UNIT 10 CANAL OUTLETS / SLUICES

Structure

10.1 INTRODUCTION

An outlet is a device built at the head of a water course to control the flow of water in and into the water course. An outlet connects the water course with the distributing channel and provides a measure of discharge passing through it. Outlets are essential for efficient and safe running of a water course. There are various types of outlets commonly provided on any canal. Sluices are outlets provided in dams.

Objectives

At the end of this Unit you should be able to develop an understanding about the following :

- sluices in general,
- chute size of checks,
- maximum length of water course at an outlet,
- classification of outlets,
- non-modular outlets,
- semi-modular or flexible outlets,
- modular outlets, and
- design parameters concerning an outlet, such as –
  - flexibility,
  - sensitivity,
  - proportionality,
  - setting,

efficiency,

minimum modular loss,

modular limits, and

modular range.

10.2 SLUICES

Sluices as pointed out above, are provided in dams to release water into the main channel for purposes of further distribution. Depending upon the command area, whether the land to be irrigated is on only one side or on either bank of the river, there may be one or more sluices. The sluices consist of a concrete barrel or conduit provided with trashracks, control gate and a stoplog gate at the upstream end of the set-up. Suitable transitions are provided in case the conduit is not circular. At the exit end of the sluice is provided an energy dissipating device, such as a stilling basin.

SAQ 1

What are sluices and where are they provided? Give a few sketches to explain your answer.

10.3 CHUTE SIZE OF CHECKS

The area irrigated from one individual outlet is called *check* or *chak* of the outlet. The outlet (or chute) size depends upon the size of the check.

10.4 MAXIMUM LENGTH OF WATER COURSE AT OUTLET

The length of a water course irrigating a check should not exceed 3 km with a view to reduce loss of water, and other practical considerations. Where the length exceeds this limit it would be preferable to locate outlets further away as per field situations.

10.5 CLASSIFICATION OF OUTLETS

Canal outlets are classified into three types, namely,

(a) Non-modular outlets,

(b) Semi-modular (or flexible) outlets, and

(c) Modular outlets.

10.5.1 Non-modular Outlets

They are outlets whose discharge capacity depends on the difference in the water levels in the distributary (that supplies water to the water course) and the water course. The discharge through such outlets varies over a wide range with fluctuations in the water levels of either the water course or the distributary. A shutter provided at the upstream end regulates this outlet. The head loss in a non-modular outlet is lesser than that of a modular outlet. Such outlets are preferable for low head conditions. There is, obviously, a drawback with this outlet in that the discharge may vary even when the water level in the distributary remains constant. Therefore, it is very difficult to maintain equitable distribution of water at all such outlets during periods of keen demand of water.

Pipe as Non-modular Outlet

It is the simplest and the oldest type of outlet. When a pipe (fitted under the distributary embankment) discharges freely in air, it is semi-modular and when the pipe is submerged (in the water course) it is non-modular. The silt conduction (that comes with distributary water) of the pipe outlet is good, and efficiency is high. However, a pipe outlet with a free overfall can be provided only at a few locations where sufficient level difference between the parent channel and water course is available.

Pipes are usually embedded all around in concrete with face walls of masonry. In Uttar Pradesh, they are usually fixed 22.5 cm below the water surface level in the parent channel (say, a distributary or a minor).

The pipe varies from 10 to 30 cm in diameter. It rests on a light concrete foundation to prevent unequal settlement of the pipe and leakage problems. The water level in the distributary is maintained about 25 cm higher than the pipe inlet. If considerable fluctuation is expected in the water level in the distributary, the inlet of the pipe is fixed below the minimum water level in the distributary. Figure 10.1 shows some important details of a pipe outlet. The discharge, Q, through the outlet, is given by the following formula :

$$Q = \left[\pi d^2/4\right] \cdot \left[(2\,gHd)/(1.5d + f \times L)\right]^{1/2} \qquad \ldots (10.1)$$

where, d = diameter of pipe outlet,

H = difference in water levels of the distributary and the water course,

L = length of pipe outlet, and

f = friction factor for pipe, depending upon its material and condition.

