UNIT 7 CANAL SYSTEMS

Structure

7.1 INTRODUCTION

A water conveyance system that carries water from the supply point to the point of use comprises canals through open cuts, rocks or earth formations, and may include flumes formed in partially excavated sections, etc. These structures compose a canal.

In this unit you will be learning about the various canal systems that are provided for carrying water for a number of purposes.

Objectives

After going through this unit you would be able to explain the various types of canal systems and their purpose, such as :

- alluvial and non-alluvial canal,
- inundation and permanent canal,
- feeder or link canal,
- conveyance and distribution canal,
- power canal, and
- navigation canal.

You would also appreciate the importance of the capacity of a canal as its basic design function.

7.2 CLASSIFICATION OF CANALS

Canals may be defined as artificial channels constructed on the ground to carry water from one place to the other. The water may be released from a reservoir or from a river or another canal; and the canal conveys it further on.

Canals are classified in a number of ways. According to the material through which the water is conveyed, the canal may be classified as an *alluvial* or a *non-alluvial* canal. Based on the nature of source of supply, it may be termed as an *inundation* or a *permanent* canal. Depending on how the water is fed from one system to another, it may be a *feeder* or a *link* canal. From a large canal, water has to be conveyed and distributed to small fields and so the canal may be called a *conveyance* or *distribution* canal. And, depending upon the function, the canal may be termed as an *irrigation, power* or *navigation* canal. The various types of canals are discussed in the following sub-sections.

7.2.1 Alluvial and Non-alluvial Canal

Depending upon the bed and side material a canal may be designated as an alluvial or non-alluvial canal.

Alluvial Canals

A canal flowing through *alluvium* – ground formations consisting of non-cohesive sediments (i.e., silt, sand and gravel) is called an alluvial canal. A canal flowing through such sediments transports some of this material along with the flowing water. Because of the complex nature of alluvial deposits which stands in the way of deriving analytical solutions, experimental methods are generally adopted for obtaining solutions of problems related to alluvial canals. Irrigation canals in this country are usually constructed in alluvial soil and without any lining. These canals take their supplies from rivers which always carry sediment rolling on the bed or held in suspension, which is passed on to the offtaking canals. If the velocity in a canal is very high, the water will erode its bed and if the velocity is very low, the sediment held in suspension will get deposited. A canal should, therefore, be designed for a velocity such that neither the bed is eroded nor the sediment is deposited but is transported to the fields. Such a velocity is known as non-scouring and non-depositing velocity. These canals are known as flowing through non-rigid boundaries.

Non-alluvial Canals

Non-alluvial canals are those that have been lined with some suitable material to provide a rigid bed and banks so as to avoid the problems associated with alluvial boundaries.

SAQ 1

Differentiate in detail between alluvial and non-alluvial canals.

7.2.2 Inundation and Permanent Canal

Inundation canals are those which depend for their supply on the periodical rises in the water level of the river from which they are taken off. They are not provided with permanent headworks (Figure 7.1). The water is simply let into them when the river rises through the marginal flood embankments and they are provided with a regulator five to six kilometers away from the river. Owing to the changes in the river course, the offtakes of the canals have often to be changed, and fresh channels dug or creeks cleared out.

