BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY .

WRE - 302
Open-Channel Hydraulics

Experiment No. : 05

Name of the Experiment: Flow Through a Cut-throat Flume.

Date of Performance : 01-02-14
Date of Submission : 08-02-13

Name : MD. Raiful Islam.
Student ID : 1016022
Level : 3 ; Term : I
Department : WRE

Upstream depth of flow, Ha (m) →

Objective:

- To determine the theoretical discharge at free flow condition.
- To determine the submergence ratio and to check the effect of submergence.
- To determine the value of coefficient of discharge.
- To verify the value of C and n.

Experimental Setup:

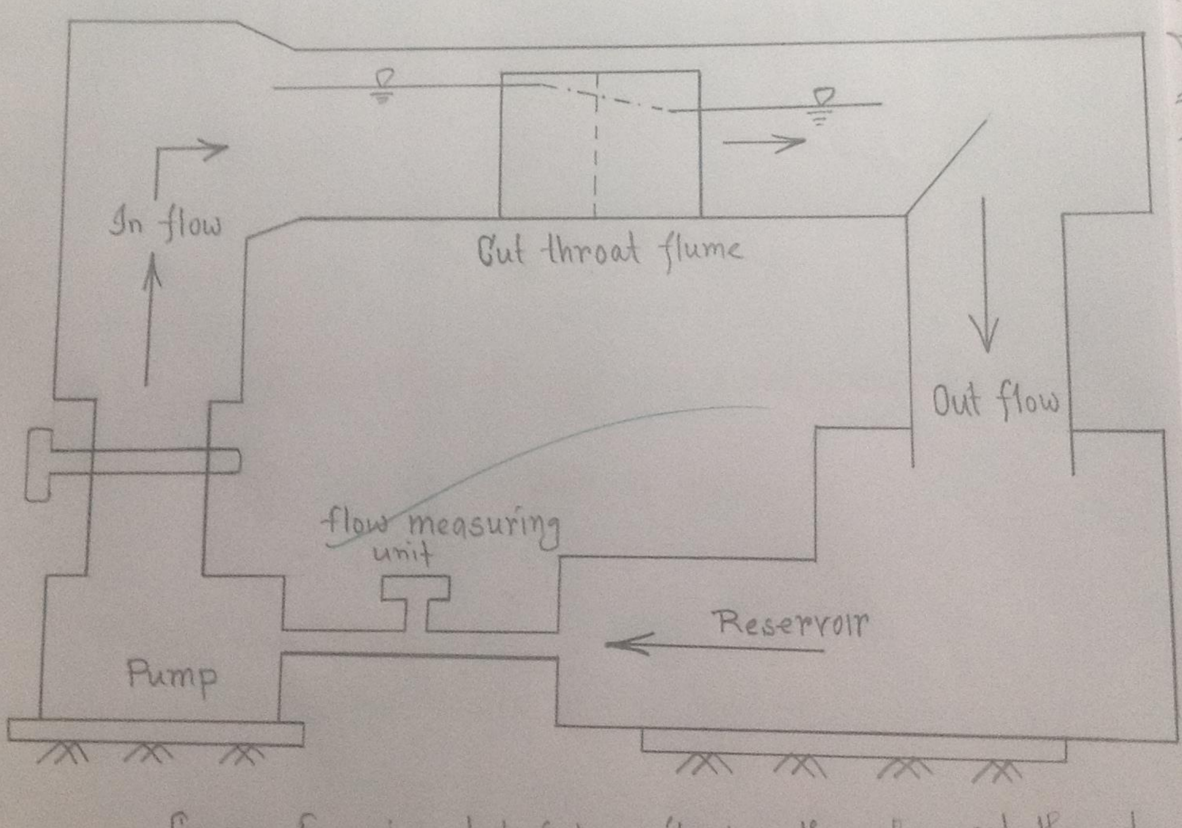

figure: Experimental Setup flowing through a cut throat flume.

Upstream depth of flow, Ha (m) →

Related formula :

The theoretical discharge throgh a Cut throat flume in free flow condition is given by

$$Q_{tf} = C H_a^n$$

where, C = free flow coefficient

H_a = upstream flow depth

n = flow exponent.

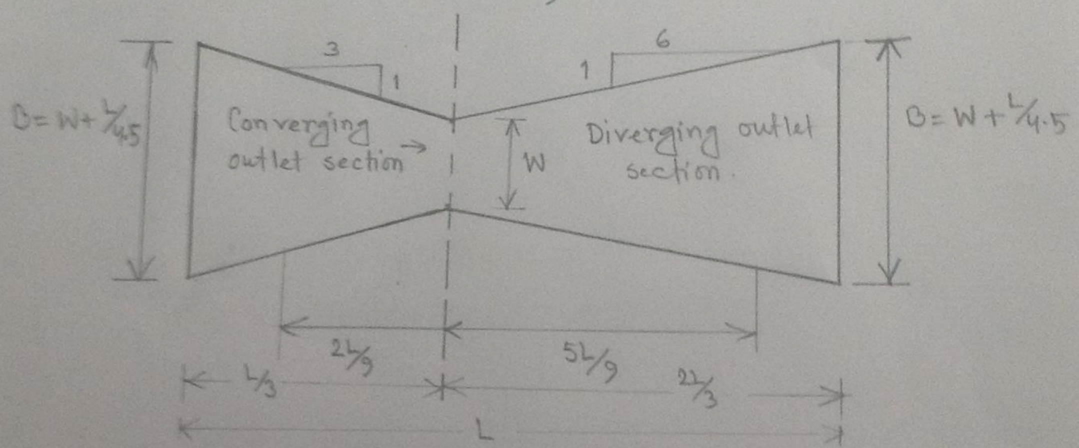

figure : flow through Cut throat flume

Again, free flow co-efficient is given by

$$C = KW^{1.025}$$

where, K = flume length coefficient.

W = the width of the throat

Upstream depth of flow, H_a (m) →

Submergence ratio is given by $\frac{H_b}{H_a}$

where, H_a = flow depth at upstream section

H_b = flow depth at downstream section.

if $H_b/H_a \leq 60$; it is free flow condition

$H_b/H_a > 60$; it is submerged flow condition.

Coefficient of discharge, C_d is the ratio of actual discharge to the corresponding theoretical discharge. Therefore,

$$C_d = \frac{Q_a}{Q_{tf}}$$

where, Q_a = Actual discharge.

Q_{tf} = Theoretical discharge.

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St. ID - 1016022

5.9 Data sheet:

Throat width, W= 0.205 m m^3/s

Actual discharge, Q_a = 0.07167 m^3/sec.

Flume length, L= 0.90 m

K= 3.7 n= 1.84 S_t= 65%

H_a m	Q_{tf} m^3/s	C_{df}	H_b m	Submergence Ratio H_b/H_a	Comments on submergence
0.296	0.0776	0.923	0.0909	0.307	free flow Condition

Verification of C and n

Actual discharge ,Q_a (m^3/s)	H_a (m)
0.097	0.3570
0.0885	0.3385
0.0807	0.3165
0.07167	0.2960
0.1110	0.3858

01.02.14

Upstream depth of flow, Ha (m) →

Data Sheet for Calibration Curve:

Calibration Equation: $Q_a = 0.65 * H_a^{1.794}$

where, $0 \leq H_a \leq 18$ (inch)
45.72 (cm)

Upstream depth of flow, H_a (m)	0	0.09	0.18	0.27	0.36	0.4572
Actual discharge Q_a (m^3/sec)	0	0.0086	0.0299	0.062	0.104	0.1596

Sample Calculation:

Flume length coefficient, $K = 3.70$

Flow exponent, $n = 1.84$

free flow coefficient, $C = K W^{1.025}$

$$= 3.70 * (0.205)^{1.025}$$

$$= 0.729$$

Theoretical discharge, $Q_{if} = C H_a^{n}$

$$= 0.729 * (0.296)^{1.845}$$

$$= 0.07761 \text{ m}^3/\text{sec}$$

$$= 0.0776 \text{ m}^3/\text{sec.}$$

Coefficient of discharge, $C_d = \frac{Q_a}{Q_{if}}$

$$= \frac{0.07167}{0.0776}$$

$$= 0.923$$

Submergence ratio, $\frac{H_b}{H_a} = \frac{0.0909}{0.296}$

$$= 0.307$$

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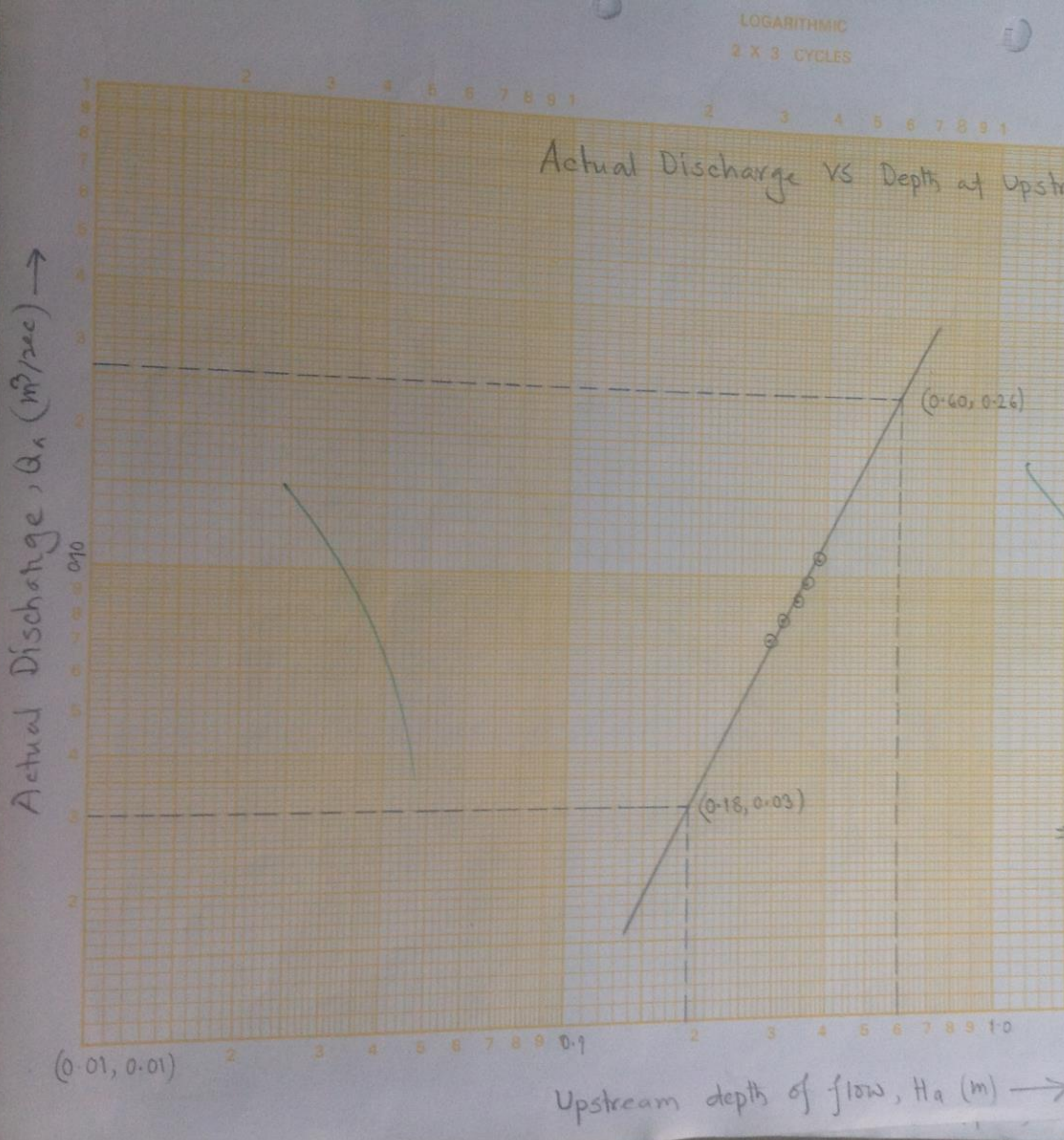