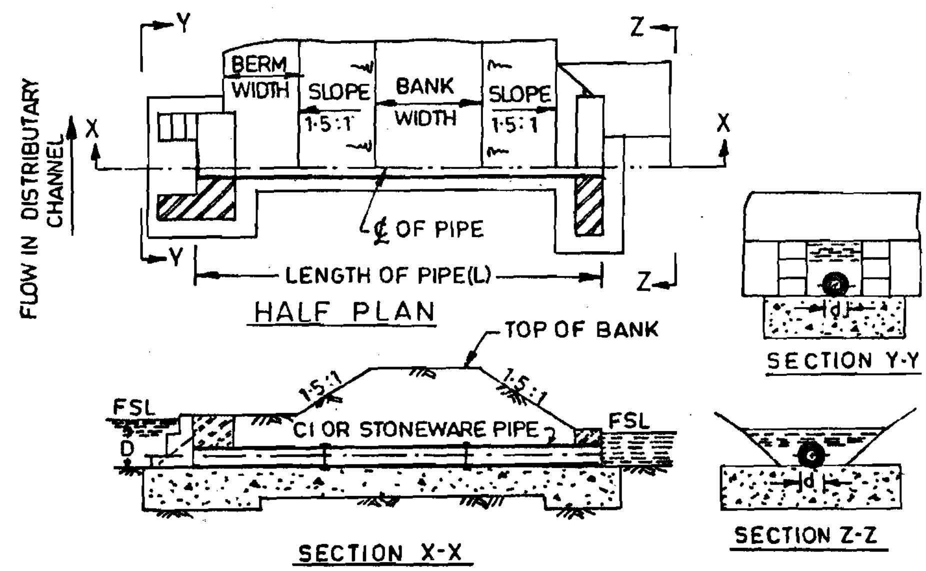

Figure 10.1 : Pipe Outlet

Since the flow at the entrance is disturbed, there is generation of turbulence there and, thus, the outlet generally carries its due share of sediment. In order to increase further the sediment drawn by the outlet, the inlet end of the pipe is lowered. It is usual to lay the pipe at the bottom of the distributary to let the outlets draw a fair share of sediment. The outlet pipe slopes upwards in the direction of flow; this arrangement increases the amount of sediment withdrawn by the outlet without affecting the discharge through the outlet.

It is clear that, in general, the discharge through a non-modular outlet will vary with water levels in the distributary and the water course. In the case of fields situated at high elevations, the level of the water course being high, it could happen that the discharge is relatively small. But in fields located at low elevations, the discharge is relatively larger due to the water course being at a lower level. Further, the tail reach may be completely dry or may be flooded, depending upon the amount of withdrawal of water in the head reaches. It is possible to increase the discharge through the pipe outlets by deepening the water course and thus lowering the water level in it as far as practicable. Owing to the flow conditions, the discharge may vary from outlet to outlet, and also at different times on the same outlet due to sediment content in the distributary channel. Due to these reasons, equitable and proper distribution of water is very difficult. These are the serious disadvantages of pipe outlets. However, the chief advantage of the pipe outlet is that it can work well for low heads as well. Pipe outlets are provided in the beginning stages of distribution or for additional irrigation in a season when excess water is available.

Most of the Irrigation Departments, in the states, have their own standardized and officially approved discharge tables for outlets. In Uttar Pradesh, the size of outlets are determined from the data given in Table 10.1. This table applies to outlet pipes upto 6 m long. Where outlets exceed this length, the next higher ventage should be adopted. The silt conduction of pipe outlets is quite good. It can further be improved by keeping the inlet pipe at a lower level and placing the pipe sloping upwards.

Table 10.1 : Recommended Sizes of an Outlet

No.	Ventage	Average Dischage, in cumec, with Outlets having Submerged Outfall			
		Free overfall	1 to 20 % lift	21 to 50 % lift	over 50 % lift
	1	2	3	4	5
1.	2 × 15 cm	0.050	0.039	0.033	0.024
2.	15 cm + 15.5 cm	0.044	0.035	—	—
3.	15 cm + 10.0cm	0.036	0.028	0.024	0.018
4.	15 cm + 7.5 cm	0.031	0.024	—	—
5.	15 cm	0.025	0.019	0.017	0.012
6.	12.5 cm	0.019	0.015	—	—
7.	10 cm	0.011	0.009	0.008	0.006
8.	7.5 cm	0.006	0.0045	—	—

The pipe outlets, as mentioned above, suffer from the disadvantage that, since the capacity of the outlet is quite uncertain, equitable distribution of water is very difficult. Even when the discharge in the distributary is constant, the discharge passing down the outlet would depend upon the level of field being irrigated.

10.5.2 Semi-modular or Flexible Outlets

In this type of module, the discharge is dependent only on the water level in the distributary while the water level in the water course does not affect the discharge, provided a minimum working head required for its working is available. A semi-module is more suitable for ensuring equitable distribution of water at all outlets of a distributary. However, the only disadvantage of the semi-modular outlet is the comparatively higher loss of head it entails.

Some of the semi-modular outlets include following types :

(a) Semi-modular pipe outlet

(b) Kennedy's gauge outlet

(c) Open flume outlet

(d) Orifice semi-module

They are described in the following sub-sections.

Semi-modular Pipe Outlet

The pipe outlet, discussed above as a non-modular outlet, also works as a semi-module when it discharges freely into the water course. In this arrangement, the exit end of the pipe is placed higher than the water level in the water course. Here, the working head, H, is the difference between the water level in the distributary and the centre of the pipe outlet. The pipe outlet has a high efficiency and the sediment conduction is good. The discharge through the pipe outlet cannot be increased by the cultivator by digging the water course with a view to lowering the water level in the water course. Generally, a pipe outlet is set so that it works as subproportional outlet (i.e., the rate of change of discharge through it is smaller than the rate of change of discharge in the distributary), that is, its exit end is kept less than 0.3 × (depth of flow in the distributary) below the water surface in the distributary.

Kennedy's Gauge Outlet

This type of outlet was invented by Kennedy. A modified version named Kennedy's gauge outlet is discussed here.

This arrangement enables the discharge to take place at atmospheric pressure. Semi-modularity is thus obtained, as the discharge is made independent of water level in the water course.

This outlet includes an orifice with a bellmouth entry, a 3 m long diverging delivery pipe and an intermediate vertical air column above the throat (Figure 10.2). Free circulation of air occurs around the jet due to the air vent pipe, and this makes the discharge through the outlet independent of the water level in the watercourse. The water jet flows into the cement concrete pipe which is an extension of the cast iron delivery pipe. Thereafter the water is discharged into the watercourse. Such an outlet is easily manipulated by the cultivator by blocking the air vent pipe, thereby increasing the discharge through the outlet. Due to this defect besides the high cost, Kennedy's gauge outlet is not recommended.