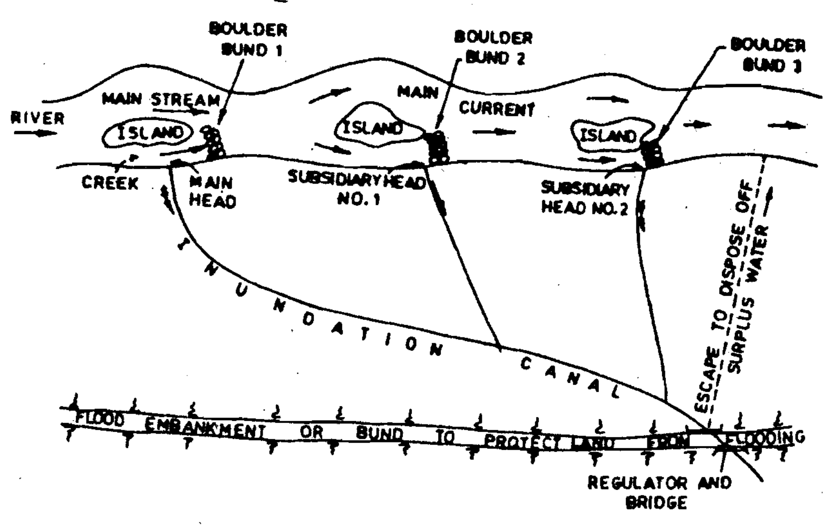

Figure 7.1 : A Typical Layout of an Inundation Canal Headworks

The supplies of these canals are not always of the desired magnitude. In regions where inundation canals exist, the rainfall is very scanty and the crops chiefly depend on these canals and wells. In order that the water of a canal may be made to flow on the surface of the country, the canal must generally have a direction making an acute angle with that of the river, and a general slope flatter than that of the river. But, when the country falls away from the river, a canal may offtake at right angles to the river. Lands fed by inundation canals are more fertile than those fed by perennial canals, because they bring in large quantities of silt that is rich in beneficial salts and nutrients.

Inundation canals have the following advantages :

1) They make available large quantities of water at cheap rates for the irrigation of large areas of alluvial land,

2) They bring down with them large quantities of fertilizing silt. Lands fed by irrigation from inundation canals become, therefore, more productive than those fed by permanent canals,

3) On account of non-perennial irrigation there is comparatively less trouble of waterlogging, in case of inundation canals than with respect to permanent canals. If, however, the weir controlled canals are also non-perennial, then the inundation canals have no such advantage over them.

There are following disadvantages of inundation canals :

1) There is little control over them,

2) Due to the fluctuating nature of supply, the cultivator is not sure about his crops maturing. He is, therefore, not so careful and attentive to cultivating his land. He does not improve it and leaves everything to chance,

3) In order to utilise a maximum amount of flow in a short time, the distribution works have to be made of a much larger size, thus entailing more expenditure,

4) To utilise maximum water in a short time the cultivator becomes lavish in the use of water in a good season while clamouring for supply in a bad season,

5) The heads of inundation canals are liable to destruction by erosion or silting leading either to a reduction or a complete stoppage of supplies. There is, however, a remedy for this. A number of canals can be linked up in a series and fed from a head which is not liable to be damaged.

6) Inundation canals are particularly liable to silting leading to large expenditure on silt clearance. Of course, by a proper design the amount of silt could be reduced.

A canal is said to be permanent when its source of supply is sufficiently well assured so as to warrant the construction of a regular graded channel supplied with works for regulation and distribution. Permanent canals are generally provided with permanent masonry headworks, regulator and distribution works and are constructed with engineering skill.

The permanent canals may be perennial which receive assured supplies from ice fed rivers throughout the year, or may be seasonal such as kharif channels in which supply is available from springs only during the kharif season.

In hilly (or mountainous) areas, the users through their own efforts have constructed canals, taking off from mountain streams. However, these canals lack any headworks except for boulder-made diversions that can be manipulated as per the prevailing flow situation in the river. These canals have a very steep grade, are unlined and lack any regulating structure along its course. Outlets of sorts, made of wood or even small boulders feed the mountain lands on one side of the river, as it generally runs along the river or along a high land. There is always a very high loss of flow due to leakage through sides and bed of the canal; but, all the same, it brings much needed water to the fields that would otherwise be dependent on rainfall only. Such canals are in existence in the valley of Kashmir (where they are known as *Kuhls*), and other sub-Himalayan terrains along the Great Himalayas.

SAQ 2

What do you understand by the terms permanent and inundation canals? Give examples from practical field.

