UNIT 5 COMPONENTS OF WEIRS AND BARRAGES

Structure

5.1 INTRODUCTION

In Unit 4 you were told about weirs and how they differ from barrages. In this unit, you will learn about the components of weirs and barrages, their functions and the hydraulic design considerations. All these components are necessary in a headworks for diverting the river flow into the canal.

Objectives

At the end of this unit you, will know about the purpose and functions of

- scouring sluices,
- canal head regulators,
- divide walls,
- fish ladders,
- log chute,
- gates, and
- considerations for designing the various components of headworks.

5.2 SCOURING SLUICES

The scouring sluices or undersluices are gate controlled openings in the weir with crests at a low level. They are located on the same side as the offtaking channel. If two canals take off on either side of the river, it would be necessary to provide undersluices on either side.

The usual functions of the scouring sluices are to :

a) preserve a clear and well defined river channel approaching the canal head regulator,

b) scour silt deposited in front of canal regulator and control silt entry into the canal,

c) facilitate working of barrage crest gates or weir shutters,

d) the winter floods are passed without dropping the weir shutters or raising the barrage gates, and

e) lower the highest flood level by providing greater discharge per metre length than the weir.

The discharge capacity of undersluices is provided greater of the following:

a) two times the maximum discharge in the offtaking canal,

b) 20 per cent of maximum flood discharge, and

c) maximum winter discharge.

SAQ 1

i) What are scouring sluices?

ii) What are the usual functions of scouring sluices?

iii) How do you fix the discharge capacity of undersluices?

5.3 CANAL HEAD REGULATORS

The head regulator serves to :

a) regulate the supply of water in the canal, and

b) control the entry of silt into the canal.

The head regulator is normally aligned between 90° and 110° with respect to the axis of the weir or barrage. The regulation is done by means of gates. The old head regulator used to have a number of small span gates operated manually by winches. However, the modem trend is to provide steel gates of spans ranging from 6 to 10 m and operated by electric winches.

The height of the gates is determined by the difference in the crest level and the pond level. To check the flood water from entering the canal, a breast wall between the pond level and the high flood level is provided.

Control of silt entering the canal is provided by keeping the crest of the head regulator about 1 to 1.5 m higher than the crest of the undersluices. If a silt excluder is provided, it is necessary to further raise the crest of the head regulator by a minimum of 0.75 m.

Head regulators are generally provided with a very wide and shallow waterway and the drowned weir formula

$$Q = 0.667\, L\, C_1 \sqrt{(2g)}\, [(H + h_a)^{3/2} - h_a^{3/2}] + L\, C_2\, d\, \sqrt{[2g\,(H + h_a)]} \qquad ...(5.1)$$

may be used where,

C_1 and C_2 = numerical coefficients whose values may be taken as 0.577 and 0.80, respectively,

H = difference of upstream and downstream water levels (m),

h_a = head due to velocity of approach (m),

L = clear length of waterway (m), and

d = depth of downstream water level above the crest (m).

Sometimes, the waterway at the head regulator would work out more than the width of the canal. In such cases the crest level is changed so as to keep the waterway equal to the width of the canal. If it is not possible to do so, then the waterway as worked out is provided with a flared wall in the downstream of the regulator to join the canal width.

The same principles of design as applicable to the weir are used to determine the total length and thickness of floor and protection works. Usually, the most critical condition of uplift pressure occurs when high flood is passing down the weir and the canal gates are closed.

Figure 5.1 shows a typical plan of a head regulator while Figure 5.2 is a typical section through a canal head regulator.