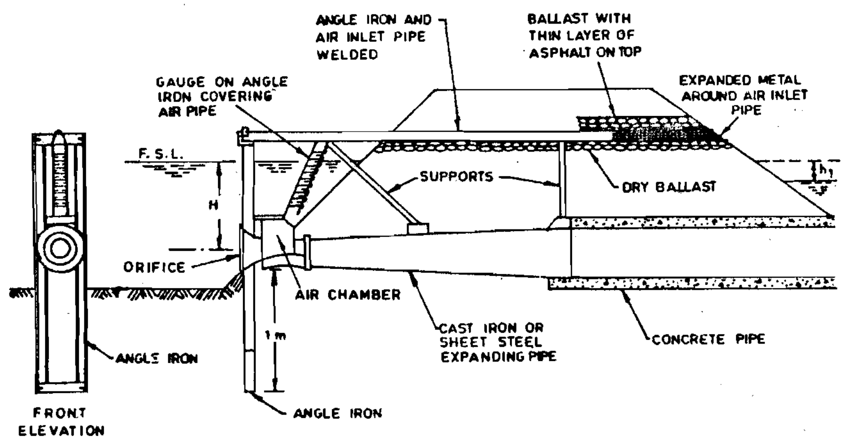

Figure 10.2 : Kennedy's Gauge Outlet

Open Flume Outlet

It is a weir with a long constricted throat and expanding flume on the downstream. This arrangement ensures formation of a jump. There are various types of such an outlet, but the general working principle is the same. The one commonly used in Punjab is described here.

The open flume outlet, it is to reiterate, is a weir with a sufficiently constricted throat to ensure supercritical flow and long enough to ensure that the controlling section remains within the throat at all discharges upto the maximum one. Downstream of the throat comprises a gradual expansion (Figure 10.3).The controlling section is provided with cast iron or steel bed and check plates while the rest of the structure is of brick masonry. The device ensures a hydraulic jump to form which in turn ensures that the outlet discharge is independent of the water level in the watercourse. The discharge through the outlet varies as $H^{1.5}$, and the efficiency of the outlet lies between 80 and 90 percent. In order to prevent floating material from blocking the outlet the throat width of the outlet should be more than 60 mm. The outlet is either shallow and wide, or deep and narrow for the range of outlet discharges normally allowed. While a shallow outlet may not draw its fair amount of sediment, a narrow outlet would get easily blocked.

The discharge is given by the formula :

$$Q = C \times B \times H^{1.5} \quad \ldots (10.2)$$

where, Q = discharge, (cumec),

B = width of the throat, (m),

H = the depth of water above the crest, (m) and,

C = a constant for the set–up depending upon the width of the flume.

For B = 0.06 m to 0.09 m, $C = 1.60$

= 0.09m to 0.12 m, $C = 1.64$

= over 0.12 m, $C = 1.66$

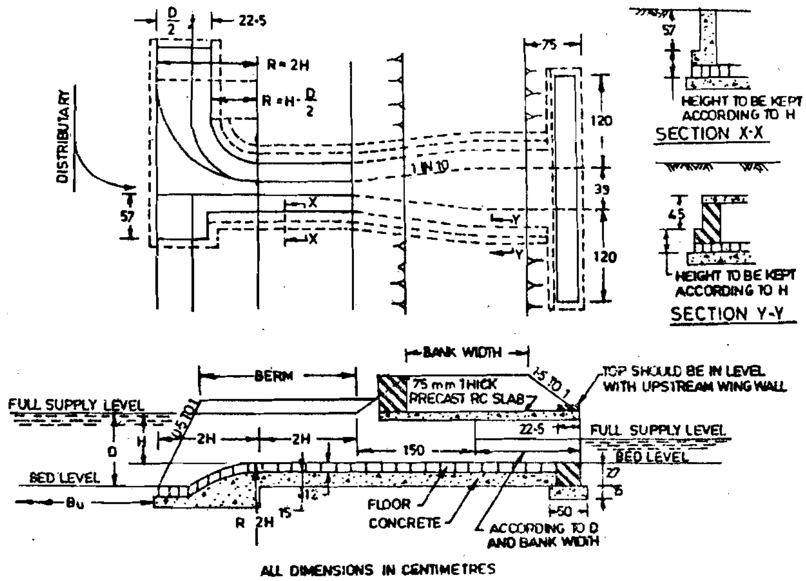

Figure 10.3 : Plan of Open Flume Outlet (*For Distributary above 0.6 m Depth and H less Full Supply Depth*)

Orifice Semi-module

A gradually enlarging flume on the downstream of an orifice forms the orifice semi-module. Figure 10.4 shows the Crump's adjustable proportional module. The flow through the orifice is rendered supercritical which on emerging into the expanding flume forms a hydraulic jump and so the discharge remains independent of the water level in the watercourse. In order that the discharge coefficient does not vary very much, the roof block is given a suitable shape to ensure converging streamlines. Two bolts embedded in a masonry key keeps the roof block in place. For alterations, the masonry can be dismantled and the roof block adjusted suitably. After that, the masonry key is re-built. Thus alterations can be made at a small cost. Any damage to the masonry key will indicate the tampering of the the outlet by the cultivators. This is the main advantage of this outlet.

The base plates and the roof blocks are manufactured in standard sizes of the throat width, B_t, such as, 61, 76, 99, 122, 154, 244 and 305 mm. The desired supply through the outlet is obtained by using these standard sizes with the required opening of the orifice.

