influence of Baffle Block and sill for Determination characteristic of contraction coefficient (cc) and Discharge coefficient (cd) for Flow under sluice Gate

by Sunik .

Influence of Baffle Block and Sill for Determination Characteristic of Contraction Coefficient (Cc) and Discharge Coefficient (Cd) for Flow Under Sluice Gate

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ABSTRACT

The contraction coefficient (Cc) and discharge coefficient (Cd) always rise in flow while sluice gate operated with variation of open gate and discharge (Q). To know it, laboratory experiment was development used trapezoid baffle block compared with sill. This experimental research used prototype model made from fiberglass (horizontal channel), sluice gate installed on it. Dimension of horizontal fiberglass channel: length (L) = 9 m, width (B) = 50 cm; sluice gate dimension, height (h) = 80 cm, thick (t) = 1 cm, width (b) = 50 cm. Variation of discharge (Q) and open gate (a = 1,2,3,4 cm). Two models of trapezoid baffle block (T1, T2) installed as three rows, specified location 25 cm after sluice gate combine with sill (different dimension). Water depth (h) and velocity (v) were measured during each running test then Froude number, contraction coefficient (Cc) and discharge coefficient (Cd) were calculated. The result showed that trapezoid baffle block model T2 (used no sill, sill 2 cm and sill 2.7 cm, Fr = 0.11 - 0.75) gives the better performance modelling of Cc and Cd in term of the initial Froude number with R^2 = 0.8086 (Cc) and R^2 = 0.8273 (Cd). It was concluded that using three rows configuration of trapezoid baffle block, T2 model gave better model than T1.

Keyword *: Trapezoid Baffle Block, Sill, Contraction coefficient, Discharge coefficient, Froude Number*

1. INTRODUCTION

Research of free-surface flow (depend on the tailwater depth) under sluice gate is important to provide a prediction tool for optimize hydraulic infrastructure operation (irrigation, drainage or installation in dams). Sluice gates placement as hydraulic structure commonly in a channel used to control and rises water level. Henderson (1966) state that the discharge through a sluice gate is affected by the upstream flow depth for free flow.

Simulation operation flow under sluice gate with variation open gate will rise contraction coefficient (Cc) and discharge coefficient (Cd). Contraction coefficient (Cc) define as the ratio of water depth at vena contracta. Discharge coefficient (Cd) define as the ratio of actual discharge to the theoretical discharge. In this research, flow under sluice gate was simulated, contraction coefficient (Cc) and discharge coefficient (Cd) was analyze. Adding structure as baffle block (to reduce velocity and energy of flow, Chaudry, 2008) or sill (to increase the water level at the downstream-end of the channel, Raju, 1980) usually placement in front of sluice gate with certain distance for energy dissipator while running flow being simulation to reach the stable condition.

Benchmark value of Cc and Cd must be under 1 as a safe value for sluice gate and adding structure stabilization.

This research was development from earlier research (Sunik, 2001, 2015) and aims to analyze characteristics of Cc and Cd with two models of trapezoid baffle block (T1, T2) that located in front of sluice gate in a channel using prototype channel model test.

Some researcher as Gilles (1943), Benjamin, (1956), Betts (1978), Cheng et.al (1980), Dae-Geun (2007), Fangmeier and Strelkoff (1967), Roth and Hager (1999), Isaacs (1977), Masliyah, et. al (1985) Mohammed and Khaleel (2013), Montes (1997), Nago (1978), Noutsopoulos and Fanariotis (1978), Oskuyi and Salmasi (2011), Rajaratnam (1977), Rajaratnam and Subramanya (1967), Roth and Hager (1999), Sunik (2001, 2019), Swami (1990), Yen et. al (2001) had been done many experiment and investigated about contraction coefficient and coefficient discharge for flow under sluice gate.

Henderson (1966) derived two equations to compute Cd for each flow condition:

Free flow $$C_d = \frac{C_c}{\sqrt{1+\eta}} \qquad \eta = \frac{C_c \, x \, b}{y_1} \qquad \ldots(1)$$

The contraction coefficient is defined as the ratio of the water depth at vena contracta, y2 to gate opening (Cc = y2/b).

2. EXPERIMENTAL WORK

The experimental research was development from earlier research (Sunik, 2001, 2019). Figure 1 explained about configuration in experiment laboratory. Measurement for water depth (h) and velocity (v) implemented into 12 section in the channel in front of the sluice gate installation. Measurement for each section consist of left, middle and right part that each part measure in above, middle and bottom of height flow (one section consists of nine measured). The local velocity (v) for 12 section was measured in the same procedure. Running measurement as (1-upstream-y_1, 2-under the gate, 3-before baffle block installation, 4-before the jump (the initial depth, y_2), 5-above the baffle block, 6-the end baffle block, 7-after the jump (sequent depth, y_3), 8-end of roller, 9-end of jump, 10-3/4 length before the sill, 11-1/2 length before the sill, 12-1/4 near the sill) for the depth (y) of water. Value of velocity and the depth affecting value of Froude number (Fr).

