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AS-4212

B. Tech. (Seventh Semester) Examination, 2013

WATER RESOURCES ENGINEERING-II

(CE41T03)

Time Allowed : Thred hours

Maximum Marks : 60

Note. : *Attempt all questions as directed.*

Section-A **10×2=20**

(Short Answer Type Questions)

Note : *Attempt all questions. Each question carries 2 marks.*

Department of Civil Engineering

Institute of Technology, GGV

B.Tech. Third Year [V^{th} Sem.]

Subject: Fluid Mechanics II

Subject Code: CE31T03

Maximum Masks:60

SET- II

Note: (i) Section-A, all questions carry equal marks. 02 Marks allotted for each question.
(ii) Section-B, Attempt any one question from each Unit. All question carry equal Marks.

SECTION – A

Q(1) In turbulent flow the shear stress is mainly due to the
(a) density of the fluid (b) dynamic viscosity of the fluid
(c) kinematic viscosity of the fluid (d) eddy viscosity of the fluid
ANSWER: (d)

Q(2) The losses are more in
(a) laminar flow (b) turbulent flow (c) transition flow (d) critical flow
ANSWER: (b)

Q(3) For boundary layer thickness δ, velocity u is given by expression
(a) $u=0.88\,U_\infty$ (b) $U_\infty=0.99\,u$ (c) $u=0.99\,U_\infty$ (d) $U_\infty=0.88\,u$
where u is velocity at y distance from wall, U_∞= Free stream velocity
ANSWER: (c)

Q(4) The wake
(a) always occurs before a separation point (b) always occurs after a separation point
(c) is a region of high pressure intensity (d) none of the above
ANSWER: (b)

Q(5) In a channel the alternate depth of flow are the depths
(a) which occur at the same specific energy (b) at which total energies are same
(c) for the same specific force (d) none of the above
ANSWER: (a)

Q(6) When Froude Number is in between 4.5 to 9, type of jump is
(a) Oscillating Jump (b) Strong Jump (c) Uniform Jump (d) Steady Jump
ANSWER: (d)

Q(7) The rapid closure of valve in a water pipeline will result in water hammer pressure of magnitude:
(a) $\rho C^2 V$ (b) ρ/CV^2 (c) $\rho C/V$ (d) ρCV
ANSWER: (d)

Q(8) . Dimensional analysis is useful in
(a) checking the correctness of a physical equation
(b) determining the number of variables involved in a particular phenomenon
(c) determining the dimensionless groups from the given variables
(d) the exact formulation of a physical phenomenon
ANSWER: (c)

Q(9) In a Francis turbine, maximum efficiency is obtained when
(a) relative velocity is radial at the outlet (b) absolute velocity is radial at the outlet
(c) velocity of flow is constant (d) guide vane angle is 90 degrees
ANSWER: (a)

Q(10) A fast centrifugal pump impeller will have
(a) Propeller type blades (b) Parabolic blades
(c) Backward facing blades (d) Forward facing blades
ANSWER: (c)

SECTION – B

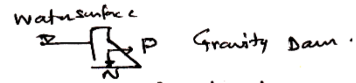
Unit -I

Q (1) Explain in brief different types of Dam. **Marks 08**

A. Based on Materials of Construction

1. Rigid dam It is constructed with rigid materials like masonry, concrete, steel or timber. It is designated as, (a) masonry dam, (b) concrete dam, (c) steel dam, (d) timber dam.

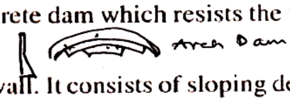
2. Non rigid dam It is constructed with non-rigid materials such as earth, clay, rock materials, etc. It is designated as, (a) earthen dam, (b) rock-fill dam, (c) composite dam.



B. Based on Structural Behaviour

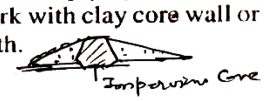
1. Solid gravity dam It is constructed with masonry or concrete. It resists the forces acting on it by its own weight. It is approximately triangular in section.

2. Arch dam It is a curved masonry or concrete dam which resists the forces acting on it by the principle of arch action.



3. Buttress dam It behaves like a retaining wall. It consists of sloping deck on the upstream side which is supported by a number of buttresses in the form of triangular reinforced concrete wall or counterforts. It resists the forces acting on it by the buttresses.

