EXPERIMENT 7 DISCHARGE OF IRRIGATION CHANNEL BY MANNING'S FORMULA

Structure

7.0 OBJECTIVE

After completing this practical exercise, you will be able to:

- compute velocity and discharge in an open channel.

7.1 INTRODUCTION

Accurate estimate of flow rate in both lined and unlined channels is absolutely essential in order to apply the required amount to crop for favourable crop growth. Various methods are available to measure the flow rate in water courses. However, the velocity of flow and discharge can be estimated fairly accurately based on empirical methods developed for this purpose. Manning's formula is widely and extensively used for this purpose.

7.2 EXPERIMENT

7.2.1 Theory

Manning's formula is widely applied to compute velocity of flowing water in an open channel using channel cross-section, slope of the channel and channel surface roughness providing resistance to flow of water, known as Manning's roughness coefficient. The formula is used to design the cross-section (bottom width, water depth and side slope of the channel) of the channel for conveying desired amount of water for a given slope of the land surface.

$$v = \frac{R^{2/3} S^{1/2}}{n} \tag{7.1}$$

Where,

v = mean velocity of water flowing in the channel, m/sec;

R = hydraulic radius of the channel flow, m;

S = hydraulic slope, dimensionless, (m/m); and

n = Manning's roughness coefficient of the channel.

$R = \frac{a}{p}$ refers to the ratio of cross-sectional area of flow (a) and the wetted parameter (p).

$a = b \times d$ (rectangular channel)

$a = (b + d \times s) \times d$ (trapezoidal channel)

Where,

b = bottom width;

d = depth of flow; and

s = side slope (generally $s=1$, for loose soil $s=2$, for stiff clay $s=0.5$).

The value of Manning's roughness coefficient for various types of channel material is given in Table 7.1.

Table 7.1: Values of Manning's Roughness Coefficient 'n'

Type of channel	Manning's n
Earth channel	
Straight and uniform	0.023
Winding, sluggish	0.025
Stony bed, weeds on bank	0.035
Small drainage ditches	0.040
Lined channels	
Concrete	0.015
Masonry, rubble	0.017 - 0.030
Metal, smooth	0.011 - 0.015
Wooden	0.011 - 0.014
Vegetated waterways	0.020 - 0.040

The mean velocity of flow in the earthen (unlined) as well as lined channels should not be too little to allow deposition of silting material. However, in the unlined channels, excessive velocity of flow may result in erosion or scouring of bottom and sides of the channels. Very few soils can withstand velocities exceeding 1.5 m/sec. Permissible velocities depending on the type of soil are given in Table 7.2

Table 7.2: Permissible Velocities for Different Soil Textures

Type of Soil	Permissible Velocity, cm/sec
Bare channel	
Sand and silt	45
Loam, sandy loam and silt loam	60
Clay loam	65
Clay	70
Vegetative channel	
Poor vegetation	90
Fair vegetation	120
Good vegetation	150

Discharge (Q) can be computed by multiplying velocity (v) with area of cross-section (a) expressed as:

$$Q = a \times v \tag{7.2}$$

7.2.2 Requirements

- Specifications of the channel
  - bottom width;
  - depth of channel;
  - depth of water flow; and
  - side slope (in case of trapezoidal channel).
- Roughness coefficient
- Channel slope or gradient

7.2.3 Procedure

- calculate 'a' and 'p' as explained above using 'b', 'd' and 's';
- read 'n' from Table 7.1 depending on the surface of channel;
- compute 'v' using equation 7.1;
- compare the calculate velocity with recommended velocity (Table 7.2), values should almost match; and
- compute 'Q' using equation 7.2.

7.3 OBSERVATIONS AND CALCULATIONS

Example 7.1

Compute the flow velocity and discharge by Manning's equation using following data.

b	d	s	S	n*
20 cm	10 cm	1.5:1	1 m in 1000 m	0.015

* good earthen channel (straight and uniform)

$t = b + 2ds$

$= 0.20 + 2 \times 0.10 \times 1.5$

$= 0.20 + 0.30$

$= 0.50$ m

$$a = \left(\frac{t+b}{2}\right) = \left(\frac{0.5+0.2}{2}\right)$$

$= 0.35$ m^2

$p = b + 2(d\sqrt{s^2+1})$

$= 0.20 + 2(0.10\sqrt{1.50^2+1})$

$= 0.56$ m

$$R = \frac{a}{p} = \frac{0.35}{0.56} = 0.625 \text{ m}$$

$$v = \frac{R^{2/3} S^{1/2}}{n}$$

$$= \frac{(0.625)^{2/3} (0.001)^{1/2}}{0.023}$$

$$= \frac{0.73 \times 0.031}{0.023}$$

$$= 1.0 \text{ m/sec}$$

$$Q = v \times a$$

$$= 1.0 \times 0.35$$

$$= 0.35 \text{ m}^3\text{/sec}$$

$$= 350 \text{ litre/sec } (1\text{m}^3 = 1000 \text{ litre})$$

Exercise

b	d	S	n*
30 cm	60 cm	1 m in 800 m	0.023

7.4 RESULTS

v = ... m/sec

Q = ... m³/sec

= .... litre/sec (1m^3 = 1000 litre)

7.5 PRECAUTIONS

- In case of unlined channel, the cross-section and depth of channel need to be measured at a number of points.
- The gradient needs to measured accurately.
- Roughness coefficient should be appropriately selected based on type of channel surface.