UNIT - VII

(1) Briefly Explain about classification of Canals?

(A) 1. A Canal is an artificial channel generally trapezoidal in shape constructed on the ground to carry water to the fields either from the river or from a tank or reservoir.

Canals can be classified in following ways:

(a) classification based on the nature of source of supply

(1) permanent Canal (2) Inundation canal.

A Cararal is Said to be permanent when it is fed by a permanent Source of supply. The canal is a well made up regular graded channel. It has also permanent masonry works for regulation and distribution of supplies. A permanet Canal is also Sometimes known as perennial Canal when the source from which Canal takes is an ice fed perennial river.

Inundation canals usually draw their supplies from rivers whenever there is a high stage in the river.

They are not provided with any headworks for diversion of river water to the canal. They are however provided with a canal head regulator. The head of the canal has to be changed sometimes to suit the changing pattern of river course.

(b) Classification base on financial output

(1) productive canal (2) protective canal.

productive canals are those which yield a net revenue to the nation after full development of irrigation in the area.

protective canal is a sort of relief work constructed with the idea of protecting a particular area from famine.

(c) Classification based on the function of the canal

1. Irrigation canal
2. Carrier canal
3. feeder canal
4. Navigation canal
5. power canal.

Ans An Irrigation Canal Carries water to the agricultural fields. A Carrier Canal besides doing irrigation carries water for another canal. upper chenab canal in West punjab (pakistan) is the Example of one such canal. A feeder Canal is constructed with the idea of feeding two or more canals. Examples of such Canals are: Rajasthan feeder Canal and Sirhind feeder.

(d) Classification based on boundary surface of the canal

Based on the type of boundary surface Canals may be of the following types:

1. Alluvial Canals
2. Non-alluvial canals
3. Rigid boundary canals

An alluvial Canal is the one which is Excavated in alluvial soils such as silt. A non-alluvial Canal is the one which is Excavated in non-alluvial soils, such as loam, clay, hard soil (murram), rock etc. Rigid boundary canals are those which have rigid sides and rigid base such as lined canals.

(e) **Classification based on the discharge and its relative importance in a given network of canals**

1) main canal
2) Branch canal
3) major distributary
4) Minor distributary
5) water course.

f) **Classification based on canal alignment**

According to the alignment, a canal may be classified as under

1) contour canal
2) watershed canal
3) side slope canal

(2) Design an irrigation channel on Kennedys theory to carry a discharge of 45 Cumecs. Take $N = 0.0225$ and $m = 1.05$. The channel has a bed slope of 1 in 5000.

Solution

Step 1 : Let us assume a trial depth $D = 2m$

Step 2 : $V_0 = 0.55m \; D^{0.64} = 0.55 \times 1.05 (2)^{0.64} = 0.9 m/sec.$

Step 3 : $A = Q/V_0 = 45/0.9 = 50 m^2$

Step 4 : For a trapezoidal section having $\frac{1}{2} : 1$ side slopes,

$$A = BD + 0.5D^2$$

$50 = B(2) + 0.5(2)^2$ from which $B = 24m$

Step 5 : perimeter $P = B + D\sqrt{5} = 24 + 2\sqrt{5} = 28.47 m$

$$R = A/P = 50/28.47 = 1.756 m$$

Step 6 : compute velocity of flow from kutters equation $V = C\sqrt{RS}$

where $S = 1/5000$

$$C = \frac{23 + \frac{1}{0.0225} + \frac{0.00155}{1} \times 5000}{1 + \left[23 + \frac{0.00155}{1} \times 5000\right] \frac{0.0225}{\sqrt{1.756}}} = 49.4$$

$$V = 49.4 \sqrt{\frac{1.756 \times 1}{5000}} = 0.926 \text{ m/sec.}$$

Step 7: Thus $V_0 < V$. In order to increase $V_0$ increase the value of D. Let D = 2.2 m in the next trial

$$V_0 = 0.55 \times 1.05 (2.2)^{0.64} = 0.957 \text{ m/sec.}$$

$$A = 45/0.957 = 47.04 m^2$$

$$47.04 = B(2.2) + 0.5(2.2)^2 \text{ from}$$

which B = 20.28 m

$$P = 20.28 + 2.2\sqrt{5} = 25.2 m$$

$$R = 47.04/25.2 = 1.867m$$

$$C = \frac{23 + \frac{1}{0.0225} + \frac{0.00155}{1} \times 5000}{1 + \left[23 + \frac{0.00155}{1} \times 5000\right] \frac{0.0255}{\sqrt{1.867}}} = 49.918$$

$$V = 49.918 \sqrt{\frac{1.867 \times 1}{5000}} = 0.965 m/sec$$

Ratio of the two velocities $= 0.965/0.957$

$= 1.008 \simeq 1.$

Hence no further trial is necessary

Thus, $D = 2.2m$ and

$B = 20.28m \simeq 20.3m$

Note: If further trials are made, the final values will be $D = 2.23$ m and

$B = 19.8m$

(3) What are the Drawbacks in Kennedy Theory

1. Kennedy did not notice the importance of B/D ratio.
2. He aimed to find out only the average regime conditions for the design of a channel.
3. No account was taken of silt concentration and bed load, and the complex silt carrying phenomenon was incorporated in a single factor m.
4. Silt grade and silt charge were not defined.
5. Kennedy did not give any slope Equation.
6. Kennedy used Kutter's Equation for the determination of the mean velocity and, therefore, the limitations of Kutter's Equation got incorporated in Kennedy's theory of channel design.