$$n = \frac{\log 0.26 - \log 0.03}{\log 0.60 - \log 0.18}$$

$$= 1.794$$

$$C_1 = \text{antilog}(\log 0.26 - 1.794 \times \log 0.60)$$

$$= 0.65$$

$$C_d = \frac{Q_a}{Q_{tf}} = \frac{Q_a}{KW^{1.025} \times H_a^{n}}$$

$$= \frac{0.26}{3.7 \times (2.03)^{1.025} \times (.60)^{1.84}}$$

$$= \frac{0.26}{0.284} = 0.9129$$

$$C_1 = C \cdot C_d$$

$$\Rightarrow C = \frac{C_1}{C_d} = \frac{0.65}{.9129} = 0.712$$

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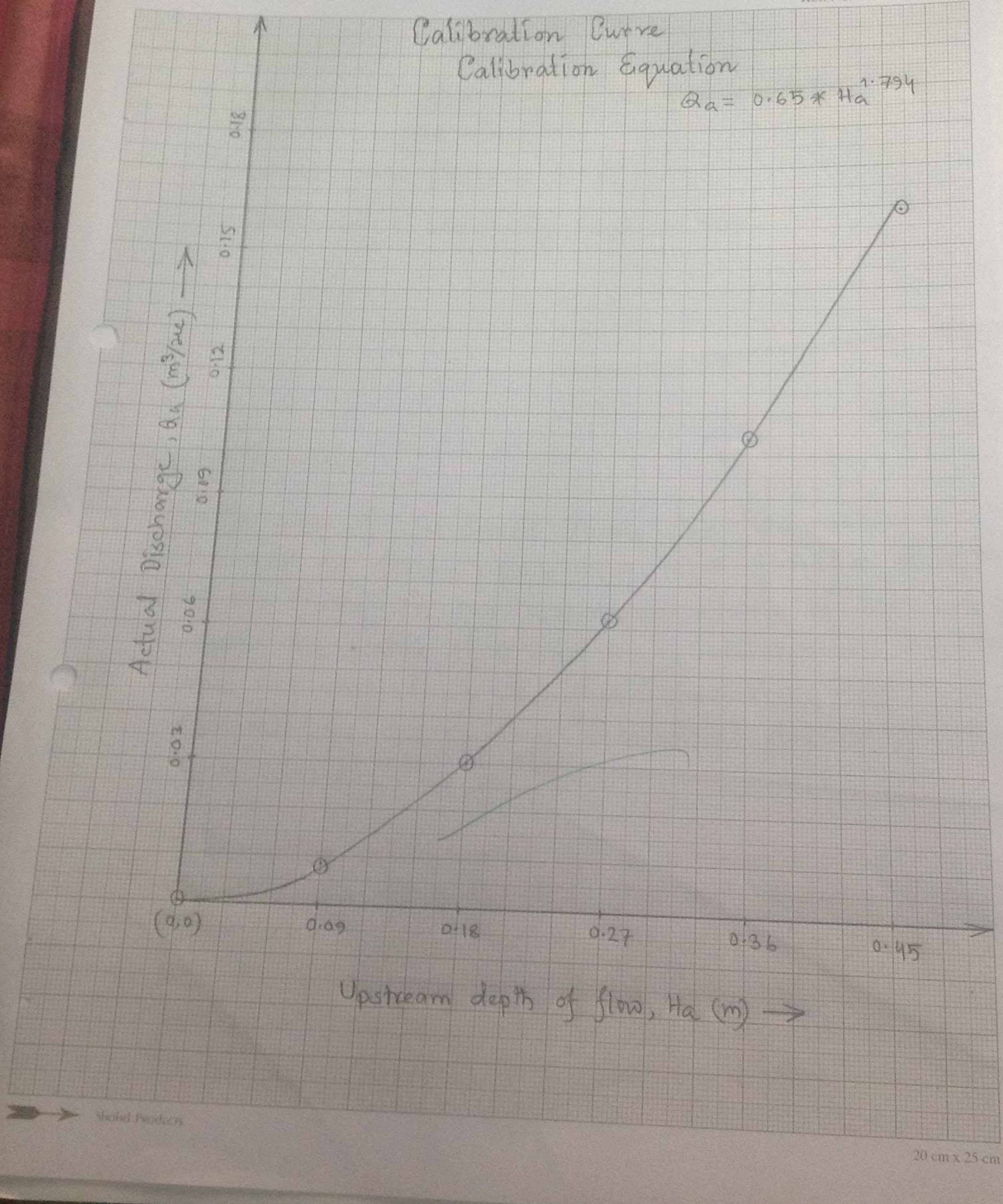

Shield Products

20 cm x 25 cm

Result :

- Theoretical discharge of the flow condition.
  $Q_{tf} = 0.0776 \ m^3/sec.$
- Submergence ratio = 0.307;
- Coefficient of discharge, $Cd = 0.923$

Discussion :

- In case of cut throat flume the flow coefficien, c as well as flow exponent, n is a function of length of the flume. for our laboratory flume of 20.5 cm length, the value of c and n is determined as .729 and 1.84 respectively. Therefore establishing empirical equation for determining theoretical discharge is $Q_{tf} = 0.729 * H_a^{1.84}$.

- Transition submergence, S_t is a measurement of wheather the flow is free flow or submerged flow. When submergence (i.e transition submergence) cross 60% the flow condition turned into submerged flow from free flow. The transition submergence is found to be 65%, therefore it is submerged flow condition.

- Submergence ratio for the flowing condition yeilds a value of 0.307. Therefore, there was large difference between the upstream and downstream depth of flow.

- Coefficient of discharge which is the ratio of actual discharge to the theoretical discharge was found 0.923. It simply recognize arround 7% of the theoretical discharge is unattainable due to head loss.

- A set of data containing the value of actual discharge and upstream depth of flow were used to plot a log-log graph. This graphical analysis produce a straight line. The slope of this line gives the value of flow exponent n to be 1.794. This value is slightly deviated from the empirically evaluted value of 1.84

- Variation in the value of the coefficient of discharge Cd was noticable (e.g $C_d = 0.923$ from experiment, $C_d = 0.912$ from graph). It is because graphical value exhibits an average.

- flow coefficient C was 0.729 which was empirically evaluted. It was reduced to a value equal to 0.712 which was found from the graph. Therefore, these two value converge into the acceptable range.

- Calibration equation thus establish as $Q_a = 0.85 * H_a^{1.794}$ which is valid in the range $0 \leq H_a \leq 45.72$ (cm).

- Calibration curve is convex to the origin, passing through the origin as well. It significanty expren actual discharge will increasengly increase with the increase of upstream depth of flow.

- Cut throat flume contains a converging outlet section followed by diverging outlet section. The slope of convergence is $1/3$ whereas the slope of divergence is $1/6$. The gentle slope of divergence enhance the flume to eliminate eddi energy loss due to the formation of eddi or separation of the streamline.

- By analyzing fronde number, subcritical flow was occurred at upstream (i.e $Fr < 1$) which was followed by supercritical flow at downstream (i.e $Fr > 1$)

Assigned Question :

Q.1 What are the advantages, disadvantages and uses of cut throat flume?

* Advantages :

- it can be fabricated in a wide variety of materials including cast in concrete, steel sheet as per design requirement.

- flow tables are available for a number of standard sizes.

- All flume dimension are proprotional and can be increase or decrease as required to satisfy special application requirements.

- the flat bottom allows the flume to be easily placed into existing channel with reduced excavation or construction cost.

- the absence of a raised or descending throat section help to reduce the upstream pool depth.

- Two or more cut throat flumes installed parallel to one another can be used very effectively for flow proportioning. which is common at the entrance to rectangular basins, lagoon diversion structures, race-way and other places where one flow stream must be split into two or more equally divided streams.

* Disadvantages:

- Changes in channel width relative to the throat width and overall flume length can affect the accuracy of flow readings.
- In earthen channels, upstream bypass and downstream scour may occur.
- Cut throat flume with throat widths below 3-inch in size should not be used on unscreened sanitary flows due to the likehood of clogging.

* Uses:

- it is used to measure the flow of surface waters, sewage flow and industrial discharge.
- used in straight sections of small irrigation channels for flow measuring purpose.

Q.2 Among the four measuring devices, viz, Broad crested weir, Venturi flume, Parshall flume and Cut throat flume, which device seems to be best in an irrigation project of Bangladesh? Justify your answer.

Most of the irrigation project of Bangladesh contains earthen channel. In case of the use of broad crested weir for water supply with sediment there will be deposition of sediment in the upstream of the structure. Thus creating a dead water zone, ultimately making the structure ineffective.

In case of venturi flume difference between upstream and downstream is relatively small. So, we can not be able to increase irrigation area in case of low water head using such structure. Although Parshall flume gives very accurate measurement, it needs well fabrication which is very tough in the context of our country. The Cut throat flume is an attempt to improve on the Parshall flume mainly by simplifying the construction details. So the flume is economic and normally used in straight sections of small irrigation channels there will be deposition of sediment in the upstream of the structure. Thus creating a dead water zone, ultimately making the structure ineffective.

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WRE - 302
Open-Channel Hydraulics

Experiment No.: 01

Name of the Experiment: Determination of State of Flow in Open Channel .

Date of Performance :16-11-13
Date of Submission:23-11-13

Name: MD. Raiful Islam.
Student ID : 1016022
Level :3 ; Term : I
Department : WRE

Objective :

(i) To measure water depth at both up-stream (u/s) and down-stream (d/s) of a weir.

(ii) To determine the Reynolds number (Re) and Froude number (Fr).

(iii) To determine and observe the state of flow.

(iv) To determine critical depth of the flow.

(v) To observe the subcritical and supercritical flow.

Experimental Setup :

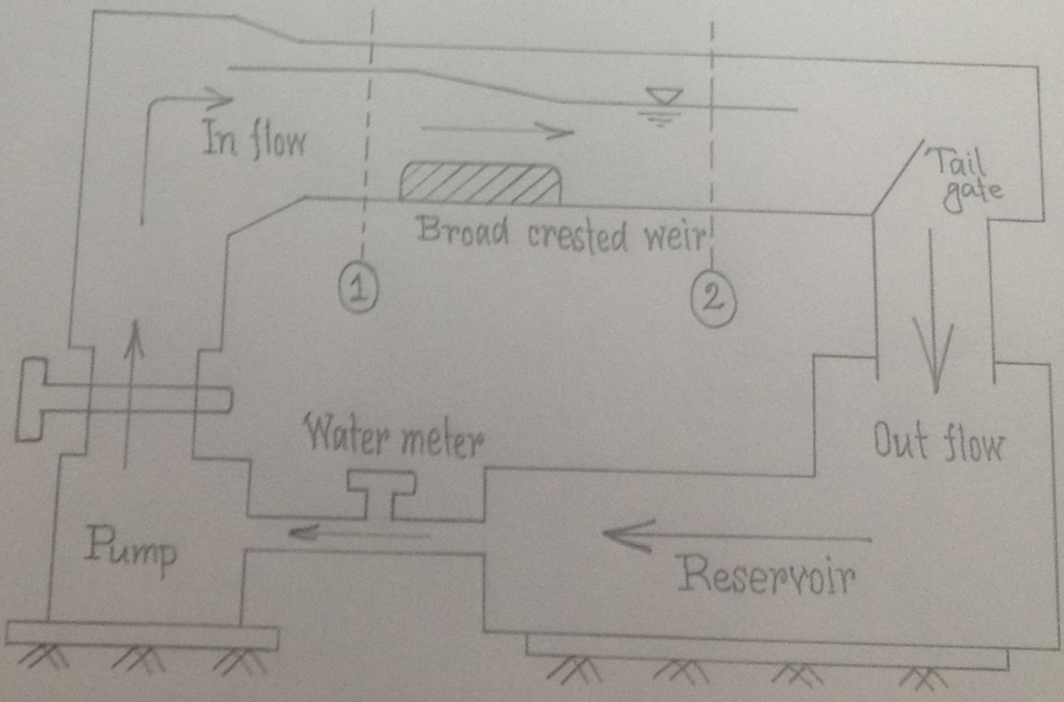

Figure: Schematic diagram of experimental setup.

Related formula:

Sate of flow in an open channel is based on the combined effect of viscosity and gravity. The effect of viscosity relative to the inertia is expressed by Reynolds number. Therefore,

$$\text{Reynolds number, } R_e = \frac{\text{Inertia force}}{\text{Viscous force}} = \frac{F_I}{F_V}$$

Here, $F_I = ma$
$= \rho L^3 \cdot L/T^2$
$= \rho V^2 L^2$

$F_V = \mu \frac{du}{dy}$
$= \mu (V/L) L^2$

On Simplification, $R_e = \frac{VL\rho}{\mu}$
$= \frac{VL}{\nu}$
$= \frac{VR}{\nu}$ [In case of Open Channel L=R

where,

V = Mean velocity

R = Hydraulic radius $= \frac{A}{P}$

A = Wetted area

P = Wetted perimeter

ν = Kinematic viscosity of water.

When, $R_e < 500$; the flow is laminar

$500 < R_e < 12500$; the flow is transitional

$R_e > 12500$; the flow is turbulent

Again, the effect of gavity relative to the inertial force is expresset by the froude number. Therefore,

$$\text{froude number, } f_r = \sqrt{\frac{\text{Inertia force}}{\text{Gravitational force}}}$$

$$= \sqrt{\frac{f_I}{f_G}}$$

Here, $f_I = ma$

$= \rho V^2 L^2$

$f_G = mg$

$= \rho L^3 g$

On simplification, $f_r = \sqrt{\frac{V^2}{gL}}$

$$= \frac{V}{\sqrt{gD}}$$

where,

V = Mean velocity

g = Gravitational acceleration

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$= \rho L^3 g$

On simplification, $f_r = \sqrt{\frac{v^2}{gL}}$

$$= \frac{V}{\sqrt{gD}}$$

where,

V = Mean velocity

g = Gravitational acceleration

D = Hydraulic mean depth = $\frac{A}{T}$

A = Wetted area

T = Top width

When, $F_r > 1$; the flow is supercritical.

$F_r = 1$; the flow is critical.

$F_r < 1$; the flow is subcritical.

Critical depth is the depth at which the velocity is such that the froude number is equal to unity for a given discharge and channel section.

Putting $F_r = 1$ in the previous expression of the froude number we get,

$$F_r = 1 = \frac{V}{\sqrt{gD}}$$

$$\Rightarrow \frac{V^2}{2g} = \frac{D}{2} \quad \text{---(i)}$$

Again, $V = \frac{Q}{A}$

$= \frac{Q}{By_c}$

where, Q = Discharge

Therefore, equation (i) reduces to-

$$\frac{Q^2}{B^2 y^2 g} = \frac{A}{T}$$

$$\Rightarrow \frac{Q^2}{B^2 y^2 g} = \frac{By}{B}$$ [In case of rectangular channel, $T = B$

$$\Rightarrow y^3 = \frac{Q^2}{B^2 g}$$

$$\Rightarrow y_c = \sqrt[3]{Q^2/gB^2}$$ [at critical point $y = y_c$

$$\therefore y_c = \sqrt[3]{Q^2/gB^2}$$

where, y_c = critical depth

B = Width of the channel.

