Comparative Analysis of the Discharge coefficient by using V-Notch and Trapezoidal Notch

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***Abstract*— This paper represents the hydraulic experiment performed on "notch apparatus" to determine the effect of notch shape on notch flow characteristics. In the recent time, flood control has been a major concern, thus, it is necessary to design a head of notch. In this paper it is the comparative analysis of V-notch and trapezoidal notch. A water collecting tank was constructed and calibrated at the upstream so as to determine the head, H of water flowing over the notch. There was a slot in which a flat plate is inserted the upstream from the downstream. It was discovered experimentally that shape and water height over the notch has effect on coefficient of discharge and volume discharged. The coefficient of discharge obtained is: 0.469 for v-notch and 0.2332 for trapezoidal notch. Thus, trapezoidal notch has lower discharge than the triangular notch.**

***Keywords*— Notches, V-notch, Trapezoidal notch, Discharge, Head discharge.**

I. INTRODUCTION

Notch is a hydraulic structure set perpendicular to the flow direction with the objective to measure the flow discharge. The lower triangular part of the notch manages the normal range of discharges at the measurement structure, the notch upper part living up to expectations for the unpredictable higher top flows. Notches are usually used to observe rivers flow keeping in mind the end goal to shield from flooding and bolster navigation in rivers. The V-notch notch is one of the sharp crested notches with a triangular section, used to measure small discharge values subsequent to the water head over the notch peak that is generally touchy to changes in flow. The basic principle is that discharge is directly related to the water depth above the bottom of the V-notch, this distance is called head. The V-notch design causes small changes in discharge to have a large change in depth allowing more accurate head measurement than with a trapezoidal notch. A trapezoidal notch is a combination of a rectangular notch and two triangular notches as shown in figure. It is, thus obvious that the discharge over such a notch will be the sum of the discharge over the rectangular and triangular notches.

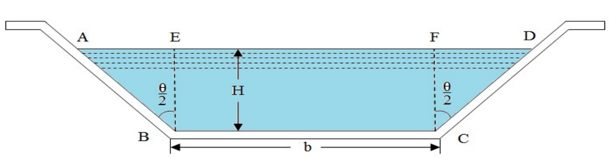

Fig : Trapezoidal Notch

II. LITERATURE REVIEW

Kandaswamy and Rouse (1975) was the first to provide the following equation for the discharge Q over a normal notch:

$Q = 2/3\ C_d\ L\ h \sqrt{2gh}$

where C_d = discharge coefficient ; L = length of notch ; g= gravitational acceleration ; and h = head above crest .

Bezin & Rehboc (1929) gave the following equation for discharge coefficient :

$C_d = 0.6075 + 0.334[h/(h+w)]$ where w = height of the notch in quest ion.

Frazer & Rehbock (1930) presented the following equation for discharge coefficient :

$C_d = 0.615 + 0.338[h/(h + w)]^2$

Swiss Society for Engineers and Architects, Rehbock proposed the following equations for C_d :

$C_d = 0.615 + 0.308[h/(h+w)]^2$

Rehbock (1929) proposed the following formula for C_d :

$C_d = 0.605 + 0.08\ h/w$

Kandaswamy and Rouse (1975) proposed following equations for notch and sill range respectively:

$C_d = 0.61 + 0.08h/w$; for $0 < h/w < 6$

$C_d = 1.06[1 + w/h]3/2$; for $0 < w/h < 0.6$

Govinda Rao and Muralidhar (1962) have conducted analysis of experimental data on trapezoidal and triangular notch notches and have successfully established the curve between C_d and wet ted perimeter.

Smith and Liang (1969) carried out experimental study on triangular broad crested notch and gave a plot of discharge coefficient Vs H/L, in which, H in Head above crest and L is the length of broad crested notch . This set of experiments proved vital in further studies.

Srinivasalu and Raghavendran (1970) proposed proportional notch with parabolic bottom. An average discharge coefficient as obtained by them is 0.63.The parabolic bottom remained to be analysed.