4. Embankment dam It is non-rigid dam constructed simply by earth work in trapezoidal section. Sometimes, it may be of earth work with clay core wall or rock fill. It resists forces acting on it by its shear strength.



C. Based on Functions

1. Storage dam It is constructed to form a reservoir in which the water is stored during the period of rainy season or flood and utilised for the irrigation in the period of draught. The water is also utilised for the generation of hydroelectric power, water supply, etc.

2. Detention dam It is mainly constructed to detain the flood water temporarily in a reservoir and then released gradually so that the downstream area may not be damaged due to sudden flood water.

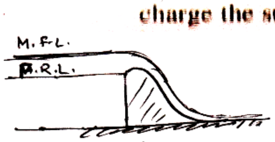
3. Diversion dam It is constructed to divert the water from a perennial river to a channel for the purpose of irrigation or to a conduit for the purpose of generation of hydroelectric power.

4. Coffer dam When an area in the river bed is enclosed temporarily by sheet piling for excluding water for the sake of construction of well foundation (i.e. pier foundation) then it is known as coffer dam.

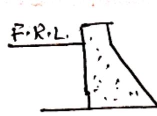
D. Based on Hydraulic Behaviour

1. Over flow dam The dam which consists of crest shutters or waste weirs on the top to allow the surplus water to overflow, is known as overflow dam.

2. Non overflow dam The dam in which spill ways are provided to discharge the surplus water and the water is not allowed to flow over the crest, is



(1) Over flow Dam.



(2) Non over flow Dam.

OR

Q (2) Discuss in brief step by step method of design of Gravity Dam. **Marks 08**

(a) Multiple step method -

For Economic design of gravity Dam, the Section of the dam divided into various zones. Each zone is designed in such a way that all the requirements of stability are satisfied. In fig (a) shows typical seven zones in non overflow gravity Dam.

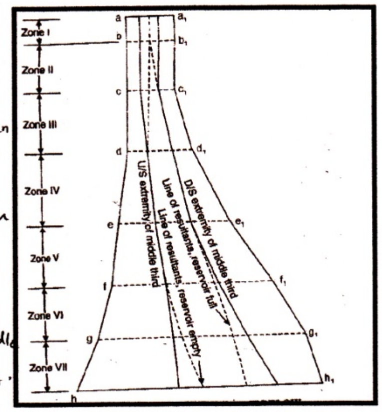


Figure (a) Multiple Step Method

Zone I - The height is controlled by free board.

Zone II - U/s & D/s face are vertical

Zone III - Reservoir is empty FR passes through middle third point.

Zone IV - Maximum inclined pressure at toe

Zone V - FR in well within middle third point

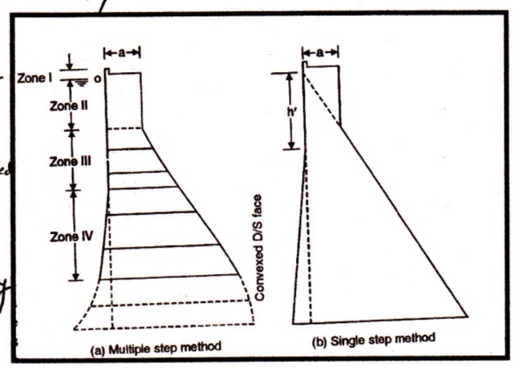
Zone VI - Max. pressure at U/s & d/s for Reservoir full and empty

Zone VII - Max. compression at d/s toe exceeds the working limit.

(b) Single Step Method - For high dams going beyond zone IV it is found that the shape of U/s and d/s slopes are sometimes obtained of unusual shape.