The prototype model as horizontal channel made from fiberglass (used for trial running flow, with dimension as width (B) = 50 cm, length (L) = 9 m). Sluice gate placed on it with dimension, width (b) = 50 cm, thick (t) = 1 cm, height (h) = 80 cm, using added device (trapezoid baffle block and sill) as energy dissipator, present in Figure 1. Simulation of flow for each run was trial until configuration of hydraulic jump was performed in stabilized to the desire location of 25 cm downstream from the sluice gate.

Fig. 1 : Trapezoid baffle block configuration in front of sluice gate

Fig. 2 : Water depth and velocity measurement for 12 section

Table 1 : Configuration dimension of trapezoid baffle block

No	Model Baffle Block	Type	Run	(b_b) mm	(l_b) mm	(h_b) mm
1	T	T1	12	7	7	7
		T2	12	14	14	14

Table 2 : Configuration dimension of sill for the channel

No	Model Baffle Block	Type	Sill type	(hs) (cm)
1	T	T1	s_1, s_2	no sill; 2
		T2	s_2, s_3	2 and 2.7

Configuration dimension of trapezoid (T) baffle block type of T1, width (b_{b1}) = 7 mm, length (l_{b1}) = 7 mm and height (h_{b1}) = 7 mm; type of T2, width (b_{b2}) = 14 mm, length (l_{b2}) = 14 mm and height (h_{b2}) = 14 mm. Sill placed in downstream channel with dimension width (b_{s1}) = 50 cm, thick (t_s)= 1 cm, height $(h_{s1}, h_{s2}, h_{s3}$ = no sill, 2 cm, 2.7 cm). Variation of open gate (a) = 1 cm, 2 cm, 3 cm, 4 cm.

Two set of experiments test with a total of 94 run, using trapezoid baffle block in cross sectional (three rows, each baffle block made from fiberglass) mixing with configuration of sill that placed in downstream present in Table 1 and Table 2.

Regression method (Nawari, 2007) was used to analyze relation between contraction coefficient (Cc), discharge coefficient (Cd) and Froude number (Fr) to know influence of Fr against to Cc and Cd. Determination coefficient value was criteria that showed the variable against to the response (Sembiring, 1995) as:

$$R^2 = 1 - (\Sigma\ JKG / \Sigma JKT) \qquad ...(2)$$

where:

Σ JKG = sum of error square

Σ JKT = total sum of squares

RESULTS AND DISCUSSION

3.1 Contraction Coefficient (Cc)

Correlation result between Froude number and contraction coefficient model T1, T2 show in Figure 3; value of Cc present in Table 3.

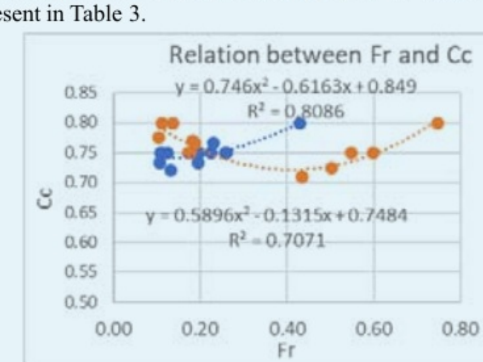

Fig. 3 : Contraction coefficient (Cc) for trapezoid baffle block model T1, T2

Table 3 : Value of Contraction Coefficient (Cc) for T1 and T2 model

No	Run	Type	Q	a	sill	Fr	Cc
1	39	T1	4.01	1	-	0.13	0.72
2	37	T1	6.86	2	-	0.13	0.75
3	35	T1	9.91	3	-	0.11	0.73
4	34	T1	14.11	3	-	0.20	0.73
5	32	T1	13.31	4	-	0.11	0.75
6	40	T1	18.03	4	-	0.11	0.75
7	42	T1	7.84	1	2.7	0.43	0.80
8	43	T1	11.51	2	2.7	0.20	0.75
9	44	T1	12.27	2	2.7	0.26	0.75
10	45	T1	16.31	3	2.7	0.23	0.77
11	46	T1	18.03	4	2.7	0.23	0.75
12	47	T1	20.71	4	2.7	0.26	0.75

