MANUAL OF FLUID MECHANICS LABORATORY-II

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR, J&K, INDIA

Vision of the Institute

To establish a unique identity of a pioneer technical Institute by developing a high-quality technical manpower and technological resources that aim at economic and social development of the nation as a whole and the region, in particular, keeping in view the global challenges

Mission of the Institute

M1. To create a strong and transformative technical educational environment in which fresh ideas, moral principles, research and excellence nurture with international standards.

M2. To prepare technically educated and broadly talented engineers, future innovators and entrepreneurs, graduates with understanding of the needs and problems of the industry, the society, the state and the nation.

M3. To inculcate the highest degree of confidence, professionalism, academic excellence and engineering ethics in budding engineers.

Vision of the Department

To create a unique identity of the Department by achieving excellent standards of quality technical education keeping pace with the rapidly changing technologies and to produce Civil Engineers of global standards with the capability of accepting new challenges.

Mission of the Department

M1. To promote academic growth in the field of Civil Engineering by offering state-of-the-art undergraduate and postgraduate programmes.

M2. To provide knowledge base and consultancy services in all areas of Civil Engineering for industry and societal needs.

M3. To inculcate higher moral and ethical values among the students to become competent Civil Engineers with overall leadership qualities.

M4. To flourish as the Centre of Excellence in the emerging areas of research related to Civil Engineering and its allied fields.

Course Objectives

1. Experimentally observe the variation of resistance coefficient by varying wall roughness in pipes and open channels.
2. Obtain transverse velocity profiles in pipes and open channels and study the related phenomena.
3. Experimentally determine the energy loss through various pipe fittings.
4. Experimentally study the important characteristics of hydraulic jump.

Program Specific Objectives

1. Ability to demonstrate professional engineering approach, including application of principles and utilization of technical resources such as software's towards solving technical problems requiring civil engineering interventions.
2. Ability to furnish and/or analyze designs and construct structural systems, produce related documents, drawings and reports, and present objective estimates of the related quantities.
3. Ability to conduct field and laboratory investigations pertaining to civil engineering domain, and utilize modern tools and techniques of surveying.

Do's & Don'ts

Do's

4. Follow all safety rules strictly.
5. Before performing experiment read instrument manual carefully.
6. Count all accessories before receiving equipment's in the lab

7. All personal accidents, injuries and illness, however slight occurring in the laboratory must be immediately reported to the instructor
8. Ask lab instructor if you are not sure about what to do.
9. Results of experiments should be countersigned by the concerned faculty.
10. Personal items should be stored in proper areas.
11. Exercise caution when handling liquids in the vicinity of electrical equipment.
12. Notify the faculty in charge in advance for late hour working.
13. Return all equipment's and glassware to its original location after finishing all the lab work.
14. In case of fire alarm sounds, evacuate the building via nearest exit.
15. Maintain discipline while working in the lab.

Don'ts

1. Do not try to spill out the water or any other liquid from instruments.
2. Do not try to touch the mechanical parts of the equipment while in running condition.
3. Do not put your hands into running water during experimentation.
4. Do not remove experiments from cabinets without the permission of the instructor.
5. Do not leave the experiments running unattended.
6. Do not try yourself repair any faulty instrument.
7. Do not operate machine without permission.
8. Do not try to copy observations of experimentation of fellow students.
9. Do not put any hazardous material in to the running liquid of any equipment.
10. Do not take laboratory equipment, glassware outside the lab.

List of Experiments:

1. To find friction factor for pipes of different materials.
2. To determine the minor head loss coefficient for different pipe fittings.
3. To determine the surface profile and total head distribution of a vortex.
4. To determine the elements of a hydraulic jump in a rectangular channel.
5. To determine the Manning's rugosity coefficient of a laboratory flume.
6. To obtain the velocity distribution for an open channel and to determine the values of α, β and n.

List of Equipment

1. Pipe Friction Apparatus.
2. Losses in pipe and Bend Pipe Apparatus.
3. Free vortex Apparatus and Forced vortex Apparatus.
4. Tilting Flume; Dimensions: Length=24m, width =1m, depth = 30cm
5. Tilting Flume; Dimensions: Length = 7.50m, width = 30cm, depth =30cm
6. Tilting Flume with Length = 3.50
7. Hydraulic Jump Flume

Experiments

Experiment 1: To find friction factor for pipes of different materials.