Rao and Shukla (1971) have established following equations for the discharge coefficient for notch of trapezoidal cross sect ion of finite crest width as

$C_d = 0.482 + 0.02\ (\frac{h}{p})$; For $(\frac{h}{B}) = 0.08$

$C_d = 0.527 + 0.049\ (\frac{h}{p})$; For $(\frac{h}{B}) = 1.0$

$C_d = 0.578 + 0.061\ (\frac{h}{p})$; For $(\frac{h}{B}) = 1.6$

$C_d = 0.611 + 0.08\ (\frac{h}{p})$; For (B) > 1.6

Where, h = head over notch;

p = notch height;

B = notch width.

Keshava Murthy and Pillai (1986) have designed linear proportional notches having compound base notch. The discharge coefficient is varying from 0.625 to 0.631. Further, they have shown that C_d increases as W/a decreases for trapezoidal base notches and the discharge coefficient has minor variation with respect to head for quite a large range of head ($0.15 \leq Hc / P \leq 2.5$) .

Boiten and Pitlo (1982) have derived the head discharge relations for different shapes of broad crested V-notch under free flow as well as submerged flow conditions. In their study they have shown that C_d increases with h/ l ratio with the increase in angle of V-notch.

Keshava Mur thy and Giridhar (1989) proposed a simple geometrical notch called inverted-V-notch or inward rectanlge as a practical proportional notch . They gave an equation for discharge as follows.

$$Q = 0.448\ L\ W\ 2\ C_d \sqrt{2gd}\ (h - 0.0817d)$$

for the head range of 0.22d £ h £ 0.94d and reported that average coefficient of discharge as 0.61 with an indication error of ± 1.5%.

Keshava Mur thy and Giridhar (1990) developed a linear head discharge relationship for chimney notch of the form

$$Q = 0.5227\ P1/2\ (H - 0.1112P); \qquad 0.2993P \leq H \leq 3.3061P$$

Where P = p/W ; H = h/W

in which p=height of trapezium; h=head above notch crest ; W=half width of notch crest ; and reported that discharge coefficient varies from 0.6 to 0.61.

Swamee, P.K. et al . , (1994) proposed an equation for discharge for the alternate linear notch by considering Cd (=0.92) , as

$$Q = 0.166\ \pi\ b0\ h$$

$$Q = 0.166\ \pi\ b0\ h \sqrt{gh} \qquad h \geq hmin$$

where h_{min} is 4h* ;h* = length parameter , b0 = notch base width, h=head over notch crest and g= gravitational acceleration.

III. APPARATUS

a) Notch Tank
b) Notch Plates
c) Hook Gauge
d) Measuring Tank

Specification

1. Notch Tank:

Notch tank is having steadying arrangement with baffles and provision for fixing interchangeable notch plates. Fill up the steadying zone with 25mm or 40mm ballets to get steady flow.

2. Notch Plates:

Triangular of 60^0

Trapezoidal , all made of brass sheet .

3. Hook Gauge:

Is fixed on the notch tank's top edge , which should be kept in horizontal position with the help of spirit level . It is used to measure the depth of water .

4. Measuring Tank :

Size : 0.7 x 0.7 x 0.3 metre

With overflow arrangement , gauge glass ,scale arrangement and a drain valve to measure the actual discharge.

Maintenance:

1. After completing the experiment drain the water from the notch tank and measuring tank.
2. Lubricate the hook gauge.

Formulae:

1. Co-efficient of discharge , $C_d = Qa/Qt$
2. Actual discharge , Qa $= \frac{A\ X\ h}{t}$ m^3/Sec.

Where ,

A = Area of measuring tank

$= 0.7 \times 0.3 = 0.21\ m^2$

h = Raise of water level in metre

T = Time for raise of water in sec.

3. The theoretical discharge is calculated by noting the 'head' (H) over the notch plates, measured with the help of the hook gauge .For different types of Notch plates, different formulas should be used to calculated the theoretical principles of flow.