No	Run	Type	Q	a	sill	Fr	Cc
1	72	T2	4.66	1	-	0.18	0.75
2	73	T2	4.76	1	-	0.18	0.77
3	79	T2	12.79	4	-	0.11	0.78
4	80	T2	14.51	4	-	0.11	0.80
5	91	T2	7.73	1	2	0.75	0.80
6	88	T2	12.27	2	2	0.43	0.71
7	87	T2	15.47	3	2	0.14	0.80
8	86	T2	16.03	3	2	0.19	0.77
9	85	T2	15.47	4	2	0.17	0.75
10	92	T2	8.85	1	2.7	0.60	0.75
11	93	T2	13.57	2	2.7	0.50	0.73
12	94	T2	17.88	2	2.7	0.55	0.75

Based on R^2 value that close to 1 for determination coefficient, the better performance showed by trapezoid baffle block type T2 that used no sill, sill = 2 cm and sill = 2.7 cm at the channel, with Fr = 0.11 - 0.75, Cc = 0.73 – 0.80. In all type combination of trapezoid baffle block with sill, the value of Cc was below 1 while benchmark usually for free flow was based on the conformal mapping method ($\pi/(\pi+2)$) ≈ 0.611 (in Belaud, 2009), it means the series dan rows of baffle block that installed affected the Cc value going to increased and strong relation between value Fr to contraction coefficient had present (value of Cc influenced by Fr, while Fr depend on velocity (v) and depth of water (y)).. The equation presented as:

$$y = 0.746x^2 - 0.6163x + 0.849, \quad R^2 \text{ value} = 0.8086$$

Adding device i.e sill at the channel influenced velocity of flow, affected to Cc value. All value of Cc under 1 as benchmark mean that configuration of trapezoid baffle block T2 model safe for implementation.

Value Cc reach 0.80 in combination a = 1 cm and sill = 2.7 cm (T1) and a = 4 cm, no sill; a = 1, sill = 2 cm; a = 3, sill = 2 cm (T2) with value for Fr in range 0.1 – 0.75 (sub critic).

3.2 Discharge Coefficient (Cd)

Correlation result between Froude number and discharge coefficient model T1, T2 show in Figure 4; value of Cd present in Table 4.

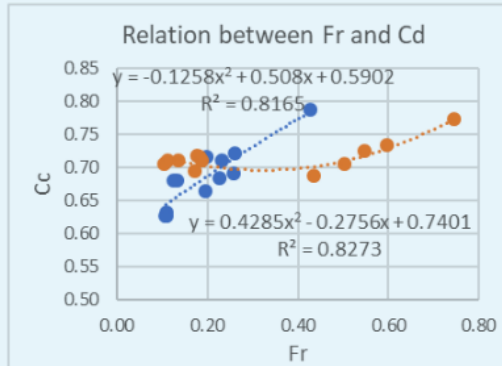

Fig. 4 : Discharge coefficient (Cd) for trapezoid baffle block model T1, T2

Table 4 : Value of Discharge Coefficient (Cd) for T1 and T2 model

No	Run	Type	Q	a	sill	Fr	Cd
1	39	T1	4.01	1	-	0.13	0.68
2	37	T1	6.86	2	-	0.13	0.68
3	35	T1	9.91	3	-	0.11	0.63
4	34	T1	14.11	3	-	0.20	0.66
5	32	T1	13.31	4	-	0.11	0.63
6	40	T1	18.03	4	-	0.11	0.63
7	42	T1	7.84	1	2.7	0.43	0.79
8	43	T1	11.51	2	2.7	0.20	0.72
9	44	T1	12.27	2	2.7	0.26	0.72
10	45	T1	16.31	3	2.7	0.23	0.71
11	46	T1	18.03	4	2.7	0.23	0.68
12	47	T1	20.71	4	2.7	0.26	0.69

No	Run	Type	Q	a	sill	Fr	Cd
1	72	T2	4.66	1	-	0.18	0.72
2	73	T2	4.76	1	-	0.18	0.72
3	79	T2	12.79	4	-	0.11	0.71
4	80	T2	14.51	4	-	0.11	0.71
5	91	T2	7.73	1	2	0.75	0.77
6	88	T2	12.27	2	2	0.43	0.69
7	87	T2	15.47	3	2	0.14	0.71
8	86	T2	16.03	3	2	0.19	0.71
9	85	T2	15.47	4	2	0.17	0.69
10	92	T2	8.85	1	2.7	0.60	0.73
11	93	T2	13.57	2	2.7	0.50	0.70
12	94	T2	17.88	2	2.7	0.55	0.72

Based on R^2 value, the better performance showed by trapezoid baffle block type T2 that used no sill, sill = 2 cm and sill = 2.7 cm at the channel, with Fr = 0.11 - 0.75, Cd = 0.69 – 0.77, describe as:

$$y = 0.4285x^2 - 0.2756x + 0.7401, R^2 \text{ value} = 0.8273$$

The value R^2 close to 1 for determination coefficient. It means that a strong relation between value Fr to discharge coefficient had present (value of Cd influenced by Cc). All benchmark value under 1, it means that configuration of trapezoid baffle block T2 safe for implementation.