Aim: To find friction factor for pipes of different materials.

Equipment: Pipes of 15mm dia of different materials viz. M.S., Stainless steel, Copper and Aluminum, manifolds together with means of varying flow rate, U-tube differential manometer, collecting tank.

Introduction and Theory: When liquid flows through a pipe under pressure, some head is lost in overcoming the friction between the pipe wall and flowing fluid. The frictional resistance offered to flow depends on type of flow. Mostly the flow of fluids in pipes lies in turbulent zone. On the basis of the experimental observations the laws of fluid friction for turbulent flow are as under:

The frictional resistance in the case of turbulent flow is

i) proportional to $(\text{velocity})^n$ where n varies from 1.72 to 2.0.

ii) independent of pressure.

iii) Proportional to density of flowing fluid.

iv) Slightly affected by variation of temperature of the fluid.

v) Proportional to area of surface in contact.

vi) Dependent on the nature of the surface in contact.

The generally accepted formula governing turbulent flow in pipes may be summarized as follows:

$$h_f = \lambda L V^2 / 2 gD$$

$$h_f = 8 \lambda LQ^2 / \pi^2 gD^5$$

Where λ is known as Darcy friction coefficient which is a dimensionless quantity, L is length of pipe, V is mean velocity of low in pipes, Q is discharge through pipe, g is acceleration due to gravity and D is diameter of the pipe.

Experimental Set up: The apparatus consists of a manifold through which four pipes of different materials, each of 15mm dia and made of M.S., stainless steel, copper and aluminum are provided with means of varying flow rate. Each pipe is connected to a common pipe to get discharge in each pipe. The pipes are provided with two pressure tapping ,0.6 meter apart. A U-tube differential manometer is provided to find the difference of head between two pressure tapings. The tapping may be connected to a manometer turn by turn. A collecting tank is used to find the discharge of water through the pipes.

Experimental Procedures:

Note down the relevant dimension as diameter and length of pipe between the pressure tapings, area of collecting tank etc. Pressure tapings of a pipe is kept open while for other three pipes it is kept closed. The flow rate was adjusted to its maximum value. By maintaining suitable amount of steady flow or near by steady flow in the pipe circuit, there establishes a steady non uniform flow in the circuit. Time is allowed to stabilize the levels in the two limbs of manometer.

The discharge flowing in the circuit is recorded together with the water levels in the two limbs of a manometer. The flow rate is reduced in stages by means of flow control valve and the discharge and readings of manometer are recorded.

This procedure is repeated by closing the pressure tapings of this pipe, together with other two pipes and for opening of another left pipe.

Observation and Computation Sheet:

Dia of Pipe D = 1.5cm

Length of pipe between pressure tapings L = 120cm

Area of collecting tank =

Material of pipe =

S.No.	Manometer Readings	Discharge Measurement	$\lambda = (\pi^2 gD^5/8LQ^2)h_f$

	Left Limb, h_1 (cm)	Right Limb, h_2 (cm)	Diff. of head in terms of water, h_f = $12.6(h_1 - h_2)$	Initial (cm)	Final (cm)	Time (s)	Discharge, Q (cm^3/s)	

Average friction factor, λ =

Further, the observations show that the coefficient λ is not a constant but its value depends on the roughness conditions of the pipe surface and the Reynolds no. of the flow

Precautions:

Apparatus should be in leveled condition.

Reading must be taken in steady or near by steady conditions. And it should be noted that water level in the inlet supply tank should reach the overflow condition.

There should not be any air bubble in the manometer. And check that with no flow in the pipe the initial difference of the water levels in the manometer limbs was observed to be zero.

Discharge must be varied very gradually from a higher to smaller values.

Experiment 2: To determine the minor head loss coefficient for different pipe fittings.

Aim: To determine the minor head loss coefficient for different pipe fittings.