In single step method the U/s slope is kept vertical for some depth to be determined by trail. It may preliminarily be fixed by

$h' = 2a\sqrt{\rho - i}$



Method of Design of Gravity Dam

Unit –II

Q (1) (a) At energy dissipater structure below a low spillway the discharge is 19 m^3/sec and the energy loss is 1 m in hydraulic jump. Determine the depths of flow at both ends of the jump. **Marks 04**

We know $h_L = \frac{(y_2-y_1)^3}{4y_1y_2} = 1 = \frac{y_1^3\left(\frac{y_2}{y_1}-1\right)^3}{4y_1y_2} = \frac{1}{y_1} = \frac{\left(\frac{y_2}{y_1}-1\right)^3}{4\left(\frac{y_2}{y_1}\right)}$

But $\frac{y_2}{y_1} = \frac{1}{2}\left[\sqrt{1+8F_1^2}-1\right] = \frac{1}{2}\left[\sqrt{1+\frac{8q^2}{gy_1^3}}-1\right]$

$\therefore x = \left(\frac{y_2}{y_1}\right) \quad \therefore \frac{1}{y_1} = \frac{(x-1)^3}{4x}$

$\because x = \frac{1}{2}\left[\sqrt{1+\frac{8q^2}{gy_1^3}}-1\right] \qquad x = \frac{1}{2}\left[-1+\sqrt{1+\frac{8\times19^2}{9.81\times y_1^3}}\right]$

$\therefore x = \frac{1}{2}\left[-1+\sqrt{1+\frac{294.39\,(x-1)^{3\times3}}{64\,x^3}}\right] = \frac{1}{2}\left[-1+\sqrt{1+\frac{4.6(x-1)^9}{x^3}}\right]$

By trail $x = 2.806$

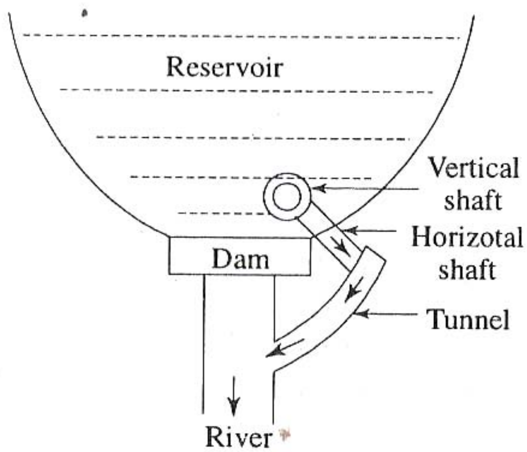
$y_1 = \frac{4x}{(x-1)^3} = \frac{4\times2.806}{(2.806-1)^3} = 1.905\,m.$

$\therefore y_2 = x\times y_1 = 2.806\times1.905 = 5.347\,m.$

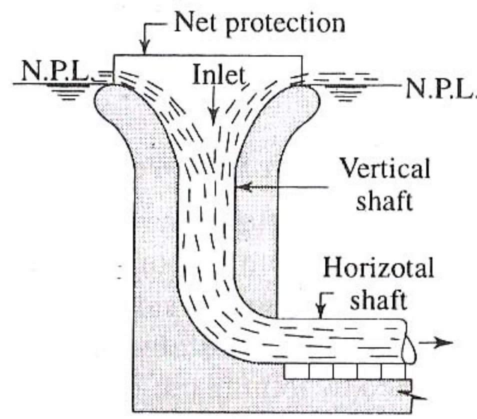
(b) Discuss in brief shaft spillway with neat sketches. **Marks 04**

Shaft Spill Way

It consists of a vertical shaft which is constructed with masonry work or plain cement concrete or reinforced cement concrete on the bed of the reservoir just at the upstream side of the dam. The inlet mouth of the vertical shaft is conical shaped. The vertical shaft is connected with horizontal shaft. The horizontal shaft again may be taken through the body of the dam (in case of gravity dam) or through the base of the dam (in case of earthen dam) or may be connected to a tunnel outside the dam. The inlet mouth is kept at the normal pool level of the reservoir. So, when the water rises above the N.P.L. it enters the shaft from all directions and flows out through the shaft. In order to arrest the floating debris, a net protection is provided on the inlet mouth (Fig. 12.11 a and b).



(a) Position of shaft



(b) Section of shaft

OR

Q (2) Explain in brief USBR stilling basin. **Marks 08**

Stilling Basins

The basins are usually provided with special appurtenances including chute blocks, sills and baffles piers.

Chute blocks: are used to form a serrated device at the entrance to the stilling basin. Their function is to furrow the incoming jet and lift a portion of it from the floor producing a shorter length of jump than would be possible without them.

The sill: is usually provided at the end of stilling basin. Its function is to reduce further the length of the jump and to control scour. The sill has additional function of diffusing the residual portion of high velocity jet that may reach the end of the basin.