(4) A channel section has to be designed for the following data :

Discharge Q = 30 cumecs

Silt factor f = 1.00

Side slope = $\frac{1}{2}$ : 1

Find also the longitudinal slope.

Solution

1. The value of f is given as 1.00

2. velocity $V = \left[\frac{30 \times 1}{140}\right]^{1/6} = 0.773 m/sec$

3. Area $A = \frac{30}{0.773} = 38.8$ Sq.m

4. $P = 4.75\sqrt{Q} = 4.75\sqrt{30} = 26m$

5. $D = \frac{P - \sqrt{P^2 - 6.944A}}{3.472} =$

$\frac{26 - \sqrt{676 - 6.944 \times 38.8}}{3.472} = 1.67m$

$B = P - 2.236D = 26 - 2.236 \times 1.67 = 22.26m$

6. Hydraulic mean radius.

$$R = \frac{5}{2}\frac{v^2}{f} = \frac{5}{2} \times \frac{1}{1}(0.773)^2 = 1.49m$$

Also
$$R = \frac{BD + D^2/2}{(B+D)\sqrt{5}}$$

$$= \frac{1.67(22.26) + 1.67^2/2}{22.26 + 1.67\sqrt{5}}$$

$$= 1.49m$$

Hence, checked

7. slope
$$S = \frac{f^{5/3}}{3340\,(Q)^{1/6}} = \frac{1}{3340\,(1.764)}$$

$$= \frac{1}{5880}$$

Hence, the channel has a bed width $B = 22.26m$ and a depth of 1.67m. The longitudinal slope $S = 1/5880$.

(5) using tractive force approach design a channel in alluvial soil for the following data:

i) Discharge : 45 Cumecs

ii) Bed slope : 1/4800

iii) Mannings N = 0.0225

iv) permissible tractive stress : 0.0035 kN/m²

v) Side slopes : ½ : 1

Solution :-

$$R = \frac{\tau c}{w \cdot S} = \frac{0.0035}{9.81 \times 1/4800} = 1.713\,m$$

$$V = \frac{1}{N} R^{2/3} S^{1/2} = \frac{1}{0.0225} (1.713)^{2/3} (1/4800)^{1/2}$$

$$= 0.918\ m/s$$

$$A = Q/V = 45/0.918 = 49\,m^2$$

$$P = A/R = 49/1.713 = 28.61\,m$$

$$P = 28.61 = B + 2.236D$$

$$A = 49 = BD + 0.5D^2$$

and solving these we get $D \simeq 1.94\,m$ and $B = 24.27$

(6) Explain about KENNEDY'S Theory

(A) 1. Kennedy selected a number of sites on upper Bari Doab Canal System one of the oldest in Punjab (Pakistan) for carrying out investigations about velocity and depth of the channel.

2. The sites selected by him did not require any silt clearance for more than thirty years and were they supposed to be flowing with non-silting non-scouring velocity.

Kennedys' study revealed the following:

1. The flowing water has to counteract some amount of friction against the bed of the canal. This gives rise to vertical eddies rising up gently to the surface.

2. These eddies are responsible for keeping most of the silt in suspension. Some eddies may start from sides but these are for most of its part horizontal and so do not have any silt supporting power.

The silt supporting power is, therefore, proportional to the bed width of the stream and not to its wetted perimeter.

3. He also defined Critical velocity as non-silting non-scouring velocity and gave a relation between Critical velocity to the depth of flowing water.

4. The relation is

$$V_0 = 0.55 D^{0.64} \quad \text{—— (1)}$$

In general $V_0 = C D^n$ —— (2)

where $V_0$ = Critical velocity

$D$ = Depth of water over bed portion of a channel.

$n$ = Any index number.

5. Since the Equation has been derived on the basis of observations on one canal system only it is applicable to only those channels which are flowing in sandy silt of the same quality or grade as that of Upper Bari Doab Canal System.

6. Kennedy later realised the importance of silt grade on critical velocity and introduced a factor m known as critical velocity ratio (C.V.R) in his equation.

7. The equation is then written as

$$V_0 = 0.55\, m\, D^{0.64} \quad \text{--- (3)}$$

where m = C.V.R = $\dfrac{\text{Critical velocity for the avg}}{\text{Critical velocity for upper Bari Doab canal system}}$ --- (4)

8. Sand coarser than the standard were assigned value of m from 1.1 to 1.2 and those finer than the standard from 0.9 to 0.8. Generally in a system of canal, higher C.V.R. is assumed in head reaches and lower value of C.V.R. is assumed towards its tail end.