Equipment: A flow circuit of 15mm dia with different pipe fittings as

i) Large bend

ii) Gate Value

iii) Sudden enlargement from 15mm dia to 25mm dia

iv) Globe value

v) Sudden contraction from 25mm dia to 15mm dia

vi) Small bend

With a means of varying the flow rate, u-tube differential manometer, collecting tank.

Introduction and Theory: In long pipes, the major loss of energy in pipe flow is due to friction while the minor loses are those which as caused on account of the change in the velocity of flowing fluid (either in magnitude or direction). Losses due to change in cross section, bends, valves and fittings of all types are categorized as minor losses. In short pipes, above losses may sometimes outweigh the friction losses.

The minor energy head loss hL in terms of the velocity head can be expressed as

$$h_L = k \;.\; v^2 \;/\; 2g$$

Where k is loss coefficient, which is practically constant at high Reynolds number for a particular flow geometry, v is velocity of flow in the pipe and g is acceleration due to gravity.

However, for sudden enlargement of the section , the simultaneous application of continuity, Bernoulli's and momentum equation shows that

$$h_L = k. \quad (v - v_1)^2 \;/\; 2g$$

Here v and v_1 are velocities of flow in the smaller and large diameter pipes respectively.

Experimental Set up: The experimental set up consists of a pipe circuit of 15mm dia fitted with following fittings with means of varying flow rate.

i.	Large beng	ii.	Gate Valve	iii.	Sudden enlargement
iv.	Globe valve	v.	Sudden contraction	vi.	Small bend

Pressure tapings are provided on upstream and down stream ends of each of these fittings to enable the measurement of pressure head difference across the fittings to compute the head loss through the fittings. The pressure tapings are connected to a differential manometer. A collecting tank is used to find the actual discharge of water through the pipe fittings.

Experimental Procedures:

Note down the relevant dimension of each individual fittings, area of collecting tank etc.

Pressure tapings of a fitting is kept open while for other fittings it is kept closed.

The flow rate was adjusted to its maximum value. By maintaining suitable amount of steady flow or near by steady flow in the pipe circuit, there establishes a steady non uniform flow in the circuit. Time is allowed to stabilize the levels in the two limbs of manometer.

The discharge flowing in the circuit is recorded together with the water level in the two limbs of a momometer. The flow rate is reduced in stages by means of flow control valve and discharge and readings of manometer are recorded.

This procedure is repeated by closing the pressure tapings of this fittings together with other fittings and for opening of another left fittings.

Observation and computation sheet:

1. Diameter of pipe = 15mm

2. Area of pipe a =

Area of collecting tank A =

Type of fitting:

S.No	Discharge Measurement				Manometer Reading			V = Q/a (cm/s)	Loss Coeff. ,k = (2g/ v^2). h_L
	Initial (cm)	Final (cm)	Time (s)	Discharge, Q (cm^3/s)	Left Limb, h_1 (cm)	Right Limb, h_2 (cm)	Diff. of Head, $h_L = 12.6(h_1 - h_2)$		

Average loss Coefficient, k =

Type of fitting; **Suden Enlargement**

1. Diameter of smaller pipe = 15 mm
2. Area of smaller pipe a=
3. Diameter of large pipe = 25mm
4. Area of bigger pipe a_1=
5. Area of collecting tank A=

S.No	Discharge Measurement	Manometer Reading	V = Q/a	V_1 = Q/a_1 (cm/s	Loss Coeff. ,k = [2g/(v –

								(cm/s)	)	$v_1)^2 . h_L$
	Initial (cm)	Final (cm)	Time (s)	Discharge, Q (cm^3/s)	Left Limb, h_1 (cm)	Right Limb, h_2 (cm)	Diff. of Head, $h_L = 12.6(h_1 – h_2)$			

Average loss coefficient k =

Experiment 3: To determine the surface profile and total head distribution of a vortex.

FREE VORTEX:

Aim: To plot the surface profiles of a free vortex by measurement of the surface profile coordinates and to show that the total energy is constant throughout the vortex.

Equipment : Open Perspex cylinder stationary about its vertical axis, pointer gauge and graduated carriage.