Q = Discharge

St. ID- 1016022
Group-4

1.8 Data sheet:

Determination of state of flow and critical depth

Discharge, Q= 0.0156 m^3/s Flume width, B= 0.3048 m

Critical depth, y_c= 0.0644 m Temperature, = 25.6 °C

ν= 0.87896×10^{-6} m^2/s

Section	Depth of flow y (m)		Area A=B y (m^2)	Perimeter P=(B+2y) (m)	Hydraulic Radius R=A/P (m)	Hydraulic Depth D=A/T (m)	Velocity V=Q/(By) (m/s)	Froude number F_r	Reynolds number R_e	State of flow
1	0.1995 0.1995 0.1995	0.1995	6.08×10^{-2}	0.7036	0.0863	0.1995	0.257	0.183	25233	Subcri. turbulent
2	0.0364 0.0443 0.0372	0.03946	1.2×10^{-2}	0.3637	0.0313	0.0394	1.30	2.09	46293	Super Critical turbulent

Rahat
16.11

Sample Calculation:

Obtained values:

Discharge, $Q = 0.0156\ m^3/sec$

flume width, $B = 0.3048\ m$

Kinematic viscosity, $\nu = 0.87896 \times 10^{-6}\ m^2/sec$

(at temperature 25.6°c)

Calculation is provided for section-1

Depth of flow, $y = \frac{19.95 + 19.95 + 19.95}{3}\ cm$

$= 19.95\ cm$

$= 0.1995\ m$

Wetted area, $A = By$

$= 0.3048 \times 0.1995\ m^2$

$= 0.06081\ m^2$

Wetted perimeter, $P = (B + 2y)$

$= 0.3048 + 2 \times 0.1995$

$= 0.7038\ m$

Hydraulic Radius, $R = A/P$

$= \frac{0.06081}{0.7038}$

$= 0.0864\ m$

Hydraulic depth, $D = \frac{A}{T}$

$$= \frac{A}{B}$$

$$= \frac{0.06081}{0.3048}$$

$$= 0.19951 \text{ m}$$

Velocity, $V = \frac{Q}{By}$

$$= \frac{0.0156}{0.3048 \times 0.1995}$$

$$= 0.2565 \text{ ms}^{-1}$$

Froude number, $F_r = \frac{V}{\sqrt{gD}}$

$$= \frac{0.2565}{\sqrt{9.81 \times 0.19951}}$$

$$= 0.18337 < 1$$

Reynolds number, $R_e = \frac{VR}{\nu}$

$$= \frac{0.2565 \times 0.0864}{0.87896 \times 10^{-6}}$$

$$= 25213.43$$

$$= 25214$$

Critical depth calculation :-

Critical depth, $y_c = \sqrt[3]{\frac{Q^2}{gB^2}}$

$= \sqrt[3]{\frac{(0.0156)^2}{9.81 \times (0.3048)^2}}$

$= 0.06439 \text{ m}$

$= 6.44 \text{ cm}$

Result :

(i) At section-1 : $F_r = 0.183$ and $R_e = 25233$; So the state of flow is subcritical turbulent.

(ii) At section-2 : $F_r = 2.09$ and $R_e = 46,293$; So the state of flow is supercritical turbulent.

(iii) Critical depth for the given channel (flume) is found to be 0.0644 m or 6.44 cm.

Discussion:

- Construction of any hydraulic structure need to investigate the state of flow i.e flow behaviours where it would be constructed. That is the practical application of this experiment.
- The section of critical depth is the boundary line of subcritical and supercritical zone.
- Reynold number at section 1 and 2 is found to be 25,233 and 46293 respectively indicating that the flow of the flume at both section is turbelent
- Critical depth for the given condition is found to be 6.44 cm which implies at this section frondian number is equal to unity.
- Creating a disturbance by a small particle and by the obzervation of wave propagation subcritical and supercritical was physically identified.
- At upstream fronde number is found 0.183 indicates subcritical flow wheather the value was 2.09 at downstream indicates supercritical flow.

Need to improve the discussion quality.

Assignment Question :

Q.1 Why the state of flow and critical depth of a river to be determined ?

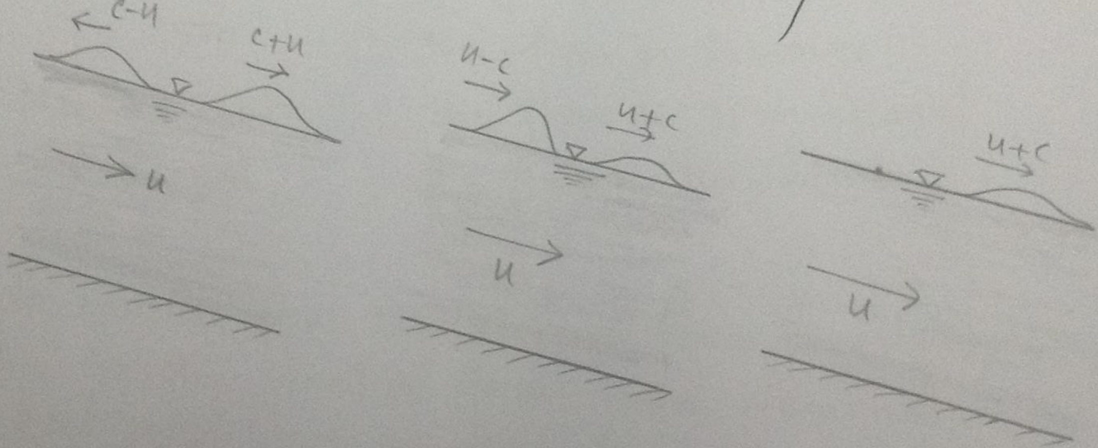
The state of flow is very important as the flow behaviour is dependable on it. In order to construct different structures in rivers and canals and to predict the river response the state of flow must be known. Determination of critical depth is also useful in determining different flow phenomena.

At subcritical zone fluid is flown with velocity less than the wave velocity and hydraulic structures constructed in this part is less vulnarable than the supercritical zone.

Q.2 How you can determine that the flow in a river is subcritical, critical or supercritical without taking any measurement ?

Supercritical flow normally occurs downstream of a sluice gate and at the feet of drops and spillways. flow upstream of a hydraulic jump is supercritical and downstream of a jump is subcritical.

In an open channel, a small-amplitude wave can be easily produced by gently throwing a small object in water. In subcritical flow, one wave front propagates upstream at a velocity (c-u) and the other wave front propagates downstream at a velocity (U+c). In supercritical flow, both the wave front propagate downstream at velocities (U-c) and (u+c). In critical flow, one wave remains stationary and the other moves downstream at velocity (U+c).



(a) Subcritical
$Fr<1$; $u<c$

(b) Supercritical
$Fr>1$; $u>c$

(c) Critical
$Fr=1$; $u=c$

Therefore, by observing an elementary wave wheather it propagates upstream against the flow remains stationary or propagates downstream can be used to physically identify the state of flow.

Q.3 Reynolds number and froude number which one is more significant in determining flow behaviour of a river? why?

River flow exhibits one kind of open-channel flow where fronde number is more significant than Reynolds number.

Based on Reynolds number Open-channel flow are of following types:

$Re < 500$; the flow is laminar
$500 < Re < 12500$; the flow is transitional
$Re > 12500$; the flow is turbulent

In laminar flow the viscous force are very strong relative to the inertial force and dominate the flow. But most open channel flows including those in rivers and canals are turbulent. The Reynolds number of most open channel flow is high of the order of 10^6, indicating that that viscous force are very weak relative to the inertial fore therefore, do not play a significant role in determining the flow behaviour.

Depending on the effect of gravity classification is as follows: Subcritical ; $Fr < 1$
Critical ; $Fr = 1$
Supercritical ; $Fr > 1$

Generally the flow in most rivers and canals is subcritical. Since the state of open channel flow is primarily governed by the gravity force relative to the inertial force, froude number is the most important parameter to indicate state of flow. Again the froude number of open channel flows varies a wide range covering both subcritical and supercritical flows.

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Refference:

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   — MD. Abdul Halim
2. Open-Channel Hydraulics (Chapter-4)
   — Ven Te Chow.
3. flow in Open-Channel
   — K. Subramanya
4. link: www.utexas.edu/1805_s.pdf
   en.wikipedia.org/wiki/Hydraulics.

BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY .

WRE - 302

Open-Channel Hydraulics

Experiment No. : 02

Name of the Experiment: FLOW OVER A BROAD CRESTED WEIR .

Date of Performance : 23-11-13

Date of Submission : 18-01-14

Name: MD. Raiful Islam.

Student ID. : 1016022

Level : 3 ; Term : I

Department : WRE

Objective:

(i) To determine the theoretical discharge of the weir.

(ii) To measure the actual discharge and hence to find out the coefficient of discharge.

(iii) To calibrate the weir.

Experimental Setup:

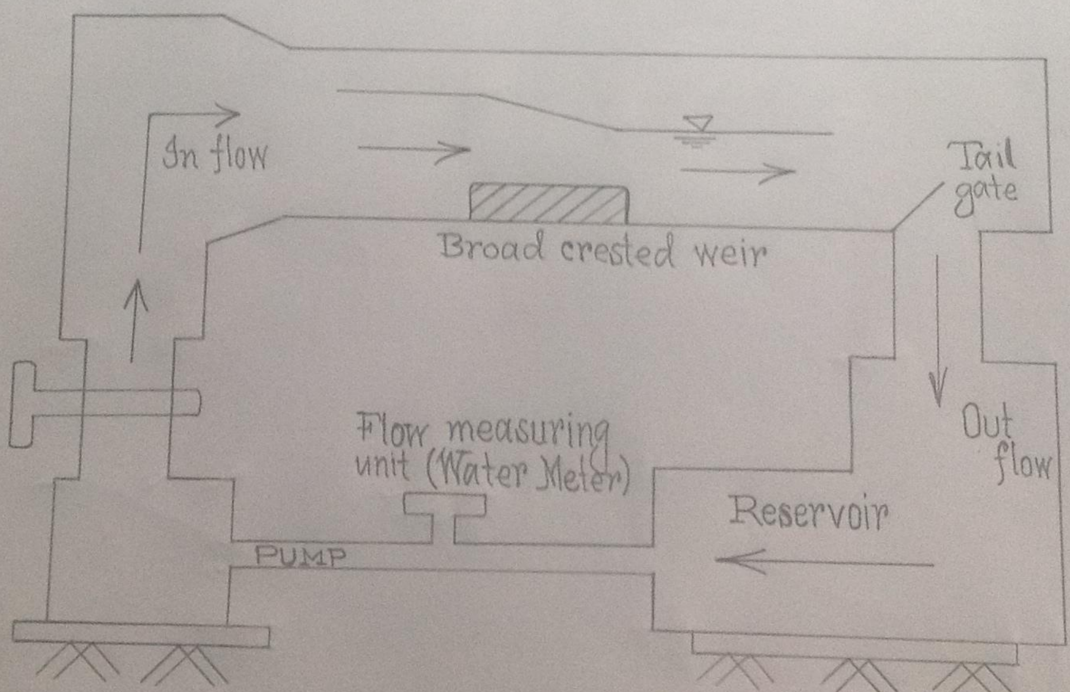

Figure: Set up for flow over a broad-crested weir

Related formula:

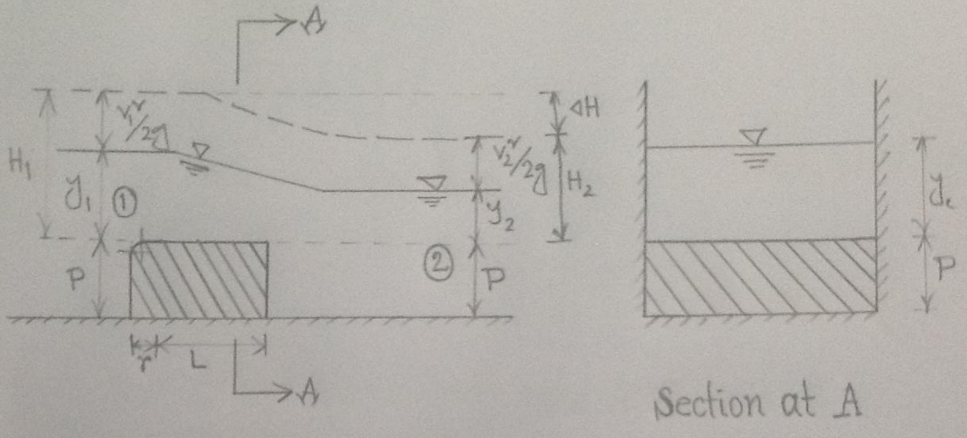

Figure: Flow over a broad-crested weir.