For a trapezoidal notch ,

$$Qt = \frac{2}{3}\sqrt{2g}\ B\ H^{3/2} + 2\ x\ \frac{8}{15}\sqrt{2g}\ \ H^{5/2}\ \tan\frac{\theta}{2}$$

Where , Qt = Theoretical discharge
B = Breadth of notch
H = Head of water over the notch
g = Acceleration due to gravity = 9.81

For a 'V' Notch

$$Qt = \frac{8}{15}\sqrt{2g}\ H^{5/2}\ \tan\frac{\theta}{2}$$

Where , Qt = Theoretical discharge

H = Head of water over the notch

g = Acceleration due to gravity = 9.81

θ = Angle of notch (60^0)

IV. EXPERIMENTAL PROCEDURE

A. Calibration of the Downstream Chamber of the Notch Flow Channel

The calibration of the downstream chamber was done so as to determine the volume of water contained with respect to height with the aid of a measuring cylinder.

Certain quantity of water was measured with the measuring cylinder. The measured quantity of water was then poured inside the collecting chamber and the total height above the base of the chamber was noted and the corresponding values were recorded. The above procedure was repeated until the chamber was filled with water.

B. Experimental Determination of the of Notch Shape on Hydraulic Discharge

This is to determine the relationship between head on notches (triangular (v-notch) and trapezoidal) and the resultant discharge Q over the notches.

The instruments used include notch channel, notches (triangular and trapezoidal), measuring rule, stop watch, and measuring cylinder.

The notch apparatus was levelled on the hydraulic stand and one of the notches was installed (trapezoidal or V-notch). The type of notch used was written down on the attached table. The water tap was turned on to fill the upstream portion of the water chamber until the water level is even with the crest of the notch.

While for the V-notch, the vertex of the V serves as an indicator. The calibrated scale to the surface of the water was adjusted by matching the tip to its reflection. The value was taken and recorded as the Notch Height in the attached table. The flow was increased to its maximum, and the upstream water level was allowed to rise to the corresponding hole by the side of the channel. The shield was removed and certain volume of water allowed to flow over the notch into the downstream chamber with time and the associated reading was recorded. The upstream water level was decreased successively for other additional flows following the appropriate procedure for each. The experimental procedure was repeated for the other notch.

Fig.2. Experimental View of Trapezoidal Notch.

V. PRECUATION

It was ensured that the water flow channel was balanced on the stand before the experiment commenced. Also, the water level was adjusted to the crest of the notches before further addition of water so as to obtain the actual height of the notch. It was ensured that error due to parallax of the measuring bar was avoided. It was ensured that the shield was appropriately removed to allow discharge over the notches and was immediately put back to obstruct flow after as pecified period of time, so as to obtain accurate volume of water discharged with time.

VI. RESULT AND DISSCUTION

For a trapezoidal notch ,

$$Qt = \frac{2}{3}\sqrt{2g}\ B\ H^{3/2} + 2\ x\ \frac{8}{15}\sqrt{2g}\ H^{5/2}\ \tan\frac{\theta}{2}$$

Where, Q_t= Theoretical discharge

B = Breadth of notch

H = Head of water over the notch

g = Acceleration due to gravity = 9.81

First, We Determine the rectangular part of the trapezoidal section and than determine the triangular section.

In this experiment various types of graph has been found to determine known value is given below;