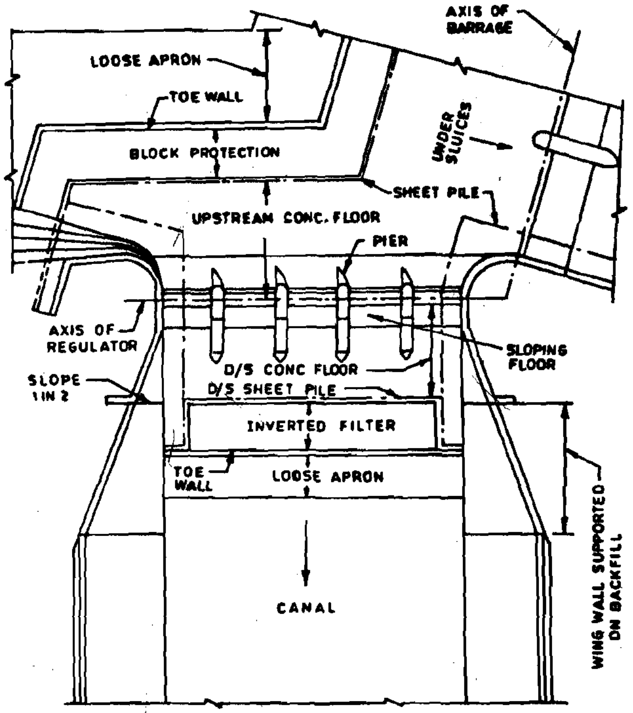


Figure 5.1 : Plan of Head Regulator

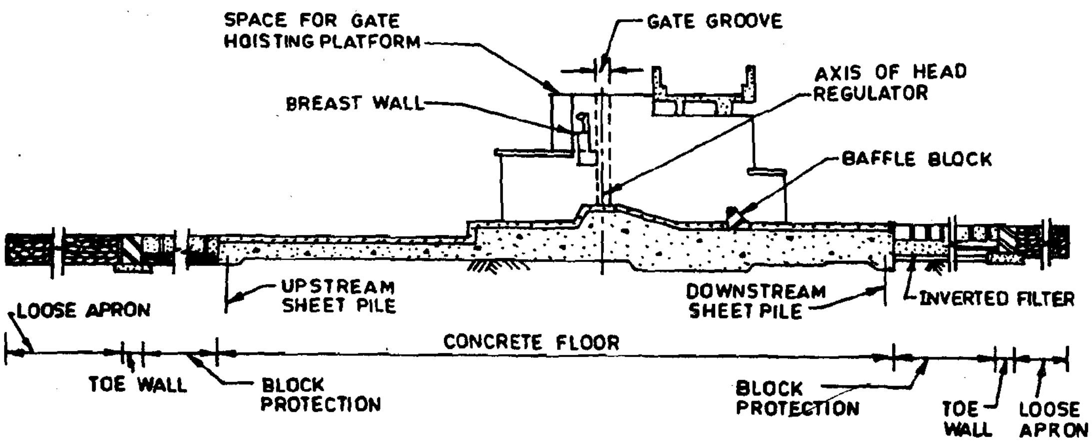


Figure 5.2 : Cross-section through a Head Regulator

SAQ 2

i) What are the functions of canal head regulators?

ii) How are the crest levels of canal head regulators fixed?

5.4 POND

The pond is the pool of water created upstream of a weir or a barrage between the divide wall and the canal head regulator. The pond level has to be maintained at a specified level to be able to pass the desired discharge into the canal head regulator. The pond level in the undersluice pocket, upstream of the canal head regulator, is kept 1 - 1.2 m above the full supply level of the canal. The level of the crest of the head regulator is obtained by deducting from the pond level, the head over the crest required to pass the full supply discharge into the canal at the specified pond level.

SAQ 3

What is the pond level in a barrage?

5.5 DIVIDE WALL

It is a wall separating the undersluices and the weir or barrage bays and extends a little upstream of the canal regulator and in the downstream, upto the end of loose protection of the undersluices. Normally, it is a concrete or masonry structure with a top width of 1.5 - 3 m, and aligned at right angles to the axis of the weir. The main functions of the divide wall are to :

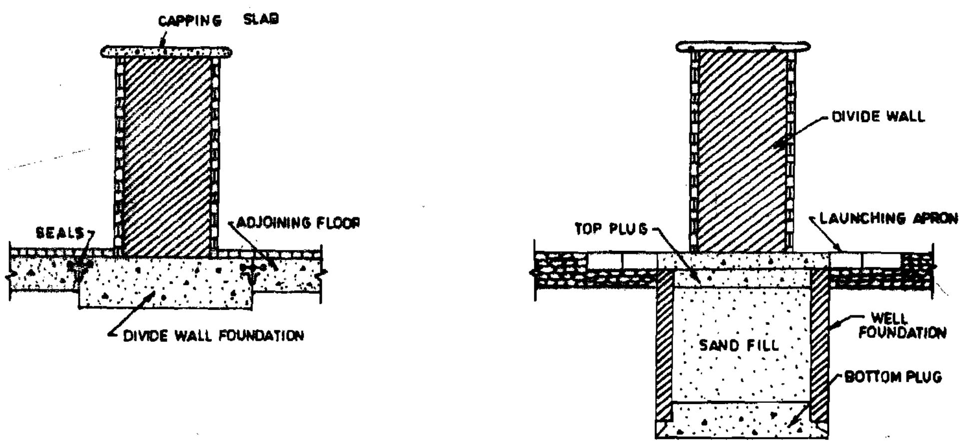
a) separate the floor of undersluices which is at a lower level than the weir proper,

b) separate the pockets upstream of the canal head regulator to facilitate scouring operations, and

c) prevent formation of cross currents to avoid their damaging effects. Additional divide walls are sometimes provided for this purpose.

Divide walls are costly structures. A large number of divide walls were provided sometimes back in barrages with a view to control cross currents. This function of the divide wall is not fully established. The modern trend is to provide divide wall to separate undersluices from weir only. These walls are likely to be subjected to maximum differential pressure when the full discharge of the river is passing through the undersluices and no discharge is passing through the weir. In this condition there will be difference in the water level on the two sides. Also there may exist difference in silt pressures on the two sides. The discharge passing down the undersluices may flush off the silt. The values of differential pressure are taken arbitrarily say 1 m for water heads and about 2 m for silt pressure.

These walls are founded on wells closely spaced beyond the pucca floor upto the end. Typical cross-section of the divide wall on pucca floor and beyond are given in Figure 5.3.



(a) On Pucca Floor (b) Beyond Pucca Floor

Figure 5.3 : Cross-section of Divide Wall

SAQ 4

i) What is a divide wall?

ii) What are the functions of a divide wall?

5.6 FISH LADDER

A fish ladder is generally provided to enable the fish ascend the head waters of the river and thus reach their spawning grounds for breeding or to follow their migratory habits in search of food.

The general requirements of a fish ladder are :

a) the slope of the fish ladder should not be steeper than 1 : 10, so as to ensure a current of velocity not exceeding 2 m/s in any portion of the fishway,

b) the compartments of bays of the pass must be of such dimensions that the fish do not risk collision with the sides and upper end of each bay when ascending,

c) plenty of light should be admitted into the fishway,

d) the water supply should be ample at all times, and

e) the top and sides of a fishway should be above ordinary high water level.

Fish ladders are generally located adjacent to the divide wall near the undersluices because there is always some water in the river section below them.