Baffle piers: are blocks placed in the intermediate position across the basin floor. Their function is to dissipate energy mostly by impact action. They are useful in small structures with low incoming velocities. They are unsuitable where high velocities make cavitation possible.

Classification of Stilling Basins

Stilling basins can be classified into:

1. Stilling basins in which . $F1 < 4.5$ This is generally encountered on weirs and barrages.
2. Stilling basins in which . $F1 > 4.5$ This is a general feature for medium and high dams.

U.S.B.R. Stilling Basin IV

The USBR Type III stilling basin (USBR, 1987) employs chute blocks, baffle blocks, and an end sill as shown in Figure (a) The basin action is very stable with a steep jump front and less wave action downstream than with the free hydraulic jump. The position, height, and spacing of the baffle blocks as recommended below should be adhered to carefully. If the baffle blocks are too far upstream, wave action in the basin will result; if too far downstream, a longer basin will be required; if too high, waves can be produced; and, if too low, jump sweep out or rough water may result. The baffle blocks may be shaped as shown in Figure (a) or cubes; both are effective. The corners should not be rounded as this reduces energy dissipation.

The recommended design is limited to the following conditions:

1. Maximum unit discharge of 18.6 $m^3/s/m$
2. Velocities up to 18.3 m/s entering the basin.
3. Froude number entering the basin between 4.5 and 17.
4. Tailwater elevation equal to or greater than full conjugate depth elevation. This provides a 15 to 18 percent factor of safety.
5. The basin sidewalls should be vertical rather than trapezoidal to insure proper performance of the hydraulic jump.

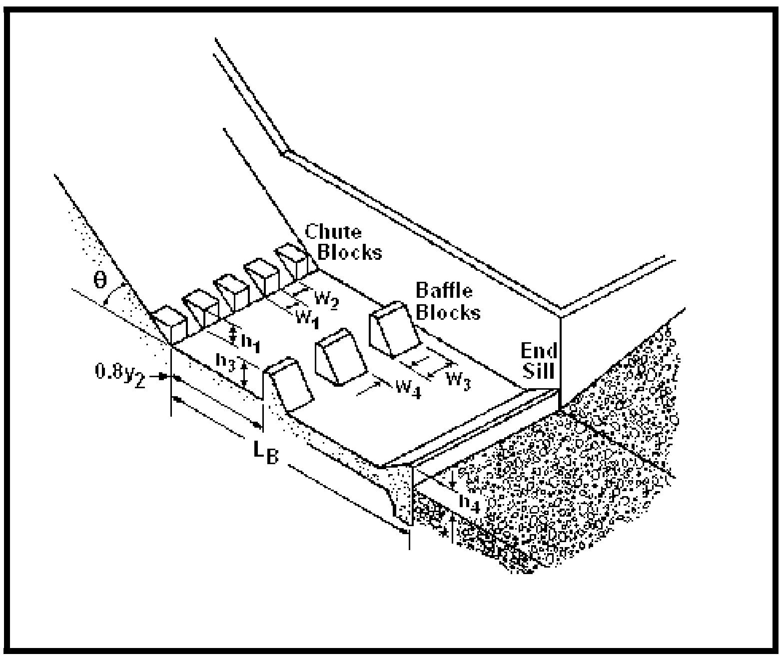


Figure (a) USBR Type III Stilling Basin

USBR Type IV Stilling Basin

The USBR Type IV stilling basin (USBR, 1987) is intended for use in the Froude number range of 2.5 to 4.5. In this low Froude number range, the jump is not fully developed and downstream wave action may be a problem, For the intermittent flow encountered at most highway culverts, wave action is not judged to be a severe limitation. The basin, illustrated in Figure employs chute blocks and an end sill.

The recommended design is limited to the following conditions:

1. The basin sidewalls should be vertical rather than trapezoidal to insure proper performance of the hydraulic jump.
2. Tailwater elevation should be equal to or greater than 110 percent of the full conjugate depth elevation. The hydraulic jump is very sensitive to tailwater depth at the low Froude numbers for which the basin is applicable. The additional tailwater improves jump performance and reduces wave action.

