DEPARTMENT OF CIVIL ENGINEERING

MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY

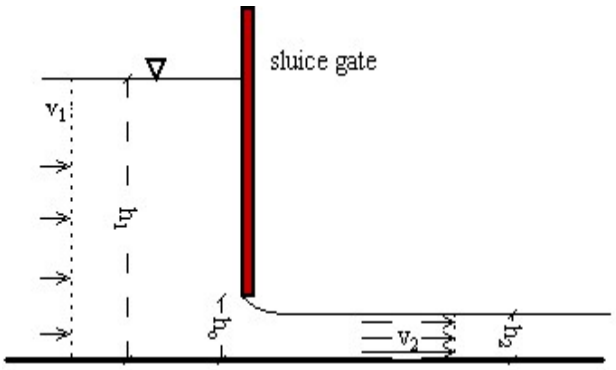
CE 362 Open channel flow Sessional

Experiment No. 5

FLOW BENEATH A SLUICE GATES

5.1General

Sluice gate is a classic example of the application of the concepts of energy and momentum. Sluice gate used in open channel to control and regulate the flow as well as to measure the discharge through the channel. Sometimes it is used to raise the water level and maintain a constant operating level in irrigation canal. Sluice gate also used for draining the excess water for both urban areas and rural agricultural areas..



Types of sluice gates

Flap sluice gate: A fully automatic type, controlled by the pressure head across it; operation is similar to that of a check valve. It is a gate hinged at the top. When pressure is from one side, the gate is kept closed; a pressure from the other side opens the sluice when a threshold pressure is surpassed.

Vertical rising sluice gate: A plate sliding in the vertical direction, which may be controlled by machinery.

Radial sluice gate: A structure, where a small part of a cylindrical surface serves as the gate, supported by radial constructions going through the cylinder's radius. On occasion, a counterweight is provided.

Rising sector sluice gate: Also a part of a cylindrical surface, which rests at the bottom of the channel and rises by rotating around its center.

Needle sluice: A sluice formed by a number of thin needles held against a solid frame through water pressure as in a needle dam. The gates of a Guillotine lock work in a way similar to a sluice gate, but most canal lock gate are hinged to swing like doors.

5.2Practical Applications

1. Sluice gates commonly control water levels and flow rates in rivers and canals**.**
2. Sluice gates are also used in wastewater treatment plants and to recover minerals in mining operations, and in watermills.

	
vertical rising sluice gate	**Sluice gate ,Jaipur, India**
	
Sluice gates in Farakka Barrage	A **sluice gate**, constructed on a canal by the Local Government Engineering Department at Sakoa village in Aditmariupazila of **Lalmonirhat**

5.3 Theory

Description of the sluice gate:

The simple form of a sluice gate consists of a horizontal channel bed having a vertical gate which can be lifted vertically up and down.

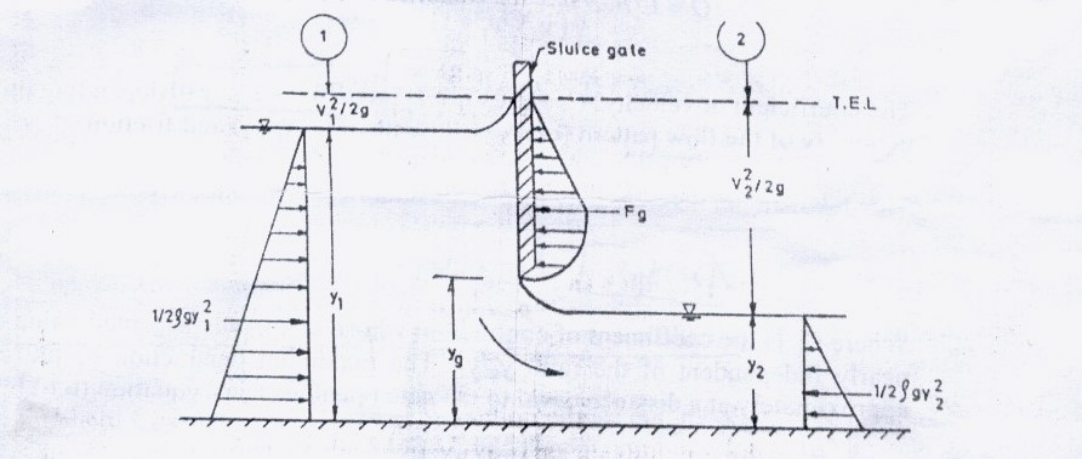


Figure: 5.1Sluice Gate

Theoretical discharge:

The Bernoulli equation may be applied in those cases where there is a negligible loss of total head form one section to another or where the magnitude of the head loss is already known. Flow under a sluice gate is an example of converging flow where the correct form of the equation for discharge may be obtained by equating the energies at section 1 and section 2 as shown in the figure 5.1. As the energy loss between the sections is negligible,

$$H_1 = H_2 \qquad (5.1)$$

And therefore,

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} \qquad (5.2)$$

Expressing the velocities in terms of Q, the above equation becomes

$$y_1 + \frac{Q^2}{2gb^2y_1^2} = y_2 + \frac{Q^2}{2gb^2y_2^2} \qquad (5.3)$$

Where, b is the width of the sluice gate.