The various types of fish ladders are :

a) pool type,

b) steep channel type,

c) fish lock, and

d) fish lift or elevator type.

Types (a) and (b) are generally provided in barrages while types (c) and (d) are suitable for high dams only. The main problem in the design of fish ladders is to dissipate energy in such a way as to provide smooth flow at sufficiently low velocity. A typical fish ladder is shown in Figure 5.4 which shows a typical cross-section of a fishway.

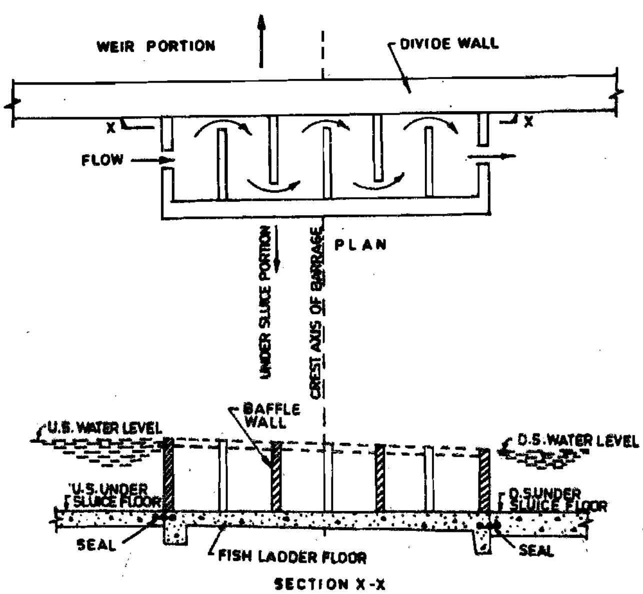


Figure 5.4 : Typical Cross-section of a Fishway

SAQ 5

i) What are the general requirements of a fish ladder?

ii) What are the various types of fish ladders?

5.7 LOG CHUTE

A log chute is provided in certain headworks where timber is floated down the river. The log chute is located next to the canal head regulator and consists of a passage in the structure to allow the timber to float past the regulator along with the water without damaging the structure. The passage is provided with a gate which may be closed when there is no timber to be floated down.

SAQ 6

Why and where is a log chute provided in a barrage?

5.8 GATES

The gates provided on barrages and canal head regulators are, generally, vertical lift gates in which the gate leaf moves vertically up and down while engaging or disengaging with the sealing elements.

5.8.1 Barrage Gates

These gates are for water heads upto 15 m and so are low head gates. The slide gate is the simplest type of vertical lift gate in which the movement of the gate leaf on the track of the gate frame structure is of sliding type. It is an economical choice since it has no moving parts. Large frictional force due to sliding movement makes it unsuitable for high heads. The slide gate has a continuous bearing under compression all around the gate resting on the seat all around the opening for sealing and transfer of hydrostatic load on the gate to the masonry structure.

5.8.2 Canal Head Regulator Gates

As the required discharge into the canal can be passed at pond level, a gate controlled opening is necessary from the crest to the pond level. The gate is sometimes in two sets, one rising and the other falling. In order that the flood water does not overtop the gate a reinforced concrete breast wall is provided from the pond level to above the high flood level. The breast wall spans from pier to pier. When the gate is fully open, it rises up clear off the pond level so that supplies can be passed into the canal. When fully closed, it shuts the opening from crest to bottom of the breast wall. Above the top of gate, the opening is permanently closed by the breast wall. It would be very expensive to provide gates right upto the high flood level due to higher cost of the gates, heavier machinery to operate them due to the greater weights and water pressures and the high level of the operating platform to provide the necessary clearance for lifting the gates. A bridge and working platform are provided across the head regulator for the operation of gates.

SAQ 7

i) What type of gate is provided in a barrage?

ii) What type of gate is provided in a canal head regulator?

5.9 DESIGN CONSIDERATIONS

The method of weir design has been evolved largely on the study of causes that led to their failure.

The design of a weir or barrage, like any other hydraulic structure consists of two phases :

a) the hydraulic design, and

b) the structural design.

The hydraulic design deals with the evaluation of the hydraulic forces acting on the structure and the determination of the configuration of the structure for the best economic and functional efficiency. The structural design consists of dimensioning the various parts of the structure to enable it to resist safely all the forces acting on it. This is done by the accepted norms of structural analysis and design.

The problems involved in the hydraulic design of weirs on permeable foundations may be treated under the following classification :

a) Surface flow, and

b) Subsurface flow.

By surface flow, we obtain,

1) Depth of sheet piles with respect to scour considerations,

2) Level and length of the horizontal part of the downstream floor,

3) The thickness of the floor on the sloping glacis considering the hydraulic jump formation,

4) Length and thickness of upstream and downstream loose aprons, and

5) Length, shape, and free board of the guide banks.

By subsurface flow, we obtain,

1) Total length of impervious floor and depth and location of sheet piles,

2) Exit gradient at the end of the impervious floor,

3) Thickness of the downstream impervious floor considering the uplift pressure, and

4) Provision of inverted filter at the end of the floor.

Sheet piles are rolled steel members that are driven into the soil in straight lines at predetermined locations below the concrete floor of the barrage and perfectly fixed to it to serve as a cutoff and thus reduce the uplift pressure under the floor.

You will read more about the pile line in Unit 6 under Section 6.3.

