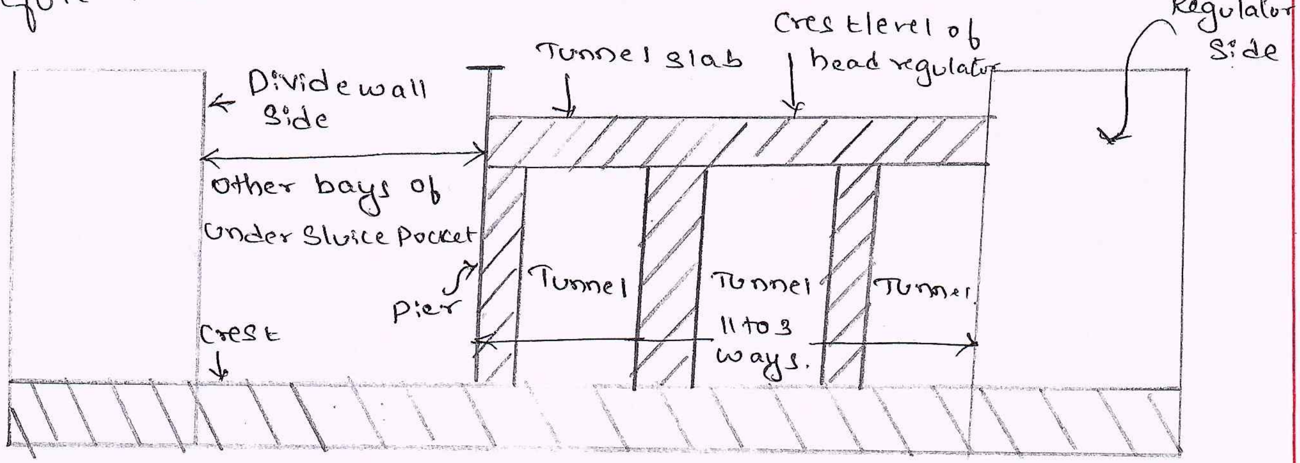
$$t = \frac{u}{\gamma_c} \quad \text{where } \gamma_c = \rho \gamma_w = 2.24 \times 9.81 = 22.0\ KN/m^2$$

a) Thickness at 6m $t_6 = \frac{21.8}{22.0} = 0.99\,m$

$$t_{12} = \frac{14.0}{22.0} = 0.64\,m$$

$$t_{18} = \frac{6.4}{22.0} = 0.29\,m$$

10a. Silt excluders :- Silt excluders are those works which are constructed on the bed of the river, upstream of the head regulator. The clearer water enters the head regulators & the silted water enters the silt Excluder. In this type of works, the silt is, therefore, removed from the water before it enters the canal.



Dis Advantages:-

i) Simultaneous use of under Sluices – masked by the Silt Excluder tunnels, for Silt Exclusion and their assigned purpose of passing high river discharges, Cannot be obtained

ii) The tunnels constructed on the river bed will have to be of robust construction, as to withstand river action.

iii) In the presence of tunnels, on the river bed in the under-Sluice pocket, Securing of good approach condition.