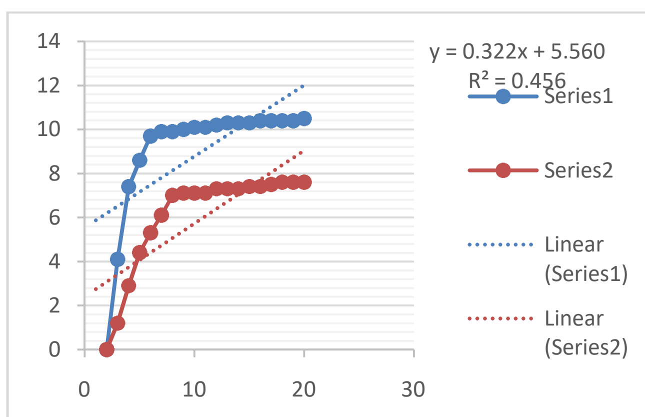

Fig.3. Depth graph of V-Notch vs Trapezoidal Notch

Depth of the V-notch is higher than the Trapezoidal notch

R^2 for V-notch = 0.456

R^2 for Trapezoidal notch = 0.653

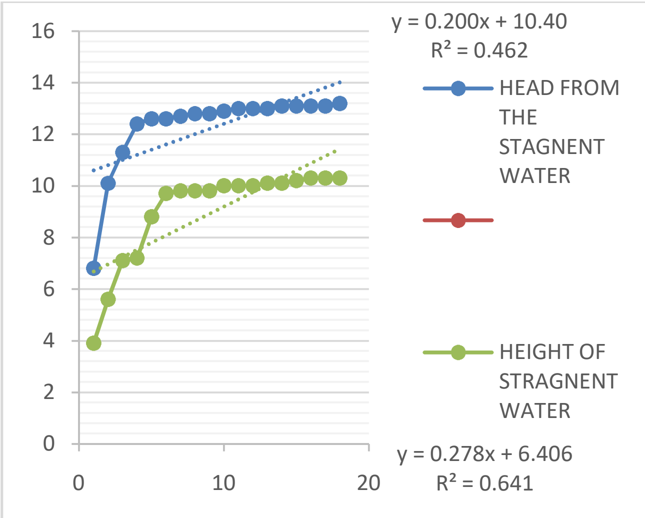

Fig.4.Head graph of V-notch vs Trapezoidal Notch

Head of the V-notch is higher than the trapezoidal Notch.

R^2 for V-notch = 0.462

R^2 for Trapezoidal notch = 0.641

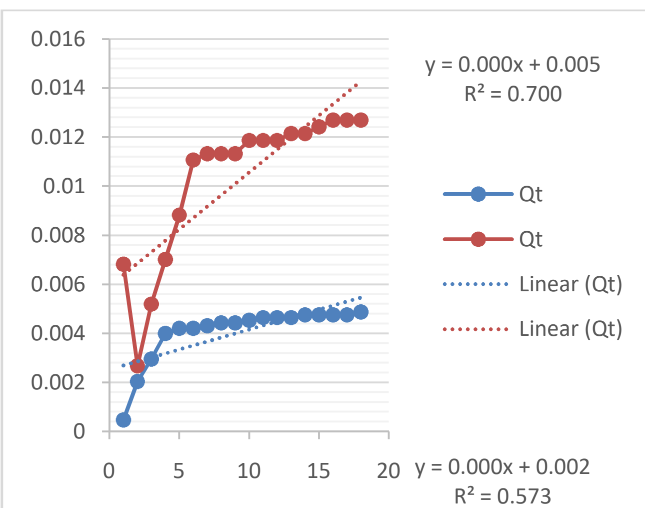

Fig.5.Qt graph of V-notch vs Trapezoidal Notch

Theoretical discharge of V-notch is suddenly increase and than displace linearly and trapezoidal is decrease and than increase in a certain point.

R^2 for V-notch = 0.700

R^2 for Trapezoidal = 0.573

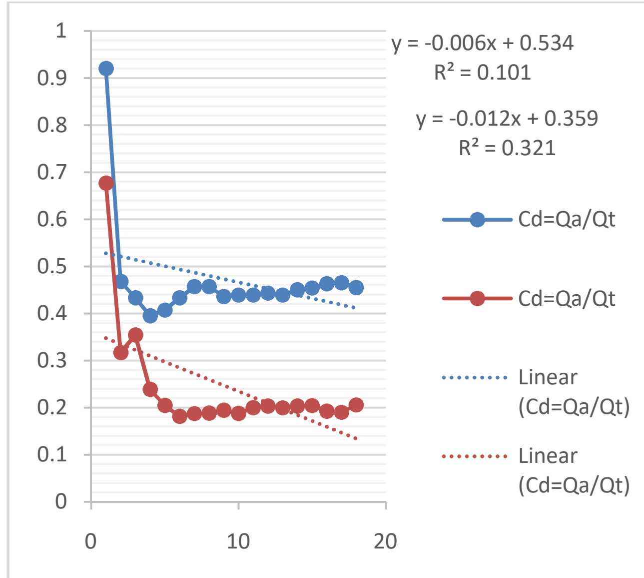

Fig.6.Cd graph of V-Notch vs Trapezoidal Notch

Cd of V-notch is higher than the trapezoidal notch.