5.9.1 Design for Surface Flow

Two considerations are to be fulfilled in determining the depth of the downstream pile line :

a) That with a suitable length of the floor, it gives a safe exit gradient under the maximum head. This is dealt with in the treatment of subsurface flow.

b) That its bottom is nearly at or below the level of the flood scour for that section of the work for which the depth is being determined.

The depth of upstream pile line is determined only by the second of the above considerations. The normal depth of scour, R, in metres, below the high flood level, for a discharge intensity, q, in cumec/m, is given by Lacey's equation as

$$R = 1.34\,(q^2/f\,)^{1/2} \qquad ...(5.2)$$

The value of q would be different for the weir and the undersluices section and should be taken separately for each. Here f is the silt factor which can be determined by observing the water surface slope of the river during high flood and substituting in Lacey's slope equation

$$S = 0.00030\,\frac{f^{5/3}}{Q^{1/6}} \qquad ...(5.3)$$

Lacey's depth of scour, R, applies to regime flow only. Due to curved flow or otherwise, where there is a likelihood of disturbance to flow, the depth of scour would be more. Lacey has suggested the following classes of scour:

Class	Reach	Depth of Scour
A	Straight	1.25 R
B	Moderate bend	1.50 R
C	Severe bend	1.75 R
D	Right angled bend	2.00 R

Class A is likely to occur anywhere below the loose aprons. Class B is likely to occur anywhere along the aprons of guide banks in a straight reach and Classes C and D at and below the noses of guide banks or at the loose weir aprons in case heavy swirls develop for some reason. For the design of the sheet piles, it will be generally sufficient to take them down to the level obtained by measuring the normal depth of scour, R, below the high flood level (HFL), though sometimes upto 1.5 R on the upstream side and 2.0 R on the downstream side is taken in conservative designs.

For the design of the launching aprons, the maximum depth of scour below HFL may be taken as:

Upstream of the concrete floor	1.5 R
Downstream of the concrete floor	2.0 R
At noses of guide banks	2.25 R
In transition from nose to straight portion of guide banks	1.5 R
Straight portions	1.25 R.

Loose Protection Downstream of the Concrete Floor

Just below the end of the concrete floor an inverted filter 1.5 D to 2 D long should be provided, where D is the depth of scour below the bed (Figure 5.5). In the figure, xR is the depth of scour below HFL where x is the coefficient of R for different situations as mentioned in the previous paragraph. The depth of the inverted filter is kept equal to the depth of downstream launching apron. It may comprise of concrete blocks 1.0 to 1.2 m deep placed over a 0.6 m thick layer filled with graded filter material. The space between the blocks are filled with clean fine gravel. The inverted filter is required from considerations of subsurface flow. The design criterion for inverted filter is given by Terzaghi as

$$\frac{D_{15} \text{ of filter}}{D_{15} \text{ of foundation}} \geq 5 \geq \frac{D_{15} \text{ of filter}}{D_{85} \text{ of foundation}} \qquad \text{...(5.4)}$$

Here, D_{15} and D_{85} represent the particle sizes which are, respectively, coarser than the finest 15 and 85 per cent of the soil, by weight.

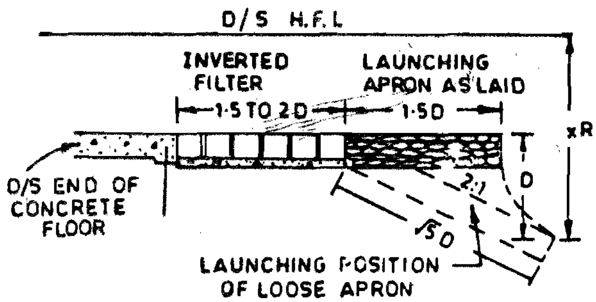


Figure 5.5 : Launching Apron

The loose apron is provided after the inverted filter. The quantity of stone included in the apron should be enough to provide a cover of approximately 1 m thickness over a slope of 2:1 (H:V) below the level at which originally laid down to the bottom of the deepest scour that is likely to take place at a given location. The length of the apron after having been launched will be $\sqrt{5}\, D$ and its thickness being 1 m, the sectional area of the launching apron will be $1.0 \times \sqrt{5}\, D = 2.24\, D$. The apron as initially laid must have the same quantity of stone hence the same sectional area. It may be laid in a length equal to 1.5 D and the thickness will correspondingly be almost 1.5 m. As scour takes place the apron launches itself and provides a stone pitching on the side of the soil. For this reason, such aprons are also called launching aprons.

Loose Protection Upstream of the Concrete Floor

Just upstream of the concrete floor of the weir, a block protection of 0.6 m thick concrete blocks over 0.85 m packed stone should be provided for a length equal to *D*. Upstream of the block protection, loose apron should be provided in the same manner as for the downstream apron. *D* in this case will refer to depth of scour hole below upstream bed, the bottom of scour hole being determined after applying the appropriate coefficient to *R*.

The launching aprons for protection of guide bunds or afflux bunds are also designed in the same manner.

Design of Downstream Horizontal Floor In Relation to Hydraulic Jump

The different components include :

Glacis

The glacis should be sloped down at a slope of 1 in 3 to 1 in 5 (*V* to *H*) for maximum dissipation of energy combined with economy and stability of the jump.

Level of Downstream Horizontal Floor

The level of the downstream floor is determined by the consideration that the hydraulic jump should not form lower than the toe of the glacis. Consider that the water is passing over the crest of the work, with a certain head (Figure 5.6). The discharge intensity, *q*, (cumec/m) on the crest can then be determined by the discharge formula for the crest,

$$q = C K^{3/2} \qquad \ldots(5.5)$$

where,

C = 1.71 for a broad crest, and

K = head measured from the total energy line to the crest, (m).