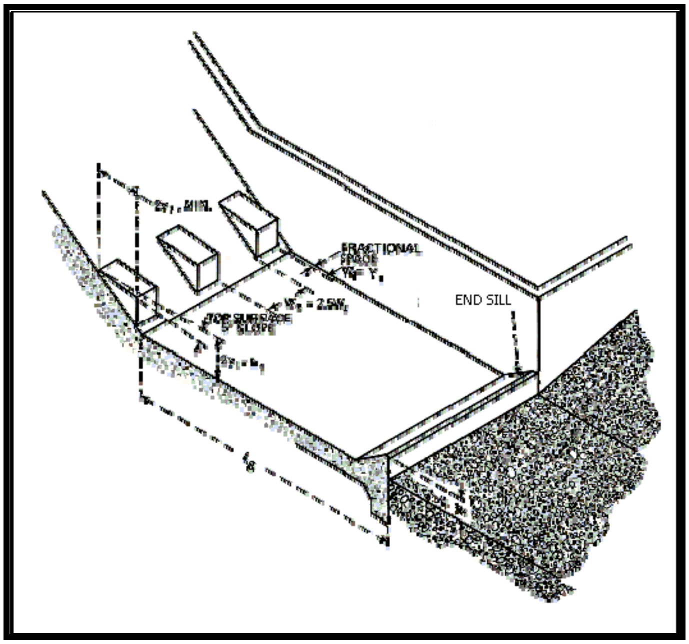


Figure USBR Type IV Stilling Basin

Unit –III.

Q (1) An impervious floor of a weir on permeable soil is 16 m long and has sheet piles at both ends. The upstream pile is 4 m deep and the down steam pipe is 5 m deep. The weir creates a net head of 2.5 m. Neglecting the thickness of the weir floor, calculate the uplift pressures at the junction of the inner faces of the pile with the weir floor, by using Khosla's theory. (Use Khosla's curve)

Marks 08

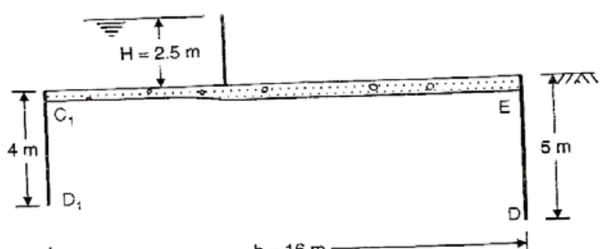


FIG. (a)

(i) *Pressure at point E*

$$\Phi_E = \frac{100}{\pi}\cos^{-1}\left(\frac{\lambda - 2}{\lambda}\right)$$

$$\alpha = b/d = 16/5 = 3.2$$

$$\lambda = \frac{1+\sqrt{1+\alpha^2}}{2} = \frac{1+\sqrt{1+(3.2)^2}}{2} = 2.176$$

$$\therefore \quad \Phi_E = \frac{100}{\pi}\cos^{-1}\left(\frac{2.176-2}{2.176}\right) = \frac{100}{\pi}(85°.35) \times \frac{\pi}{180} = 47.42\%$$

Let us now apply correction for interference of u/s pile, given by

$$C = -19\sqrt{\frac{D}{b'}}\left(\frac{d+D}{b}\right)$$

where $d = 5$ m ; $D = 4$ m; $b' = 16$ m

$$\therefore \quad C = -19\sqrt{\frac{4}{16}}\left(\frac{5+4}{16}\right) = -5.34\%$$

$\therefore$ Corrected $\Phi_E = 47.42 - 5.34 = 42.08\%$

or $P_E = 0.4208 \times 2.5 = \mathbf{1.052\ m}$

(ii) Pressure at point C_1

For finding Φ_{C1}, imagine the pile to be situation at the downstream

$$\Phi_{C_1} = 100 - \Phi_E$$

where $\Phi_E = \frac{100}{\pi}\cos^{-1}\left(\frac{\lambda-2}{\lambda}\right)$ where $\alpha = b/d = 16/4 = 4$

$$\therefore \quad \lambda = \frac{1+\sqrt{1+\alpha^2}}{2} = \frac{1+\sqrt{1+(4)^2}}{2} = 2.562$$