Introduction and Thoery: If a fluid is allowed to rotate freely, i.e., is subjected to any external force, the streamline will form concentric circles. This type of flow is known as free vortex and is an example of irrotational flow.

In real fluids, whirl pools , tornadoes, flow around channel bends and motion around the drain hole of a wash basin approximate to free vortex flow.

If the fluid is assumed to be ideal, the total energy head for all the streamlines will be the same.

$$Z_2 - Z_1 = \frac{v_1{}^2}{2g}\left[1 - \left(\frac{r_1}{r_2}\right)^2\right]$$ or in other words v.r = constant

where Z_1 , Z_2 = Elevations of streamlines (1) and (2) on the water surface above datum.

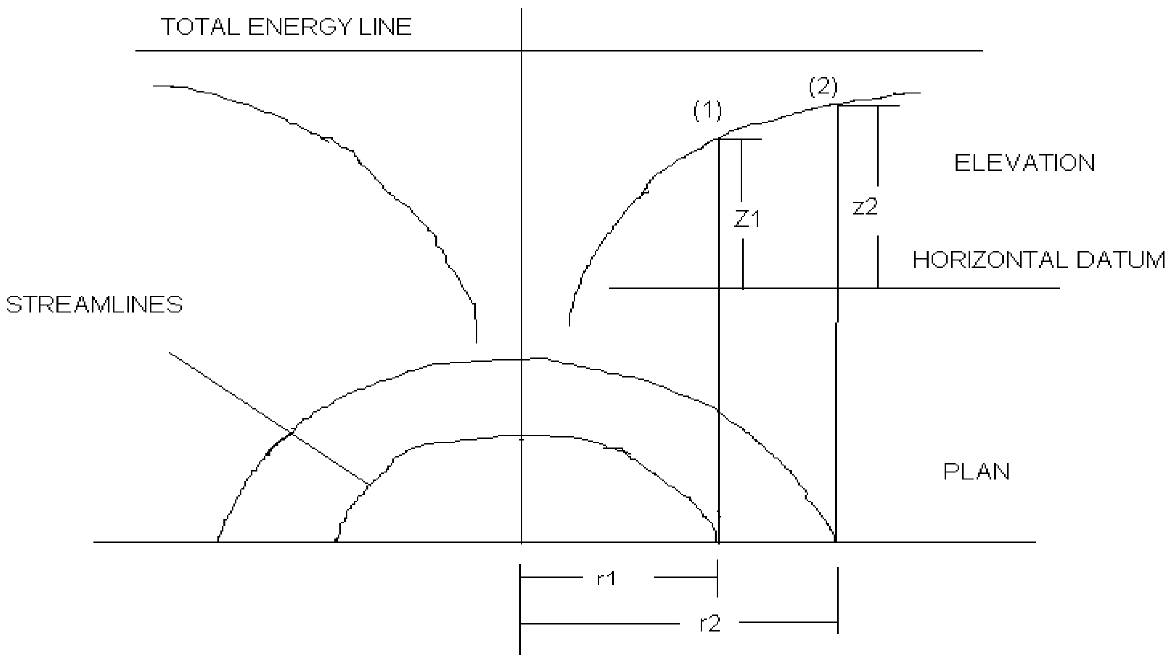
V_1 = velocity of vortex at streamline (1)

r_1 , r_2 = radii of (1 and 2) from the centre of the vortex.

Theoritically it can be proved that the surface profile is asymptotic to the total energy line and to the vertical axis of the vortex.

Experimental Setup: The experimental set-up consists of a circular cylindrical tank around which four circumferential jets have been placed along the inner circumference of the cylinder near its bottom, which helps in the formation of free vortex.(It is assumed that the torque exerted by these jets is negligible).

A pointer gauge on graduated carriage is provided to measure the depth of vortex formation at various points.



FREE VORTEX

Experimental Procedure:

The water supply was admitted to the Perspex cylinder through the four circumferential jets. By maintaining suitable amount of steady flow in the cylinder, the depth of flow at any particular point was observed not to change over a period of time. The resulting water surface profile is recorded by traversing the pointer gauge across a radius of the cylinder which represents the variation of the sum of the pressure head and the datum head. The surface profile at the centre of the vortex that is at $r = 0$ were taken as the datum of all subsequent readings.

