Practical Manual on Land & Water Management Engineering

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Preface

The authors are engaged in research as Ph.D. Scholars at ICAR- IARI, New Delhi and GBPUAT, Pantnagar. All the authors contributing to the practical manual are engaged in the sub discipline of Soil and Water Conservation Engineering. The manual contains practical experiments related to the domain of Land and Water Management. The practical manual will be beneficial to the entire fraternity of students, teachers and researchers engaged in the concerned discipline. The authors have attempted to put the practical experiments in a precise manner. Sample problems have been included after every practical in order to gain a comprehensive understanding of the practical subject. The authors believe gaining a practical knowledge of the subject is the uttermost important pillar for the development of skills and entire upliftment of the discipline.

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Suggestions for the refinement and betterment of the practical manual are always welcome.

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Experiment No - 1

Determination of Soil Bulk Density by Field Method

1.1 General

Knowledge of soil and water relationship is valuable to improve irrigation practices and to make the best use of water. Soil bulk density is an important parameter, which influences the soil-water relationship. It is very useful in irrigated regions as it influences the capacities of well drained soils in the field to retain water available for plants, and the flow, or movement of water in soils.

1.2 Theory

1.2.1 Bulk density

The bulk density of a soil is defined as the ratio of the mass of dried soil to the total volume of soil. In other words, it is the mass of a dry soil per unit bulk volume, the latter being determined before drying. It is expressed as:

$P_b = M_s / V_t = M_s / (V_s + V_a + V_w)$

Here, ρ_b = bulk density; gm/cc

M_s= Mass of solid; gm

V_t= Total soil volume; cc

V_s= Volume of solid; cc

V_a= Volume of air; cc

V_w= Volume of water; cc

The term bulk density and apparent specific gravity are often used synonymously. Apparent specific gravity is the ratio of the weight of a unit bulk volume of soil to the weight of an equal volume of water. However, since, 1gm of water fills a volume of 1 cc at normal temperatures; the two terms have equal numerical value.

1.3 Scope of the Test

Bulk density is an important soil physical property considering its influence on the water holding capacity and hydraulic conductivity of soil. It is influenced by the structure, texture and compactness of the soil. The bulk density of uncultivated soils usually varies between 1.0 and 1.6; however compact layers may have a bulk density of 1.7 to 1.8. When working with the irrigated soils, it is necessary to know their bulk density in order to account for the water applied in irrigation, since it is impractical to measure, by direct means, the volume of water, which exists in the form of soil moisture in a given volume of soil. It is necessary to measure the weight of water in a given weight of soil by observing the loss of weight in drying and then convert the weight percentage so obtained to a volume percentage by use of the bulk density; thus, the volume of water in a given volume of soil may be determined. From this data the additional requirement of water in volumetric basis may also be calculated.

1.4 Objective

1. To determine the bulk density of soil.
2. To plot moisture content by weight and moisture content by volume and then determine the soil bulk density from the graph.

1.5 Procedure

1. The usual method of determining the bulk density or apparent specific gravity of a soil is to obtain an uncompacted soil sample of known volume. Core samplers are commonly used for this purpose. The sampler that has a cutting core is driven into the soil and an uncompacted core obtained within the tube.
2. The samples are carefully trimmed at both ends of the cylinder.
3. They are dried in an oven at 105°C-110°C for about 24 hours until the moisture is driven off and the sample is then weighted. The volume of a soil core is the same as the inside volume of the core cylinder.
4. The weight of the soil in grams divided by the volume of soil core in cc is the bulk density of soil.
5. From the data, calculate moisture content by weight.
6. Find moisture content by volume by multiplying the m/c by weight with bulk density.

1.6 Data Sheet

Determination of Soil Bulk Density by Field Method

Group No.	**Volume of Cylinder (c.c)**	**Weight of beaker (gm)**	**Weight of beaker+wet soil (gm)**	**Weight of Wet soil (gm)**	**Weight of beaker+dry soil (gm)**	**Weight of dry soil (gm)**	**Moisture content by weight (%) (θ_m)**	**Bulk Density ρ_b**	**Moisture content by volume (%)**

Experiment No - 2

Soil Suction Measurement with Tensiometer

2.1 General

The functions of soil moisture in plant growth are very important. Particularly in irrigated regions the soil moisture condition is of special interest and importance, because the depth of water to apply in irrigation and the interval between irrigations are both influenced by present moisture condition and use rate of applied water. Soil suction measurement with tensiometer at various time intervals is an indirect mean of measuring soil moisture in the soil.

2.2 Theory

2.2.1 Soil Suction

In unsaturated soils, water is held in the soil matrix under negative pressure due to attraction of the soil matrix for water. Instead of referring to this negative pressure the water is said to be subjected to a tension exerted by the soil matrix. The tension with which the water is held in unsaturated soil is termed as soil-moisture suction or soil-moisture tension.

2.2.2 Tensiometer

The tensiometer is a mechanical device for measuring soil- water tension in the field. The essential parts of a tensiometer consist of the porous cup with a reservoir of water inside, the connecting tube, and the sensing element of a vacuum gauge or a mercury manometer. A porous ceramic cup is positioned in the soil where information regarding soil water is desired. The cup, the connecting tube, and the sensing element of a vacuum indicator are all filled with water. Water in the soil near the cup is in hydraulic contact with bulk water inside the cup through pores in the cup wall. Flow, in or out through the cup wall, tends to bring the cup water into hydraulic equilibrium with the soil water. As water moves out of the cup because of the suction in the soil water, the vacuum created in the cup is registered on the gauge. Conversely an increase of water will lower the tension, water will move into the cup, and the gauge will read less tension. Fluctuations of soil moisture are registered by the tensiometer, as long as tension does not exceed 0.8 atm. As soil water is depleted by root extraction, or replenished by rainfall or irrigation, corresponding changes in readings on the tensiometer gauges occur.

2.3 Scope of the test

Tensiometer readings plotted as a function of time provide a useful record of soil water conditions in the neighborhood of the cup. They do not provide direct information on the amount of water held in the soil. Tension measurements are useful in deciding when to irrigate, but they do not indicate how much water should be applied. A special curve named soil moisture characteristic curve (Moisture Content V_s soil suction curve), plotted from tensiometer readings is an indirect measure of soil moisture content. The tensiometer readings are also very useful in determining the use rate of applied water.

2.4. Limitation of Tensiometer

Tensiometer does have a definite limitation in the range of values they can measure. The practical limit is about 0.8 atm. At this pressure air enters the closed system through the pores of the cup and makes the unit inoperative. The air entry or bubbling pressure of the ceramic cup limits this range.

2.5. Objectives

1. Use of tensiometer to measure soil moisture tension.
2. Measure the moisture content of the soil by weight.
3. Plot the soil moisture characteristic curve (moisture content vs. suction).

2.6 Procedure

1. For field installation, a hole is made in the soil using an auger of diameter larger than the porous ceramic tube. Insert the porous ceramic tube part in the hole and refill the hole with the material excavated. The soil surrounding the tensiometer ceramic tube should be refilled and compacted well to ensure good contact.
2. When suction equilibrium has been reached, take the necessary measurements. For the laboratory set-up, take tensiometer reading 1 day after installation.
3. Take soil samples from the depth where tensiometer was installed. Determine the weight of the soil.
4. Put the soil sample in an oven at about 110°C and allow the water to evaporate. The evaporation process at least takes 24 hours. Determine the weight of the dry soil and the weight of water.

Data Sheet

Group No.	Weight of can (gm)	Weight of wet soil + can (gm)	Weight of dry soil + can (gm)	Moisture content (%)	Soil suction (cm of Hg)	Soil Suction (atm)	Soil Suction (centibar)

Experiment No - 3

Determination of Grain Size Distribution of Soil by Sieve Analysis

Objectives

1. To determine the grain size distribution of soil by dry sieving.
2. To determine uniformity coefficient and coefficient of curvature.