Simplifying and re-arranging the terms, one obtains

$$Q = by_1\sqrt{\frac{2gy_2}{\frac{y_1}{y_2}+1}} \quad (5.4)$$

or alternatively,

$$Q = by_2\sqrt{\frac{2gy_1}{\frac{y_2}{y_1}+1}} \quad (5.5)$$

The small reduction in flow velocity due to viscous resistance between section 1 and 2 may be allowed for by a coefficient Cv. then

$$Q = C_v\, by_2\sqrt{\frac{2gy_1}{\frac{y_2}{y_1}+1}} \quad (5.6)$$

The coefficient of velocity, C_v varies in the range $0.95 < C_v < 1$, depending on the geometry on the flow pattern (expressed by the ratio $\frac{y_g}{y_1}$) and friction.

The downstream depth y_2 may be expressed as a function of the gate opening y_g i.e.

$$y_2 = C_c y_g \quad (5.7)$$

Where Cc is the coefficient of contraction who's commonly accepted value of 0.61 nearly independent of the ratio $\frac{y_g}{y_1}$. The maximum contraction of the jet occurs approximately at a distance equal to the gate opening. Thus equation 5.6 becomes

$$Q = C_c C_v by_g\sqrt{\frac{2gy_1}{\frac{c_c y_g}{y_1}+1}} \quad (5.8)$$

The above equation can be written as

$$Q = C_d by_g\sqrt{2gy_1} \quad (5.9)$$

Where C_d is the coefficient of discharge and is a function of C_v, C_c, b, y_g and y_1, therefore,

$$C_d = \frac{C_v C_c}{\sqrt{\frac{c_c y_g}{y_1}+1}} \quad (5.10)$$

Equation 5.9 may also be written as

$$Q_a = C_d Q_t \quad (5.11)$$

So that

$$Q_t = by_g\sqrt{2gy_1} \quad (5.12)$$

Where, Q_t and Q_a are the theoretical and actual discharges, respectively.

Forces and sluice gate:

The momentum equation may be applied to the fluid within any chosen control volume where the external forces are known or can be estimated to a sufficient degree of accuracy. The horizontal components of these forces acting on the fluid within the control volume shown in fig 5.1 are the resultants of the hydrostatic pressure distributions at sections 1 and 2, the viscous shear force on the bed and the thrust of the gate. It should be noted that the equation permits the resultant gate thrust (F_g) to be determined even though the pressure distribution along its surface is not hydrostatic. Over a short length of smooth bed the contribution of the shear force may be neglected. The resultant force applied to the fluid within the control volume in the downstream direction is given by

$$F_x = (\frac{1}{2}\rho g y_1^2 - \frac{1}{2}\rho g y_2^2 - F_g)\, b \quad (5.13)$$

The effect of this force is to accelerate the fluid within the control volume in the downstream direction. Hence,

$$F_x = \rho Q_a V_2 - \rho Q_a V_1 \quad (5.14)$$

Substituting for F_x and gathering terms, one obtains

$$F_g = \frac{1}{2}\rho g y_2^2 \left[\{(\frac{y_1}{y_2})^2 - 1\} - \frac{\rho Q_a^2}{b^2 y_2}(1 - \frac{y_2}{y_1})\right] \quad (5.15)$$

Simplifying and eliminating Q_a, We get

$$F_g = \frac{1}{2}\rho g \frac{(y_1 - y_2)^3}{y_1 + y_2} \quad (5.16)$$

The pressure distribution on the gate cannot be hydrostatic, as the pressure must be atmospheric at both the upstream water level and at a point where the jet springs clear of the gate.