Observations and Computation Tables:

Reading of carriage when pointer is at center of the cylinder, r_0 =

Reading of pointer at datum, Z_0 =

Reading of carriage, r_1	Reading of pointer, Z_1	$r = r_1 - r_0$	$Z = Z_1 - Z_0$	$\frac{v^2}{2g} = \frac{(Z_2 - Z_1)}{1 - \left(\frac{r_1}{r_2}\right)^2}$	$Z + \frac{v^2}{2g}$

Graph to plot : Plot a graph between r vs Z.

Comment: Small increase in $Z + \frac{v^2}{2g}$ is expected near periphery of the cylinder due to torque applied by the jets which is assumed as negligible.

FORCED VORTEX:

Aim: To determine the surface profile and total head distribution of a vortex.

Equipment: Perspex cylinder free to rotate about its vertical axis, variable speed controller cum A.C. to D.C. converter to rotate the cylinder, v belt , pointer gauge mounted on graduated carriage, , D.C motor.

Introduction and Theory: For a constant speed of rotation ω,

$$V = \omega .\ r$$

Where r = radius V = velocity of flow at the radius

If the horizontal plane passing through the lowest point r of the vortex is taken as datum, theory shows that

$$Z = \omega^2 r^2/2g \text{ and } H = \omega^2 r^2/g$$

where Z = distance to surface profile above horizontal plane passing through lowest point of the vortex.

H = total energy head above horizontal plane passing through the lowest point of the vortex.

Experimental Procedure: Water was poured into the cylinder until it was approximately half to two thirds full. The cylinder was rotated at a constant speed. The free surface of water takes the form of a forced vortex. By maintaining suitable amount of steady flow in the cylinder and the depth of flow at any particular point was observed not to change over a period of time. The resulting water surface profile is recorded by traversing the pointer gauge across a radius of cylinder. Also the tangential velocities at different radial distances are measured with the help of a miniature current meter/pitot-tube. The surface profile at the centre of the vortex i.e., r = 0 were taken as datum for all subsequent readings. The speed of rotation of the cylinder was measured.

Observations and Computation Sheet:

No. of revolutions =

Time =

Angular velocity ω = ($2\pi \times$ No. of revolutions) / time (in rad/sec.)

Pointer Gauge reading at centre of cylinder, Z_0 =

Reading of carriage with pointer at the centre, r_0 =

Reading of the carriage, r_1 (cm)	Radius $r = r_1 - r_0$ (cm)	r^2 (cm^2)	Pointer Gauge reading, Z_1 (cm)	$Z=Z_1 - Z_0$ (cm)	$Z = \omega^2 r^2/2g$	Currentmeter/ pitot-tube reading, (cm)	$H=\omega^2 r^2/g$

Graph to Plot: The surface profile and variation in total energy head with radius is plotted in graphical form i.e., plot Z vs r and H vs r .

Plot Z vs r^2 and H vs r^2 and obtain the slopes of these two lines and thus obtain the value of $\omega^2/2g$ and ω^2/g and calculate the values of the angular speed and compare these values with the observed value of ω

Precautions: Reading must be taken in steady or nearby steady condition.

There should not be any air bubble in the pitot tube.

Holes of pitot-tube must be free from dust and be kept open.

While taking reading for surface profile the travel of pointer gauge should be kept small.

Experiment 4: To determine the elements of a hydraulic jump in a rectangular channel.

Aim: To determine the elements of a hydraulic jump in a rectangular channel.

Introduction :

A hydraulic jump occurs in an open channel when the flow changes from super-critical to sub-critical. The water level abruptly rises at the hydraulic jump. A large number of rollers or turbulent eddies are formed at the hydraulic jump, which causes dissipation of energy. Hydraulic jumps are created in various hydraulic structures, such as spillways, falls, etc., to dissipate excess energy so that the channel bed is not eroded.

The hydraulic jump is analyzed by applying the impulse momentum equation to control volume.