Apparatus required

Weighing balance, IS sieves, Mechanical sieve shaker, Thermostatically controlled oven etc.

Theory

Grain-size analysis, which is among the oldest of soil tests, is widely used in engineering classifications of soils. It is utilized in part of the specifications of soil for earthen dams, and other soil embankment construction and conducting sediment studies. The standard grain-size analysis test determines the relative proportions of different grain sizes as they are distributed among certain size ranges. Grain-size analysis of soils containing relatively large particles is accomplished using sieves. A sieve is similar to a cook's flour sifter. It is an apparatus having openings of equal size and shape through which grains smaller than the size of the opening will pass, while larger grains are retained. Obviously, a sieve can be used to separate soil grains in a sample into two groups: one containing grain smaller than the size of the sieve opening and the other containing larger grains. By passing the sample downward through a series of sieves, each of decreasing size openings, the grains can be separated into several groups, each of which contains grains in a particular size range. The various sieve sizes are usually specified and are standardized.

The following particle classification names are given depending on the size of the particle:

1. Boulder: particle size is more than 300mm.
2. Cobble: particle size in range 80mm to 300mm.
3. Gravel (G): particle size in range 4.75mm to 80mm.

   - a. Coarse Gravel: 20 to 80mm.
   - b. Fine Gravel: 4.75mm to 20mm.

4. Sand (S): particle size in range 0.075mm to 4.75mm.
   - a. Coarse sand: 2.0mm to 4.75mm.
   - b. Medium Sand: 0.425mm to 2.0mm.
   - c. Fine Sand: 0.075mm to 0.425mm.

Fig 1: Set of IS sieves

Procedure

- a. Take a representative sample of soil received from the field and dry it in the oven.
- b. Use a known mass of dried soil with all the grains properly separated out. The maximum mass of soil taken for analysis may not exceed 500 g.
- c. Prepare a stack of sieves. Set the sieves one over the other with an ascending order (sieves having larger opening sizes i.e., lower numbers are placed above the one with smaller opening sizes i.e., smaller numbers).
- d. Make sure sieves are clean. If many soil particles are stuck in the openings try to poke them out using brush.
- e. The whole nest of sieves is given a horizontal shaking for 10 min in sieve shaker till the soil retained on each reaches a constant value.
- f. Determine mass of soil retained on each sieve including that collected in the pan below.
- g. Calculate the cumulative mass of soil fraction retained on each sieve. Calculate the percentage finer.
- h. Plot a graph of percentage finer (along y-axis) Vs sieve size in mm (along x-axis in log scale). Draw a smooth curve encompassing the plotted

points.

- i. Record the values of percentage sand, percentage silt and percentage clay size fractions from the graph.
- j. Record D_{10}, D_{30} and D_{60} from the graph.
- k. Calculate coefficient of uniformity (C_U) and coefficient of curvature (C_C).
- l. Classify the soil based on gradation.

Calculation

1. The percentage of soil retained on each sieve will be calculated on the basis of total weight of soil sample taken.

2. Cumulative percentage of soil retained on successive sieve is found.

Observation table

S No.	IS Sieve size	Particle size (mm)	Weight retained on each sieve	Corrected weight retained on each sieve = Weight retained on each sieve – Weight of sieve	Percentage on each sieve	Cumulative percentage retained on each sieve	% Finer
1.	4.75 mm	4.75					
2.	2.00 mm	2					
3.	1.00 mm	1					
4.	600 µ	0.6					
5.	425 µ	0.425					
6.	300 µ	0.3					
7.	212 µ	0.212					
8.	150 µ	0.15					
9.	106 µ	0.106					
10.	75 µ	0.075					
11.	Pan						
Total							

Results

1) The given soil is ____________________ grained.

2) (i) % sand = (ii) % silt = (iii) % clay size =

3) (i) D_{10} = (ii) D_{30} = (iii) D_{60} =

4) Coefficient of uniformity, $C_U = D_{60} / D_{10} =$ ______________________.

5) Coefficient of curvature, $C_c = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$ ______________________.

6) Particle size and gradation classification of the given soil: ______________________.

Experiment No - 4

Determination of friction factor for pipes

Objective: To determine the friction factor for the pipes

Apparatus required: A flow circuit of G. I. pipes of different diameter viz. 15 mm, 25mm, 32 mm diameter, U-tube differential manometer and a collecting tank.

Theory:

Friction factor in pipes or Major losses: A pipe is a closed conduit through which fluid flows under the pressure. When in the pipe, fluid flows, some of potential energy is lost to overcome hydraulic resistance which is classified as:

1. The viscous friction effect associated with fluid flow.
2. The local resistance which result from flow disturbances are caused by sudden expansion and contraction in pipe Obstruction in the form of valves, elbows and other pipe fittings, curves and bends in the pipe and entrance and exit losses.

The viscous friction loss or major loss in head potential energy due to friction is given by Darcy-Weisbach pipe friction equation as follows:

$$h_f = \frac{flv^2}{2gd} \qquad \ldots\ldots (1)$$

Or $$f = \frac{2gdh_f}{lv^2} \qquad \ldots\ldots (2)$$

h_f = Major head loss

l = Length of pipe

f = Darcy-Weisbach Friction factor

v = Inlet velocity

g = Acceleration due to gravity

d = Diameter of pipe

Procedure

1. Gradually open the inlet valve of the set-up to let water into the pipes and connecting tubes. Disconnect the pressure tapping from the manometer, allow the water to flow freely thorough the flexible tubes connected to the pressure tapping to remove air bubbles if any. After ensuring that there are no air bubbles, connect the flexible tubes back to the manometer.
2. Record the size of the pipes, the distances of the pressure tapping which are to be used as lengths-of pipes and temperature of water flowing.
3. Allow the discharge to come to steady state and note the difference in pressure between the tapings.
4. For the same discharge, close the outlet valve of the collecting tank. Allow the water level in the collecting tank to rise by a certain amount. Note the time taken for this rise in water level and the area of the collecting tank. The discharge is equal to the volume of water collected divided by the time taken.
5. Repeat the procedure for different values of different discharges and different pipes.

Observation table

Length of the pipe, l =

Diameter of the pipe, d =

Sr. No.	**Volume of water collected in tank**	**Time**	**Discharge *Q***	**Velocity of flow** $v = \frac{Q}{A}$	$\frac{v^2}{2g}$	**Reading of differential manometer**	**Darcy-Weisbach Friction factor *f***
1.							
2.							
3.							

Experiment No - 5

Determination of the Minor Losses in Pipes Due to Sudden Enlargement, Sudden Contraction and Bends

Objective

To determine the minor losses in pipes due to sudden enlargement, sudden contraction and bend.

Apparatus required

A flow circuit of G. I. pipes of different pipe fittings viz. Large and Small bends, Sudden enlargement from 25 mm to 50 mm diameter, Sudden contraction from 50 mm to 25 mm diameter, U-tube differential manometer, collecting tank.

Theory

The fluid flows through different pipe fittings such as sudden contraction, sudden enlargement valve, elbow or bend, tee section etc. Sudden changes in the flow path result in secondary flow patterns, denoted as separation region and vena contracta (flow area contraction due to secondary flow). Vortices and eddies occur in these regions, consuming energy and resulting in an observable pressure drop. Large pressure drops are observed as the fluid is forced through non-stream1ined passages. These losses through valves and fittings are known as minor losses or fitting losses.