and $\Phi_E = \frac{100}{\pi}\cos^{-1}\left(\frac{2.562-2}{2.562}\right) = \frac{100}{\pi}(77.34°) \times \frac{\pi}{180} = 42.96\%$

$$\therefore \quad \Phi_{C_1} = 100 - \Phi_E = 100 - 42.96 = 57.04\%$$

Let us now apply correction for interference of d/s pile, given by

$$C = +19\sqrt{\frac{D}{b'}}\left(\frac{d+D}{b}\right)$$

where $d = 4$ m ; $D = 5$ m; $b' = b = 16$ m

$$\therefore \quad C = 19\sqrt{\frac{5}{16}}\left(\frac{4+5}{16}\right) = +5.97\%$$

$$\therefore \quad \Phi_{C_1} = 57.04 + 5.97 = 63.01\%$$

$$\therefore \quad P_C = 0.6301 \times 2.5 = \mathbf{1.575\ m}$$

OR

Q (2)Explain in brief effect of construction of weir on the river regime. Marks 08

Barrage or weir is essentially an obstruction in the normal flow of the river and effects changes in the river regime both upstream and downstream. The sequence of the effect of barrage on river regime may be (*i*) The river water carries its sediment load but as a result of construction of weir the supply drawn by the canal and the water past the weir is also relatively silt free resulting in silt deposition upstream, (*ii*) The heading up of water upstream of a weir results in reduced velocity and consequent deposition of bulk of the sediment load in the pond resulting in formation of irregular shoals upstream of the weir (*iii*) The water surface slope of the river upstream of the barrage flattens, *i.e.,* accretion starts upstream and degradation or retrogression downstream for the first 4 or 5 years depending on the initial heading up over the natural water levels, (*iv*) The progressive silting increases tortuosity and formation of shoals in the upstream tends to rise as the bed levels at the weir are fixed. The resistance to flow of river increases to overcome which increased head is required and as a consequence there is a tendency on the part of the river to regain its original slope, and (*v*) A stage is then reached when the pond absorbs no more silt burden and the excess of silt is passed down the weir with the reduced discharge. It results in progressive silting up downstream, an increase in tortuosity and hence a recovery of the bed level downstream.

The accretion on the upstream and retrogression on the downstream is of great importance in the design of a barrage or weir. The accretion upstream if not duly provided for or controlled may necessitate subsequent raising of the afflux bund. Likewise the excessive lowering of water levels in the downstream, excessive than anticipated, and not controlled may make it difficult to maintain the formation of hydraulic jump at the toe of glacis resulting in major damage to the structure. The effects of degradation are (*i*) Lowering of flood levels, (*ii*) Damage to foundations of structures, (*iii*) Materially affecting the functioning of dissipation devices due to reduced tail-water level, and (*iv*) Lowering of watertable.

Unit –IV

Q (1) Explain in brief stepped Fall and Rapid Fall with neat sketch. Marks 08

(a) Stepped Fall

Stepped fall consists of a series of vertical drops in the form of steps. This fall is suitable in places where the sloping ground is very long and requires long glacis to connect the higher bed level with lower bed level.

- This fall is practically a modification of the rapid fall.
- The sloping glacis is divided into a number of drops so that the flowing water may not cause any damage to the canal bed. Brick walls are provided at each of the drops.
- The bed of the canal within the fall is protected by rubble masonry with surface finishing by rich cement mortar (1:3).

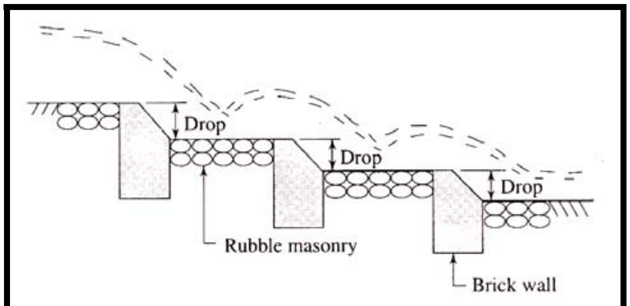


Fig: Stepped Fall

(b) Rapid Fall

The rapid fall is suitable when the slope of the natural ground surface is even and long. It consists of a long sloping glacis with longitudinal slope which varies from 1 in 10 to 1 in 20.

