

Properties of Hydraulic Jump Down Stream Sluice Gate

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Abstract: The properties of a hydraulic jump and energy dissipation downstream sluice gate have been studied. Three gate opening 2, 3, 4 cm were used to carry out the experiments in a rectangular channel. It was found that energy dissipation through the hydraulic jump is a function of Froude, Weber numbers and gate openings, and that energy dissipation decrease as Weber number increase and increase as Froude number increase, and that Weber number increases as gate opening increase while Froude number decrease as the gate opening increase.

Key words: Energy dissipation, hydraulic jump, sluice gate

INTRODUCTION

Hydraulic jump occurred widely in most of hydraulic structures, such as spillways in high dams, down stream weirs and sluice gates, where is high velocity. Hydraulic jump can be used as energy dissipation and then limited scour at the bed of channel and it is used as a mixed tools in water supply.

The hydraulic engineer takes care in design calculation development, the size and location of a hydraulic jump, (Streeter, 1996). Hydraulic jump studied by (Bidone, 1808), the condition of occurrence of a hydraulic jump is to change flow suddenly from supercritical flow (low depth with high velocity) to subcritical flow (high depth with a low velocity), (Chow, 1959). It is also happen when slope changed from steep to mild slope.

More studies and researches on hydraulic jump have been done such as (Bakhmeteff, 1979) and (Narasimhan and Bhargava, 1976). They studies submerged hydraulic jump down stream sluice gate in a glass channel 10 m long, 0.5 m wide and 0.6 m height. They found that the length of a hydraulic jump increased as depth increasing with the increasing of Froude number.

Hager and Bremen (1990) studied the effect of channel wall friction on water depth down stream hydraulic jump, mathematically, and compared their measured laboratory results with the calculated results and found that the percentage of error between the results approximately equal to 2%.

Long *et al.* (1991) studied a submerged hydraulic jump down stream sluice gate in rectangular channel 7.5 m long, 0.47 m wide and 0.52 m height, their study include velocity and water surface profile, the results were compared with a theoretical results.

In this study the properties of a hydraulic jump and energy dissipation has been studied down stream sluice gate in a rectangular channel.

Experimental work: The experiments were carried out in hydraulic laboratory in Mosul University College of engineering in 10 m long horizontal tilting channel of cross section 0.3 m width and 0.45 m height. The channel consists of toughened glass walls and stainless steel floor. Two movable carriages with point gages were mounted on brass rails at the top of channel sides. The sluice gate were made from wood 0.3 m wide, 0.4 m height and 2 mm thickness, stalled at 2.5 m down stream the channel inlet section. For discharge measurements, a full width thin-plate sharp-crested rectangular weir of 15 cm height was located down stream the channel section.

The standard weir was manufactured according to British standards (1965). The water-surface levels and heads were measured with the precision point gages whose least count 0.1 mm. The details of the channel with the sluice gate and end weir were shown in Fig. 1.

The experiments carry out on three sluice gate opening ($a = 2, 3, 4$) cm with five discharges for every sluice gate opening between (6.625-18.15)l/s. Figure 2 Shows a definition sketch for flow under sluice gate.

Dimensional analysis: For flow under a sluice gate a functional relation ship linking the main flow variables may be expressed as follows:

$$Q = f(H_1, a, b, y_0, y_1, y_2, g, \sigma, \rho, \mu) \quad (1)$$

where,

Q : Discharge per unit width

f : Equation function

H_1 : Total head upstream sluice gate

a : Sluice gate opening

b : Channel width

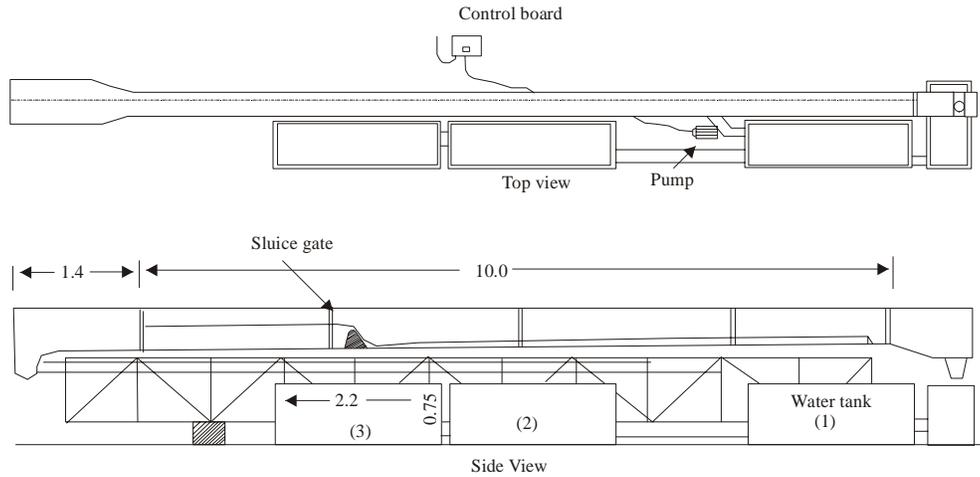


Fig. 1: the laboratory channel

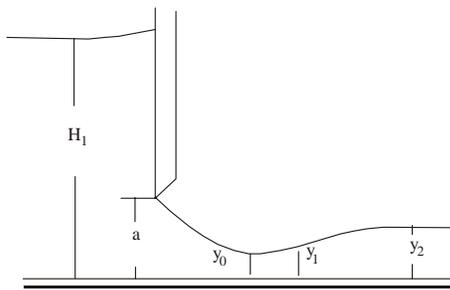


Fig. 2: Definition sketch for sluice gate

- y_0 : Concentration depth under sluice gate
- y_1 : Depth of water upstream hydraulic jump (initial depth)
- y_2 : Depth of water downstream hydraulic jump (sequent depth)
- g : Acceleration due to gravity
- σ : Surface tension
- ρ : Density of water
- μ : Dynamic viscosity

Using dimensional analysis the following functional where relationship obtains:

$$\frac{Q}{bH_1\sqrt{gH_1}} = f_1\left(\frac{y_0}{a}, \frac{y_2}{y_1}, F, W\right) \quad (2)$$

where,

$$F: \text{Froud number } (F = \frac{V}{\sqrt{gH_1}}) \quad (3)$$

$$W: \text{Weber number } (W = \frac{V}{\sqrt{\frac{\sigma}{\rho H_1}}}) \quad (4)$$

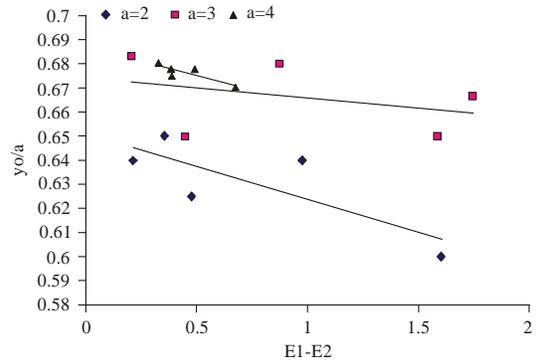


Fig. 3: The relationship between (E1-E2) and (y_0/a)

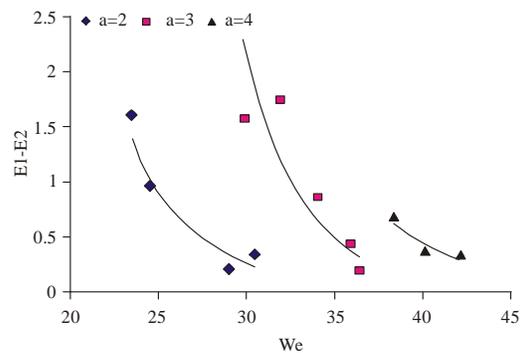


Fig. 4: The relationship between (E1-E2) and (W)