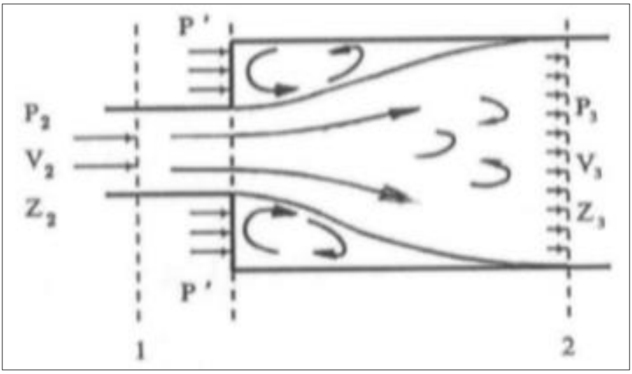


Fig 1: Schematic view of sudden expansion in pipe fittings

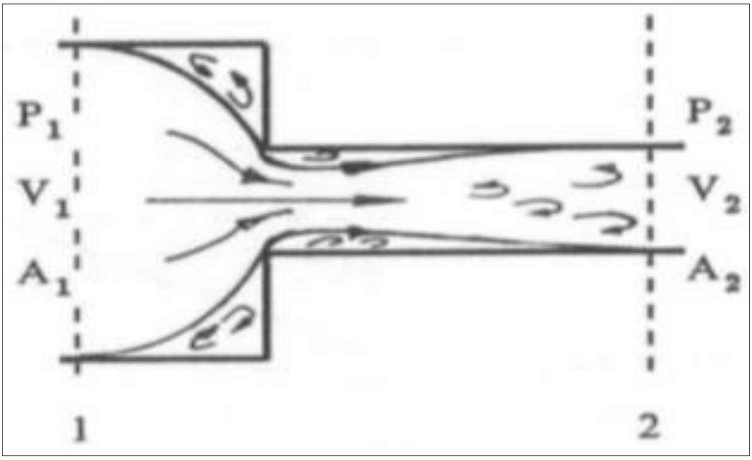


Fig 2: Schematic view of sudden contraction in pipe fittings

Formulae

Head loss due to sudden enlargement is: $h_e = \frac{(v_1 - v_2)^2}{2g}$

Head loss due to sudden contraction is: $h_c = \frac{v^2}{2g}\left(\frac{1}{C_c} - 1\right)^2$, where $C_c = 0.62$.

Head loss due to bend is: $h_b = k\frac{v^2}{2g}$

k is the coefficient of bend which depends upon angle of bend, radius of curvature and diameter of the pipe.

Procedure

1. Start the water supply.
2. Allow the water to flow through the pipe fittings like sudden enlargement, contraction, and bend.
3. Take manometer difference of each of the pipe fittings.
4. Take the time required for 100 mm rise of water level in measuring tank
5. Repeat the above steps for different readings.

Observations

1. Volume of Sump tank =
2. Volume of Measuring tank =
3. Area of measuring tank =
4. Diameter of enlargement =
5. Diameter of contraction =
6. Diameter of bend =

Type of loss due to	Sr. No.	Manometer reading		Difference of manometer reading	Time required for 100 mm rise
		h_1	h_2		
Sudden expansion	1.				
	2.				
Sudden contraction	1.				
	2.				
Sudden bend	1.				
	2.				

Calculations

1. For Sudden Enlargement

a. Diameter (d) =_______mm

b. Head Lost = ______mm of water

c. Discharge (Q) = Area of measuring Tank/Time Required for 100 mm rise

d. Velocity (V) = Q/A

e. Head lost (h_e) =

2. For Sudden Contraction

a. Diameter (d) =_______mm

b. Head Lost = ______mm of water

c. Discharge (Q) = Area of measuring Tank/Time Required for 100 mm rise

d. Velocity (V) = Q/A

e. Head lost (h_c) =

3. For Bend

a. Diameter (d) =_______mm

b. Head Lost = ______mm of water

c. Discharge (Q) = Area of measuring Tank/Time Required for 100 mm rise

d. Velocity (V) = Q/A

e. Head lost (h_b) =

Experiment No - 6

Flow through A Parshall Flume

Objectives

1. To determine the theoretical discharge under the free flow and submerged flow conditions.
2. To determine the coefficient of discharge under the free flow and submerged flow conditions.

Theory

1. Introduction

The Parshall flume is an open channel flow metering device that is used to measure the flow of surface waters and irrigation flows. It was designed by Dr. Ralph Parshall in 1915. It consists of a broad flat converging section, a narrow downward sloping throat section and an upward sloping diverging section. The reason of downward sloping throat section is to increase the head difference between the upstream section and the critical section. The upward slope in the diverging section is given to produce a high tailwater depth which reduces the length of the supercritical flow region.

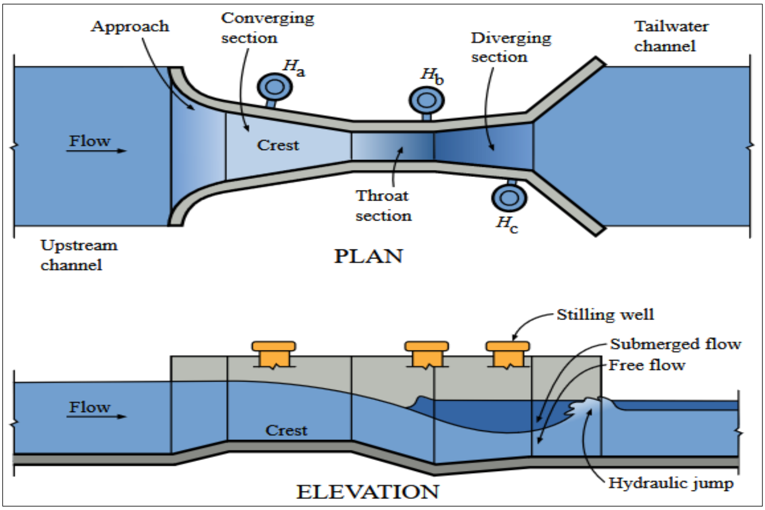


Fig 1: Schematic view of a Parshall flume installed in an open channel

2. Theoretical discharge of Parshall flume

The theoretical discharge (Q_t) for a Parshall flume is given by:

$$Q_t = KH_a^n \tag{1}$$

Where, *K* is a constant which depends upon the system of units used and width of throat. *n* is an exponent whose value depends upon the width of throat and H_a is the depth measured at the upstream.

Table 1: Values of *K* and *n* for different width of throat and equation of theoretical discharge under free flow conditions

Width of throat	Equation of theoretical discharge
3″	$Q_{tf} = 0.992H_a^{1.547}$
6″	$Q_{tf} = 2.06H_a^{1.58}$
9″	$Q_{tf} = 3.07H_a^{1.53}$

Here Q_{tf} is free discharge in cfs, width of throat is in ft. and H_a is the gauge reading in ft.

3. Coefficient of discharge

The actual discharge always varies with the theoretical discharge of the flume. So the introduction of a coefficient of discharge is necessary. If the actual discharge Qa is measured by the water meter, the coefficient of discharge is given by:

$$C_{df} = \frac{Q_a}{Q_{tf}} \text{ (in free flow condition)} \tag{2}$$

$$C_{ds} = \frac{Q_a}{Q_{ts}} \text{ (in submerged flow condition)} \tag{3}$$

Procedure

a) Determination of theoretical discharge under free flow conditions.

(i) Measure head H_a (upstream).

(ii) Calculate Q_{tf} using equation (1).

b) Determination of theoretical discharge under submerged flow conditions.

(i) Measure head H_a (upstream) and H_b (at throat).

(ii) Calculate Q_{tf} using equation (1).

(iii) Find the percentage of submergence using $\frac{H_b}{H_a} \times 100$.

Observation table

Throat width, W = In Discharge, Q = ft^3/s

Free flow condition			Submerged flow condition				
H_a (ft)	Q_{tf} (ft^3/s)	C_{df}	H_a (ft)	H_b (ft)	% Submergence	Q_{ts} (ft^3/s)	C_{df}

Experiment No - 7

Flow through A Cut Throat Flume

Objectives

1. To determine the theoretical discharge under the free flow condition.
2. To determine the coefficient of discharge.

Theory

1. Introduction

The Cut throat flume is a flow measurement flume that is used to measure the flow of surface waters, sewage flows, and industrial discharges. Unlike the Parshall flume, the Cutthroat flume lacks a parallel-walled throat section and maintains a flat floor throughout the flume. It can operate either as a free or submerged flow structure. The cut throat flume is an attempt to improve the Parshall flume by simplifying the construction. So, the flume is economical and normally used in straight sections of small irrigation channels for flow measuring purpose.