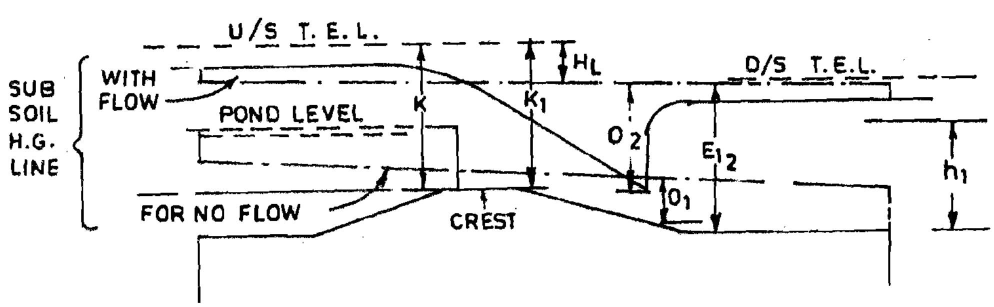


Figure 5.6 : Jump Location and Trough

For this discharge intensity the water level and hence the energy line on the downstream side will be known from the gauge discharge curve of the river. The difference between the two energy lines gives the loss of head, H_L. The location of the hydraulic jump is made with the help of Blench curves for a given discharge intensity. Knowing the values of *q* and H_L, E_{f2} or the specific energy on the downstream side of the jump can be obtained from Blench's curves (Figure 5.7). Measuring the intercept of E_{f2} below the downstream total energy line, the position of the jump on the sloping glacis is obtained.

The position of the jump should be checked for different discharge intensities. It would be usually observed that the jump shifts lower for smaller discharge intensities, especially when the effect of retrogression is taken into consideration. It may be noted that while the high flood level is not reduced materially due to retrogression, a reduction of 0.30 m being normally all that may be expected, the lower levels may go down by 1.20 to 2.20 m during low discharge due to retrogression. The minimum intensity for which a check should be