Applying Bernoulli's theorem in between section 1 and 2 we get-

$$z_1 + \frac{P_1}{\gamma} + \frac{v_1^2}{2g} = z + \frac{P}{\gamma} + \frac{v^2}{2g} \quad \text{------ (i)}$$

Let, $H_1 = y_1 + \frac{v_1^2}{2g}$

$$H = y + \frac{v^2}{2g}$$

$$\therefore v = \sqrt{2g(H_1 - y)}$$

Therefore, theoretical discharge

$$Q_t = Av$$

$$= A\sqrt{2g(H_1 - y)} \quad \text{------ (ii)}$$

Provided the critical flow occurs at control section (at $y = y_c$), then

$$Q_t = A\sqrt{2g(H_1 - y_c)}$$
$$= By_c\sqrt{2g(H_1 - y_c)}$$

Again from the relationship between total head and depth of flow we get,

$$H = \tfrac{3}{2} y_c$$

where, H = total head at any point.
y_c = Critical depth

Therefore, theoretical discharge,

$$Q_t = B\,\tfrac{2}{3}H_1\sqrt{2g(H_1 - \tfrac{2}{3}H_1)}$$
$$= B\,\tfrac{2}{3}H_1\sqrt{\tfrac{2}{3}gH_1}$$
$$= (\tfrac{2}{3})^{1.5}\sqrt{g}\,BH_1^{1.5}$$

Coefficient of dischange: is the ratio of actual dischage to the theoretical discharge which is given by

$$C_d = \frac{Q_a}{Q_t}$$

$$\therefore Q_a = C_d(\tfrac{2}{3})^{1.5}\sqrt{g}\,BH_1^{1.5} \text{------ (iii)}$$

Since in a field installation it is not possible to measure the energy head, H_1 directly eq^n (iii) is relate to the upstream depth of ~~f~~ flow over the crest, y_1 in the following way-

$$Q_a = C_v C_d \left(\frac{2}{3}\right)^{1.5} \sqrt{g}\, B y_1^{1.5}$$

where, C_v is the coefficient of velocity whose affect is considered in C_d. So, finaly

Actual discharge, $Q_a = C_d \left(\frac{2}{3}\right)^{1.5} \sqrt{g}\, B y_1^{1.5}$

Theoretical discharge, $Q_t = \left(\frac{2}{3}\right)^{1.5} \sqrt{g}\, B y_1^{1.5}$

Calibration Equation:

$$Q_a = C_d \left(\frac{2}{3}\right)^{1.5} \sqrt{g}\, B y_1^{1.5}$$
$$= K y_1^n$$

where, $K = C_d \left(\frac{2}{3}\right)^{1.5} \sqrt{g}\, B$

In case of fitting a straight line in log-log paper eq^n will reduces to

$$\log Q_a = n \log y_1 + \log K$$

the slope of the line will give the value of n like wise

$$n = \frac{\log Q_a(1) - \log Q_a(2)}{\log y_1(1) - \log y_1(2)}$$

where, 1,2 denotes two different points on the straight line.

$$k = \text{antilog}\,(\log Q_a - n \log y_1)$$

$\therefore$ Coefficient of discharge, $C_d = \dfrac{k}{(2/3)^{1.5}\sqrt{g}\,B}$

In case of regression:

Let, $\log Q_a = Y$, $\log y_1 = X$, $\log k = K$

Therefore, $Y = K + nX$

Then,

$$n = \frac{N(\Sigma XY) - (\Sigma X)(\Sigma Y)}{N(\Sigma X^2) - (\Sigma X)^2}$$

$$K = \frac{\Sigma Y - n\,\Sigma X}{N}$$

Where, N = Numbers of data.

So, $k = \text{antilog}\ K$

The correlation coefficient r is given by,

$$r = \frac{N(\Sigma XY) - (\Sigma X)(\Sigma Y)}{\left(\sqrt{N(\Sigma X^2) - (\Sigma X)^2}\right)\left(\sqrt{N(\Sigma Y^2) - (\Sigma Y)^2}\right)}$$

Where, $0 < r \leq 1.0$

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2.9 Data sheet:

Length of the weir, L= 0.3048 m   Width of the weir (or flume), B= 0.3048 m

Depth of water over weir crest (m)		Theoretical discharge Q_t (m^3/s)	Actual discharge Q_a (m^3/s)	Coefficient of discharge C_d
0.1093	0.1093	0.0188	0.0182	0.97
0.1093				
0.1093				

Calibration of weir:

i)By eye estimation(Should be done by students having odd student number)::

Actual discharge ,Q_a (m^3/s)	Depth of water above weir crest, y_1 (m)
0.0140	0.0939
0.0229	0.1254
0.0208	0.1184
0.0182	0.1093
0.0161	0.1019

ii)By regression(Should be done by students having even student number):

y_1	Q	X=log y_1	Y=log Q	XY	X^2
0.0939	0.0140	−1.02733	−1.85387	1.904536	1.05541
0.1254	0.0229	−0.90170	−1.640165	1.478936	0.81306
0.1184	0.0208	−0.92665	−1.681936	1.558567	0.85868
0.1093	0.0182	−0.96138	−1.739939	1.672743	0.92425
0.1019	0.0161	−0.99183	−1.793174	1.778524	0.98373
	Summation	ΣX= −4.80889	ΣY= −8.709084	ΣXY= 8.39331	ΣX^2= 4.63513

[illegible]
23.11.13

Depth of water over weir crest, y_1 (m) →

Data Sheet for Calibration Curve:

Calibration equation: $Q_a = 0.485\, y_1^{1.467}$

range of data: $0 \leq y_1 \leq 20.32$ (cm)

Depth of flow, y_1 (m)	0	0.03	0.06	0.09	0.12	0.15	0.2032
Discharge Q_a (m^3/sec)	0	0.00283	0.0078	0.0142	0.0216	0.03	0.0468

Sample Calculation:

Length of the weir, $L = 0.3048$ m

Width of the weir, $B = 0.3048$ m

Depth of water over weir crest

$$y_1 = \frac{0.1093 + 0.1093 + 0.1093}{3}$$

$$= 0.1093 \text{ m}$$

Theoretical dischange,

$$Q_t = \left(\tfrac{2}{3}\right)^{1.5} \sqrt{g}\, B\, y_1^{1.5}$$

$$= \left(\tfrac{2}{3}\right)^{1.5} * \sqrt{9.81} * 0.3048 * (0.1093)^{1.5}$$

$$= 0.01877 \text{ m}^3/\text{sec}$$

$$= 0.0188 \text{ m}^3/\text{sec.}$$

Coefficient of dischange,

$$C_d = \frac{Q_a}{Q_t}$$

$$= \frac{0.0182}{0.0188} = 0.9692$$

Calibration of the weir:

$$n = \frac{N(\Sigma XY) - (\Sigma X)(\Sigma Y)}{N(\Sigma X^2) - (\Sigma X)^2}$$

$$= \frac{5 \times \overset{8.39331}{\cancel{7.69342}} - (-4.80889) * (\overset{-8.709084}{\cancel{-7.953796}})}{5 \times 4.63513 - (4.80889)^2}$$

$$= 1.703$$

Calculation of graph:

value of exponent, $n = \dfrac{\log(0.028 \div 0.005)}{\log(0.15 \div 0.042)}$

$= 1.467$

$K = \text{antilog}(\log Q_1 - n \log y_1)$

$= \text{anti log}(\log 0.03 - 1.467 * \log 0.15)$

$= 0.485$

Coefficient of discharge, $C_d = \dfrac{K}{(2/3)^{1.5} * \sqrt{gB}}$

$= \dfrac{0.485}{(2/3)^{1.5} * \sqrt{9.81 * 0.3048}}$

$= 0.93$

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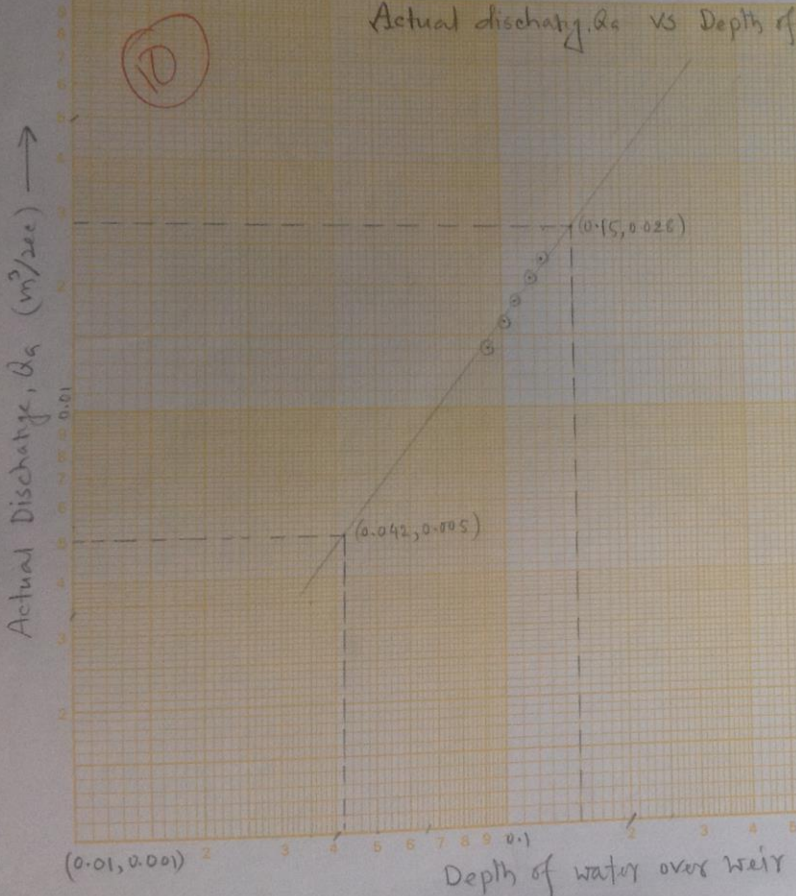
Actual discharge, Q_a vs Depth of water, y_1 Graph



$$n = \frac{\log(0.028 \div 0.005)}{\log(0.15 \div 0.042)}$$
$$= 1.467$$

$$K = \text{antilog}(\log Q_a - n \log y_1)$$
$$= \text{antilog}(\log 0.03 - 1.467 \times \log 0.15)$$
$$= 0.485$$

$$C_d = \frac{K}{(2/3)^{1.5} \times \sqrt{g}\, B} = \frac{0.485}{(2/3)^{1.5} \times \sqrt{9.81} \times 0.3048}$$
$$= 0.93$$

Group No. 04
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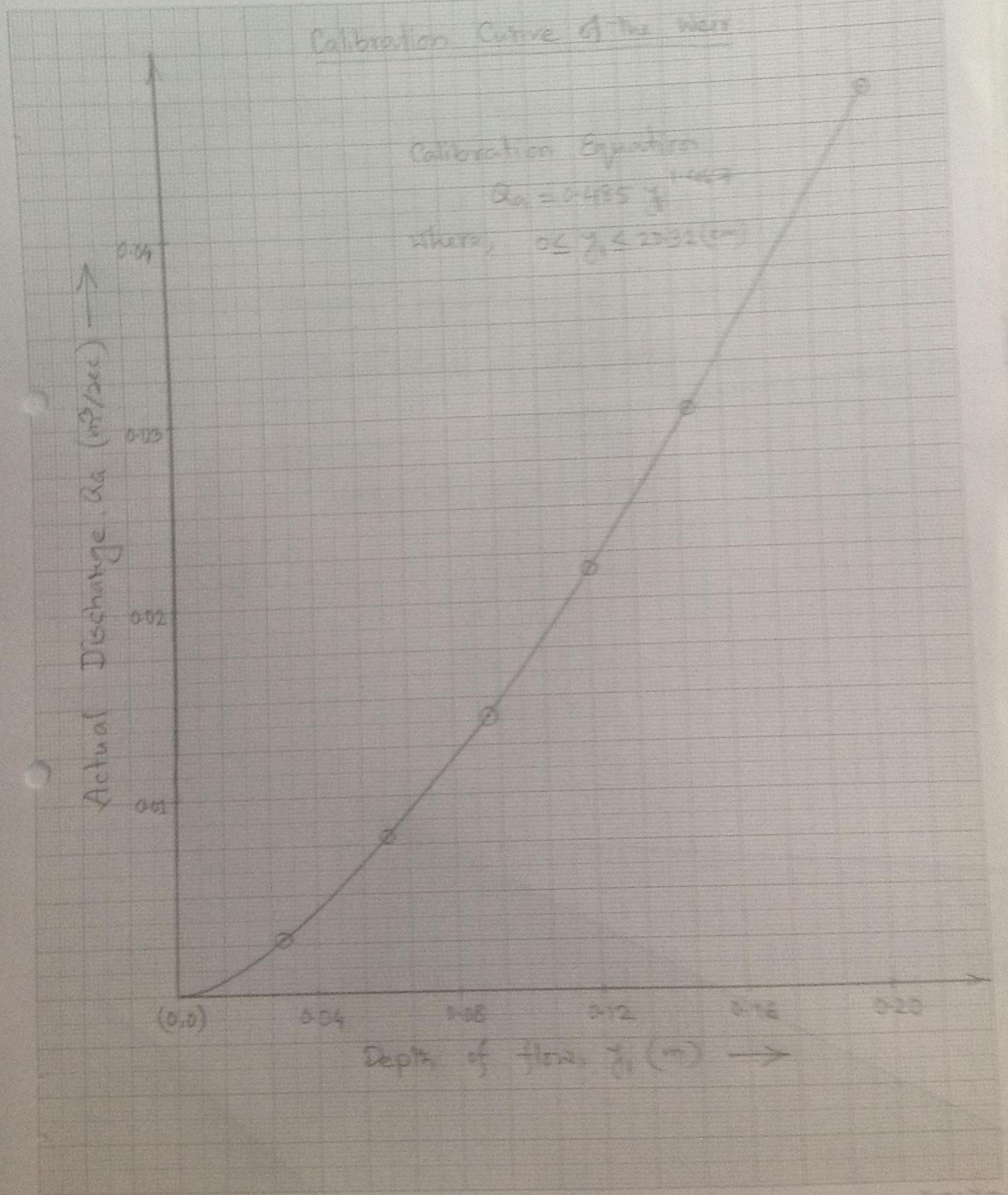


Result :

Experiment : Theoretical discharge, $Q_t = 0.0188\ m^3/sec.$

Actual discharge, $Q_a = 0.0182\ m^3/sec.$

Coefficient of discharge, $C_d = 0.97$

Calibration Curve : equation $Q_a = 0.485\, h^{1.467}$

Coefficient of discharge, $C_d = 0.93$

Regression anklysis :

value of $n = 1.703$

$r = ?$

Discussion :

- Theoretical discharge and actual discharge are found 0.0188 and 0.0182 respectively. Actual discharge is less than the value of theoretical discharge. It is because of energy loss (e.g friction) in the direction of flow.

- Coefficient of discharge, Cd is found to be 0.97 i.e the ratio of actual discharge to the corresponding theoretical discharge is equal to 0.97.