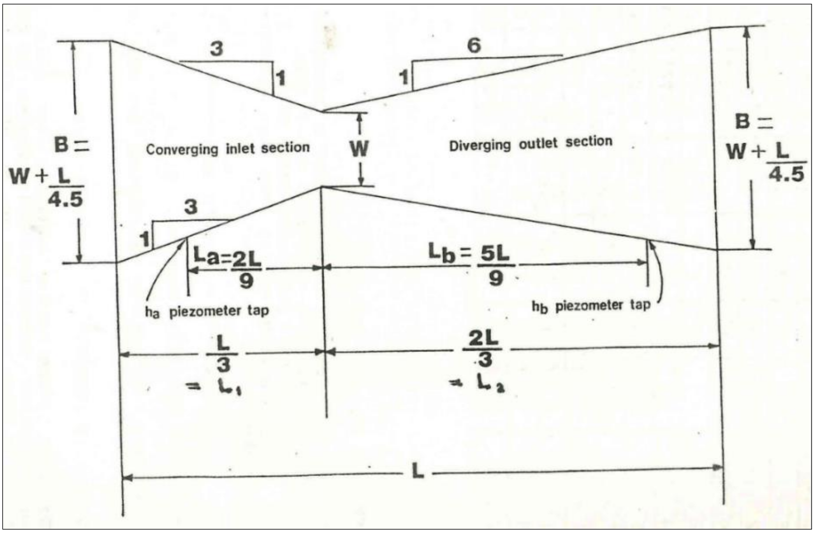


Fig 1: Schematic view of a Cut throat flume

2. Theoretical discharge under free flow condition.

The theoretical discharge under free flow condition (Q_{tf}) for a Cut throat flume is given by:

$$Q_{tf} = CH_a^n \tag{1}$$

Where *C* is the free flow coefficient and is given as:

$$C = KW^{1.025} \tag{2}$$

Where, *K* is free flow length coefficient, W is the width of neck, n is an exponent and H_a is the depth measured at the upstream at a distance $\frac{2L}{9}$ as shown in Figure 1.

Table 1: Values of *C, n,* and *K* for different flume lengths and throat widths

Length	**Throat Width**	**Coefficient (*C*)**	**Exponent (*n*)**	**Free-Flow Length Coefficient (*K*)**
18"	1"	0.494	2.150	6.100
18"	2"	0.974	2.150	6.100
18"	4"	1.975	2.150	6.100
18"	8"	4.030	2.150	6.100
36"	2"	0.719	1.840	4.500
36"	4"	1.459	1.840	4.500
36"	8"	2.970	1.840	4.500
36"	16"	6.040	1.840	4.500
54"	3"	0.960	1.720	3.980
54"	6"	1.960	1.720	3.980
54"	12"	3.980	1.720	3.980
54"	24"	8.010	1.720	3.980
108"	12"	3.50	1.560	3.500
108"	24"	7.11	1.560	3.500
108"	48"	14.49	1.560	3.500
108"	12"	22.0	1.560	3.500

2. Coefficient of discharge

The actual discharge always varies with the theoretical discharge of the flume. So the introduction of a coefficient of discharge is necessary. If the actual discharge Qa is measured by the water meter, the coefficient of discharge is given by:

$$C_{df} = \frac{Q_a}{Q_{tf}} \text{ (in free flow condition)} \qquad \text{……. (3)}$$

Procedure

(iii) Measure head H_a (upstream).

(iv) Determine the values of n and K using table 1.

(v) Calculate C using equation (2).

(vi) Calculate theoretical discharge using equation (1).

Observation table

Throat width, W = Discharge, Q = Flume length, L =

H_a	C	Q_{tf} (ft^3/s)	C_{df}

Experiment No - 8

Determination of Characteristics of a Hydraulic Jump

Objectives

1. To determine the type of the jump according to USBR classification.
2. To measure the initial depth (y_1), sequent depth (y_2), length (L) and height (h_j) of the jump.
3. To determine the total energy loss, kinetic energy loss and efficiency of the jump.

Theory

In an open channel when a supercritical flow is made to change abruptly to subcritical flow, the result is usually an abrupt rise of the water surface. This phenomenon is known as the hydraulic jump. This experiment deals with observation of hydraulic jump in a horizontal rectangular channel and development of different relationships between height, length, efficiency and energy loss of a hydraulic jump.

Hydraulic jump is useful in dissipation of excess energy in flows over dams, weirs, spillways and other hydraulic structures to prevent scouring downstream, maintaining high water levels in channels for irrigation and other water distribution purposes, increasing discharge of a sluice gate and thus increasing the effective head across the gate, mixing chemicals for water purification or wastewater treatment, increasing aeration of flows and dichlorination of waste water etc.

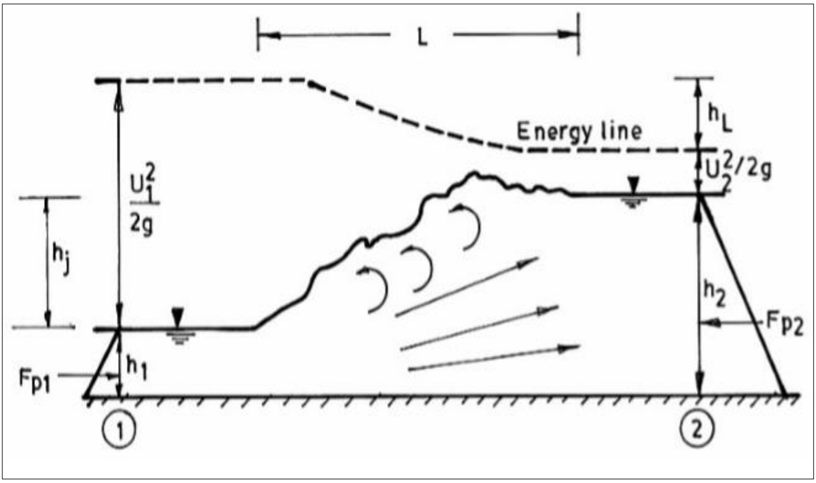


Fig 1: Schematic view of hydraulic jump in a rectangular open channel

1. Types of hydraulic jump

Depending on the Froude number before the jump (F_1), the United States Bureau of Reclamation (USBR) classified the hydraulic jumps in horizontal rectangular channels into the following five categories:

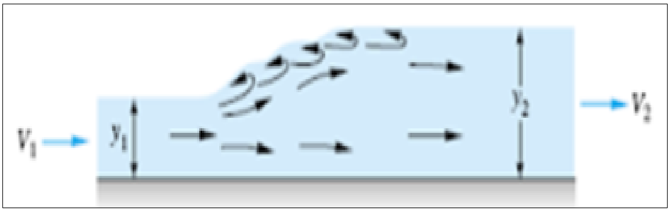
Type 1: F_1 = 1 ~1.7 Undular jump

Type 2: F_1 = 1.7 ~2.5 Weak jump

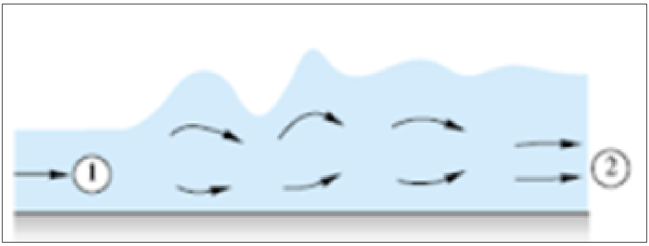
Type 3: F_1 = 2.5 ~4.5 Oscillating jump

Type 4: F_1 = 4.5 ~9.0 Steady jump

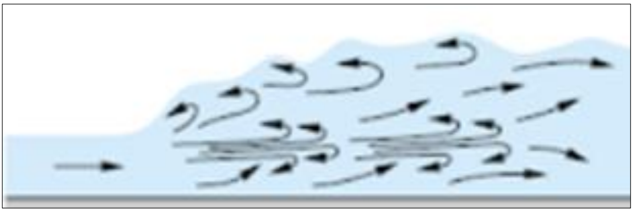
Type 5: F_1 > 9.0 Strong jump



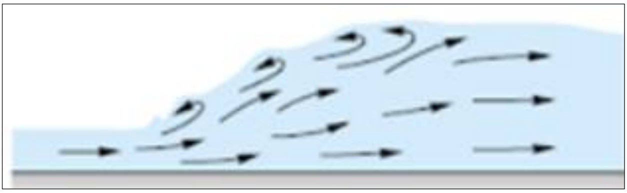
(a) Undular jump



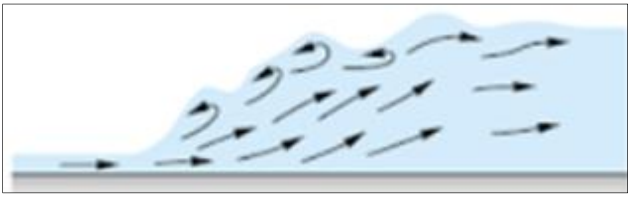
(b) Weak jump



(c) Oscillating jump



(d) Steady jump



(e) Strong jump

Fig 1: Different types of hydraulic jump

2. Initial and sequent depths

The depth of flow before the jump is known as the initial depth (y_1) and the depth after the jump is known as the sequent depth (y_2). Consider a hydraulic jump occurring in a horizontal rectangular channel.

Since the jump takes place in a short reach of the channel, $F_f \approx 0$ and since the channel is prismatic, assume that $\beta_1 = \beta_2 = 1$. The hydrostatic forces F_{p1} and F_{p2} are expressed as:

$$F_{p1} = \gamma \bar{z}_1 A_1 \text{ and } F_{p2} = \gamma \bar{z}_2 A_2 \qquad (1)$$

Where, $\bar{z}_1$ and $\bar{z}_2$ are the vertical distances of the centroids of the respective water areas A_1 and A_2 from the free surface. Now apply momentum equation between sections 1 and 2.

So,

$$\frac{Q^2}{gA_1} + \bar{z}_1 A_1 = \frac{Q^2}{gA_2} + \bar{z}_2 A_2 \qquad (2)$$

Since for a rectangular channel $Q = A_1 V_1 = A_2 V_2$, $A_1 = By_1$ and $A_2 = By_2$, $\bar{z}_1 = \frac{y_1}{2}$ and $\bar{z}_2 = \frac{y_2}{2}$ so equation (2) becomes:

$$\frac{q^2}{g}\left(\frac{1}{y_1} - \frac{1}{y_2}\right) = \frac{1}{2}\left(y_2^2 - y_1^2\right) \qquad (3)$$

Where, $q = \frac{Q}{B}$ i.e. discharge per unit width of channel. So, $q = v_1 y_1 = v_2 y_2$. Therefore equation (3) becomes:

$$\frac{V_1^2}{gy_1} = F_1^2 = \frac{1}{2}\frac{y_2}{y_1}\left(\frac{y_2}{y_1} + 1\right)$$

$$\text{or } \frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1 + 8F_1^2} - 1\right) \qquad (4)$$

Here $\frac{y_2}{y_1}$ is known as the ratio between the sequent and the initial depths.

3. Length of the jump (L)

The length of a hydraulic jump is the horizontal distance from the front face of the jump to a point immediately downstream from the roller. Silvester (1964) demonstrated that for free hydraulic jumps in horizontal rectangular channels the length of the jump is given by:

$$\frac{L}{y_1} = 9.75\left(F_1 - 1\right)^{1.01} \tag{5}$$

4. Energy loss in the jump

The total loss of energy in the jump is equal to the difference in specific energies before and after the jump. It can be shown that the total energy loss involved in a hydraulic jump in a horizontal rectangular channel is given by

$$\Delta H_{total} = \Delta E_{total} = E_1 - E_2 = \frac{\left(y_2 - y_1\right)^3}{4 y_1 y_2} \tag{6}$$

Where, E1 is the specific energy before the jump and E2 is the specific energy after the jump. The kinetic energy loss in the jump is given by the difference in velocity head before and after the jump. Thus

$$\Delta E_{K.E.} = \frac{1}{2g}\left(V_1^2 - V_2^2\right) \tag{7}$$

Where, V_1 is the velocity before the jump and V_2 is the velocity after the jump.

5. Efficiency of the jump

The ratio of the specific energy after the jump to that before the jump (E2/E1) is known as the efficiency of the jump. It can be shown that the efficiency of the jump is given by

$$\frac{E_2}{E_1} = \frac{\left(8F_1^2 + 1\right)^{\frac{3}{2}} - 4F_1^2 + 1}{8F_1^2\left(2 + F_1^2\right)} \tag{8}$$

6. Height of the jump

The difference between the depths after and before the jump is known as the height of the jump. It is given by:

$$h_j = h_2 - h_1 \qquad \ldots\ldots (9)$$

7. Experimental setup

In this experiment the hydraulic jump is produced by introducing a sluice gate in the flume. The experimental setup is given below.

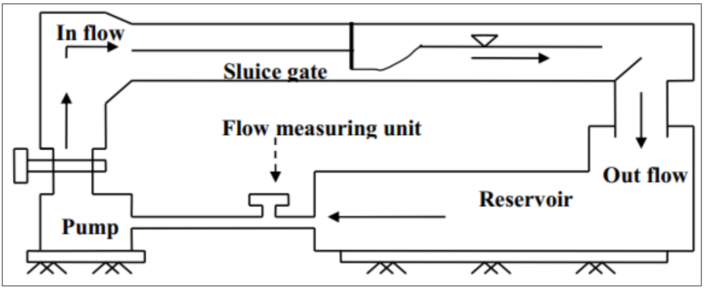


Fig 3: Experimental Setup

Procedure

1. Measure the depth of flow before the jump at three points and average them to get the initial depth y_1.
2. Measure the depth of flow after the jump at three points and average them to get the sequent depth y_2.
3. Determine the velocity before the jump (V_1), then calculate F_1 and find the type of jump.
4. Measure the length of the jump (L), then find L/y_1 and verify Eq. (5).
5. Compute the height of the jump (h_j) from Eq. (9).
6. Compute E_1 and E_2, then find the total energy loss $E_1 - E_2$ and verify Eq. (6).
7. Compute the kinetic energy loss in the jump using Eq. (7).
8. Compute the efficiency of the jump E_2/E_1 and verify Eq. (8).

Observation table

Flume width, B = cm Discharge, Q = cm^3/s

Depth		**Velocity**		**F_1**	**Type of jump**
y_1 (cm)	**y_2 (cm)**	**V_1 (cm/s)**	**V_2 (cm/s)**		

Total energy loss					**Kinetic energy loss (cm)**	**Efficiency**		
E_1 (cm)	**E_2 (cm)**	**E_1-E_2 (cm)**	**RHS of Eq.(6) (cm)**	**Comment**		**E_2/E_1**	**RHS of Eq.(8)**	**Comment**

Length of jump				**Height of jump**
L (cm)	**L/y_1**	**RHS of Eq.(5)**	**Comment**	**h_j (cm)**

Results

1. The type of jump is _____________.
2. the initial depth (y_1) is _____________.
3. The sequent depth (y_2) is ____________.
4. The length (L) of the jump is ___________.
5. The height (h_j) of the jump is ____________.
6. The total energy loss is _____________.
7. The kinetic energy loss is ______________.
8. Efficiency of the jump is _________________.