9. The value of constant C for in Eq. 1 for various grades of material may be assumed as follows.

## Value of c

| Types of material | value of c |
|---|---|
| Light Sandy silt | 0·53 |
| Coarser light silt | 0·59 |
| Sandy loam | 0·65 |
| Coarse silt | 0·70 |

The value of m in Eq. 4 for different types of silts are given in Table

## Value of m

| Type of silt | value of m |
|---|---|
| 1. Light Sandy silt in the rivers of Northern India | 1·00 |
| 2. Somewhat Coarser light Sandy silt | 1·10 |
| 3. Sandy loamy silt | 1·20 |
| 4. Rather Coarser silt or debris of hard soil | 1·30 |
| 5. Silt of river Indus in Sind | 0·70 |

10. Kennedy made use of Kutters Equation for finding the mean velocity of flow in the channel :

$$V = \frac{23 + \frac{1}{N} + \frac{0.00155}{S}}{1 + \left[23 + \frac{0.00155}{S}\right]\frac{N}{\sqrt{R}}} \sqrt{RS}$$

$$= C\sqrt{RS} \text{ (in metric units)}$$

Thus the limitations of Kutters Equation became incorporated in kennedys design procedure.

11. for Example when Q = 2 Cumecs, N = 0.0225 and m = 1 we get the following channel dimensions for various slopes :

| Slope | B (m) | D (m) | B/D |
|---|---|---|---|
| 1 in 5000 | 7 | 0.68 | 10.8 |
| 1 in 4000 | 3.2 | 0.85 | 3.8 |
| 1 in 2000 | 1.5 | 1.4 | 1.07 |

(7) Explain about LACEY'S Regime Theory

(A) 1. Dimensions width depth and slope of a regime channel to carry a given discharge loaded with a given silt charge are all fixed by nature.

2. This idea was first put forward by Lacey. Lindley's theory is also based on the same concept.

3. Lacey succeeded in evolving more generally applicable equations based on his own experiments and the experiments of the past investigators.

Regime channel :- Lacey defined regime channel as a stable channel transporting a regime silt charge. A channel will be in regime if it flows in unlimited incoherent alluvium of the same character as that transported and the silt grade and silt charge are all constant.

Incoherent alluvium :- It is a soil composed of loose granular graded material which can be scoured with the same ease with which it is deposited.

Regime Silt charge :- It is the minimum transported load consistant with bully active bed.

Regime Silt grade :- This indicates the gradation between the small and the big particles. It should not be taken to mean the average mean diameter of a particle.

Regime conditions :- A channel is said to be in regime when the following conditions are satisfied -

1. The channel is flowing in unlimited incoherent alluvium of the same character as that transported.
2. Silt grade and silt charge are constant
3. Discharge is constant.

if the above three conditions are met with fully then the channel is said to be in true regime. However it is seldom that the above conditions are realized in field. Hence, Lacey gave the idea of initial and final regime for actual channel.

## Lacey's Regime Equations

$$V = \sqrt{\frac{2}{5} f R}$$

$$A f^2 = 140.0 V^5$$

where A = Area of the channel section

and V = velocity of flow in it.

## Regime Flow Equation

$$V = 10.8 R^{2/3} S^{1/3}$$

where S = Slope of water surface

1. Perimeter Discharge (P–Q) Relation

$$P^2 = \frac{4 \times 140}{25} Q$$

$$P = 4.733\, Q \simeq 4.75 \sqrt{Q}$$

2. V–Q–f Relation

$$V = \left[ \frac{Q f^2}{140.0} \right]^{1/6}$$

3. Regime-slope Equations: (S–Q–f), (R–S–f) and (S–f–q) relationships

$$S = \frac{f^{5/3}}{3340\, Q^{1/6}} = \frac{0.0003 f^{5/3}}{Q^{1/6}}$$

4. Regime Scour Depth Relation

$$R = 0.47 \frac{1}{f^{1/3}} \left[ \frac{q}{0.21} \right]^{2/3} = 1.35 \left[ \frac{q^2}{f} \right]^{1/3}$$

## 5. Lacey's Non-Regime Flow Equation

$$V = \left[\frac{1}{Na}\right] R^{3/4} S^{1/2}$$

Na - f relation

$$Na = \frac{k' k^{1/2} f^{1/4}}{35.5} = \frac{1 (2/5)^{1/4} f^{1/4}}{35.5}$$

$$= 0.0225 f^{1/4}$$

## 6. Silt Factor - Grain Size Relationship

$$f = 1.76 \sqrt{m_d}$$

values of f

| Type of Soil | value of f |
|---|---|
| Fine silt | 0.50 to 0.70 |
| medium silt | 0.85 |
| standard silt | 1.00 |
| Medium Sand | 1.25 |
| Coarse Sand | 1.50 |