SAQ 3

Discuss in detail how inundation canals are cost-effective.

SAQ 4

Discuss the importance of control structures on a perennial irrigation system.

7.2.3 Feeder or Link Canal

Feeder or link canals supply water from a reservoir to another point wherefrom a given irrigation canal system is fed. In fact, these link canals are a means of diverting surplus water from one source to another on which the irrigation system is well developed. A feeder canal is, generally, constructed to augment the supplies of two or more existing channels. Its length is usually small. An example of this is the feeder channel supplying water during the Rabi season from the Ramganga reservoir to Lower Ganga Canal system in Uttar Pradesh.

SAQ 5

Collect some actual examples of feeder canals – incorporating cross-sectional details, lining, and length etc.

7.2.4 Conveyance and Distribution Canal

Water from a reservoir or a river (with proper headworks in place) has to be carried through canals, and thence through branches, distributaries, minors and water courses till water reaches onto the field. All these works, which help in carrying the irrigation water are known as distribution works (Figure 7.2). They are described as given below :

a) *Main Canal* – Main canal is the channel taking off at the headworks directly from the river. Since a very high discharge is conveyed through the main canal, direct irrigation is not usually carried out from it. Sometimes the main, in its head reaches, passes through a heavy cutting into the mountainous terrain, not loosing much elevation and thus retaining the command area as desired.

b) *Branch Canal* – When an area to be irrigated is reached, the main canal is divided into Branch Canals or Branches, as they are normally called. The branches convey the water to different sectors of the area. Direct irrigation from large branches is not generally done, but from smaller branches direct outlets may be provided to cover large areas by irrigation. Branches usually convey discharges in excess of 5.66 cumec (200 cusec).

c) *Major Distributaries* – These are, generally, called distributaries, and are smaller canals taking off from the branch canals and in some instances from the main canal itself. They provide water to the water courses through outlets for direct irrigation and sometimes to minor distributaries as well. They usually carry a discharge of 0.283 to 5.66 cumec (10 to 200 cusec).

d) *Minor Distributaries* – They are usually termed as only minors; they are small channels carrying discharge of less than 0.283 cumec (10 cusec) supplying water to the water courses. Minors take off from branches or distributaries but seldom from the main canal.

All the above mentioned canals are constructed and maintained by the State.

e) *Water Courses or Guls* – These are small channels constructed by the cultivators to lead the water from minors to their fields through the outlets. Outlets are provided in the irrigation canal at appropriate places. An outlet is generally a pipe embedded in the bank of the canal having a discharging capacity in direct proportion to the area to be irrigated and controlled from that outlet. Beyond the outlet the water is handled by the individual cultivator who directs it to various parts of its command. With a view to develop irrigation quickly in the command of new projects, the policy is to construct a portion of the main water course from the outlet as a part of the project at state expense. Thereafter the maintenance and regulation of the water courses is done by the cultivators themselves.