05

Advantages:-

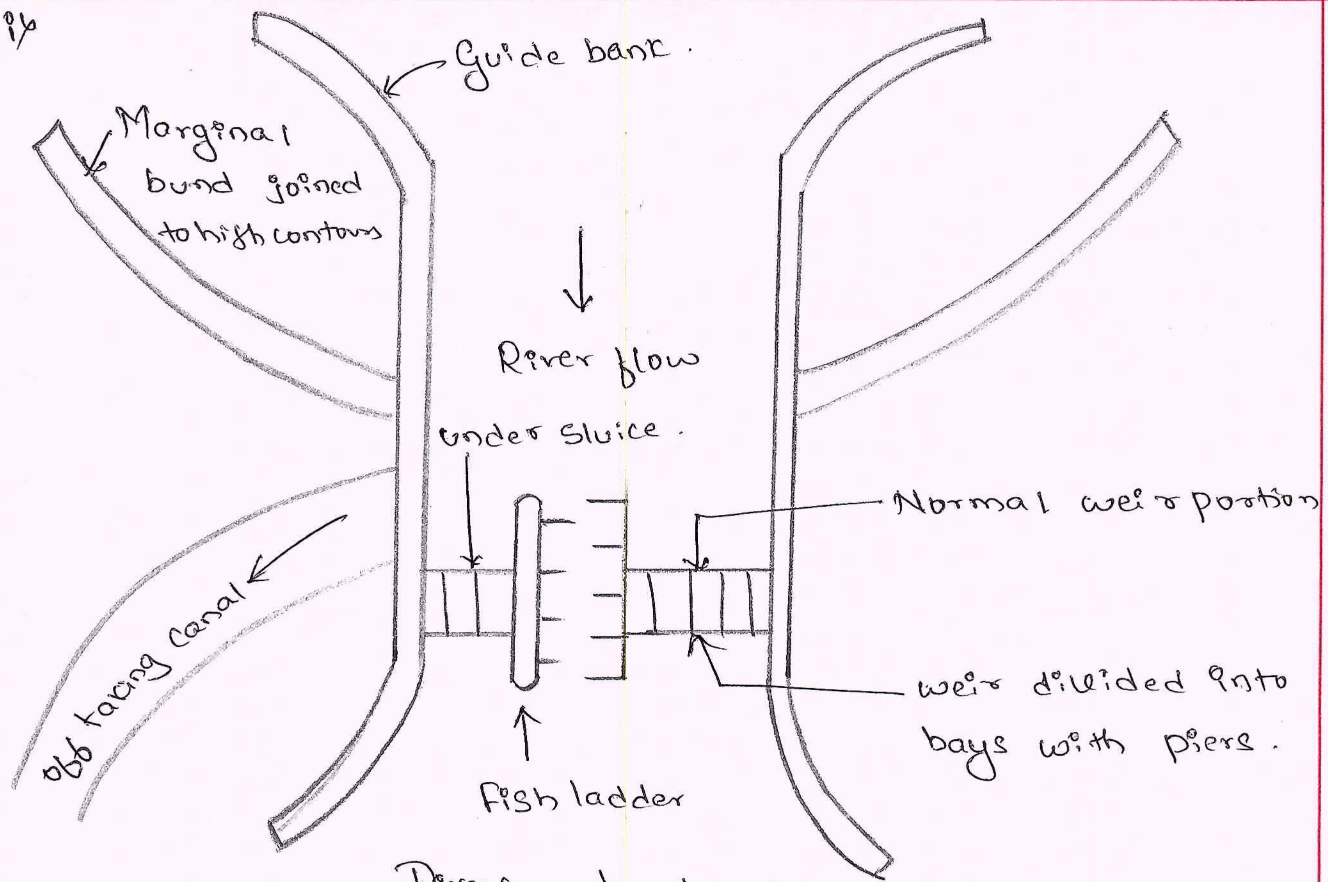
i) As the tunnels are large, there are unlikely to be Choked by rolling or Suspended debris.

ii) Since the Same gates of the Scouring Sluices can be utilised for the excluder tunnels, Some Economy in cost is Secured.

iii) At the weir, Sufficient head for operating the Excluder is generally available.

Silt ejectors :- Silt ejectors, also called Silt ejectors, are those devices which extract the silt from the canal-water after the silted water has travelled a certain distance in the off-take canal. these works are, therefore, constructed on the bed of the canal, and a little distance downstream from the head regulators.

10b. i)



Diversion headwork.

1) Weir | barrage :- Raises river water level to divert water into canal

2) Under Sluice :- Control Silt Entry and Scour deposit Silt.

3) Divide wall :- Separates weir & under Sluice flows improves flow conditions.

4) Canal head regulator :- Regulates & controls canal discharge

5) Silt Ejector :- Prevents Entry of heavy silt into canal

6) fish ladder :- Allows safe movement of fish across the structures. 05

7). Guide banks :- confine river flow and protect structure from erosion

8) Stilling basin :- Dissipates Excess kinetic energy down-stream

ii) Lane's weighted Creep theory :-

In this theory, the length of the creep, by simply adding the horizontal creep length and the Vertical creep length thereby making no distinction between the two creeps. However, Lane, on the basis of his analysis carried out on about 200 dams all over the world, Stipulated that the horizontal creep is less effective in reducing uplift than the Vertical creep. Therefore, Suggested a weightage factor of 1/3 for the horizontal creep, as against 1.0 for the Vertical creep. 05

$$L_L = (d_1+d_1) + \frac{1}{3}L_1 + (d_2+d_2) + \frac{1}{3}l_2 + (d_3+d_3)$$

$$= \frac{1}{3}(L_1+L_2) + 2(d_1+d_2+d_3) + \frac{1}{3}b + 2(d_1+d_2+d_3)$$

To ensure safety against piping, according to this theory the creep length L_L must not be less than $C_1 H_L$, where H_L is the head causing flow, and C_1 is Lane's creep co-efficient.