Experimental Setup:

The set-up consists of a rectangular tilting flume having gates at the inlet and exit. The water is supplied to the flume from an overhead tank. A sluice gate is provided near the upstream end of the flume to create supercritical flow conditions on its downstream so that a hydraulic jump can form. The depth of flow on the downstream is controlled by exit gate.

A pointer gauge trolley can move on the rails on the top of the side walls for the measurement of water depth.

A large measuring tank is provided for the collection of water and to compute the discharge.

Introduction and Theory:

The depth y_1 before hydraulic jump and the depth y_2 after the hydraulic jump (called conjugate or sequent depths) for a horizontal rectangular channel are related as:

$$\frac{y_2}{y_1} = \frac{1}{2}\left[-1+\sqrt{1+\frac{8q^2}{g{y_1}^3}}\right] \qquad (1)$$

$$\frac{y_2}{y_1} = \frac{1}{2}\left[-1 + \sqrt{1 + 8F_1^{\ 2}}\right] \tag{2}$$

where q = discharge per unit width = Q/B

F_1 = Initial Froude No. = $\frac{v_1}{\sqrt{gy_1}} = \frac{q}{\sqrt{gy_1^{\ 3}}}$

The loss of energy in the hydraulic jump is given by:

$$\Delta E = E_1 - E_2$$

$$\Delta E = \left(y_1 + \frac{v_1^{\ 2}}{2g}\right) - \left(y_2 + \frac{v_2^{\ 2}}{2g}\right) \text{ or } \Delta E = \frac{(y_2 - y_1)^3}{4y_1y_2}$$

where E_1 , E_2 are the specific energies before and after the jump, v_1, v_2 are the mean velocities before and after the jump

Height of the jump , h_j = $(y_2 – y_1)$

Length of the Jump, L_j = 5 to 7 $(y_2 – y_1)$

Procedure:

1. Measure the width of the flume. Take the pointer gauge reading at the bed of the flume at suitable sections upstream and downstream of the hydraulic jump.
2. Open the supply valve, and adjust the inlet and exit gates so that the flow becomes uniform and steady.
3. Gradually lower the sluice gate and adjust the exit gate so that a stable hydraulic jump forms on the downstream of the sluice gate.
4. Collect water in the large measuring tank for a suitable time period, and note the rise in water level.
5. Take the pointer gauge readings of the water surface to measure the depths y_1 and y_2.
6. Repeat steps 3 to 5 for different discharges.

Observations and Calculations:

Width of the flume B =

Area of the collecting tank, A =

Discharge Measurement:

S.No.	Discharge Measurement			
	Initial water level in tank (cm)	Final water level in tank (cm)	Time Taken (Sec)	Discharge (cm^3/s)
Average Discharge, Q				

S.No	Discharge, Q	Pointer gauge reading U/S			Pointer gauge reading D/S			$\frac{y_2}{y_1}$	$v_1 = \frac{Q}{By_1}$	$F_1 = \frac{v_1}{\sqrt{gy_1}}$	$E_1 = \left(y_1 + \frac{v_1^2}{2g}\right)$	v_2	E_2	ΔE	h_j
		At bed, G_0	At water surface, G	$y_1 = (G-G_0)$	At bed, G_{01}	At water surface, G_1	$y_2 = (G_1-G_{01})$								
1															
2															
3															
4															
5															
6															

Height of the jump , h_j = $(y_2 - y_1)$

Graphs to plot:

1. Plot $\frac{y_2}{y_1}$ vs F_1 on an ordinary graph paper, with F_1 as abscissa. Also draw the line representing the theoretical relation Eq. (2). Note the scatter on the observed data.
2. Plot $\Delta E/E_1$ vs F_1 on an ordinary graph paper, with F_1 as abscissa.
3. Plot h_j/E_1 vs F_1 on an ordinary graph paper, with F_1 as abscissa.

Experiment 5: To determine the Manning's rugosity coefficient of a laboratory flume.

Aim: To determine the Manning's rugosity coefficient of a laboratory flume.

Equipment: 30 cm wide tilting flume with arrangements to measure discharge. Apointer gauge mounted on top rails for the measurement of depth of flow. A gate valve to regulate inflow into the flume.