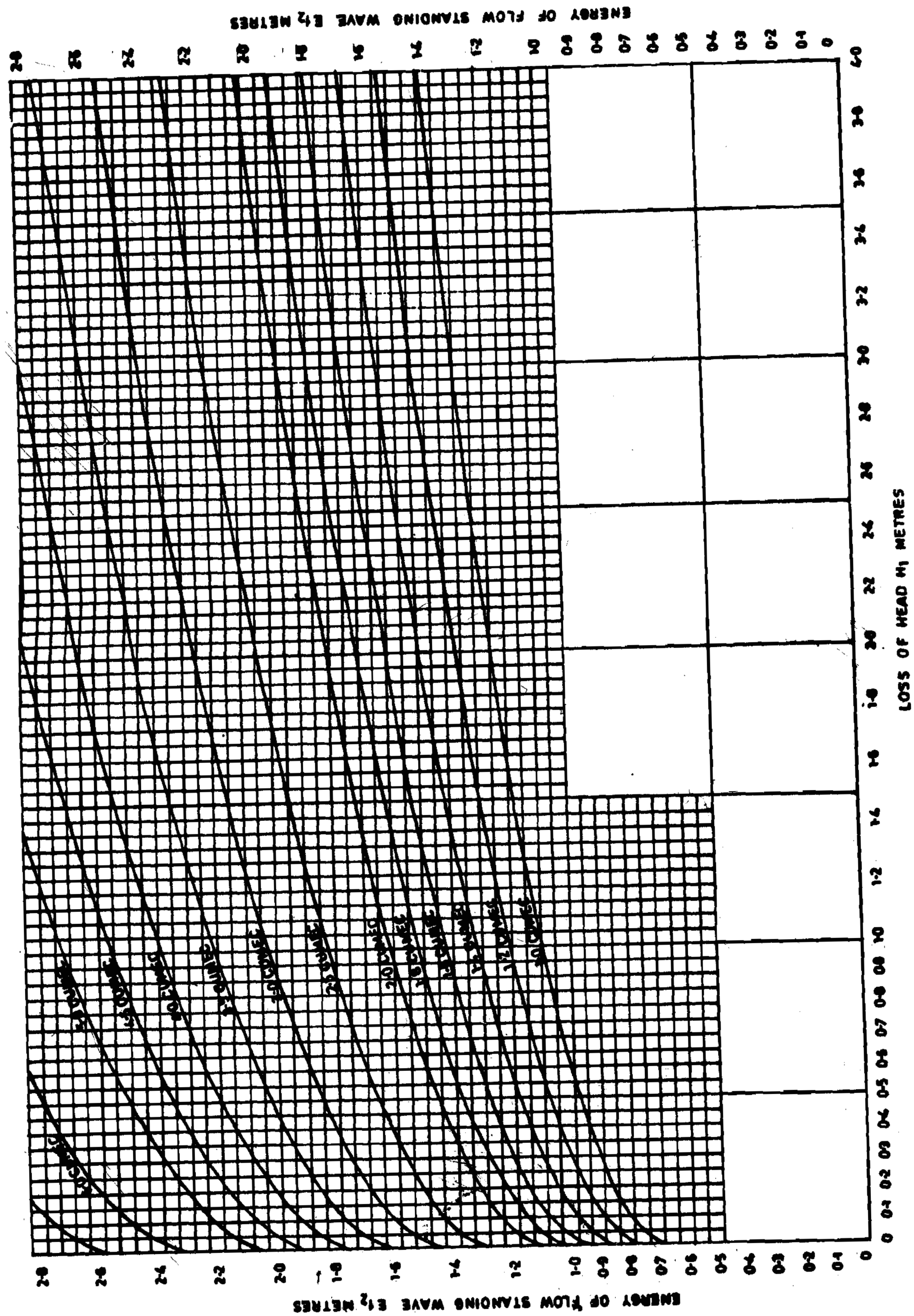


Figure 5.7 : Blench Curves

made is that corresponding to head provided by pond level on the upstream side of the crest. If a lesser discharge is required to be passed, a few of the gates may be closed and a minimum head equal to the pond level maintained on the others. The discharge per metre run over the downstream floor should be calculated on the actual width of the floor at the point under consideration, inclusive or exclusive of the width of the piers accordingly as jump forms downstream or between the piers.

The downstream horizontal floor should be provided at a level such that within the range of discharges checked, the jump always remains on the sloping glacis.

Length of Downstream Horizontal Floor

For the safety of the structure, it is necessary that the jump should on no account form lower than the glacis. It is essential that the main disturbance of the hydraulic jump dies out at a distance equal to five times the jump height. In order that the filter area and the stone protection be free from the main turbulence of the hydraulic jump, the length of the horizontal floor should nearly be equal to $5(D_2 - D_1)$, from the jump location. The maximum value of $(D_2 - D_1)$ which will occur during high flood conditions, should be used.

Design of Glacis Thickness for Uplift Pressure in the Jump Trough

As the hydraulic jump travels over the glacis for different discharge intensities, it is necessary to determine the maximum uplift pressure on each section for all discharge conditions and design it for the same. Once the maximum uplift pressure is obtained, the thickness of the glacis floor is given by

$$t = \frac{(h' - t)}{(G - 1)} \qquad \text{...(5.6)}$$

where,

$(h' - t)$ = ordinate measured from the hydraulic gradient line to the top of the floor, and

$(G - 1)$ = submerged specific gravity of the floor material.

5.9.2 Design for Subsurface Flow

Much of the profile of the weir is determined from surface flow considerations. The length of the downstream horizontal floor, its level and hence the level of the glacis, are fixed by hydraulic jump considerations. The top width of crest is determined from practical considerations, and is of the order of 2.5 m or so. The upstream slope to the crest is kept from 1:1 to 1:3. The only undetermined portion is the length of the upstream horizontal floor. As will be discussed in greater detail in Unit 6, the exit gradient for a floor with total length equal to b and the depth of downstream cutoff below bed level (measured below scoured bed, if scour is anticipated) equal to d is given by

$$G_E = \frac{(H/d)}{[1 / (\pi \sqrt{\delta})]} \qquad \text{...(5.7)}$$

where,

H = applied static head, and

δ = a function of b/d.

The critical gradient for a soil is given by $(1 - n)(G - 1)$

where,

n = porosity, and

G = specific gravity of the soil.

The value of critical gradient is very nearly equal to unity for average soils. The exit gradient should be lower than the critical gradient to provide a margin of safety. The critical value of 1/1 would be theoretically impossible of occurring, as even a small depression of the floor would lower the gradient below this value, e.g. the exit gradient for a 50 m long floor for a head of 6 m is 1/3 for 0.60 m depression and 2/3 for a 0.3 m depression. It would seem, therefore, that theoretically speaking, failure of any structure by undermining or piping should be nearly impossible. But in practical cases, there are many other factors which change the ideal conditions. The first of these is scour. If a scour hole occurs which extends nearly to the bottom of the vertical cutoff, the safe exit gradient is likely to be exceeded. The soil conditions are rarely uniform and homogeneous as assumed in theoretical calculations. Some parts of the subsoil may be more pervious than the rest resulting in concentration of flow through them. There may be faults and fissures in the subsoil which serve as nuclei for the initiation of piping. Again, the exit gradient can be increased many times by the occurrence of local surges or waves which in action resemble the working of an intermittent pump. At one time the pressure goes up by, say 0.5 m above the mean water level, next moment it falls 0.5 m below the mean water level. In a short time, the soil is subjected to a differential head of 1 m. Sudden dropping of gates resulting in a sudden application of head may also cause heavy gradient for a short time.

A factor of safety must thus be applied to the critical value of the exit gradient to obtain the safe permissible value. The following factors of safety have been recommended:

Shingle	4 to 5
Coarse sand	5 to 6
Fine sand	6 to 7

Taking the safe value of G_E and the known values of H and d, the value of $1/(\pi\sqrt{\delta})$ can be determined from the relation

$$G_E = \frac{H}{(d\,\pi\sqrt{\delta})}$$

Against this value of $\frac{1}{(\pi\sqrt{\delta})}$ corresponding value of α can be read from Khosla's curves (Figure 5.8). The total length of floor required is then given by $b = \alpha\, d$. The length of the upstream horizontal floor may be adjusted to provide the necessary total floor length. Subject to minimum depth of downstream vertical cutoff required from scour considerations, the depth of cutoff, d, and the total floor length b can be mutually adjusted to provide the most economical and suitable combination and keep a safe exit gradient.

