Heaven's Light is Our Guide

Rajshahi University of Engineering & Technology
Rajshahi

DEPARTMENT OF CIVIL ENGINEERING

Expt. No. 05

Name of Expt Determination of co-efficient of discharge for flow over a V-notch

SUBJECT : Fluid Mechanics sessional	SUBMITTED BY :
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5.1 Theory :

A V-notch weire is simply a 'V notch' in a plate that is placed so that it obstrucets an open channel flow, causing the watere to flow overe the V-notch.

It is used to metere flow of watere in the channel, by measuring the head of watere overe the V-notch creest. The triangulare weire ore V-notch is preferable to the rectangulare weire fore the measurement of wide range of flow.

Types of notch :-

a. Rectangulare notch
b. Triangulare notch
c. Trapezoidal notch
d. Stepped notch

A triangulare notch ore V-notch is shown in the following figure.

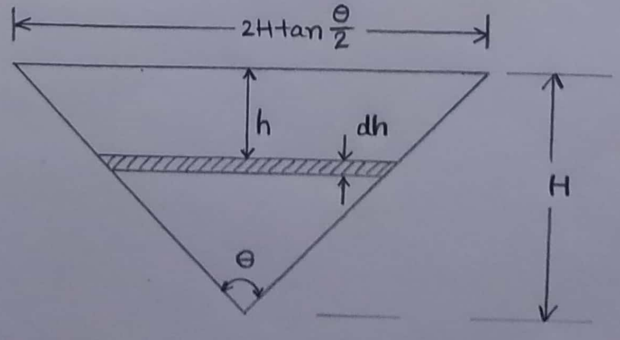


Figure 5.1 : Flow Overe a V-notch

Let H be the height of water surface and θ be the angle of notch. Then width of the notch at the water surface.

$$L = 2H \tan\frac{\theta}{2} \quad \cdots\cdots\cdots (1)$$

Considering a horizontal strip of the notch of thickness dh under a head h,

$$\text{Width of the strip}, W = 2(H-h)\tan\frac{\theta}{2} \quad \cdots\cdots\cdots (2)$$

Hence, the theoretical discharge through the strip.

$$dQ = \text{area of the strip} \times \text{Velocity}$$
$$= 2(H-h)\tan\frac{\theta}{2}\, dh\sqrt{2gh} \quad \cdots\cdots\cdots (3)$$

Integrating between the limits 0 and H and simplifying, the total theoretical discharge over the notch is given by

$$Q_t = \frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2} H^{5/2} \quad \cdots\cdots\cdots (4)$$
$$= KH^{5/2} \quad \cdots\cdots\cdots (5)$$

Where,

$$K = \frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2} \quad \cdots\cdots\cdots (6)$$

Let, Q_a be the actual discharge. Then the co-efficient of discharge, C_d is given by, $C_d = \frac{Q_a}{Q_t} \quad \cdots\cdots\cdots (7)$

$$\therefore \boxed{Q_a = KC_d H^{5/2} \quad \cdots\cdots\cdots (8)}$$

5.2 Objectives :

a. To find the value of C_d for the V-notch.

b. To plot Q_t vs. Q_a in a plain graph paper.

c. To plot Q_a vs. H in a log-log paper and to find

(i) the exponent of H and

(ii) the co-efficient of discharge, C_d

5.3 Apparatus :

a. V-notch weir plate
b. Constant steady water supply
c. Channel
d. Flow rate measuring facility
e. Point gauge

5.4 Procedure :

a) The notch plate was placed at the end of the nappe with the sharp edge on the upstream side in a vertical plane.

b) Water was allowed to channel until the water discharges over the notch plate and the flow control valve was closed and water was allowed to stop flowing over weir.

c) Water was allowed to the channel and flow control valve was adjusted to obtain head.

d) Head for each flow rate was measured and recorded in the stabilize conditions.

5.5 Observation Sheet and sample calculation :

a. Angle of the notch = 90°

b. Cross sectional area = $(45 \times 30.5)\ cm^2 = 1372.5\ cm^2$

c. Height of water measuring tank = 5 cm

d. Initial point gauge reading = 0 mm

e. Final point gauge reading = 25 mm = 2.50 cm

f. Collection time = 50 sec

g. $K = \frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2} = \frac{8}{15}\sqrt{2 \times 981}\tan\frac{90}{2} = 23.6237$

$\therefore$ Theoretical discharge, $Q_t = KH^{5/2} = 23.6237 \times (2.50)^{5/2}$

$= 233.46\ cm^3/sec$.