The waterway in this type of outlet could be either deep and narrow, which may readily get blocked, or it could be shallow and wide in which case it does not draw its fair share of sediment. The discharge through the outlet is given by :

$$Q = 4.03\ B_t\ Y \sqrt{H_s} \qquad \ldots (10.3)$$

where, Y is the depth of orifice at the smallest section, H_s is the head measured from the water level in the distributary to the lowest point of the roof block ($H_s = H - y$).

The ratio H_s / D should lie between 0.375 and 0.48 for distribution of sediment to be proportional and should be ≤ 0.8 for modular working.

10.5.3 Modular Outlets

In these outlets the discharge is independent of the water levels in the distributary and the water course. These modules may or may not have moving parts. Modular outlets with moving parts are complicated to design and construct, and hence, are expensive. Outlets without moving parts are called rigid modules.

A modular outlet provides a fixed discharge through it and so allows the farmer to draw a suitable schedule of his irrigation. But when excess or deficient supplies are carried by the distributary, the tail reach of the distributary may either get flooded or be denied of water. This happens owing to the reason that the modular outlet would not adjust its discharge level in the distributary. A modular outlet would be an ideal choice when an outlet is to be provided in a branch canal which is likely to run with large fluctuations in discharge. The outlet would be set at a level fairly low to allow it to draw its due share of water when the branch is running with low supplies. In case the branch has to carry excess supplies to meet the demands of the distributaries, the discharge through the modular outlet would not be affected and the excess supplies would reach upto the desired distributaries. Again, a modular outlet would be a proper choice where an outlet is desired to be provided upstream of a regulator or a fall with a raised crest.

Some of the modular outlets include :

(a) Gibb's rigid module,

(b) Khanna's rigid module.

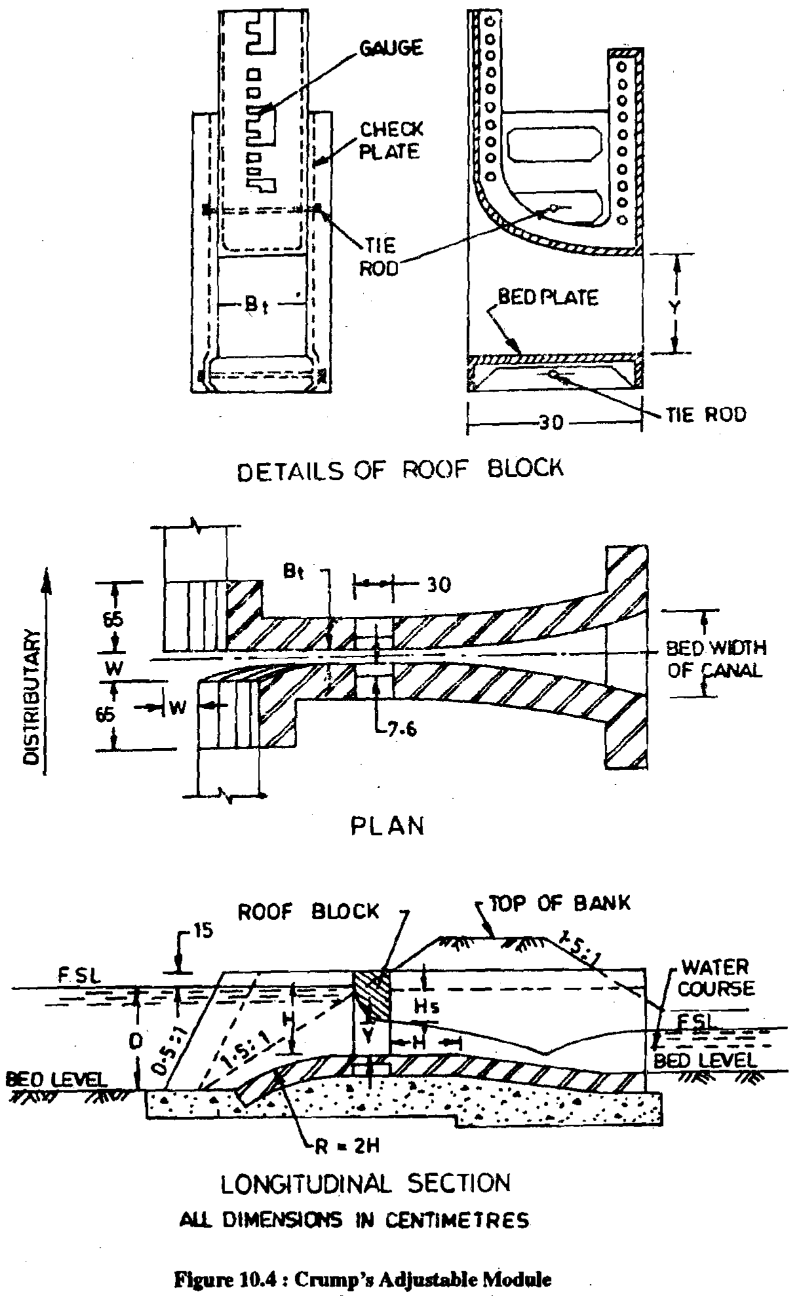

Figure 10.4 : Crump's Adjustable Module

Gibb's Rigid Module

Gibb's module (Figure 10.5) has an inlet pipe below the distributary bank. The pipe takes water from the distributary to a rising spiral which is connected to the eddy chamber. This produces free vortex motion owing to which there is heading up of water (due to smaller velocity at larger radius – a feature of vortex motion) near the outer wall of the rising pipe. The water surface thus slopes towards the inner wall. A series of baffle plates of appropriate size are attached to the roof of the eddy chamber such that their lower ends slope against the direction of flow. As the head increases, water banks up at the outer wall of the eddy chamber and strikes against the baffles and spins round in the compartment between two adjacent baffle plates. This results in dissipation of excess energy and release of a constant discharge. The outlet is relatively more expensive and its sediment withdrawing characteristic is also not good.