- Calibration of the weir gives the value of coefficient of discharge equal to 0.93.

- Value of Cd obtained from the calibration graph is less than the value obtained from the particular experiment. It is because graphical value gives somewhat an average.

- Calibration of the weir exhibits an calibration equation of $Q_a = 0.485 y_1^{1.467}$.

- The value of the exponent y_1 is found to be 1.467 which is nearly close to the ideal value of 1.50.

- for this particular broad-crested weir value of H_1/L is equal to $\frac{0.1093}{0.3048} = 0.358$ which is in between the design range $0.07 \leq H_1/L \leq 0.5$. Thats why we have neglected the effect of energy loss over the weir and the curvature of the streamline.

- Regression analysis gave the value of n equal to 1.703, this value is not in the acceptable range.

- Calibration curve obtained from the equation $Q_a = 0.485 y_1^{1.467}$ passes through the origin which significantly expres discharge is actually zero at the zero depth of flow.

- Calibration curve is of concave in shape i.e actual discharge increase exponentially (increasingly increase) with the increase of depth of flow.

Depth of water at upstream, y_1 (m) →

Assigned Question :

Q.1 What are the advantages, disadvantages and uses of broad crested weir ?

* Advantages of broad crested weir :

- Not complicated in shape.
- Low cost implementation (structural modification)
- Low need for drop in water level before and after the weir.
- Easy checking of the measurement precision.
- Lower requirements for the ~~et~~ calming of the velocity field.

* Disadvantage :

- Difficult prefabrication.
- Ramp flumes can be used with sufficient precision only for the pretreated waste water.
- Each weir is original with its own project
- Accurate hydraulic calculation and accurate construction is required.
- for water supply with sediment, there will be deposition in the upstream of the structure.
- The upstream water depth will be somewhat higher than it was without the structure.

* Uses of broad crested weir :

- Measuring the discharge of rivers.
- Using in irrigation cannal for the purpose of flow measurement.

Q.2 Why is it necessary to calibrate the weir ?

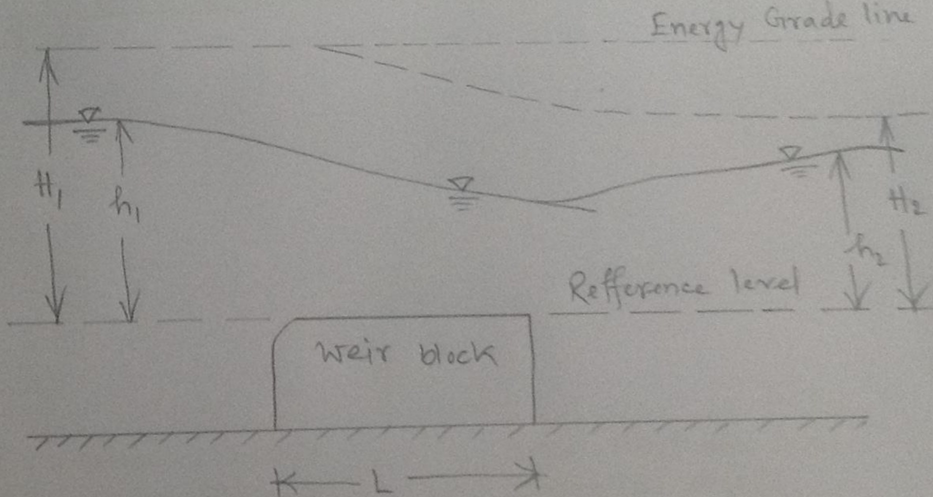
In general, the dimensions of structure (e.g. weir) whose primary function is flow measurement are standardized; but the materials from which these devices are constructed may vary. The criteria on which the choice of construction material depends include availability, cost of labor, lifetime of the structure etc. Although the cost of construction and maintanance of a structure for the estimation of discharge is important, the primary concerns are the ease and accuracy with which discharge can be measured.

Another cause of the requirement of calibration is that the equation for the discharge over a weir can not be derived exactly because -
(i) the flow pattern of one weir differs from another.
(ii) the flow pattern varies with discharge.

Q.3 Broad crested weir designed so that $0.07 \leq \frac{H_1}{L} \leq 0.5$
What does the upper and lower limit signify?

A broad-crested weir is a structure with a horizontal crest above which the fluid pressure may be considered hydrostatic. If such a situation is to exist, then with the following figure, the following inequality must be satisfied.

$$0.07 \leq H_1/L \leq 0.50$$



if H_1/L is not greater than or equal to 0.07, then the energy losses over the weir crest can not be neglected. if H_1/L is not less than or equal to 0.50 then the curvature of the streamline over the weir block is such that the assumption for hydrostatic pressure is not valid.

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WRE - 302

Open-Channel Hydraulics

Experiment No. : 03

Name of the Experiment: FLOW THROUGH A VENTURI FLUME.

Date of Performance : 18-01-14

Date of Submission : 25-01-14

Name : MD. Raiful Islam.

Student ID : 1016022

Level : 3 ; Term : I

Department : WRE

Objective:

- To determine the theoretical discharge of the flume at free flow and submerged flow condition.
- To measure the actual discharge and hence find out the coefficient of discharge at free and submerged flow.
- To calibrate the flume.

Experimental Setup:

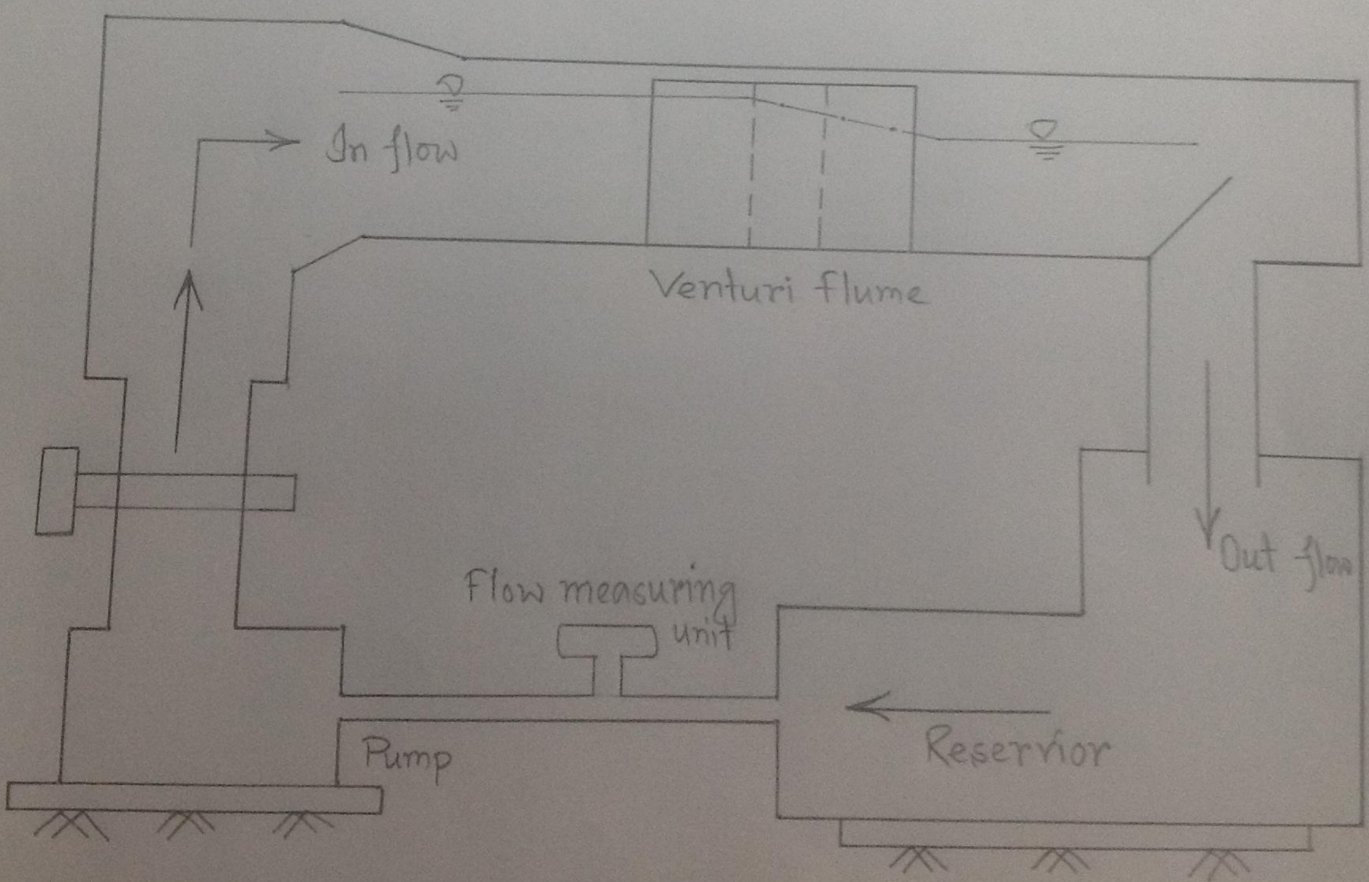

figure: Set up for flow through Venturimeter.

Related formula :

*** Theoretical discharge in flow condition :**

Considering critical flow occurs at throat section of the flume, the theoretical discharge at free flow is given by,

$$Q_{tf} = AV$$
$$= A_c V_c$$

where, A_c = Area at critical section of the flume.
V_c = Velocity at critical section of the flume.

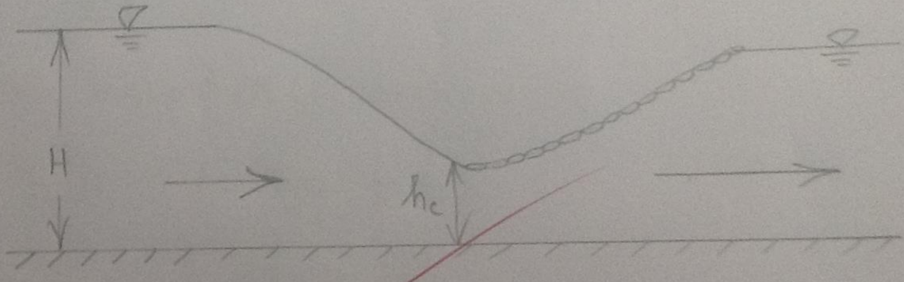

figure : free flow condition

for critical state of flow,

$$F = \sqrt{\frac{V_c^2}{gD_c}}$$

$$\Rightarrow 1 = \frac{V_c^2}{gD_c}$$

$$\Rightarrow V_c = \sqrt{gD_c}$$

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Applying energy equation between section 1 and 2,

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g}$$

$$\Rightarrow v_2^2 - v_1^2 = 2g(y_1 - y_2)$$

$$\Rightarrow v_2^2\left(1 - \frac{v_1^2}{v_2^2}\right) = 2g(y_1 - y_2) \quad \text{----- (i)}$$

if A and a are cross sectional area at section 1 and 2 respectively then, using continuity equation we get,

$$Av_1 = av_2$$

$$\Rightarrow \frac{v_1}{v_2} = a/A = M \text{ (Let)}$$

Therefore equation (i) reduces to-

$$v_2^2(1 - M^2) = 2g(y_1 - y_2)$$

$$\Rightarrow v_2 = \sqrt{\frac{2g(y_1 - y_2)}{1 - M^2}}$$

Hence, theoretical discharge, at submerged flow condition,

$$Q_{ts} = av_2$$

$$= a\sqrt{\frac{2g(y_1 - y_2)}{1 - M^2}}$$

Depth of water at upstream, y_1 (m) ⟶

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Now for a rectangular flume,

$$A_c = by_c \quad \text{and} \quad D_c = y_c$$

Therefore,

$$Q_{tf} = A_c v_c$$
$$= by_c\sqrt{gy_c}$$

From the existing relationship between total head and depth of flow we get, $y_c = \frac{2}{3}H$. Thus fininally we get,

$$Q_{tf} = \left(\tfrac{2}{3}\right)^{1.5}\sqrt{g}\, bH^{1.5}$$

where, H = measured head at upstream of the flume

* Theoretical dischatge in submerged flow condition:

During submerged flow condition there exist no critical section.

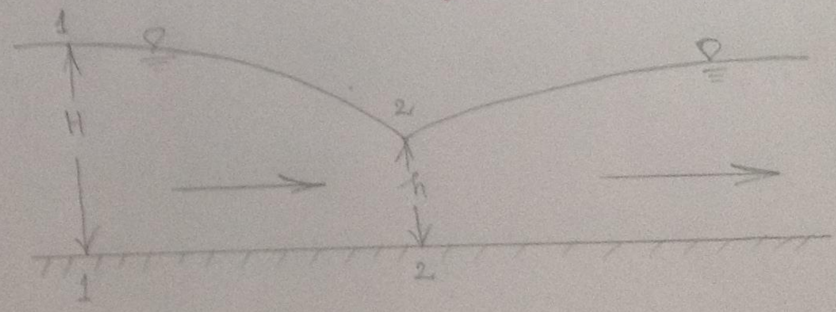


figure: Submerged flow condition.