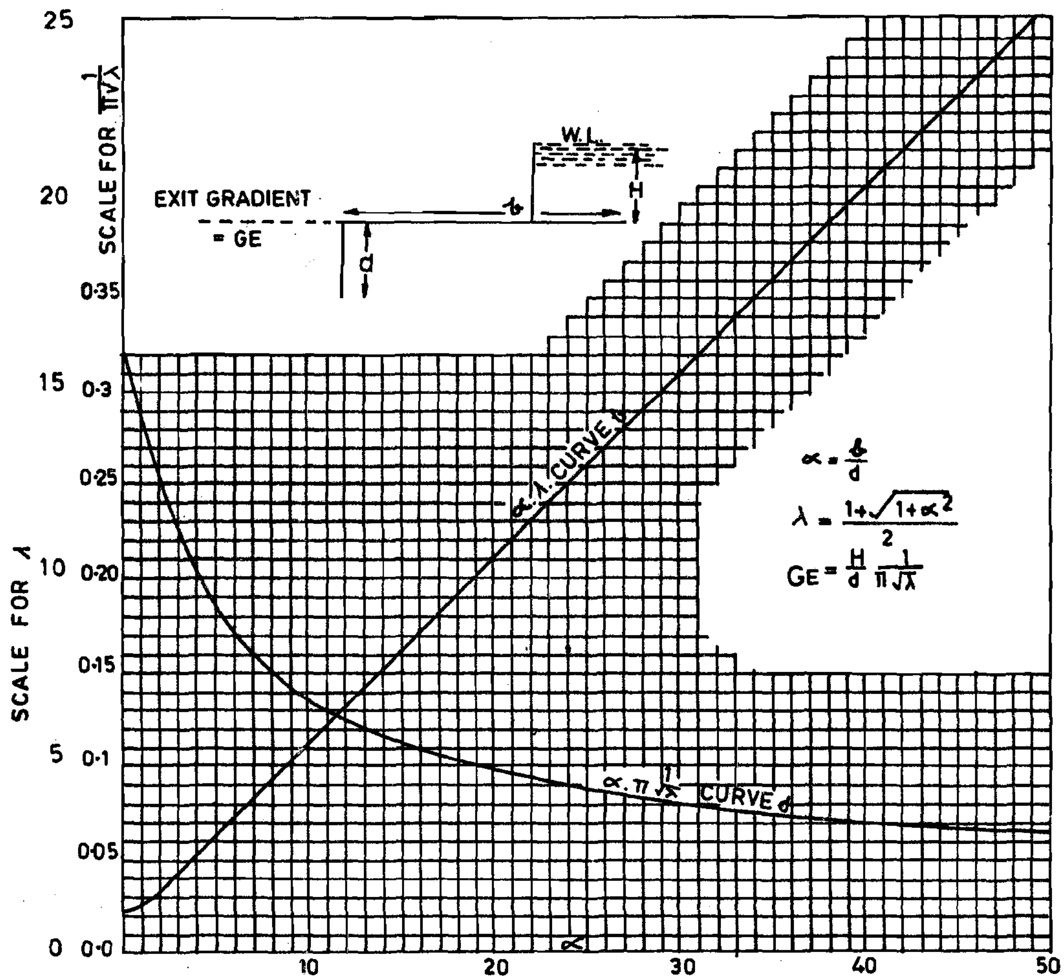


Figure 5.8 : Khosla's Curve for Exit Gradient

The uplift pressures on the floor can be determined from Khosla's curves as discussed later in Unit 6, section 6.2. The floor must be tested for maximum static head which will occur when the water is raised upto the pond level on the upstream side with no water on the downstream side. Conditions in the jump trough have to be tested at various stages of flow. It is necessary to provide vertical cutoffs at upstream and downstream ends of the weir profile to guard against scour, and against piping so far as downstream pile line is concerned. Sheet pile lines at intermediate points are also sometimes provided. They lead to local redistribution of pressure only and serve no immediately useful purpose as compared with their cost. They serve, however, as second lines of defence. Should the upstream or the downstream pile line give way, the intermediate pile lines, provided at the ends of the slopes on either side of the crest or under the crest itself will still hold the main structure, namely, the crest, the piers and gates, the bridge and operating platform on top. With this end in view some designers consider it desirable to provide intermediate pile lines also.

Pond Level

The water level is required in the undersluices pocket upstream of the canal head regulator to be maintained at a level so as to feed the canal with its full supply. This water level is the pond level. The level of the area to be irrigated and the slope of the canal determines the full supply level of the canal at the head. The full supply level (FSL) of the canal at the head is fixed on the longitudinal section of the canal. The pond level is obtained by adding 1.0 to 1.2 m to the canal FSL to provide a driving head through the canal head regulator. However, the waterway of the regulator should be enough to feed the canal with half this head, the rest being kept as a margin of reserve in case the canal silts up in the head reaches or has to be supplied with excess water.

Barrage Waterway and Discharge Intensity

The restrictions imposed on the afflux also restricts the minimum waterway. The width of waterway to be adopted is the stable perimeter of Lacey for the design flood discharge. Strictly speaking, the regime conditions are disturbed once the construction of the weir is completed and the formula does not hold. At one time, it was thought that shoal formation would be reduced if the waterway is limited but actually speaking it is not so. With a larger discharge intensity, that is, discharge per metre run, the action on the floor will be more intense and the sections will be heavier though the crest length is reduced. Also larger discharge intensity involves greater risk of outflanking and damage due to local concentration of flow.

On the contrary, a large waterway is not only uneconomical, but may also result in oblique approach of the river flow and silting up of some of the waterway. Many existing weirs have clear waterway from 10 to 20% more than Lacey's regime perimeter. The current opinion is that the waterway should be based on 50 to 100 year frequency flood; and an overall waterway between abutments equal to Lacey's should generally be adequate. In rivers with incised sections smaller waterway may be provided.