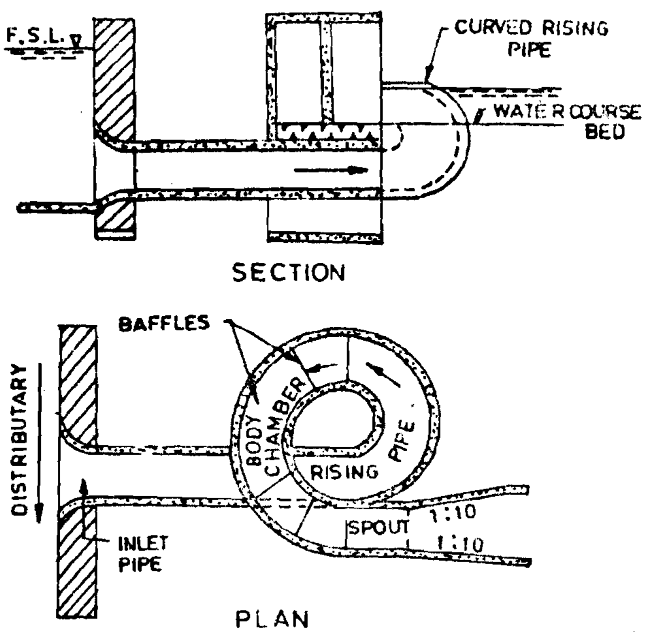

Figure 10.5 : Gibb's Module

The following discharge formula was given by Gibbs :

$$Q = r_o \sqrt{2g}\ (d_1 + h_o)^{1.5} \left[\frac{m^2 - 1}{m^3} \log_e m + \frac{1}{m} \log_e m - \frac{m^2 - 1}{2\,m^2} \right] \quad \ldots (10.4)$$

where Q = discharge passing down the module,

r_o = radius of the outer semicircle of the eddy chamber,

$m = \frac{r_o}{r_1}$ = ratio of outer radius to inner radius,

r_1 = radius of inner semicircle,

d_1 = depth of water at inner circumference,

h_o = head loss in inlet pipe.

The formula is based on the free vortex flow in which the velocity at any point varies inversely as the radius, and by Bernoulli's theorem the total energy of all filaments is constant. Gibb's formula holds good only for his standard design in which m or $\left(\frac{r_o}{r_1}\right) = 2$ and $(h_o / D) = 1/7$, where D is the difference of level measured from the minimum water level in the parent channel to the floor of eddy chamber.

Khanna's Rigid Module

Khanna's module is similar to an orifice semi-module with additional shoots fixed to the roof block (Figure 10.6). The shoots result in back flow and thus keep the outlet discharge constant. If the water level in the distributary is at or lower than its normal level, the outlet functions like an orifice semi-module. However, when the water level in the parent channels is above its normal level, the water rises in chamber A and enters the first inclined shoot. This results in a back flow and dissipates additional energy. This enables a constant discharge. The number of inclined shoots and their heights above the normal water level can be varied to meet the local requirements. The shoots are housed in a chamber to prevent them from being tampered with. If the shoots are blocked, the outlet continues to operate as a semi-module.

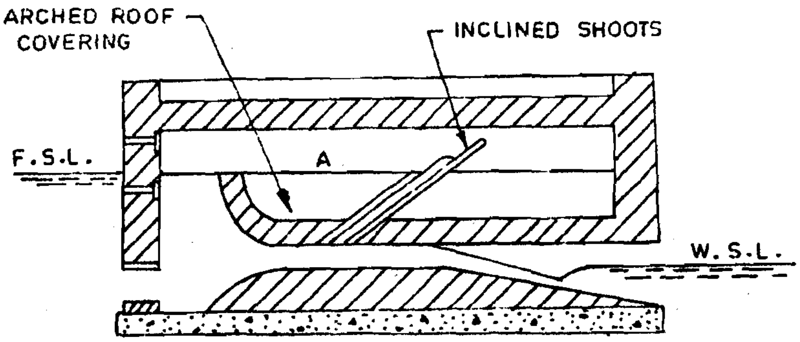

Figure 10.6 : Khanna's Module

SAQ 2

Describe a pipe as a non-modular outlet.

SAQ 3

Describe a Open flume outlet.

10.6 DESIGN PARAMETERS

Some basic parameters that characterise the performance of an outlet are : flexibility, sensitivity, proportionality, setting, efficiency, minimum modular loss, modular limits and modular range.