Theory:

The resistance of rigid boundary channels under uniform flow conditions is given by Manning's equation:

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

where , Q = Discharge in m^3/s

A = Area of cross section of flow in m^2

R = A/P = hydraulic mean radius in m

S = Longitudinal bed slope

n = Manning's rugosity coefficient and depends upon the nature of the channel boundary.

Procedure:

1. Allow the water supply into the flume by opening the valve of inlet pipe.
2. Let the flow become stedy-state.
3. Measure the depth of flow with the help of pointer gauge, in the portion of flume where the flow is uniform.
4. Measure the discharge.
5. Determine the slope of the channel bed.
6. Repeat steps 2 to 4 for different discharges by regulating the inlet valve.

Observations and Computations:

Width of the flume B = 30 cm

Longitudinal slope S =

Pointer gauge reading w.r.t. channel bed, h_0 = (   ) cm

S.No	Discharge, m^3/s	Pointer gauge reading w.r.t. water surface, h_1 (cm)	Depth of flow $h=(h_0-h_1)$ cm	Area $A=B\times h$ cm^2	P=B+2h cm	R=A/P cm	$n = \frac{A}{Q} R^{2/3} S^{1/2}$
1							
2							
3							
4							
5							
6							
Average, n							

Discharge Measurement:

Areaa of collecting tank, A = ( ) cm^2

S.No	Water levels of collecting tank		Difference, $h=(h_2 - h_1)$ (cm)	Volume, $V=A\times h$	Time reqd. to raise w.L. from h_1 to h_2 . t (sec)	Q= V/t (cm^3/s)
	Initial, h_1 (cm)	Final, h_2 (cm)				
1						
2						
3						
Average , Q						

Experiment 6: To obtain the velocity distribution for an open channel and to determine the values of α, β and n.

Aim: To obtain the velocity distribution for an open channel and to determine the values of α,β and n .

Introduction:

The velocity varies over the cross section of an open channel. The velocity distribution curve is required for the study of many open channel flow problems such as computation of discharge , mean velocity, Manning's n, energy correction factor α, and the momentum correction factor β.

The velocity at any point is generally measured with a pitot-static tube or a velocity meter, and is given by

$$v = C\sqrt{2g(l\sin\theta)\left(\frac{\rho_m}{\rho_w}-1\right)}$$

where

C is the coefficient of the pitot-static tube (=1.0)

l is the deflection of the manometer

θ is the inclination of the manometer tubes.

ρ_m and ρ_w are the densities of the manometer liquid and water, respectively.

The set-up consists of a rectangular tilting flume. The water is supplied from an overhead water tank through a 100 mm diameter pipe. Gates with rack and pinion arrangement are provided at the inlet and exit sections for controlling the flow. The inlet portion of the flume is provided with the baffle walls (or honey comb walls) to calm the flow. The flume is provided with rails on top of the side walls on which a trolley can move to and fro. The pitot-static tube (if provided) and the pointer gauge are provided on the trolley. The flume can be tilted with a screw jack provided for this purpose to give the required slope. For the measurement of discharge a large collecting tank is provided at the downstream end of the flume.

Introduction and Theory:

The discharge Q can be computed from the velocity distribution curve as

$$Q = \int v\,dA = B\int v\,dy$$

where B = width of the flume

Thus the discharge can be computed as

$$Q = B\Sigma v\Delta y = B \times (\text{the area of the velocity diagram})$$

The mean velocity V can be computed as

$$V = \frac{Q}{A} = \frac{B\Sigma v\Delta y}{B \times Y} = \frac{(\text{area of the velocity diagram})}{Y}$$

where Y = depth of flow

From the Manning's formula

$$V = \frac{1}{n}R^{2/3}S^{1/2}$$ where n is the Manning's coefficient

R = Hydraulic radius = $\dfrac{A}{P} = \dfrac{BY}{B+2Y}$

S = Bed slope

For glass n is about 0.010

The kinetic energy correction factor α is given by

$$\alpha = \frac{\int v^3 dA}{V^3 A} = \frac{\Sigma v^3 \Delta y}{V^3 Y} = \frac{(\text{area of } v^3 \text{ diagram})}{V^3 Y}$$