Crest Levels

The crest level of the weir will be determined by the permissible afflux during the maximum flood, the discharge intensity and pond level. The pond level can be maintained by a permanent masonry crest with its top at pond level or one at a lower level supplemented by falling shutters or counterbalanced gates. A permanently raised crest will result in a higher afflux and is also likely to result in loss of control on the river. There is an interrelationship between the afflux, the discharge intensity or waterway and the crest level and a suitable combination has to be evolved keeping the limits for each described above.

The downstream total energy line is the maximum flood level at the weir site before the construction of the weir plus the velocity head at that time. Both these levels are thus known. The allowable afflux is decided as above and is usually limited to 1.0 m. The upstream total energy line is, thus, obtained as the downstream total energy line plus afflux. Having also decided upon the waterway and hence the discharge intensity, q , the crest level can be worked out as:

$$q = c\,K^{3/2}$$

where,

c = 1.71 for a broad crested weir, and

K = the ordinate between the upstream energy line and the crest, or the static head + the velocity head over the crest.

The crest level can now be obtained by deducting K from the level of the upstream energy line. The difference between the crest level so obtained and the pond level is to be made up by shutters or gates. If the height of shutters is to be reduced, either the permissible afflux has to be increased or the discharge intensity reduced by increasing the waterway.

The crest level having been determined, the upstream energy line will remain fixed for a given value of the discharge intensity. The downstream total energy line will have to be somewhat lowered for purposes of design to allow for a possible drop in the maximum flood level after the construction of the weir due to retrogression of downstream bed levels. A lowering of 0.30 m will be adequate in most cases. Thus, while the upstream total energy line remains unaffected, the downstream total energy line will be depressed by 0.30 m to account for retrogression, so that the difference between the two is

$$H_L = \text{Afflux} + 0.3 \text{ m}$$

Thus, the levels of upstream and downstream energy lines are fixed for design calculations.

SAQ 8

i) What are the considerations for designing a barrage?

ii) How is the barrage designed for surface flow?

iii) How is the barrage designed for subsurface flow?

iv) How are the crest levels of barrage bays and undersluices fixed?

5.10 SUMMARY

In this unit you would have learnt about the various components of weirs and barrages, their functions and the hydraulic design. The location of the components is to be properly planned for obtaining good flow conditions and thus ensure efficient working of all the headworks and allied structures. The floor is designed for surface flows and subsurface flows. The surface flow conditions are considered to determine the depth of sheet piles, level and length of the horizontal floor, thickness of floor on the sloping glacis, length and thickness of the loose aprons and the length, shape and freeboard of guide banks. The subsurface flow conditions determine the total length of impervious floor, depth and location of sheet piles, exit gradient, thickness of the downstream impervious floor and the inverted filter at the end of the floor.

5.11 KEY WORDS

Canal Head Regulators : These are provided to control the amount of discharge entering the canals.

Crest Levels : The levels of the concrete floor on which the gate would rest. The crest may or may not be raised above the upstream floor level.

Design of Downstream Horizontal Floor in relation to Hydraulic Jump : The glacis and level of the downstream horizontal floor are designed in relation to the location of the hydraulic jump.

Design of Glacis Thickness for Uplift pressure in the Jump Trough : The downward weight of the glacis should be sufficient to prevent uplifting of the glacis.

Design for Surface Flow : Surface flow conditions determine the profile of the weir, the depth of the sheet piles, level and length of the downstream horizontal floor, the thickness of the floor, length and thickness of loose aprons on the upstream and downstream sides and the length, shape and free board of guide banks.

Design for Subsurface Flow	:	Subsurface flow conditions determine the total length of impervious floor and depth and location of sheet piles. exit gradient at the end of the impervious floor. thickness of the downstream impervious floor and inverted filter.
Discharge Intensity	:	The discharge passing over a unit width of the crest is the discharge intensity.
Divide Wall	:	It is a wall provided between the weir or barrage bays and the undersluices to separate them from each other.
Fish Ladders	:	They are passages provided in a barrage to allow the fish to migrate from the downstream to the upstream reservoir for breeding or in search of food.
Gates	:	They regulate the flow passing across the barrage or into the head regulator.
Glacis	:	The sloping floor downstream of the gate provided to arrest the position of the hydraulic jump.
Hydraulic Design	:	Barrages or weirs are designed from hydraulic considerations which include design for surface flow and subsurface flow.
Length of Downstream Horizontal Floor	:	The length provided below the glacis to prevent the disturbance of the hydraulic jump from reaching the downstream filter and stone protection.
Log Chute	:	An arrangement provided to float timber down the headworks.
Loose Protection Downstream of the Concrete Floor	:	It is an inverted filter followed by a launching apron provided downstream of the concrete floor to reduce the effect of scour.
Loose Protection Upstream of the Concrete Floor	:	It is a block protection followed by a launching apron provided upstream of the concrete floor to reduce the effect of scour.
Pond	:	It is the body of water held in the reservoir formed by a barrage or a weir upstream of the gates.
Pond Level	:	It is the level upto which water in the pond is maintained for feeding the canal.
Scouring Sluices	:	They are also called undersluices.
Structural Design	:	The components of a barrage or weir should be designed for structural stability. These are besides the hydraulic design.
Waterway	:	The width or expanse of the water.

5.12 ANSWERS TO SAQs

Answer all SAQs with respect to the preceding text.