10.6.1 Flexibility

Flexibility, F, is the ratio of the rate of change of discharge of an outlet (dQ_o/Q_o) to the rate of change of discharge of the distributary channel (dQ/Q) due to any change occurring in the water level of the distributary. Thus, mathematically we can express :

$$F = (dQ_o / Q_o) \; / \; (dQ / Q) \qquad \ldots (10.5)$$

Here, Q_o and Q are the discharges in the watercourse and the distributary channel, respectively, at a given instant. The discharge Q in terms of the depth of flow in the channel, h, can be expressed as :

$$Q = C_1 \, h^n \qquad \ldots (10.6)$$

which on differentiation gives

$$dQ = C_1 \, n \, h^{n-1} \, dh \qquad \ldots (10.7(a))$$

From Eq. 10.6 and 10.7(a)

$$\frac{dQ}{Q} = n \, \frac{dh}{h} \qquad \ldots (10.7(b))$$

Similarly, the discharge, Q_o, through the outlet in terms of the head, H, on the outlet is written as :

$$Q_o = C_2 \, H^m \qquad \ldots (10.8)$$

which gives,

$$\frac{dQ_o}{Q_o} = m \, \frac{dH}{H} \qquad \ldots (10.9)$$

Here, C_1 and C_2 are constants while, obviously, *m* and *n* are suitable indices. Hence, we can write :

$$F = \frac{m}{n} \times \frac{h}{H} \times \frac{dH}{dh} \qquad \ldots (10.10)$$

For semi-modular outlets, the change in the head *dH* acting on an outlet would be the same as the change in depth of flow *dh* in the distributary. Thus, we have :

$$F = \frac{m}{n} \times \frac{h}{H} \qquad \ldots (10.11)$$

If $F = 1$, the rate of change of outlet discharge is equal to the rate of change of discharge in the distributary. For a modular outlet, flexibility is 0; hence, it is known as a rigid outlet or module. For a semi-modular outlet, flexibility is not zero; hence, it is known as a flexible module. Outlets are classified, depending on the value of *F* as : (a) proportional outlets ($F = 1$), (b) hyper- proportional outlets ($F > 1$), and (c) sub-proportional outlets ($F < 1$). An outlet or semi-module is said to be proportional when a certain change in the distributary discharge results in a proportionate change in the outlet discharge. A proportional semi-module ensures proportionate distribution of water when the distributary discharge varies. For a proportional semi-modular outlet ($F = 1$),

$$\frac{H}{h} = \frac{m}{n} \qquad \ldots (10.12)$$

The ratio, *H*/*h*, is termed as settings which denotes the location of the outlet with respect to the depth of cross-section. All semi-modules can work as proportional semi-modules provided their sill is fixed at a particular level in reference to the bed level of the distributary. A semi-module set to function as a proportional outlet may not be proportional at all discharges in the distributary. The water level in the distributary will rise on account of silting in the head reach of the distributary and the outlet situated in the head reach would thus draw more than its due share of discharge even though the distributary discharge has not fluctuated. Whenever the modular outlet is unsuited for a given site, semi-modules of low flexibility should be used because they are least affected by channel discharge and channel regime.

The ratio of the outlet and the channel indices is taken as the setting of a proportional outlet. For hyper- and sub-proportional outlets the settings are, respectively, kept less and more than *m*/*n*. For an orifice type outlet, *m* is taken as 0.5 and for a wide trapezoidal or rectangular channel, *n* may be taken as 5/3. An orifice-type module will be proportional if the setting (*H*/*h*) is kept as 0.5/(5/3) or 0.3. For values of setting less than 0.3 the module will be hyper-proportional and for values of setting more than 0.3, the module will be sub-proportional. Likewise, a free flow weir type outlet (with $m = 3/2$) would be proportional when the setting is 0.9 which means that the outlet is fixed at 0.9 *h* below the water surface in the distributary.

6.6.2 Sensitivity

Sensitivity (*S*) of an outlet is defined as the ratio of the rate of change of discharge of an outlet (dQ_o/Q_o) to the rate of change in the water surface level of the distributary channel with respect to the depth of flow in the channel. Hence,

$$S = \frac{(d\,Q_o / Q_o)}{(d\,G / h)} \qquad \ldots (10.13)$$

where, *G* is the gauge reading.

The gauge is so fixed that when there is no flow through the outlet ($Q_o = 0$), the gauge reading is zero. Thus, $dG = dh$. Sensitivity may also be defined as the ratio of the rate of change of discharge through an outlet to the rate of change of depth of flow in the distributary channel. Therefore,

$$S = \frac{(dQ_o / Q_o)}{(d\,h / h)} \qquad \ldots (10.14)$$

and, $F = (dQ_o / Q_o) \; / \; (d\,Q / Q)$ ... (10.15)

$= (dQ_o / Q_o) \; / \; n\,(dh / h)$ (From Eq. 10.7(b))

$\therefore \; F = S / n$

or $S = n\,F$

Thus, the sensitivity of an outlet for a wide trapezoidal or rectangular distributary channel ($n = 5/3$) is equal to $(5/3)F$ and the sensitivity of a modular outlet is zero.

10.6.3 Proportionality

An outlet is said to be 'proportional' when the rate of change of discharge in the outlet is the same as the rate of change of discharge in the parent channel; in other words, when the flexibility = 1.

Therefore, $m / n \times h / H = 1$

or $H / h = m / n =$ outlet index / channel index ... (10.16)

10.6.4 Setting

It may be defined as the ratio of the depth of the crest level of the outlet below the full supply level of the channel to its full supply depth. In other words, setting = H / h. This implies that if 'proportionality' in an outlet is desired then its setting should be made = outlet index/channel index. The outlet index would depend upon the type of outlet. For a pipe or orifice type outlet $q \;\alpha\; H^{1/2}$ i.e. its index m is 1/2. For a weir type (open flueme) outlet $m = 3/2$.