The momentum correction factor (β) is given by

$$\beta = \frac{\int v^2 dA}{V^2 A} = \frac{\Sigma v^2 \Delta y}{V^2 Y} = \frac{(\text{area of } v^2 \text{ diagram})}{V^2 Y}$$

The value of α for the turbulent flow is generally from 1.05 to 1.40

The value of β for the turbulent flow is generally from 1.01 to 1.20

Procedure:

1. Measure the width of the flume.

2. Take the pointer gauge reading (G_0) when the point just touches the bed of the flume. Open the sluice valve at the inlet. Adjust the flow by using the gate at the exit till it becomes uniform and steady.
3. Take the pointer gauge at the water surface to determine the depth of flow (Y).
4. The width of the flume is divided into segments of equal width (b) for the measurement of velocity. Because of symmetry the measurements may be taken only on the segments on one side of the centre line.
5. Bring the pitot-static tube trolley (or place the current meter) over the centerline of the segment no.1. Take the manometer reading(l) (or velocity meter readings) and the pointer gauge readings at 8 to 10 points between the bed and water surface.
6. Shift the trolley to the centre of the other segments, one by one, and repeat step 5.
7. Measure the discharge by noting the water level rise in a collecting tank, and recording the area of collecting tank and time taken for the level rise.
8. Repeat steps 2 to 8 for different discharges.

Observations and Computations:

Temperature of water =

Inclination of manometer attached to the pitot-static tube (θ) =

Pointer Gauge reading when the point touches the bed (G_0) =

Diameter of the pitot-static tube, (d) =

Width of the flume, (B) =

No. of segments, =

Width of each segment, (b) =

Discharge Measurement:

Area of collecting tank, A = ( ) cm^2

S.No	Water levels of collecting tank		Difference, $h=(h_2 - h_1)$ (cm)	Volume, $V=A\times h$	Time reqd. to raise w.L. from h_1 to h_2 . t (sec)	Q= V/t (cm^3/s)
	Initial, h_1 (cm)	Final, h_2 (cm)				
1						
2						

3						
Average , Q						

Depth of flow:

Pointer Gauge at the water surface (G) =

Depth of flow, $Y = G - G_0$ =

Velocity Measurement:

S.No.	Gauge Reading, (G)	Depth, y	Velocity			
			Segment,1	Segment,2	Segment,3	Segment,4
1						
2						
3						
4						
5						
6						
7						

Graphs to plot:

1. Plot v vs y curve for each segment.
2. Plot v^2 vs y curve for each segment.
3. Plot v^3 vs y curve for each segment.

Compute mean velocity, V = (area of v-y plot)/Y

V_1 = , V_2 = , V_3 = , V_4 = , Average V =

Compute momentum correction factor, (β) = (area of v^2-y plot)/ Y

β_1 = , β_2 = , β_3 = , β_4 = , Average β =

Compute energy correction factor, α = (area of v^3-y plot)/Y

α_1 = , α_2 = , α_3 = , α_4 = , Average α =

Discharge Q = BYV

Compare this discharge with the measured discharge.

Manning's n

$$n_1 = \frac{R_1^{2/3} S^{1/2}}{V_1}, \quad n_2 = \frac{R_2^{2/3} S^{1/2}}{V_2}, \quad n_3 = \frac{R_3^{2/3} S^{1/2}}{V_3}, \quad n_4 = \frac{R_4^{2/3} S^{1/2}}{V_4},$$

Average , $n = \dfrac{n_1 + n_2 + n_3 + n_4}{4}$ Alternatively, average , $n = \dfrac{R^{2/3} S^{1/2}}{V}$

Results:

Average value of α =

Average value of β =

Average value of n =

Precautions:

1. Make sure that the pointer gauge and the pitot-static tube are on the vertical line at the centre of the segment.
2. The flow should remain steady and uniform.
3. There should be no air bubbles in the tubes of the manometer. Take the manometer readings when there are no fluctuations of the liquid surface.
4. The tip of the pitot-tube must face the direction of flow.