Depth of water at upstream, y_1 (m) →

Coefficient of discharge is ratio of actual discharge to that of theoretical discharge,

$$C_{df} = \frac{Q_a}{Q_{tf}}$$

$$\Rightarrow Q_a = C_{df} \cdot Q_{tf}$$

$$= C_{df} \left(\tfrac{2}{3}\right)^{1.5} \sqrt{g}\, B\, y_1^{1.5}$$

* Calibration:

equation: $Q = k y_1^n$

where $k = C_d \left(\tfrac{2}{3}\right)^{1.5} \sqrt{g}\, b$

$$\Rightarrow \log Q = \log k + n \log y_1$$

Let, $\log Q = Y$, $\log k = K$, $\log y_1 = X$

Therefore equations reduces $Y = K + nX$

Then, $n = \dfrac{N(\Sigma XY) - (\Sigma X)(\Sigma Y)}{N(\Sigma X^2) - (\Sigma X)^2}$ where, N = No. of data

and, $K = \dfrac{\Sigma Y - n \Sigma X}{N}$

$\therefore k = \text{anti}\log K$

The correlation coefficient r is given by -

$$r = \frac{N(\Sigma XY) - (\Sigma X)(\Sigma Y)}{\sqrt{N(\Sigma X^2) - (\Sigma X)^2}\,\sqrt{N(\Sigma Y^2) - (\Sigma Y)^2}}$$

Channel width, B= 0.3048 m   Throat width, b= 0.10 m

Actual discharge Q_a m^3/s	Free flow condition y_1 m	Q_{tf} m^3/s	C_{df}	Submerged flow condition y_1 m	y_2 m	M	Q_{ts}	C_{ds}
0.0195	0.226	0.0163	1.06	0.2405	0.1742	0.238	0.0204	0.95

Calibration of flume:

i)By eye estimation(Should be done by students having even student number):

Actual discharge ,Q_a (m^3/s)	Depth of water at upstream y_1 (m)
0.0195	0.226
0.0209	0.237
0.0180	0.2134
0.0163	0.2014
0.0148	0.1895

ii)By regression(Should be done by students having odd student number):

y_1	Q	X=log y_1	Y=log Q	XY	X^2	Y^2
0.2260	0.0195	−0.64589	−1.70997	1.10445	0.41717	2.92399
0.2370	0.0209	−0.62525	−1.67985	1.05033	0.39094	2.82190
0.2134	0.0180	−0.67081	−1.74472	1.17038	0.44998	3.04405
0.2014	0.0163	−0.69594	−1.78781	1.24421	0.48433	3.196264
0.1895	0.0148	−0.72239	−1.82971	1.32179	0.52185	3.34795
	Summation	ΣX= -3.36028	ΣY= -8.75209	ΣXY= 5.89116	ΣX^2= 2.26427	ΣY^2= 15.3342

Depth of water at upstream, y_1 (m) ⟶

Rakra

4 Data Sheet for Calibration Curve:

Calibration equation:

$$Q_a = 0.173\, y_1^{1.483}$$

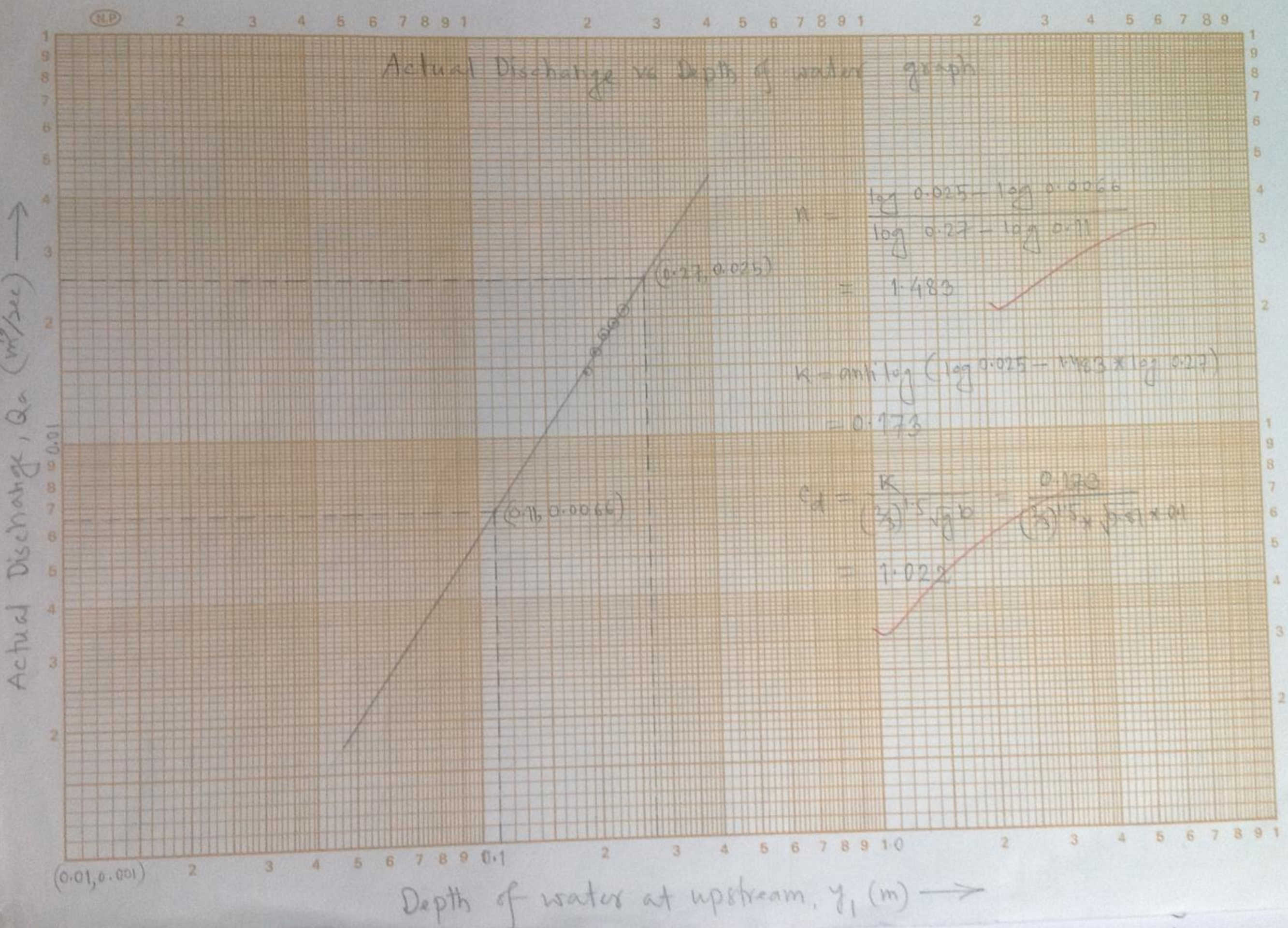
$$0 \le y \le 25.4 \text{ (cm)}$$

Depth of flow, at up stream y_1 (m)	0	0.05	0.10	0.15	0.20	0.254
Actual discharge, Q_a (m^3/s)	0	0.0020	0.0057	0.0104	0.016	0.0227

LOGARITHMIC

2 X 3 CYCLES

St. ID. 1016022

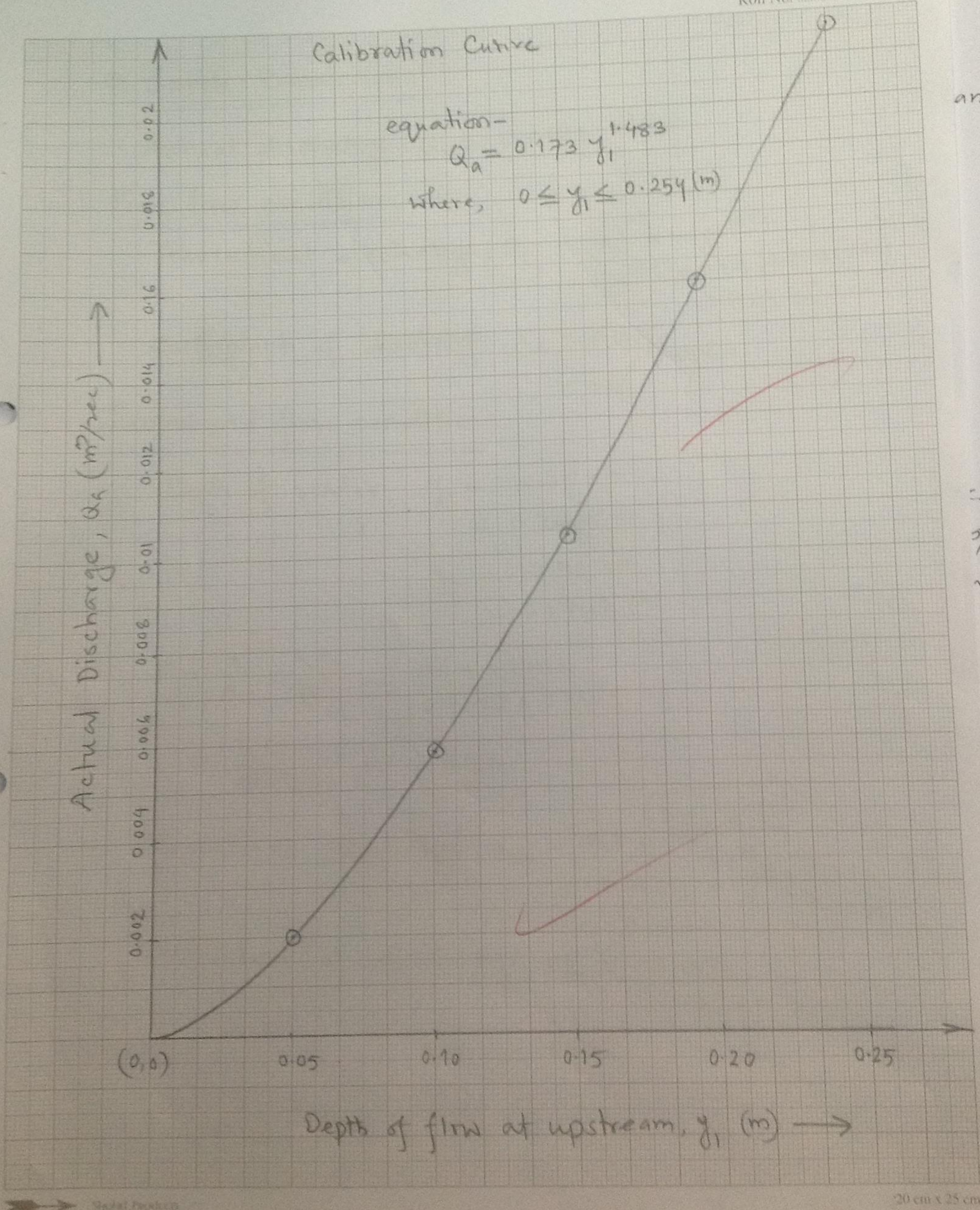


$$n = \frac{\log 0.025 - \log 0.0066}{\log 0.27 - \log 0.11} = 1.483$$

$$K = \text{antilog}\left(\log 0.025 - 1.483 \times \log 0.27\right) = 0.173$$

$$C_d = \frac{K}{\left(\frac{2}{3}\right)^{1.5}\sqrt{g}\,b} = \frac{0.173}{\left(\frac{2}{3}\right)^{1.5} \times \sqrt{9.81} \times 0.1} = 1.022$$

Roll No. ....



20 cm x 25 cm

Sample Calculation:

Actual discharge, $Q_a = 0.0195\ m^3/sec.$

Free flow condition:

Theoretical discharge, $Q_{tf} = \left(\frac{2}{3}\right)^{1.5} * b\sqrt{g}\ H^{3/2}$

$= \left(\frac{2}{3}\right)^{1.5} * 0.1 * \sqrt{9.81} * (.226)^{1.5}$

$= 0.0183\ m^3/sec$

Coefficient of discharge, $C_d = 0.0195/0.0183$

$= 1.06$

Submereged flow condition:

Depth of water, $y_1 = 24.05$ cm

$= 0.2405$ m

$y_2 = 17.42$ cm

$= 0.1742$ cm

$$M = \frac{a}{A} = \frac{by_2}{By_1} = \frac{0.1 * 0.1742}{0.3048 * 0.2405}$$

$$= \frac{0.01742}{0.0733} = 0.238$$

Theoretical discharge, $Q_{ts} = a * \sqrt{\frac{2g(y_1 - y_2)}{1-M^2}}$

$= 0.01742 * \sqrt{\frac{2 \times 9.81 * 0.07}{1-(.238)^2}}$

$= 0.0204$

Coefficient of discharge, $C_d = \frac{0.0195}{0.0204}$

$= 0.95$

Calculation for calibrating of flume:

Value of exponent, $n = \dfrac{\log Q_{a_2} - \log Q_{a_1}}{\log y_{1_2} - \log y_{1_1}}$

$= \dfrac{\log 0.025 - \log 0.0066}{\log 0.27 - \log 0.11}$

$= 1.483$

value of $K = \text{anti}\log(\log Q_{a_2} - n * \log y_{1_2})$

$= \text{anti}\log(\log 0.025 - 1.483 * \log 0.27)$

$= 0.173$

Coefficient of discharge, $C_d = \dfrac{K}{(2/3)^{1.5} * \sqrt{g}\, b}$

$= \dfrac{0.173}{(2/3)^{1.5} * \sqrt{9.81} * 0.1}$

$\simeq 1.022$

Calculation for regression analysis:

$$n = \frac{N(\Sigma XY) - (\Sigma X)(\Sigma Y)}{N(\Sigma X^2) - (\Sigma X)^2}$$

$$= \frac{5 \times 5.89116 - (-3.36028) * (-8.75209)}{5 \times (2.26427)^2 - (-3.36028)^2}$$

$$= \frac{0.04633}{0.02986}$$

$$= 1.55$$

$$K = \frac{\Sigma Y - n\,\Sigma X}{N}$$

$$= \frac{-8.75209 - 1.55 * (-3.36028)}{5}$$

$$= -0.70873$$

$\therefore$ constant, k = anti log K

= anti log (-0.70873)