The value of the channel index or n would vary with the channel section but for a wide trapezoidal section (in an alluvial soil) it may be shown that its value is 5/3. (This value is usually adopted for all irrigation channels.)

It follows that in case of pipe or orifice outlet, the setting should be made at (1/2) / (5/3) or 0.3, and in case of a weir outlet at (3/2) / (5/3) or 0.9.

10.6.5 Efficiency

The ratio of the head recovered (i.e. the head remaining after all the losses in the outlet have been accounted for) to the input head of the water flowing through the outlet is known as its "efficiency". In case of weir type outlet, efficiency is the same as drowning ratio.

The efficiency of an outlet is a measure of its conservation of head. The greater the efficiency, the smaller is the loss of head.

10.6.6 Minimum Modular Loss

It is the minimum difference between the upstream and downstream water levels which is required to enable the module to pass the design discharge. The minimum modular head (i.e., modular loss) is the least head required to ensure the proper functioning of the outlet as per design.

10.6.7 Modular Limits

The upper and lower limits of any one or more factors (discussed above) beyond which a module ceases to function as a module, are called the modular limits.

10.6.8 Modular Range

It is the range of values within which the outlet functions as per design.

Example 10.1

A discharge of 0.03 cumec is desired to pass through a pipe outlet (i.e., a non-modular arrangement), given that the available working head for it is 6 cm. Design the outlet (i.e., determine its diameter) for following considerations (F. S. L. of the distributary = 100 m) :

(a) co-efficient of discharge = 0.50,

(b) (i) lenght of outlet pipe = 15.5 m

(ii) friction factor for pipe = 0.1.

Solution

(a) $Q = Cd\left(\frac{\pi}{4}d^2\right)\sqrt{2\,g\,H}$

where, d = internal diameter of the pipe.

$\therefore\ 0.03 = 0.5\left(\frac{\pi}{4}d^2\right)\sqrt{2\times 9.81\times 0.06}$

$\therefore\ d = 0.265$ m

$= 26.5$ cm

Hence, water surface level in the water course $= 100 - 0.06 = 99.94$ m

(b) $Q = \frac{\pi}{4}d^2\ [2\,g\,H\,d/(1.5\,d + f\times L)]^{1/2}$

or, $0.03 = \frac{\pi}{4}d^2\ [2\times 9.81\times 0.06\,d/(1.5\,d + 0.1\times 15.5)]^{1/2}$

By trial and error, we get

$d \approx 0.3$ m

$= 30$ cm

Example 10.2

A water course is to take a flow of 0.04 cumec. Design an open flume outlet from the concerned distributary if the full supply depth in the distributary = 0.70 m.

Solution

For B = 0.09 m, we have C = 1.6

$\therefore\ Q = C\,B\,H^{1.5}$

i.e., $0.04 = 1.6\times 0.09\,(H)^{1.5}$

or, H = 0.425 m = 42.50 cm

$\therefore$ Setting = 42.5 / 70 = 0.61 < 0.9 (as desirable)

Thus, at this setting the outlet will not take its fair share of silt, and will not act as a proportional outlet.

Adopting B = 0.06, we have C = 1.6

$\therefore\ 0.04 = 1.6\times 0.06\,(H)^{1.5}$

$\therefore\ H = 0.56$ m

$\therefore$ Setting = 0.56 / 0.70 = 0.8 which is very near the value 0.9.

Example 10.3

An adjustable orifice semi-module is to be fitted in a distributary, for the following conditions :

Discharge of the outlet = 0.30 cumec

Working head = 0.65 m

F. S. L. of the distributary = 101.60 m

Bed level of the distributary = 100.00 m

Design the module.

Solution

$D = 101.6 - 100 = 1.6$ m

Assume $B_t = 15.5$ cm

Take $H/D = 0.8$

$$\therefore\ H = 0.8 \times 1.6 = 1.28\,\text{m}$$

$$H_s = 0.65\,\text{m}$$

$$\therefore\ Y = H - H_s = 1.28 - 0.65 = 0.63\,\text{m}$$

$H_s / D = \dfrac{0.65}{1.6} = 0.4$ (it lies between the desired limits for appropriate sediment distribution considerations)

Now $Q = 4.03\, B_t\, Y \sqrt{H_s}$

$$= 4.03 \times 0.155 \times 0.63 \sqrt{0.65}$$

$$= 0.32\,\text{cumec} \approx 0.30\,\text{cumec (O. K.)}$$

SAQ 4

What are the various design parameters of an outlet? Discuss the significance of each.

SAQ 5

What is the meaning of setting of an outlet ?

10.7 SELECTION OF THE TYPE OF MODULE

Having laid down the requirements of a good outlet and criteria of performance, it is easier to select the type of outlet most suitable for a particular location, and to design it to perform the intended functions.

From the cultivator's point of view, a rigid module is preferable, whereas from the distributors point of view, a semi-module is desirable for easy regulation of channel system. It follows that if there are frequent fluctuations in the channel, a 'proportional' module should be provided. The setting should be done to achieve the objective keeping in view the following factors :

(a) **Condition of the channel :** In a good channel, the setting may be done to achieve proportionality but in a channel which is silting, the setting should be done nearer to its bed, and an open type module should be preferred.

(b) **Condition of the water course :** More silt can pass down on a steeper water course and vice-versa. The outlets, which have to feed high commands, should naturally take less silt and should be set higher.