Note that the thrust on the gate, F_H, for a hydrostatic pressure distribution is given by

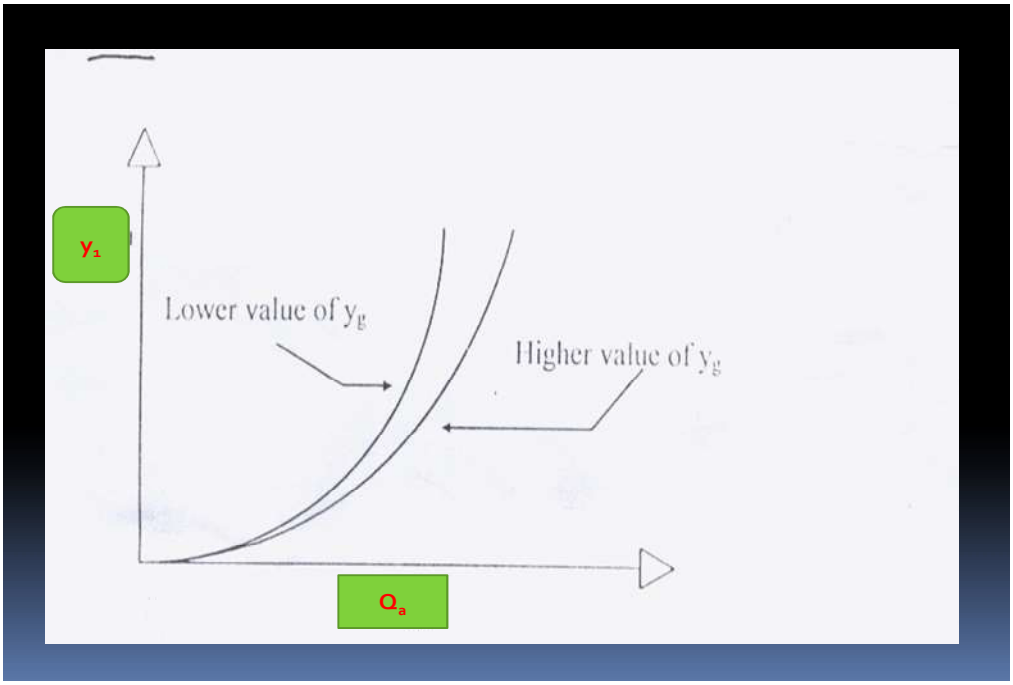
$$F_H = \frac{1}{2}\rho g (y_1 - y_g)^2 \quad (5.17)$$

5.4 Objectives

1 To determine the discharge beneath the sluice gate.
2 To determine C_c, C_v and C_d.
3 To plot y_1 Vs. Q_a for different y_g in plain graph paper.
4 To determine F_g and F_H and hence find the ratio of $\frac{F_g}{F_H}$

Typical shape of the graph:

As $Q = ky_1^n$ so, y_1 Vs. Q graph will be a parabola. Now, if y_g increases, for same y_1, Q will be increased. So, the y_1 vs. Q graph for higher y_g lies under the same graph for lower y_g

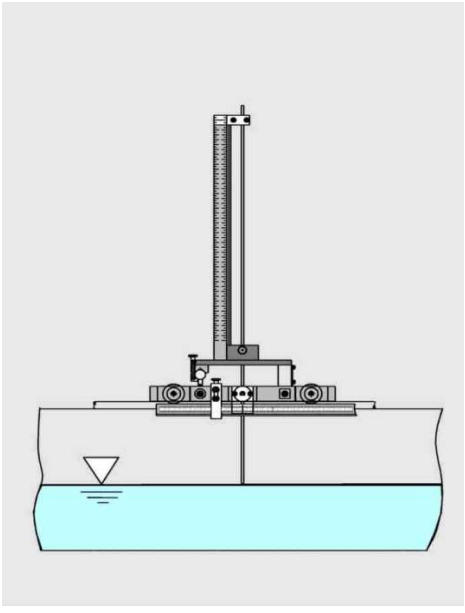


5.5. Apparatus

Flow channel, Broad crested weir, instrument carriage etc.



Sluice Gate in flow channel



instrument carriage

5.6Procedure

Determining discharge:

1. Measure y_1 and y_g
2. Calculate theoretical discharge using equation (5.12)
3. Take the reading of actual discharge from water meter.

Determining of C_v, C_c and C_d:

1. Calculate C_c from Eq. (5.7)
2. Using the value of C_c calculate C_v from eq. (5.8)

Plotting y_1 Vs. Q_a for different y_g:

Plot y_1 Vs. Q_a for different y_g in a same plain graph paper.

Determining F_g and F_H and hence find the ratio of Fg/ F_H:

1. Determine y_2
2. Determine F_g using eq. (5.16)
3. Determine F_H using equation (5.17) and calculate the ratio of F_g / F_H

DATA SHEET

5.7 Data sheet:

Width of the sluice gate, b=

Gp No	y_1 (m)	y_2 (m)	y_g (m)	Q_a (m^3/s)	Q_t (m^3/s)	C_v	C_c	C_d	F_g	F_H	F_g/F_H
1											
2											
3											
4											
5											
6											

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Signature of the Teacher

5.8Calculation

5.9Assignment

1. Explain why the pressure distribution along the surface of the gate is not hydrostatic?

2. What happens when the gate opening is greater than the critical depth?

3. When does the submergence occur and what is its effect on flow beneath a sluice gate?

5.10 Discussion