$= 0.4922$

The coefficient of correlation,

$$r = \frac{N(\Sigma XY) - (\Sigma X)(\Sigma Y)}{\sqrt{N(\Sigma X^2) - (\Sigma X)^2}\,\sqrt{N(\Sigma Y^2) - (\Sigma Y)^2}}$$

$$= \frac{5 * 5.89116 - (-3.36028) * (-8.75209)}{\sqrt{5 * 2.26427 - (3.36028)^2}\,\sqrt{5 * 15.3342 - (-8.75209)^2}}$$

$$= 0.9996$$

Coefficient of discharge, $C_d = \frac{Q_a}{Q_t}$

$$= \frac{Q_a}{.49922 * y_1^{1.55}}$$

$$= \frac{0.0195}{.49922 * (0.221)^{1.55}}$$

$$= 0.993$$

am.

$$K = \frac{\Sigma Y - n\,\Sigma X}{N}$$

$$= \frac{-8.75209 - 1.55 * (-3.36028)}{5}$$

$$= -0.70873$$

$\therefore$ constant, $k = \text{anti log } K$

$$= \text{anti log } (-0.70873)$$

$$= 0.4922$$

The coefficient of correlation,

$$r = \frac{N(\Sigma XY) - (\Sigma X)(\Sigma Y)}{\sqrt{N(\Sigma X^2) - (\Sigma X)^2}\,\sqrt{N(\Sigma Y^2) - (\Sigma Y)^2}}$$

$$= \frac{5 * 5.89116 - (-3.36028) * (-8.75209)}{\sqrt{5 * 2.26427 - (-3.36028)^2}\,\sqrt{5 * 15.3342 - (-8.75209)^2}}$$

$$= 0.9996$$

Coefficient of dischatrge, $C_d = \frac{Q_a}{Q_t}$

$$= \frac{Q_a}{.49922 * y_1^{1.55}}$$

$$= \frac{0.0195}{.49922 * (0.221)^{1.55}}$$

$$= 0.993$$

Result:

Free flow condition:

- Coefficient of discharge, $C_d = 1.06$

Submerged flow condition:

- Coefficient of discharge, $C_d = 0.95$

Calibration of venturi flume:

- $n = 1.483$
- $K = 0.173$
- Calibration equation: $Q_a = 0.173 * h^{1.483}$
- Coefficient of discharge, $C_d = 1.022$

Regression Analysis:

- $n = 1.55$
- $K = 0.49922$
- Calibration equation: $Q_a = 0.49922\, h^{1.55}$
- Coefficient of discharge, $C_d = 0.392$
- Coefficient of correlation, $r = 0.9996$

Discussion:

- Coefficient of discharge for free flow condition and submerged flow condition was found 1.06 and 0.95 respectively. Thus, for free flow condition actual discharge is greater than the value at submerged flow condition.

- Calibrating the venturi flume, the computed value of n and constant K was 1.483 and 0.173 respectively. Therefore, existing calibration equation for our laboratory venturi flume is reduced to

$$Q_a = 0.173 * y_1^{1.483}$$

- Coefficient of discharge found from graphical analysis differs slightly from the single experimental value (as Cd = 0.95 from graph; Cd = 1.06 from experiment.) because from the graphical analysis we get somewhat an average value.

- Regression analysis to establish calibration equation exhibits n = 1.55 and K = 0.49922. Thus the calibration equation will be likely as

$$Q_a = 0.49922\, y_1^{1.55}$$

Using this equation, coefficient of discharge is found 0.392

- The value of the coefficient of correlation $r = 0.9996$ significantly express that the established calibration equation ($Q_a = 0.49922\, y_1^{1.55}$) perfectly co-relate discharge with depth of flow at upstream, y_1.

- The Calibration curve (drawn with calibration eqn's $Q_a = 0.173 * y_1^{1.483}$) passes through origin which significantly expres discharge is zero at zero depth of flow. The curve is convex in shape i.e discharge will increasingly increases with the increase of depth of flow.

[B] Assigned Question :

Q.1 What are the advantage, disadvantage and uses of Venturi flume?

* Advantages of venturi flume :

- Not complicated shape of weir.
- Low cost implementation.
- Low hydraulic fall needed.
- Easy to prefabricate
- Applicable for raw sewage.
- During peak flows suspended solids are washed away.

* Disadvantages of venturi flume :

- Lower measurement range than V-notch weir
- Accurate hydraulic calculation and accurate construction is needed.
- Head different between u/s and d/s is relatively small.

* Uses :

- Venturi flume is an open flume used widely in irrigation canal for measuring discharge.
- Use as a outlet of canal to supply water in the field or distributory canal.

Q.2 What is the difference between free flow and submerged flow? How can you create submerged flow in laboratory flume?

— Under free flow condition, critical depth occurs in the vicinity of minium width which is called the flume throat or the flume neck. The attainment of critical depth makes it possible to determine the flow rate knowing only an upstream depth. This is possible because whenever critical depth occurs in the flume the upstream depth is not affected by change in downstream.

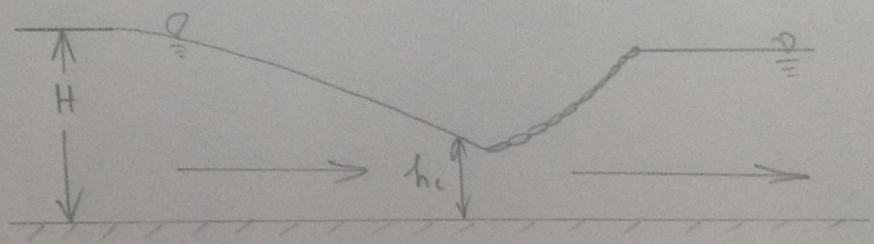
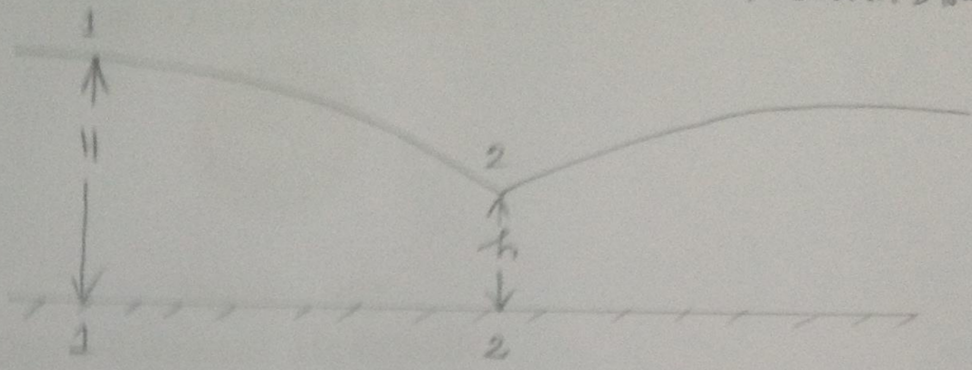


figure: free flow Condition.

— When the flow ~~are~~ conditions are such that the downstream flow depth is raised to the extent that the flow depth at every point depth is changed. A flume operating under submerged flow condition requires that two flow depth be measured one at upstream section and another is at downstream.



Submerged flow condition

In our laboratory setup we create submerged flow condition from free flow condition simply by elevating the Water Meter (i.e gate at end of the flume).

BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY.

WRE - 302
Open-Channel Hydraulics

Experiment No. : 04

Name of the Experiment: Flow Through A Parshall Flume

Date of Performance : 25-11-13
Date of Submission : 01-02-14

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Student ID : 1016022
Level : 3 ; Term : I
Department : WRE

Objective :

- To determine the theoretical discharge at free flow condition.
- To determine the theoretical discharge at submerged flow condition.
- To determine the value of co-efficient of discharge C_d for both condition.
- To verify the value of K and n.

Experiment Setup :

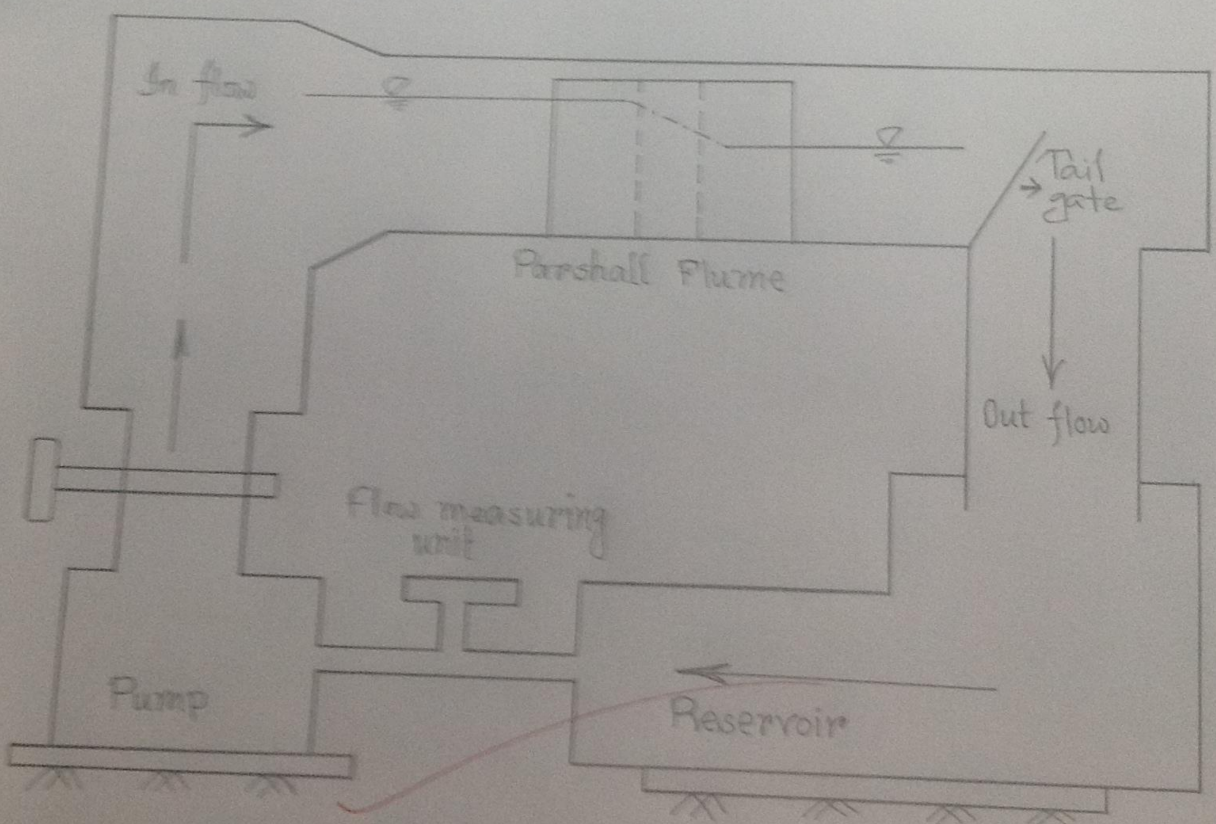

figure: Setup for flow through a Parshall flume

Related formula :

The Parshall flume is a combined calibrated device i.e there exists a definite depth discharge relationship for the flume. So, analytic determination of theoretical discharge is not required for this flume. The discharge through a Parshall flume is given by-

$$Q_t = KH_a^n$$

where, K = a constant which depends on the system of units used.

n = exponent.

H_a = upstream depth measured at the location

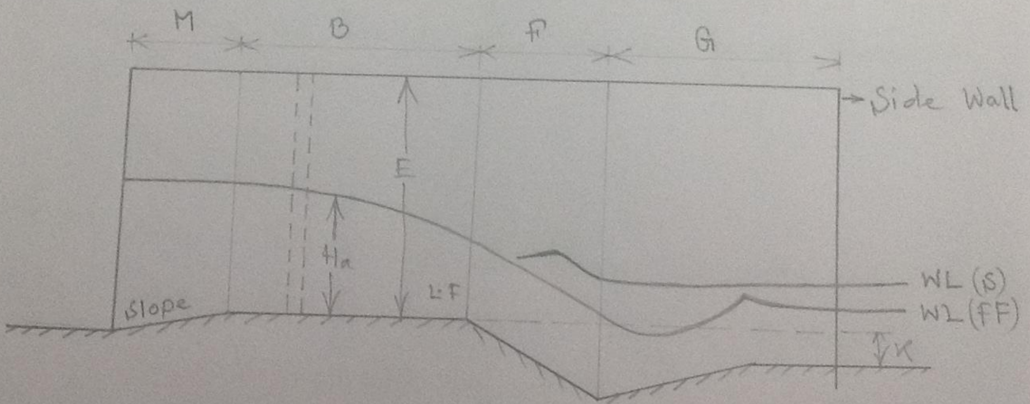

figure: free flow and submerged flow condition

The value of K and n are depend on the throat width. If the throat width of the flume is 6", the above equation reduces to,

$$Q_{tf} = 0.3812\ H_a^{1.58}$$

Coefficient of discharge is ratio of actual discharge to that of theoretical discharge, i.e

$$C_{df} = \frac{Q_a}{Q_{tf}} \quad \text{——— (ii)}$$

$$C_{ds} = \frac{Q_a}{Q_{ts}} \quad \text{——— (iii)}$$

where, C_{df} = coefficient of discharge at free flow condition.

C_{ds} = coefficient of discharge at submerged condition.

The percentage of submergence for the Parshall flume discharge is reduced. The discharge of Parshall flume then equals

$$Q_{ts} = Q_{tf} - Q_E$$

where, Q_{ts} = corrected discharge due to submergence

Q_{tf} = theoretical free flow discharge

Q_E = correction of discharge as found from the attached figure.