- Curtain walls are provided on the upstream and downstream side of the sloping glacis.
- The sloping bed is provided with rubble masonry.
- The upstream and downstream side of the fall is also protected by rubble masonry.
- The masonry surface is finished with rich cement mortar (1: 3).

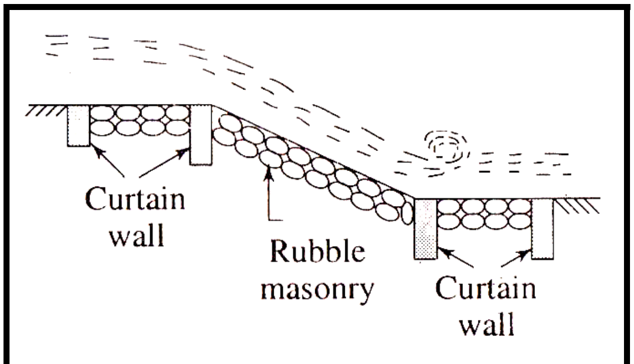
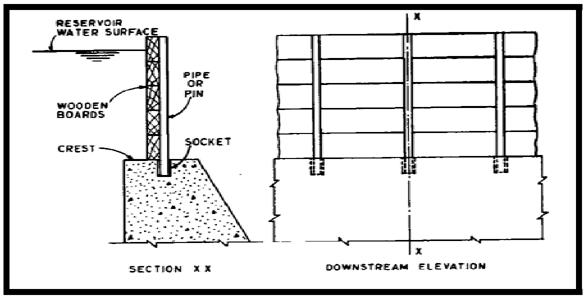


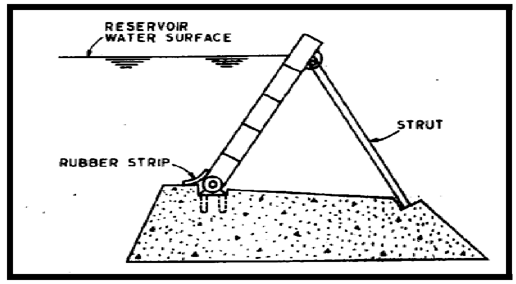
Fig: Rapid Fall

OR

Q (2) Discuss in brief flush boards and drum gates. **Marks 08**

(a) Flush Boards





(a) Temporary Flash boards **(b) Permanent Flash boards**

(1) **Flashboards.** In general flshboards consist of a series of wooden boards or panels placed on the crest of the spillway. The flashboards may be classified as *(i)* temporary flashboards ; and *(ii)* permanent flashboards.

Temporary flashboards consist of a series of wooden boards or panels supported by steel pipes or rods (called pins) inserted loosely into sockets set in the masonry or concrete at the crest of the spillway Figure (a) The steel pipes of rods are designed to bend and release the flashboards when the water surface in the reservoir reaches a certain elevation above the top of the flashboards, thus allowing the excessive floods to pass. Temporary flashboards have been used upto a height of 1·7 m. The operation of the temporary flashboards is automatic, but the disadvantage being that the flashboards are lost each time when the supports fail.

Permanent flashboards are similar in principle to the temporary type, except that they are designed to operate without damage to themselves. Permanent flashboards usually consist of wooden boards or panels which can be raised or lowered from an overhead cableway or bridge. Various types of permanent flashboards have been designed. Figure (b) shows one of the types of permanent flashboards in which the wooden boards are joined to form shutters. These shutters are placed on the crest of the spillway with their lower edge hinged at the crest and are supported in the raised position by struts or by attaching their upper edge to a bridge or cableway at the top. The shutters drop flat on the crest when the struts are tripped or when they are released from the top. These are therefore not suitable for spillways having curved crests. For raising the shutters either a crane travelling on the crest of the spillway or a trolley on a bridge or an overhead cable if there is no bridge may be used.