$\therefore$ Actual discharge, $Q_a = \frac{Ad}{t} = \frac{1372.5 \times 5}{50} = 137.25\ cm^3/sec$

$\therefore$ Co-efficient of discharge, $C_d = \frac{Q_a}{Q_t}$

$= \frac{137.25}{233.46}$

$= 0.59$

Calculation from log-log graph paper :

We know,

Theoretical discharge, $Q_t = \frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2}\ H^{5/2}$

$= KH^{5/2}$

Where, $K = \frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2}$

We also know that,

Co-efficient of discharge, $C_d = \frac{Q_a}{Q_t} = \frac{\text{Actual discharge}}{\text{Theoretical discharge}}$

$\therefore Q_a = C_d \times Q_t$

$\Rightarrow Q_a = KC_d H^{5/2}$

Here,

$Q_a = KC_d H^{5/2}$

$\Rightarrow Q_a = KC_d H^n$ [where, n = exponent of H]

$\Rightarrow \log Q_a = \log KC_d + n\log H$

Let,

$\log Q_{a_1} = \log KC_d + n\log H_1$

$\therefore \log Q_{a_1} = n\log H_1 + \log KC_d$ .... (1)

$\therefore \log Q_{a_2} = n\log H_2 + \log KC_d$ .... (2)

From equation (1) and (2),

$\log Q_{a_2} - \log Q_{a_1} = n\log\left(\frac{H_2}{H_1}\right)$

$$\therefore n = \frac{\log \frac{Q_{a_2}}{Q_{a_1}}}{\log \frac{H_2}{H_1}}$$

From the log-log graph,

$$n = \frac{\log \frac{600}{60}}{\log \frac{4.6}{1.8}}$$

$$\therefore n = 2.45$$

and,

$$K C_d = 14$$

$$\Rightarrow C_d = \frac{14}{K}$$

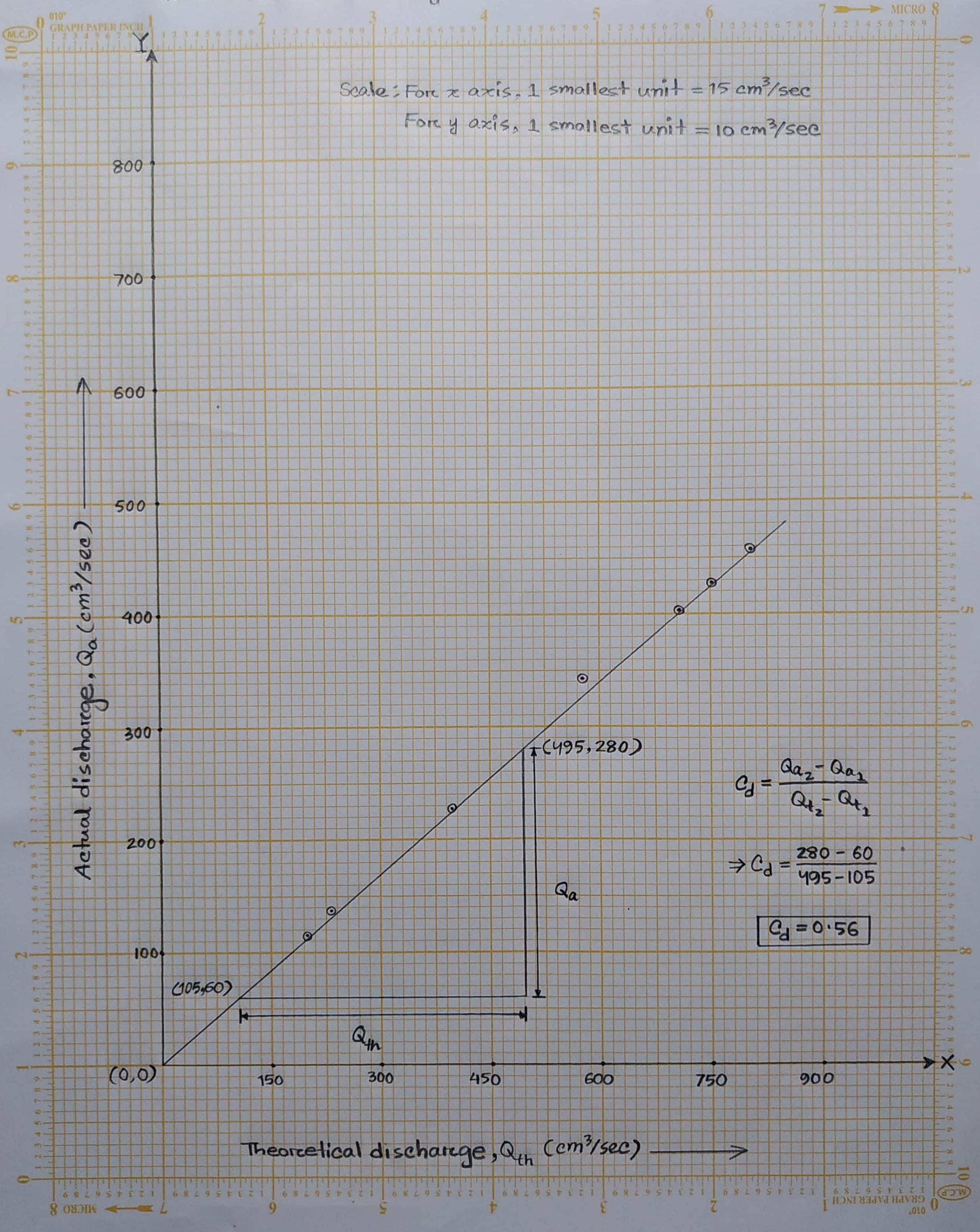
$$\Rightarrow C_d = \frac{14}{23.625} \quad [\text{We know, } K = 23.625]$$