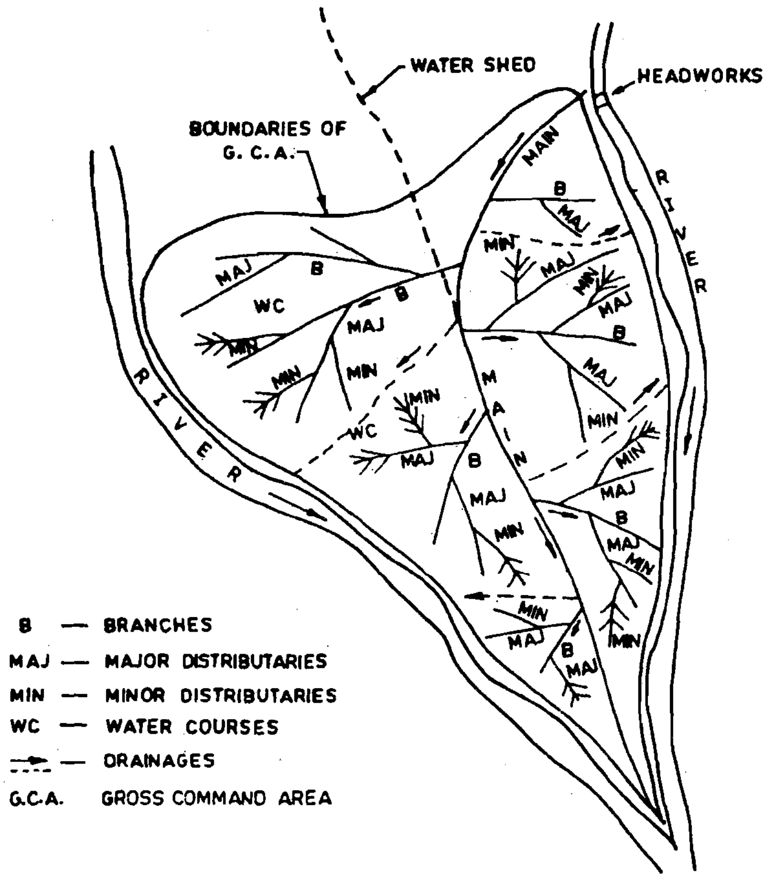

Figure 7.2 : Schematic Layout of a Canal Distribution System

SAQ 6

What are main canal, branches, distributaries and minors? Give standard cross-sections of these cannels.

SAQ 7

What are water courses and how are they operated and maintained?

7.2.5 Power Canal

A power canal is used to convey water from the reservoir (or from headworks across a river) to the power house for generating electricity, i.e., generating hydropower. Since the maximum bed slope that can be provided in a canal without inducing high velocities is generally less (i.e., flatter) than the country slope in the head reaches, vertical falls have to be provided in the canal to accommodate any extra drop in the ground profile. These falls, if of sufficient magnitude, can help develop electricity at respective locations. If power generation is combined with development of irrigation, the falls can be adjusted to be of maximum use in power generation without affecting the irrigation potential of the project. Purely hydropower canals or channels, as they are usually called, may be constructed where irrigation is not feasible or the water is fully utilised for irrigation after the power has been generated – after generation of power the water is restored to the river for irrigation use. If the length of a power canal is quite large (in order to carry water to a suitable place where the desired single fall is available and water can be easily fed back to the river) it is generally preferred to have a little steeper longitudinal slope of the canal to shorten the time of conveyance of water to the hydropower plant. In such a case the canal has to be lined to avoid erosion of the boundary material of the canal.

It is obvious that, in most cases, power canals have to pass through hilly terrains where the required magnitude of the fall in the ground is available at the tail end of the canal. Therefore, power canals need heavy expenses for the construction of cross drainage works, as all hilly canals (including irrigation canals) do entail such expenses. These cross drainage works may comprise : aqueducts, superpassages, and cut-and-cover structures. Appropriate design considerations called for to guard against land slides that can always occur in hilly slopes.

SAQ 8

Write an essay of 250 words about some existing power canals.

SAQ 9

How can an irrigation canal be utilised to develop hydroelectric power? What are the requisite features of the area that must exist for this purpose?

7.2.6 Navigation Canal

Sometimes an important function of a large canal is to offer facilities for navigation. In India, canals for navigation alone are rarely constructed. Large irrigation canals can be utilised for the transport of goods and men; however, they require special structures, like navigation locks, for negotiating falls or other hydraulic structures like barrages. Navigation canals require a certain minimum depth of flow to allow the barges to be moved, and minimum velocity of flow; otherwise navigation in the upstream direction becomes very difficult.

SAQ 10

What are the features of a navigation canal? Name some such canals that exist in India.