While open gate being increase, Fr value tend to decrease and Cc value tend to stabilize. The velocity value affected the Fr value. While the velocity flow held by baffle block, it will decrease so the Fr value became decrease too.

CONCLUSION

Configuration of baffle block (depend on number of baffle blocks, spacing between adjacent blocks, width of the block, dimension of block) paired with matched sill placement will gave better performance of Cc and Cd (< 1) while sluice gate operated with variation open gate.

It concluded that trapezoid baffle block model T2 (1.4 cm) combine with no sill and two model of sill (2 and 2.7 cm) gave better performance for Cc and Cd value (determination coefficient $R^2 = 0.8086$ and $R^2 = 0.8273$) than model T1.

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Construction Delay Analysis of Some Indian Hydropower Projects

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ABSTRACT

Delay is a significant and versatile problem occurring in construction of large projects around the globe, and Indian hydropower projects are no exception to it. This study aims at to identify and rank the critical factors governing the delay in construction of hydropower projects in India. To this end, literature was reviewed comprehensively; interviews were conducted for preparation of an exhaustive questionnaire for major Indian Hydel executing agencies. In total, 96 significant causes of delay were identified. Applying the most widely used risk identification and ranking techniques, viz., Importance Index and Fuzzy Risk Assessment, the study revealed environmental clearance, geological adversities, local issues, R&R, land acquisition, contractual, cash flow, law and order issues as major delay factors. Software tools of Statistical Package for the Social Sciences (SPSS) and MATLAB were applied for data analysis. The study concluded that IMPI and Fuzzy Risk assessment were pragmatic tools for ranking of delay factors. The ranking results indicated that there is a significant relationship existing between the responses with no major difference in opinions of the expert belonging to owners and contractors. Finally, the study recommended measures to minimize and control these delays in hydropower construction projects, specifically in India.

***Keywords**: Construction delay, Importance Index, Fuzzy logic, Hydropower, Questionnaire survey*

1. INTRODUCTION

This study concerns the construction delay analysis of hydropower schemes in the Indian perspective. It deals with the significance of assessing and analyzing the causes leading to delay in public and private hydropower schemes. According to Alkhathami (2004), construction delay is a project schedule slippage beyond the contract date on which the construction involving party agreed to finish. Due to an abnormal increase in estimated cost and highly complex and complicated nature, it is necessary to identify the critical causes of delay in the construction of hydropower projects and propose suitable mitigation measures. According to Agarwal & Kansal (2017), delays have become commonplace in Indian hydropower sector due to several reasons. Land acquisition challenges, geological adversities, Rehabilitation & Resettlement (R&R) issues, and obtaining forest/land clearances are the most common time-consuming process which disrupts the entire project schedule.

Moreover, the Central Electricity Authority estimates the average time overrun of six years for Indian hydropower projects. The construction delay causes are mostly unique in every hydropower project. However, only a few delay analyses have been carried out in India. Thus, it is in order to carry out a comprehensive study, which also forms the primary objective of this paper. Presently, hydroelectric power in India is produced by both private and public sectors. The private sector accounts only for 7.5%, and the public for about 92.5%. The private executing agencies have opportunity to grow with the development of potential regions, such as Himalayan mountain ranges and northeast of India.

Among various reasons for slippage in Indian hydro capacity additions, the major factors that form barrier to hydel development are land acquisition, R&R issues (Assocham India & PWC, 2017). It is due to difficulties of acquiring land for various components of the project such as Dam, Headrace Tunnel, Power House, etc. Dislocation and resettlement of people are time taking process and sensitive, often leading to litigation. The lengthy procedures of environment and forest clearances, viz., environmental, forest, and wildlife from three different wings of the Ministry of Environment and Forest and unpredictable nature of geology and climatic condition magnify the time overrun. In addition, law & order problem & local issues, cultural/religious/political matters, steep terrain & poor accessibility, inter-state issues, and cumulative basin studies are also some of the significant reasons for the delay.

The present research aims at to (a) identify major factors governing the delay in construction of Indian hydropower projects, (b) evaluate them based on their frequency of occurrences and degree of severity, and (c) suggest remedial measures for minimization.

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