Experiment No - 09

Frequency Analysis of Hydrologic Data by Gumbel's Method

1. General

Frequency analysis is very important in the design of practically all hydraulic structures. The peak flow that can be expected with an assigned frequency is of primary importance to adequately proportion the hydraulic structure to accommodate its effect. Flood peak values are required in the design of bridges, culvert, waterways and spillways for dams and also estimation of scour at a hydraulic structure.

2. Theory

2.1. Flood Frequency Analysis

Flood frequency analysis is a statistical approach to predict flood flows and estimate the magnitude of flood peak.

2.2. Annual Series

The values of the annual maximum flood from a given catchment area for a large number of successive years constitute a hydrologic data series called the annual series.

2.3 Mean Annual Flood

The value of a flood with a return period T = 2.33 years is called the mean annual flood. When the sample size is very large Gumbel distribution has this property.

2.4 Gumbel's Method

The "Extreme value distribution method" was introduced by Gumbel in 1941 and is commonly known as Gumbel's distribution. It is one of the most widely used probability distribution function for extreme values in hydrologic and meteorological studies for prediction of flood peaks, maximum rainfall, maximum wind speed, etc. Gumbel's equation for practical use (when sample size is finite) is given by,

$$X_T = \bar{x} + k\,\sigma_{n-1} \qquad (1)$$

Where,

X_T = value of the variable x of a hydrologic series with a return period T

$\bar{x}$ = mean of the variate k = frequency factor = $(Y_T - \bar{y}_n) / S_n$ (2)

σ_{n-1} = standard deviation of the sample = $\sqrt{\sum(x-\bar{x})^2 / (N-1)}$ (3)

y_T = reduced variate = $-[0.834 + 2.303 \log\log (T/ T-1)]$ (4)

$\bar{y}_n$ = reduced mean, given in Table 2

S_n = reduced standard deviation of the sample, given in Table 3

The recurrence interval T for each discharge is given by,

$T = (N+1)/ m$ (5) ,

Where, m = order number, N = sample size

2.5 Gumbel Probability Paper

Gumbel probability paper is an aid for convenient graphical representation of Gumbel's distribution. It consists of an abscissa specially marked for various convenient values of return period. The magnitude of the flood or any hydrologic event or the value of the variate is plotted in the ordinate, which has an arithmetic scale. Since by equation (1) & (2) X_T varies linearly with Y_T, Gumbel distribution will plot as a straight line on a probability paper. This property can be used advantageously for graphical extrapolation.

3. Objectives

1. Prepare a Gumbel probability paper.
2. Plot the Gumbel distribution (x versus T) on a Gumbel probability paper.
3. Estimate the flood discharge with recurrence interval of

(i) 100 years by graphical extrapolation

(ii) Roll No. + 20 (For Roll No. 1-50)

Roll No. – 20 (For Roll No. 51-100)

Roll No. – 60 (For Roll No. 101-150)

4. Procedure

4.1. Procedure for Gumbel Distribution

1) Assemble the discharge data in decreasing order of magnitude. Find the value of T for each discharge. Here the annual flood value is the variate x.

2) Find $\bar{x}$ and σ_{n-1} for the given data.
3) Use Tables 2 and 3 to determine $\bar{\ }_{n}$ and S_n appropriate to the given N.
4) Find y_T for a given T using Eq. (3). 5) Find K using Eq. (2).
5) Determine the required X_T by Eq. (1).

4.2. Procedure for Preparation of Gumbel Probability Paper

1) To construct the T scale on the abscissa, first construct an arithmetic scale of Y_T values from – 2 to +7.
2) For selected values of T, say 1.01, 1.1,1.2, 1.5, 2, 3, 4, 5, 7, 10, 15, 20, 30, 40, 50, 100, 200, 500 and 1000, find the values of Y_T from eqn. (3) and mark off those positions on the abscissa. The T scale is now ready.
3) Now plot the X_T - T points in the probability paper.
4) The plotted points will follow a straight line.
5) By extending the straight line extrapolation is done.

5. Given Data

Table 1: Maximum Annual Flood

Year	**1957**	**1958**	**1959**	**1960**	**1961**	**1962**	**1963**	**1964**	**1965**	**1966**
Max Flood (m^3/s)	62500	71300	68500	64800	64700	69400	56400	63100	64200	68900
Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Max Flood (m^3/s)	56600	66100	61200	66500	55900	56500	77000	63800	43100	74000

Table 2: Reduced mean $\bar{\ }_{n}$ in Gumbel's extreme value distribution (N = sample size)

N	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
10	0.4952	0.4996	0.5035	0.5070	0.5100	0.5128	0.5157	0.5181	0.5202	0.5220
20	0.5236	0.5252	0.5268	0.5283	0.5296	0.5309	0.5320	0.5332	0.5343	0.5353
30	0.5362	0.5371	0.5380	0.5388	0.5396	0.5402	0.5410	0.5418	0.5424	0.5430
40	0.5436	0.5442	0.5448	0.5453	0.5458	0.5463	0.5468	0.5473	0.5477	0.5481
50	0.5485	0.5489	0.5493	0.5497	0.5501	0.5504	0.5508	0.5511	0.5515	0.5518
60	0.5521	0.5524	0.5527	0.5530	0.5533	0.5535	0.5538	0.5540	0.5543	0.5545
70	0.5548	0.5550	0.5552	0.5555	0.5557	0.5559	0.5561	0.5563	0.5565	0.5567
80	0.5569	0.5570	0.5572	0.5574	0.5576	0.5578	0.5580	0.5581	0.5583	0.5585
90	0.5586	0.5587	0.5589	0.5591	0.5592	0.5593	0.5595	0.5596	0.5598	0.5599
100	0.5600									

Table 3: Reduced standard deviation S_n in Gumbel's extreme value distribution (N = sample size)

N	0	1	2	3	4	5	6	7	8	9
10	0.9496	0.9676	0.9833	0.9971	1.0095	1.0206	1.0316	1.0411	1.0493	1.0565
20	1.0628	1.0696	1.0754	1.0811	1.0864	1.0915	1.0961	1.1004	1.1047	1.1086
30	1.1124	1.1159	1.1193	1.1226	1.1255	1.1285	1.1313	1.1339	1.1363	1.1388
40	1.1413	1.1436	1.1458	1.1480	1.1499	1.1519	1.1538	1.1557	1.1574	1.1590
50	1.1607	1.1623	1.1638	1.1658	1.1667	1.1681	1.1696	1.1708	1.1721	1.1734
60	1.1747	1.1759	1.1770	1.1782	1.1793	1.1803	1.1814	1.1824	1.1834	1.1844
70	1.1854	1.1863	1.1873	1.1881	1.1890	1.1898	1.1906	1.1915	1.1923	1.1930
80	1.1938	1.1945	1.1953	1.1959	1.1967	1.1973	1.1980	1.1987	1.1994	1.2001
90	1.2007	1.2013	1.2020	1.2026	1.2032	1.2038	1.2049	1.2049	1.2055	1.2060
100	1.2065									

Data Sheet

Frequency Analysis of Hydrologic Data by Gumbel's Method

N=

$\bar{x}$ =

Flood Discharge, X (m^3/s)	**Order number, m**	**$T = (N+1)/m$ (years)**	**Flood Discharge, X (m^3/s)**	**Order number, m**	**$T = (N+1)/m$ (years)**

σ_{n-1}=

Preparation of Gumbel Probability Paper

Return Period, T (Years)	**Y_T**

Experiment No - 10

Estimation of Runoff by Rational Method

Rational Method

To design soil conservation structures with the proper capacity and to meet the need of respective condition it is necessary to estimate peak runoff rate. There are number of formulae and methods for calculating the maximum rate of runoff for given area. The rational method is used for calculating the maximum rate of runoff for a given area. The rational method is commonly used in predicting peak runoff rate of small watershed. The rational formula proposed by C.E. Ramser is expressed in F.P.S. unit as –

$$Q = C\ I\ A \qquad (1)$$

Q = Design peak runoff rate, m^3 / sec.

C = Runoff coefficient

I = Maximum average rate of rainfall over the entire drainage area which may occur during the time of concentration, m /sec.