(b) Drum Gates

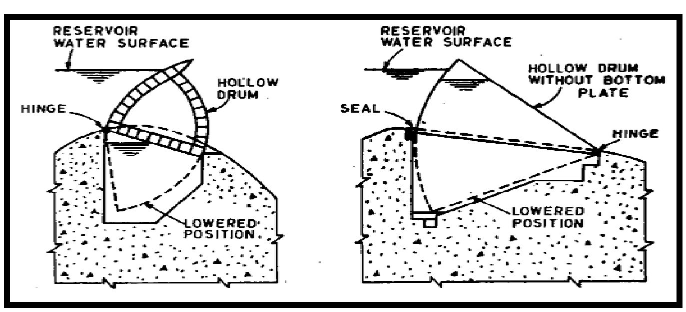


Figure Drum Gate

Several dam projects include spillway drum gates. These gates are unique in that the gates are lowered to release water. Water flows over the top of the gates. Figure shows a cross section through a drum gate. The gate is a hollow steel structure, hinged on the upstream side that floats in a bath of water contained within a float chamber bounded by reinforced concrete walls. Water is let into the float chamber to raise the gate (raising the reservoir level and shutting off spillway flow) and water is released from the chamber to lower the gate (initiating spillway flows and lowering the reservoir level). Gate seals prevent water from going around the gates, and gate stops or seats keep the gates from rotating too far up and out of the float chamber. Since the gates are hollow and relatively water tight in order to allow them to float, a drain usually connected from the interior of the gate by a flexible hose to an outlet through the concrete at some location to allow any water that gets into the gate to exit.

Unit -V

Q (1) Explain in brief design principles of C-D Works. Marks 08

The main objective of design is to determine the dimensions arrangement of structures proposed to be constructed. In cross drainage works, unlike other hydraulic structures, suitable structures have to be provided for the canal as well as the natural drain to carry one water conveyance channel over, below or through the other appropriately. Obviously in a design procedure for a cross drainage work determination of hydraulic parameters of the natural drainage as well as the canal crossing the former constitute important considerations. The arrangement of structures and their structural strength are also of equal importance. The important steps involved in the design of a cross drainage work could be summarized as follows:

(A) Determination of drainage parameters

(*i*) Design flood discharge and high flood level (H.F.L.)
(*ii*) Waterway required for the drain.
(*iii*) Velocity of flow through the barrel.
(*iv*) Height of opening or clearances.
(*v*) Number of spans or openings.

(B) Determination of canal parameters

(*i*) Size of canal waterway or its contraction.
(*ii*) Design of transitions.
(*iii*) Bank connections.

(C) Determination of hydraulic forces

(*i*) Head loss through barrels.
(*ii*) Uplift pressure on the roof of the barrel or trough.
(*iii*) Uplift pressure on the floor of the barrel.

After determining the above parameters structural design can be done.

OR

Q(2) Classify aqueducts and explain under what circumstances each one is used. Marks 08

(1) Type I (Irrigation canal passes over the drainage)

(a) Aqueduct

(b) Siphon aqueduct

Selection of type of cross-drainage works

- Relative bed levels
- Availability of suitable foundation
- Economical consideration
- Discharge of the drainage
- Construction problems

Aqueduct

The aqueduct is just like a bridge where a canal is taken over the deck supported by piers instead of a road or railway. Generally, the canal is in the shape of a rectangular trough which is constructed with reinforced cement concrete. Sometimes, the trough may be of trapezoidal section.

- An inspection road is provided along the side of the trough.
- The bed and banks of the drainage below the trough is protected by boulder pitching with cement grouting.
- The section of the trough is designed according to the full supply discharge of the canal.
- A free board of about 0.50 m should be provided.
- The height and section of piers are designed according to the highest flood level and velocity of flow of the drainage.
- The piers may be of brick masonry, stone masonry or reinforced cement concrete.
- Deep foundation (like well foundation) is not necessary for the piers. The concrete foundation may be done by providing the depth of foundation according to the availability of hard soil.

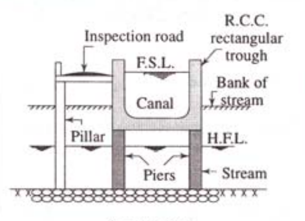


Fig: Aqueduct

Siphon Aqueduct

The siphon aqueduct, the bed of the drainage is depressed below the bottom level of the canal trough by providing sloping apron on both sides of the crossing.

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

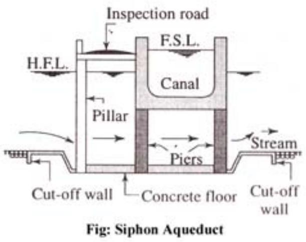


Fig: Siphon Aqueduct