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4.9 Data sheet:

Throat width, W= 0.134 m m   Actual discharge, Q_a = 0.0196 m³/sec m³/s

Free flow condition			Submerged flow condition						
H_a m	Q_{tf} m³/s	C_{df}	H_a m	H_b m	% Submergence $=100*H_b/H_a$	Q_{tf} m³/s	Q_E m³/s	Q_{ts} m³/s	C_{ts}
0.1685	0.0229	0.86	0.1871	0.1576	84.23	0.0269	5.6×10^{-3}	0.0213	0.92

Verification of K and n

Actual discharge, Q_a (m³/s)	H_a (m)
0.0170	0.1462
0.0155	0.133
0.014	0.1295
0.0196	0.1685
0.0185	0.152

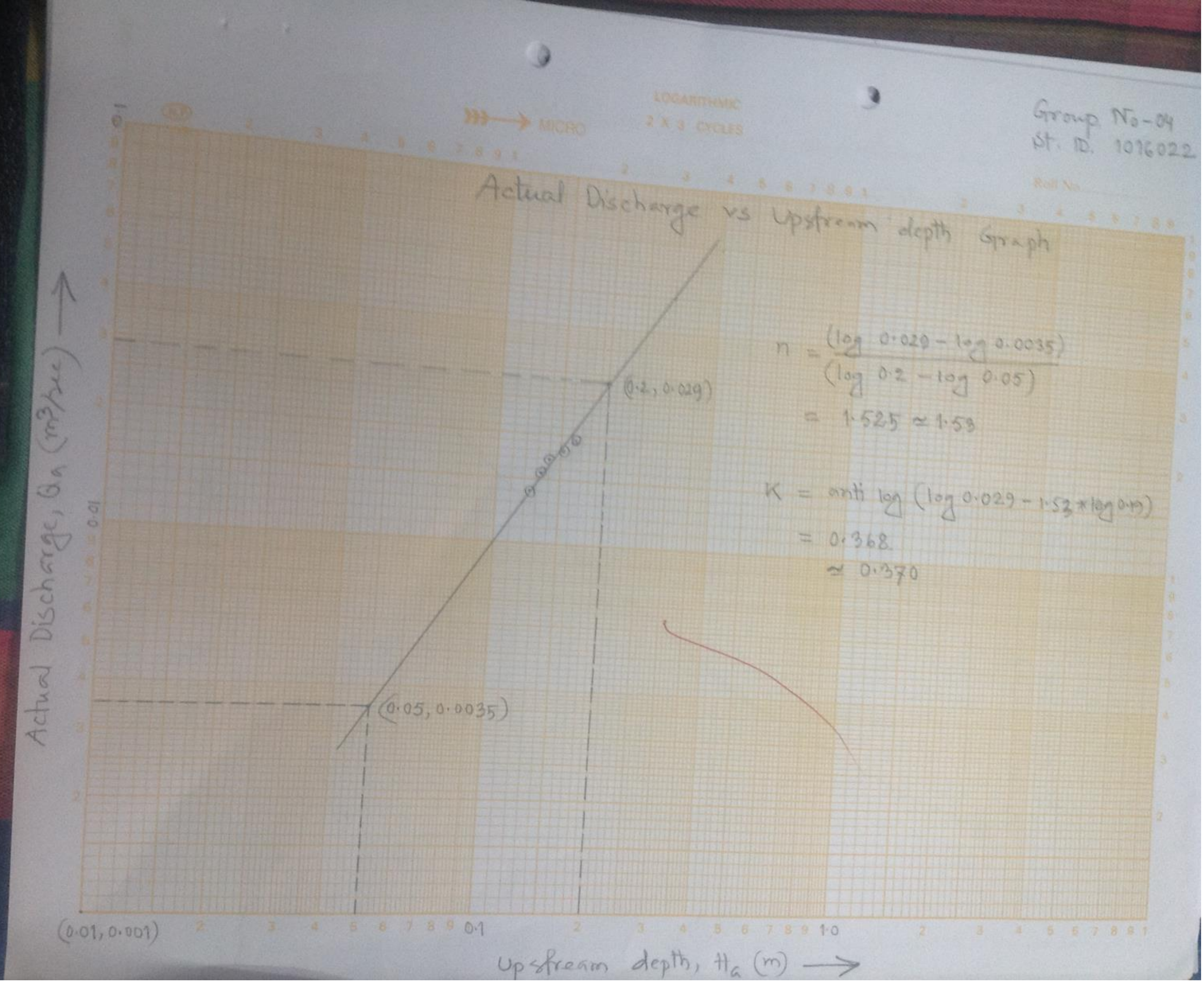
25.01.14

[4] Data Sheet for Calibration Curve:

Calibration Equation: $Q_a = 0.370 * H_a^{1.53}$

where, $0 \leq H_a \leq 0.2083$ (m)

Up stream depth, H_a, (m)	0	0.04	0.08	0.12	0.16	0.2083
Actual Discharge Q_a (m^3/sec)	0.00	0.0027	0.0078	0.0144	0.0224	0.0336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LOGARITHMIC
2 X 3 CYCLES
MICRO
Actual Discharge vs Upstream depth Graph
(0.2, 0.029)
(0.05, 0.0035)
(0.01, 0.001)
0.1
1.0
0.01
$n = \dfrac{(\log 0.029 - \log 0.0035)}{(\log 0.2 - \log 0.05)}$
$= 1.525 \simeq 1.53$
$K = \text{anti}\log(\log 0.029 - 1.53 * \log 0.19)$
$= 0.368$
$\simeq 0.370$
Actual Discharge, Q_a (m^3/sec)
Upstream depth, H_a (m)

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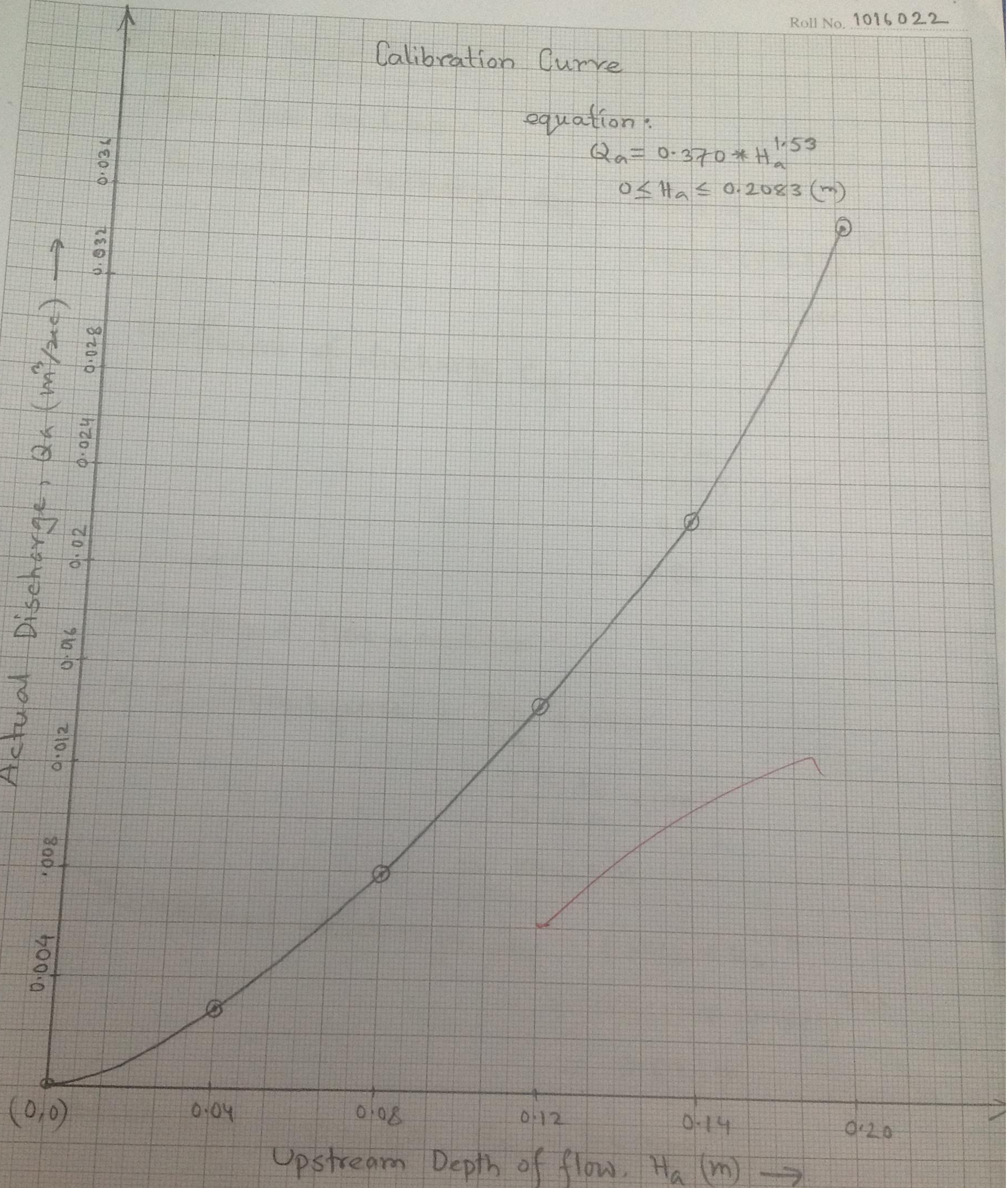

Shohid Products

20 cm x 25 c

4 Sample calculation :

free flow condition:

Theoretical discharge, $Q_{tf} = 0.3812 \, H_a^{1.58}$

$= 0.3812 * (0.1685)^{1.58}$

$= 0.0229 \ m^3/sec.$

Coefficient of discharge, $C_{df} = \frac{Q_a}{Q_{tf}}$

$= \frac{0.0196}{0.0229}$

$= 0.857$

$= 0.86$

Submerged flow condition :

% of submergence $= \frac{H_b}{H_a} * 100\%$

$= \frac{0.1576}{0.1871} \times 100\%$

$= 84.23\%$

Theoretical discharge, $Q_{tf} = 0.3812 * H_a^{1.58}$

$= 0.3812 * (0.1871)^{1.58}$

$= 0.0269$

Discharge correction, $Q_E = 5.6 \times 10^{-3}$

Therefore, theoretical dischatge at submerged condition, $Q_{ts} = Q_{tf} - Q_E$

$= 0.0269 - 5.6\times10^{-3}$

$= 0.0213$

Coefficient of discharge, $C_{ds} = \frac{Q_a}{Q_{ts}}$

$= \frac{0.0196}{0.0213}$

$= 0.9202$

$= 0.92$

Graphical calculation:

Value of $n = \frac{\log 0.029 - \log 0.0035}{\log 0.20 - \log 0.05}$

$= 1.525$

$\simeq 1.53$

Value of K = antilog $(\log 0.029 - 1.53 * \log 0.20)$

$= 0.368$

$= 0.370$

Result:

free flow condition:

Theoretical discharge, $Q_{tf} = 0.0229$ m³/sec.

Coefficient of discharge, $C_{df} = 0.86$

Submerged flow condition:

Theoretical discharge, $Q_{ts} = 0.0269$ m³/sec.

Coefficient of discharge, $C_{ds} = 0.92$

Graphical analysis:

Value of $n = 1.53$

Value of $K = 0.370$

Calibration equation, $Q_a = 0.370 * H_a^{1.53}$

Discussion:

- Coefficient of discharge at free flow condition and submerged condition was found 0.86 and 0.92 respectively. Therefore at submerged condition head loss is less than the value occured at free flow condition.

- In case of submerged flow condition there found a backwater effect. Due to this phenomena the coefficient of discharge in free flow condition is normally greater than the submerged flow condition.

- In free flow condition froude number at upstream section is found 0.397 which is less than unity i.e subcritical condition exists.

- In submerged condition, at both upstream and the downstream section exhibits frounde number greater than unity (1.12 and 1.36 respectively).

- Degree of submergence for our experiment setup was found to be 84.23%. Therefore a discharge correction was carried out valued at 5.6×10^{-3} m/sec. In case of % submergence less than 65% no correction is needed as in such high upstream and down stream height difference, backwater effect may be neglected.

- In order to find out the value of exponent n and K, "Actual discharge vs Upstream depth" is plotted in a log-log graph. The slope of the obtaining straight line gives value of n equal to 1.53 and K = 0.370. Therefore the ~~em~~ calibration equation reduces to a form $Q_a = 0.370 * H_a^{1.53}$.

- Calibration curve representing the equation $Q_a = 0.370 * H_a^{1.53}$ is concave to the origin passing through the origin aswell significantly expressn its logarithomic increase of discharge with upstream depth of flow.

- In submerged flow condition measurements of depth is taken both at upstream and downstream because of in this situation critical section was not found.

4) Assigned Question :

Q.1 What are the advantage, disadvantage and uses of Purshall flume?

Advantages of Purshall flume:

- The main advantage of the Purshall flume is its relatively low loss of head. The head loss is only about a fourth of that needed to operate a weir having same crest length.
- The tapered approach section followed by the downstream sloping floor of the throat gives the Parshall flume its ability to withstand relatively high degree of submergence without affecting the rate.
- Another advantage is its self-cleaning capacity due to the fact that the high velocity washed out the debris and sediments present in the flow.

Disadvantage of Purshall flume:

- Purshall flume become invalid like weir, because of the deposition of debris.
- The fabrication of this flume is very tough and required to be done as per specification.

Uses of Purshall flume :

- ~~The~~ The Purshall flume is the most ~~widly~~ widely used flume and has been the standard for flume measurement.
- Practically this type of flume is being used in small irrigation canal for flow measurement purposes.

2. Why a downward narrow section and upward diverging section is provided in Purshall flume?

The possibility of submergence in the downstream section is necessary to maintain critical flow through the throat of the flume minimum slope is provided. To prevent the flume from becoming submerged either slope is raising or narrowing the throat at downward section.

If the water just upstream is smooth with no surface boils and waves; accuracy may not be greatly affected by velocity of approach. Excessive flow velocity at the flume entrance can cause errors. Therefore, upstream diverging section is provided for the elimination of error.