$$\therefore C_d = 0.59$$

Table : Fore calculating discharege

No. of obs.	Area of Water (cm^2)	Volume of Water (cm^3)	Collection time (sec)	Actual discharge Qa (cm^3/sec)	Effective Head H (cm)	Theoretical discharge Q_t (cm^3/sec)	Co-efficient of discharge C_d
1	1372.5	6862.5	59	116.31	2.35	199.99	0.58
2	1372.5	6862.5	50	137.25	2.50	233.46	0.59
3	1372.5	6862.5	30	228.75	3.10	399.72	0.57
4	1372.5	6862.5	20	334.735	3.60	580.91	0.59
5	1372.5	6862.5	17	403.68	3.90	709.60	0.57
6	1372.5	6862.5	16	428.91	4.00	755.97	0.57
7	1372.5	6862.5	15	457.50	4.10	804.106	0.57
					Average C_d =		0.58

Variation of actual discharge (Qa) with respect to theoretical discharge (Q_{th})



The variation of Actual discharge (Qa) with respect to effective head (H)

K+E LOGARITHMIC 3 x 5 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

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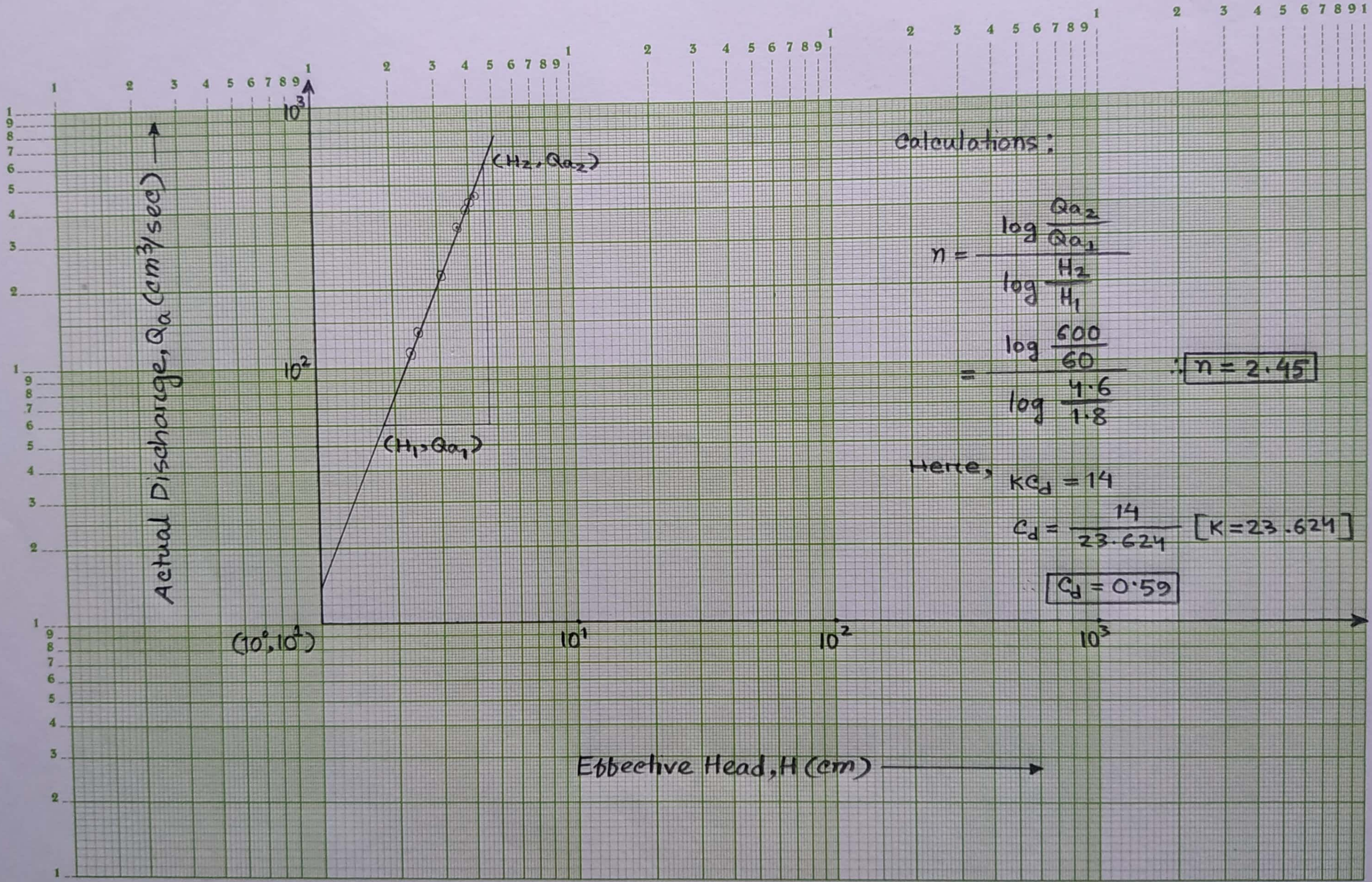

Calculations:

$$n = \frac{\log \frac{Qa_2}{Qa_1}}{\log \frac{H_2}{H_1}}$$

$$= \frac{\log \frac{600}{60}}{\log \frac{4.6}{1.8}}$$

$\therefore$ $\boxed{n = 2.45}$

Here, $KC_d = 14$

$$C_d = \frac{14}{23.624} \quad [K = 23.624]$$

$\boxed{C_d = 0.59}$

5.6 Results and Discussions :

Average value of C_d for V-notch = 0.58

The value of C_d from plain graph paper = 0.56

The value of C_d from log-log graph paper = 0.59

The exponent of H, n = 2.45

Discussions :

a) The experimental set up for V-notch was made carefully.

b) The height of water was observed carefully with the help of gauge.

c) The readings were taken when the water was at stable condition or flowing of the water was not allowed in this experiment.

Assignment

a) Why does the V notch give more accurate flow measurement?

Answer: When we are using a V notch, the notch is V in shape. Depth of water above the bottom of the V is called head (H). The V-notch design causes small changes in discharge. Hence causing a large change in depth and the sensitivity of the measurement increases. Thus it allows more accurate flow measurement.

b) Why C_d of rectangular notch is less than V-notch or triangular notch?

Answer: The average discharge co-efficient in rectangular notch is less than average C_d in V-notch. The C_d increases when the volume flow rate increases. V-notch gives more accurate & higher value of C_d than rectangular notch. This is due to the space for the water to flow through the notch. For triangular notch the space of water increases as the height of depth of water increases related to the angle of the notch. But for rectangular notch, the space of water is constant for every depth. For this reason, the C_d of rectangular notch is not very accurate. Thus C_d of rectangular notch is less than the C_d of triangular or V-notch.