A = Watershed area in, m^2.

Since 'C' is dimensionless coefficient formula may be readily converted into metric unit as under.

$$Q = 0.0276\ CIA \qquad (2)$$

In which, Q = Design peak run-off rate, m^3 / sec

C = Runoff coefficient.

I = Maximum average of rainfall over the entire area which may occur during the time of concentration, cm / hr

A = Watershed area, hectare

Value of 'C' in rational formula

Slope %	Sandy loam	Clay & silt loam	Stiff clay
1. Wood Land			
0-5%	0.10	0.30	0.40
5-10%	0.25	0.35	0.60
10-30%	0.30	0.50	0.60
2. Pasture land			
0-5%	0.10	0.30	0.40
5-10%	0.16	0.36	0.55
10-30%	0.22	0.42	0.60
3. Cultivated land			
0-5%	0.30	0.50	0.60
5-10%	0.40	0.60	0.70
10-30%	0.52	0.72	0.82

The rational method is applicable for watershed area less than 1300 ha. The method is based upon two assumptions.

1. Rainfall occur at uniform intensity for a duration, at least equal to time of Concentration.
2. Rainfall occurs at uniform intensity over entire area of watershed.

Since there are hardly rainfalls satisfying both the conditions. The estimation of runoff based on this method is rather approximate. However, the method is considered sufficiently accurate for run-off estimation on design of expensive structure where the consequence of failure is limited. Design run-off is the rate to measure surface runoff by basic hydrograph method and unit hydrograph method.

Time of concentration

The time of concentration of watershed is the time required for runoff water to flow from the most remote (in time of flow) point area to outlet. When duration of storm is equal to the time of concentration, it is assumed that all parts of watershed are contributing simultaneously to the discharge of outlet. Time of concentration vary greatly with the nature and extent of vegetation in a given watershed. However, reasonable estimation of time of concentration can be obtained by dividing distance from the most remote point to the outlet of the area by the average velocity selected.

Average velocity is used to determine the time of concentration

Average slope of channels measured from farthest point of watershed to outlet	**Velocity, meter /sec**
1-2%	0.6
2-4%	0.9
4-6%	1.2
6-10%	1.5

Another approach to estimate the time of concentration is by the application of following empirical formula.

$$T_c = 0.0195\, L^{0.77}\, S^{-0.385} \qquad (3)$$

In which, T_c = Time of concentration, minutes

L = Maximum length of flow, meter

S = Average slope of area, meter / meter.

Problems

1. Estimate peak run-off rate for a 10 years recurrence interval and time of concentration, if the intensity of 1 hr. rainfall expected in 6.3 cm. Watershed is composed of 20 ha. of cultivated crop on 3% slope and 30 ha. of pasture on 7% slope in silt loam soil. Maximum length of path of water particles is 700 m and average slope of path is 4 %. (The rainfall intensity for calculated Tc is 16.5 cm/hr).
2. Determine the peak runoff rate for 35 years recurrence interval and time of concentration from an area in clay loam containing 20 ha. of cultivated land on 1 % slope. 35 ha. of pasture land on 7 % slope and 30 ha. of wood land on 12 % slope. The most remote point in the watershed is 3200 m away from outlet and 8 m below this point. The maximum intensity of 1 hour rainfall expected during the recurrence interval is 7.5 cm. (The rainfall intensity for calculated Tc is 6.3 cm/hr).
3. Calculate time of concentration where maximum length of watershed is 700 m and most remote point is 9 m above the out let point.

Experiment No - 11

Hydrograph Analysis

1. General

Hydrograph analysis is used for flood routing, flood forecasting and determining design discharge for any hydraulic structure.

2. Objective

1) To draw the recession limb of hydrograph on a semi-log paper.
2) To find the recession constant for base flow.
3) To find the recession constant for interflow.
4) To find the recession constant for surface run-off.
5) To find the surface run-off.

3. Theory

Rain falling on a catchment area will make its way to the point of concentration where it will leave the catchment. In a gravity flow situation, this will be the lowest point in the catchment if the discharge is through surface stream. On the other hand, if the catchment discharge is solely by means of ground water movement, the situation is more complex and the flow can be distributed over a wide front. But in the laboratory the flow is constrained to leave the model catchment at a single point, we shall not consider this case here.

In practice, a catchment area is defined only once when the point of concentration has been fixed and as streamflow data are needed here, the site of a new or pre-existing flow measurement structure is usually chosen. When rain falls on the catchment the time taken for the water to reach the point of concentration will depend on the horizontal distance it has to travel and also on the velocity.

4. Hydrograph

A graphical representation of discharge in a stream plotted against time chronologically is called a hydrograph. Depending upon the units of time involved, hydrographs are, i. Annual Hydrograph ii. Monthly Hydrograph iii. Seasonal Hydrograph iv. Flood Hydrograph

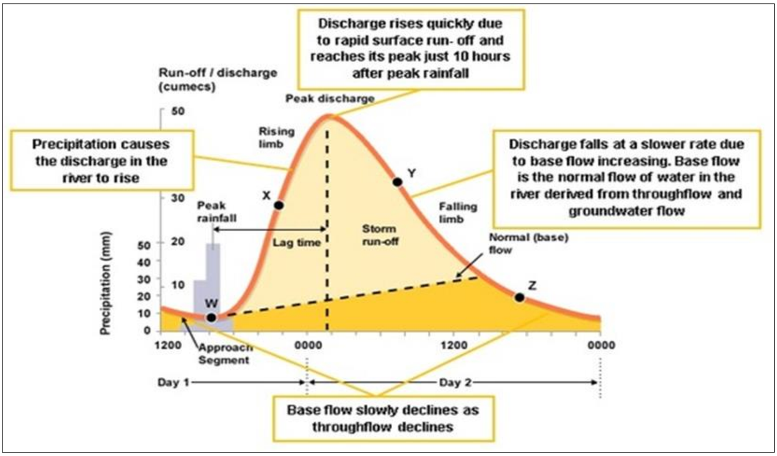
a. **Annual Hydrograph:** Showing variation of daily or weekly or 10 daily mean flows over a year.

b. **Monthly Hydrograph**: Showing variation of daily mean flow over a month.

c. **Seasonal Hydrograph**: Showing variations of the discharge in a particular season such as the monsoon season or dry season.

d. **Flood Hydrograph:** Hydrographs due to a storm representing stream flow over a catchments.

Flood hydrographs result due to an isolated storm is typically a single-peaked skew distribution of discharge. Fig. 3 shows a typical hydrograph resulting from a single rain storm. The duration and intensity of the rainfall is shown by the block in the upper part of this figure and if the rainfall persists for longer than the time of concentration of the catchment, the run-off hydrograph will level off at the peak value on the catchment.



Discharge rises quickly due to rapid surface run- off and reaches its peak just 10 hours after peak rainfall

Precipitation causes the discharge in the river to rise

Discharge falls at a slower rate due to base flow increasing. Base flow is the normal flow of water in the river derived from throughflow and groundwater flow

Base flow slowly declines as throughflow declines

Fig.3: A typical hydrograph resulting from a single rain storm

Under these circumstances, the recession curve part of the hydrograph is delayed until the rain stops.

During the early stages of the storm, so long as no recent rain has fallen, the ground will be able to absorb the water falling on it and add it to the ground water already present. When all the voids are filled, the excess must flow over the surface and enter the stream directly as surface flow. When the surface flow first reaches the point of concentration it produces a sharp rise in the hydrograph and this hydrograph discontinuity can be used to separate the ground water contribution from the direct run-off, as indicated in the figure.