Available loss of head would often dictates the type of an outlet. The orifice outlets require more loss of head than the open type and are better located in the head reaches where the depth of channel is considerable. When an outlet has to feed high commands and is provided in a channel with wide banks, a pipe-cum-semi-module (Figure 10.7) would be desirable both from the point of view of economy and silt draw-off.

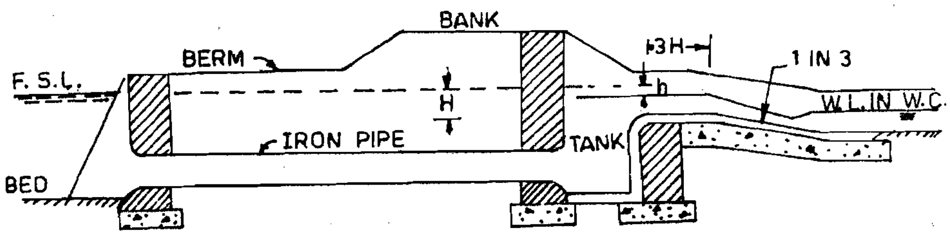

Figure 10.7 : Pipe-cum-Semi-module

SAQ 6

How do you select the type of a module for an outlet? Discuss in detail with reference to every related factor.

10.8 REQUIREMENTS OF A GOOD OUTLET

Following are the requirements of a good outlet :

(a) It should be simple in design, construction and working.

(b) It should not be easily tampered with by the cultivator; but if tampered, it should be easily detected.

(c) It should work efficiently with a small working head.

(d) The outlet should draw its fair share of sediment carried by the parent channel.

(e) From the point of view of distribution, it should take proportional discharge with varying supply in the parent channel.

(f) From the point of view of the cultivator, it should give design discharge irrespective of any fluctuation in the parent channel.

10.9 SUMMARY

Canal outlets are devices to regulate/control the flow of water from a bigger channel into a smaller one. These outlets are of various categories. Non-modular outlets work under the difference of water levels on either side of the device; in semi-modular (i.e., flexible) outlets the discharge is dependent only on the water level in the main channel, namely, a distributary; and, in modular outlets the discharge is fixed, i.e., it is independent of the water level on either side of the device. Various designs are available under each category of the outlets.

The basic design parameters that help assess the performance of an outlet are : flexibility, sensitivity, proportionality, setting, efficiency, minimum modular loss, modular limits, and modular range. Section of the type of module, vis-a-vis, a given field situation depends on the condition of the channel, condition of water course (going into the fields), and the available head under which the device is to function.

A good outlet should be simple, not easily liable to tampering (and any tampering should be easily detectable), and should be efficient with a small working head. It should take a fair share of sediment carried by the parent channel; and, it should take discharge proportional to the main flow in the distributary, or should yield the design discharge under all conditions, as the case may be.

10.10 KEY WORDS

Chute Size of Checks : The area irrigated from one individual outlet is called "check" or "chak" of the outlet. The outlet or chute size depends upon the size of the check.

Classification of Outlets : This helps in the appropriate selection of an outlet in order to meet the particular requirement of discharge to be released from the distributary to the water course.

Design Parameters : The factors to be considered in the adoption of a particular outlet.

Efficiency : It is the ratio of the head recovered (i.e., the head remaining after all the losses in the outlet have been accounted for) to the input head of the water flowing through the outlet.

Flexibility	:	It is the ratio of the rate of change of discharge of an outlet to the rate of change of discharge of the distributary channel due to the change in the water level of the distributary.
Maximum Length of Water Course at Outlet	:	This is a factor that helps locating an outlet with reference to the length of a water course.
Minimum Modular Loss	:	It is the minimum difference between the upstream and downstream water levels which is required to enable the module to pass the design discharge.
Open Flume Outlet	:	It is an outlet having a weir with a long constricted throat and expanding flume on the downstream.
Orifice Semi-module	:	A gradually enlarging flume on the downstream of an orifice.
Pipe as Non-modular Outlet	:	When a pipe discharge under submerged conditions, it is called a non-modular outlet.
Semi-modular or Flexible Outlets	:	A module in which the discharge is dependent only on the water level in the distributary while the water level in the water course does not affect the discharge, provided the minimum working head required for its working is available.
Sensitivity	:	Sensitivity of an outlet is the ratio of the rate of change of discharge of an outlet to the rate of change in the water surface level of the distributary channel with respect to the depth of flow in the channel.
Setting	:	It is the ratio of the depth of the crest level of the outlet below the full supply level of the canal to its full supply depth.
Sluices	:	Sluices are openings provided in a dam to release water to the downstream.

10.11 ANSWERS TO SAQs

Read through the relevant sections of the text, and the reference material.

FURTHER READING

1) Asawa, G. L.; "*Irrigation Engineering*", Wiley Eastern Ltd, New Delhi, 568p, 1983.

2) Varshney, R. S.; Gupta, S. C.; Gupta, R.; *Theory and Design of Irrigation Structures,* Nem Chand & Bros, Roorkee, 858p, 1972.

3) Singh, Bharat; "*Fundamentals of Irrigation Engineering*", Nem Chand & Bros, Roorkee, 8th ed, 608 p, 1988.

4) Novak, P.; Moffat, A. I. B.; Nalluri, C.; Narayanan, R.; '*Hydraulic Structures*', Unwin Hyman, London, 546p, 1990.