7.3 CAPACITY OF A CANAL

The capacity of a canal is the discharge that can be conveyed through the canal to meet the requirements of the system besides maintaining sufficient freeboard for safety of the banks. When a number of crops are grown in the command area of the canal system, the water requirements for each crop is different. The canal capacity will be such that it will meet the maximum of the peak demands for the various crops grown in the command area.

The canal capacity at any given point should be adequate not only to supply the total need of the outlets and offtaking canals below the point, but should also cover the losses experienced during transmission. The losses in the canal take place on account of two causes : a) evaporation, and b) seepage. The evaporation losses are usually a small proportion of the total losses in earthen canals. They depend on the water surface area, relative humidity, wind velocity and temperature. In hot dry summer months of May and June, these losses are maximum, but they would rarely exceed 10 % of the total losses. The seepage loss is dependent on the nature and porosity of the soil, the depth of flow, turbidity and temperature of water, the age and shape of the canal section, and the depth of the ground water table below the ground surface.

Greater the sectional area (A) of a canal, larger is the capacity of the canal for a given energy slope(s), and Manning's roughness coefficient(n). The average velocity of flow (V) in the canal is given by the following equation (using Manning's formula, in metric units) :

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

where, R is the hydraulic mean depth of the section for a given flow depth (y). The discharge (Q) that will be carried by the channel is given by the following relationship :

$$Q = A V$$

It is clear that the required value of Q (depending upon the maximum of the peak demands) can be obtained by the adequate value of A and maximum permissible value of V (depending on the nature of the boundary material – lined canals can sustain higher values of valocity). Increasing V beyond a critical value (by adjusting 's' – in effect the bed slope) is not done with a view to avoid scouring of the boundary material.

Appropriate desgin procedures are available for arriving at required cross-sectional areas of canals.

SAQ 11

What are the various losses encountered during transmission of water through a canal in an earthen section, and how are then accounted for in design procedures?

7.4 SUMMARY

Canals are channels that carry water from the service to the location where it is to be used, or where it is to be fed back to the drainage system (or the sea) as for a purely navigation canal. Canals can be classified according to the boundary material (alluvial or rigid-bed canal, etc.), nature of source of water (inundation or permanant canal), how they are being fed (feeder, main, distributary canal, etc.), or the purpose of its construction (irrigation, power, navigation, or multi-purpose canal).

Capacity of a canal is the maximum flow (discharge) that it can take at any given time, and this is the governing factor for the design of its cross-section.

7.5 KEY WORDS

Alluvial Canals : Canals flowing through ground formations consisting of non-cohesive sediments (i.e., silt, sand and gravel) are called alluvial canals.

Capacity of a Canal : The capacity of a canal is the discharge that can be conveyed through the canal section to meet the requirement of the system besides maintaining sufficient freeboard for safety of the banks.

Conveyance Canals : Main canals that carry water for some purpose are called conveyance canals.

Distribution Canals : Smaller canals that supply water from the main canal for the irrigation of fields are called distribution canals.

Feeder Canals : Feeder or link canals supply water from a reservoir to a given irrigation canal system.

Inundation Canals : Inundation canals are those which depend for their supply on the periodical rises in the water level of the river from which they are taken off.

Link Canals : They are also known as feeder canals.

Navigation Canal : A navigation canal is one that is used to transport men and goods.

Non-alluvial Canals : Non-alluvial canals are those that are provided with some lining to have a rigid bed and banks, and thus avoid the problems associated with alluvial beds.

Permanent Canals : Permanent canals are those whose source of supply is well assured to warrant the construction of a regular graded channel, provided with works for regulation and distribution.

Percolation Losses : Losses of water due to seepage and deep percolation of water from the canal to the lower soil formations are called percolation losses.

Power Canal : A canal that supplies water for power generation is called a power canal.

Seepage Losses : Percolation losses are also called seepage losses.

7.6 ANSWERS TO SAQs

Refer the relevant preceding text in the unit or other useful books on the topic listed in the section "Further Reading" to get the answers of the SAQs.