The hydrograph shown in Fig.3 is typical for storms of duration shorter than the time of concentration of the catchment. The streamflow which is measured during a flood is the result of several watershed functions. Obviously, a major part of the flood is the result of direct run-off. Surface run-off is the streamflow which results when the overland flow arrives at a channel. The overland flow regime appears to follow a laminar or a distributed laminar type of resistance law. In contrast, the channel flow is always turbulent. It is convenient to define the following three parts of a flood hydrograph:

1. Concentration curve or rising limb
2. Crest segment
3. Recession curve or depletion curve or falling limb

The concentration curve exists between the point of rise at the beginning of the flood and the peak (if it can be recognized) or the point of inflection of the curve on the rising limb just prior to the peak. The crest segment exists between the point of inflection on the rising side and the point of inflection on the recession side of the peak. The shape of the rising limb is influenced mainly by the character of the storm which caused the rise. The point of inflection on the falling side of the hydrograph is commonly assumed to mark the time at which surface inflow to the channel system ceases.

4.1 Recession Limb

The recession limb extends from the point of inflection at the end of the crest segment to the commencement of natural ground water flow. It represents the withdrawal of water from storage within the basin. The starting point of the recession limb shows the maximum storage. The shape of the recession is largely independent of the characteristics of the storm causing the rise. However, the recession curve for a basin is a useful tool in hydrology.

Barnes showed that the following equation could be used to define the recession curve. $Q_t = Q_o (K_{rec})^t = Q_0\, e^{-\alpha t}$ (1)

Where,

Q_t = flow t time units after Q_o

Q_o = flow measured t time earlier

K_{rec} = recession constant

t = time in between Q_o & Q_t

e = Napierian base

$\alpha = -\ln K_{rec}$

Eq. (1) will plot as a straight line on semi-logarithmic graph paper provided K_{rec} for groundwater (K_{rb}) since, presumably, both interflow and surface runoff have ceased. By projecting this slope backyard in time and replotting the difference between the projected line and the total hydrograph, a recession which for a time consists largely of interflow is obtained. With the slope applicable to interflow thus determined, the process can be repeated to establish the recession characteristics of surface runoff.

5. Base flow separation

Base flow may be separated by any of the following three methods.

a. Straight line separation

In this method the separation of the base flow is achieved by joining with a straight line the beginning of the surface runoff to a point on the recession limb representing the end of the direct runoff. An empirical equation for the time interval N (days) from the peak to the point B is $N = 0.83A^{0.2}$ Where A = drainage area in km^2 and N is in days. Points A and B are joined by a straight line to demarcate to the base flow and surface runoff. It should be realized that the value of N obtained as above is only approximate and the position of B should be decided by considering a number of hydrographs for the catchment. This method of base flow separation is the simplest of all three methods.

b. Fixed base length separation

In this method the base flow curve existing prior to the commencement of the surface runoff is extended till it intersects the ordinate drawn at the peak (point C in Fig. 4). This point joined to point B by a straight line. Segment AC and CB demarcate the base flow and surface runoff. This is probably the most widely used base flow separation procedure.

c. Variable slope separation

In this method the base flow recession curve after the depletion of the flood water is extended backwards till it intersects the ordinate at the point of inflection (line EF in Fig. 4). Points A and F are joined by an arbitrary smooth curve. This method of base-flow separation is realistic in situations where the groundwater contributions are significant and reach the stream quickly. It is seen that all the three methods of base-flow separation are rather arbitrary. The selection of any one of them depends upon the local practice and successful predictions achieved in the past. The surface runoff hydrograph obtained after the base-flow separation is also known as direct runoff hydrograph (DRH).

6. Procedure

1. This experiment is done in the basic hydrologic system.
2. There is an artificial sand bed in the setup.
3. First artificial rainfall is created.
4. Reading of runoff starts at the beginning of rainfall.
5. Reading is recorded at every 10 second interval.
6. The rainfall will be stopped after 100 sec.
7. Reading is continued up to two consecutive readings become same.
8. The total hydrograph is then plotted in a plain graph paper.
9. The recession limb will be plotted on semi log paper.
10. A tangent is drawn at the constant value of the recession limb.
11. The slope of this tangent gives the recession constant for base flow (K_{rb}).
12. The ordinates of the tangent give the value of the base flow.
13. Now by subtracting the ordinates of this tangent from the total runoff we get the hydrograph for interflow and surface runoff.
14. If interflow is neglected i.e. taking the recession constant for interflow 1, then the surface runoff is calculated by subtracting the ordinate of base flow from the total hydrograph.

7. Assignment

1) What is surface run-off?

2) What is the time of concentration?

3) What is a synthetic unit hydrograph?

4) What is an S-curve?

5) Distinguish between lag time and time to peak.

6) Draw a neat figure of a hydrologic cycle and show the following in it:

a. Surface run-off

b. Ground water flow

c. Evaporation

d. Transpiration

Data Sheet

Hydrograph Analysis

Area of Watershed =

Duration of Rainfall=

Time	Discharge	Time	Discharge	Time	Discharge

Computation of Recession Constants

Time	Recorded hydrograph, Total runoff	Recession constant for base flow K_{rb}	Base flow	Surface runoff	Recession constant for surface runoff K_{rs}

Experiment No - 12

Visit to Watershed

Watershed

"Watershed can be defined as a unit of area which covers all the land which contributes runoff to a common point or outlet and surrounded by a ridge line". It is also known as catchment area or drainage area.

Watershed Management/development

Watershed management/development refers to the conservation, regeneration and judicious utilization and management of all natural resources like land, water, vegetation, animals and human being) within watershed, for achieving sustainable crop production and for the well-being of the people.

Main Objectives of Watershed Development Project

1. To control damaging runoff and degradation and conservation of soil and water.
2. To manage and utilize the runoff for useful purposes.
3. To protect, conserve and improve the land of watershed for more efficient and sustained production.
4. To protect and enhance the water resources originating in the watershed.
5. To check the soil erosion and reduce the effect of sediment yield on the watershed.
6. To rehabilitate the deteriorating lands.
7. To moderate the flood peaks at downstream areas.
8. To enhance the ground water recharge.
9. To improve and increase the production of timber and wild life resources.
10. To intensity agricultural extension activities.
11. To increase productivity per unit area

The watershed development Programme is directly related to socio economic condition of rural peoples. The upliftment of socio economic status of rural people is only the parameter which showing the positive effect of watershed development Programme.

The watersheds put under different land uses and land treatment produce different amount of runoff and soil loss. It is therefore essential to determine the efficiency of various soil and water conservation measures in controlling runoff and soil loss.

Evaluation of watershed development Programme is carried out by comparing the situation between the predevelopment conditions and post development conditions.

The visit should be arranged for study of watershed development work (soil and water conservation work) carried out in a watershed project with following objectives:

- Observation and technical data collection regarding different agronomical and engineering measures adopted in watershed. (Format).
- Socio-economic data collection (before and after w/s development project).
- Impact of soil and water conservation work on ground water recharging (through discussion), irrigated area (actual field visit) and socio-economic conditions of the watershed dwellers.

The format should be prepared for each watershed considering following points

Sr. No.	Particulars	Pre Watershed	Post Watershed
1.	Rainfall data		
2.	Runoff produced		
3.	Basic data		
	1.Area of watershed		
	a. Cultivable land		
	b. Non cultivable land		
	c. Forest land		
	d. Revenue land		
	e. Other land		
	ii. Population		
	a. Male		
	b. Female		
	c.Working population		
	iii. Live stock		
	a. Crossed breed		
	b. Indigenous		
	c. Sheep		
	d. Goats		
4.	Milk production		
5.	Nos. of wells and tube well		
6.	Avg. depth of water table below ground level		
7.	Area under SWC measure		
	Contour bunds		
	Farm bunds		
	Trenches (Contour/staggered)		
	Other measures		
8.	Check dams		
	Nos. of Temporary C.D		
	Nos. of Permanent C.D.		
	Nos. Of Nala bunds		
	Nos. of K.T.weir		
	Others		
9.	Land under irrigation		
	Seasonal		

	Perennial		
10.	Cropped area		
	Kharif		
	Rabi		
	Summer		
11.	Avg. yield of crop per unit area		
12.	Migration for employment		

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