DISCUSSION

Variation of (E1-E2) with ($\frac{y_0}{a}$, W, F): Figure 3 shows the variation of the dissipated energy through the hydraulic jump (E1-E2) with the ratio of the head of water downstream the gate to the gate opening, the data shows

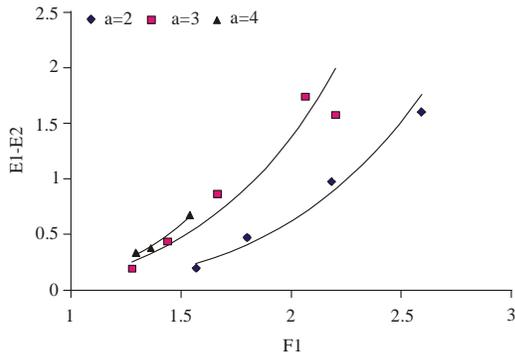


Fig. 5: The relationship between (E1-E2) and (F)

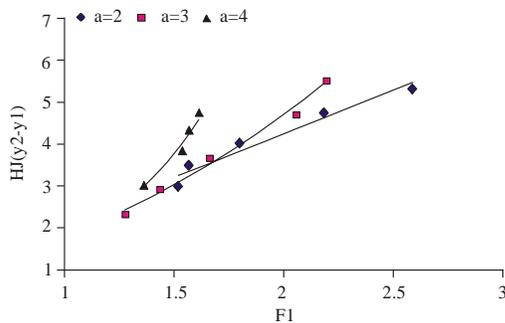


Fig. 6: The relationship between (F) and (Hj)

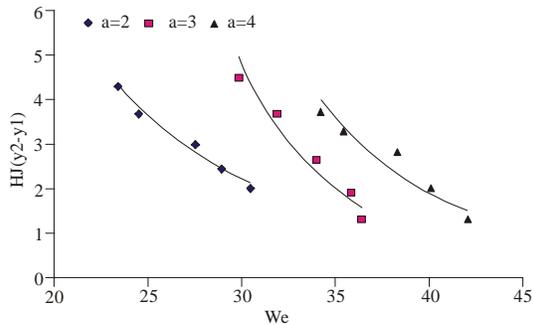


Fig. 7: The relationship between (W) and (Hj)

that as the ratio ($\frac{y_0}{a}$) increase (E1-E2) decrease and a high energy dissipation occurred at a gate opening 2 and 3 cm.

Figure 4 Shows that as Weber no. W Increase energy dissipation decrease and as the gate opening increase Weber no. W increase while Fig. 5 Shows that as Froud no. F Increase energy dissipation increase and that as the gate opening increase Froud no. F decrease.

Variation of (Hj) with (E1-E2 and F, W): Figure 6 and 7 shows variation of the height of the hydraulic jump (Hj)

Table 1: Maximum laboratory variables

Run. No.	Gate opening	Max (E1-E2)	Max (F)	Max (W)	Max (E%)
1-5	2	1.601	2.589	30.471	18
6-10	3	1.742	2.197	36.396	14
11-15	4	0.673	1.615	42.084	3

with Froud no. F and Weber no. W , respectively. Figure 6 shows that when (Hj) increase Froud no. F increase for all the gate opening under study and that as the gate opening increase (Hj) increase, while Fig. 7 Shows the variation of the height of the hydraulic jump (Hj) with Weber no. W . From Fig. 7 we can see that as (Hj) increase Weber no. W decrease and as the gate opening increase Weber no. W increase. Table 1 shows the details of Run No. and maximum variables laboratory.

CONCLUSION

The experimental study of the hydraulic jump downstream sluice gate leads to the following conclusions:

- Dissipated energy through the hydraulic jump increase as (y_0/a) decrease and a high energy dissipation occurred at a gate opening 2 and 3 cm
- Weber no. W increase as energy dissipation decrease and as the gate opening increase W no. increase
- Froud no. F increase as energy dissipation increase and that as the gate opening increase Froud no. decrease
- Max energy dissipation at gate opening 2 cm approaches 18%

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