R^2 for V-notch = 0.101

R^2 for Trapezoidal = 0.321

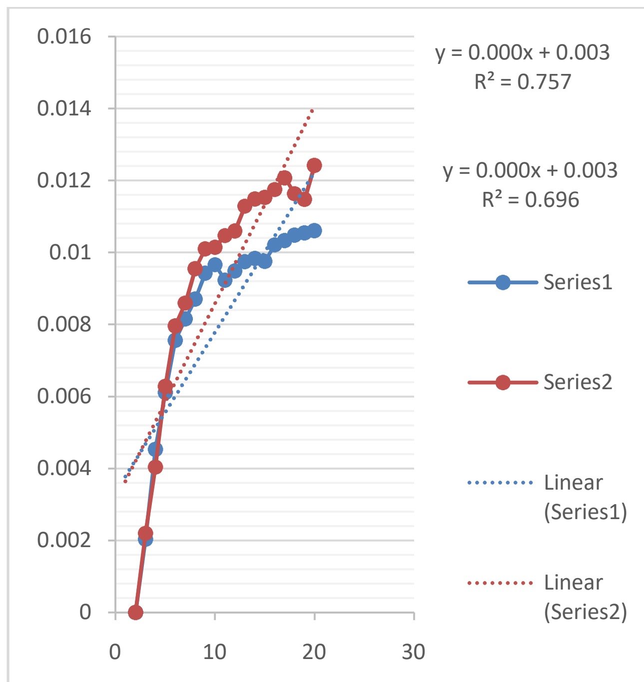

Fig.7.Velocity graph of V-Notch vs Trapezoidal Notch

Velocity of the V-notch is lower than the Trapezoidal notch.

R^2 for V-notch = 0.757

R^2 for Trapezoidal = 0.696

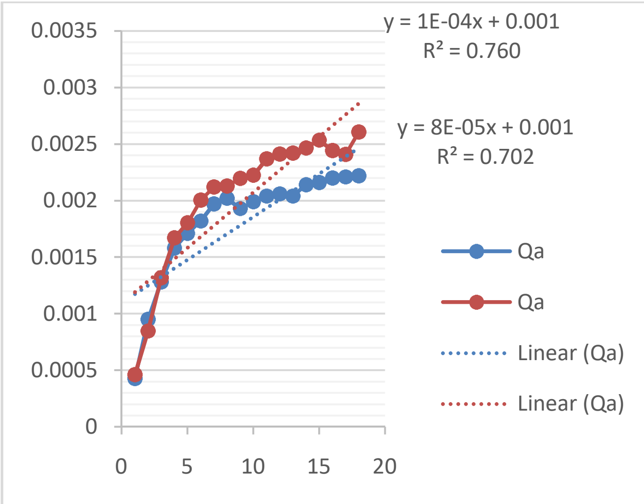

Fig.8.Qa graph of V-Notch vs Trapezoidal Notch

Actual discharge of the V-notch is lower than the trapezoidal notch.

R^2 for V-notch = 0.760

R^2 for Trapezoidal = 0.702

VII. CONCLUSION

In this paper we have tried to find out some main factors like discharge, head, velocity, etc. by taking different notches. We have found from the experiment that the trapezoidal notch gives better discharge than the V-notch.

The values which we got creates a standard trend of all the data. Here the theoretical discharge value for V-notch is 0.0068 and for trapezoidal notch is 0.0155.While the actual discharge value obtained for V-notch is 0.00648 and for rectangular notch is 0.0205.

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