International Journal of Research in Engineering and Applied Sciences (IJREAS)
Available online at http://euroasiapub.org/journals.php
Vol. 6 Issue 7, July 2016, pp. 24~28
ISSN(O): 2249-3905, ISSN(P) : 2349-6525 | Impact Factor: 6.573 | Thomson Reuters ID: L-5236-2015

A REVIEW OF PERAMETRIC STUDIES OF PIANO KEY WEIR

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Article history:

Received June 9th, 2016;
Approved July 15th , 2016;
Available online: Aug 2st, 2016.

Keywords:

Piano key weir, Labyrinth weir, Spillway capacity.

Abstract

Dams play important roles in development of any country. It provides flood control, water for drinking purpose, hydroelectric power, navigation and irrigation. Dams in India are 30 to 40 years old and required rehabilitation. Storage capacity of dam day by day decreases due to siltation. Modified shape of Labyrinth weir called piano key weir is implemented to overcome these problem. The Piano key weir is a modified shape of Labyrinth weir with overhanging on upstream or downstream or on both sides. The zigzag shape of Piano key weir permits to multiply the crest length of a given spillway length, which increase discharge capacity without increasing the submergence area on upstream side of dam. From last decade Piano key weir is in the core of research investigations. Mostly experimental models are studied to determine the co-efficient of discharge. In this paper we have highlight the earlier studies on different parameters which impact on flow capacity of the Piano key weir.

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1. INTRODUCTION:

Piano key weir concept was recently developed by Blanc university of Briska in Algeria and Lemperiere (Hydrocoop) in Franch, Lemperiere and Quamane 2003 [3].

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With compare to Sharpe crested weir, discharge capacity increased by zigzag shape of Piano key weir similar to Labyrinth weir, however over hang on both side reduce the foundation width compare to Labyrinth weir. The typical Piano key weir has folded rectangular crest with slopping floor on both side. Fig.1 shows a typical Piano Key weir geometry.

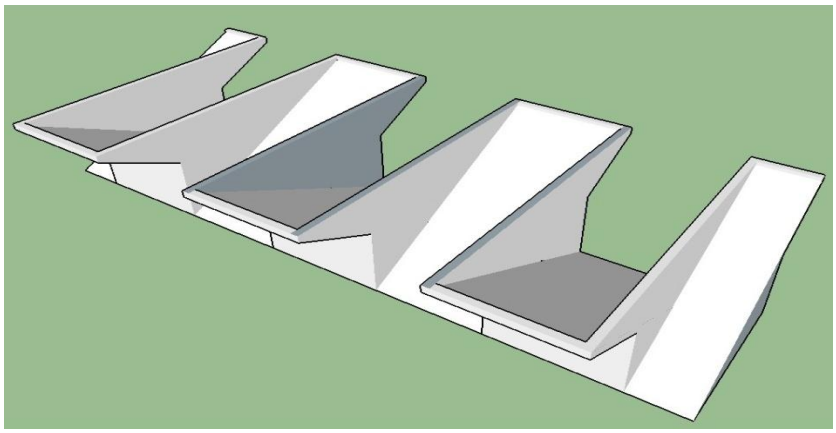

Figure. 1 Piano key weir

Tullis (1995), et al. work on the design of the Labyrinth weirs. According to his study, head on crest, total crest length are shown as the parameter affecting the flow capacity of weir. Their equation are valid for ratio of H_t/P is approximately 0.9, wall thickness of crest is P/6 and angle between 6^0 to 35^0. Lemperiere et al. (2003)[3]., in conventional Labyrinth weir, $1m^3$ to $2m^3$ reinforced concrete is required to increase the flow by 1 m^3/s. Main disadvantages of Labyrinth weir is that it cannot be easily placed on ogee weir. A large flat area is required to support the vertical wall. To overcome this disadvantages of traditional Labyrinth weir, a new kind of weir (Piano key weir was developed) by Blanc and Lemperiere, Quamane and Lemperiere, the first Piano key weir model study show discharge capacity was 4 times more than Sharpe crested weir at constant head. In the Lemperiere and Quamane [4] for low cost efficiency preferred a simple longitudinal section. They developed two solutions in the study. In first solution, there are similar downstream and upstream overhangs, implementation of precast concrete. In second solution, there is only upstream overhang. Cost saving approximately10% higher than the cost saving of first solution. Second Solution doesn't support the use of precast concrete. Along with this by using the Piano key weir the cost could be minimize and the safety could be ensured. Lemperiere (2009) [8]. proposed the relationship for Piano key weir and head discharge,

$$q = 4.3\, h \sqrt{P_m} \qquad (1.1)$$

In which, h = upstream head over the weir crest.

In 2011, Anderson and Tullis [10] discussed the 'h' parameter given by Lemperiere (2009) [8].. They presented a study to examine the sensitivity of Piano key weir by using three models with outlet key width to inlet key width ratio vary from 0.8, 1.0 and 1.25. The outlet key width to inlet key ratio 1.25 is most effective out of three studied models. it was concluded that most optimize model is the one with bo/ai ratio is 1.25. Dr. Nayan

Sharma (2012)[11], proposed preliminary design procedure in a typical project. Main input variables are the discharge to be executed by the Piano key weir discharge (Q_{pkw}) and maximum available head (H), here the maximum height of Piano key weir (P) and width of structure (B) are the principle constrain. Machiels, et al. (2012)[11], based upon previous experimental test result, preliminary design method was proposed. Mario oertel (2015)[15], for experimental model discharge co efficient comparison with Anderson and Tullis (2012) [10] as well as for numerical model discharge co efficient shown that investigated discharge H/P >0.15 result from the experimental as well as numerical model are closed to those collected by Anderson and Tullis (2012)[10]. But they cannot be reproduced exactly. Dr. Salesh issa khassaf (March 2016) [16], at low head ratio (H/P = 0.25) the efficiency of Piano key weir was nearly 400 % compare to Sharpe crested weir at similar head. In tested Piano key weir models, the most governing parameters are the key widths bo/ai, magnifying length L/B, and overhangs length Bo/B.

2. ANALYSIS AND DISCUSSION:

To describe the impact of various parameters on flow capacity of Piano key weir, its discharge co efficient C_{dpk} shown in equation (2.1) the Piano key weir discharge co efficient is the function of, unit less geometric and hydraulic parameters as shown in equation,

$$Q_{pk} = Cd_{pk} \times (2g)^{0.5} \times H^{1.5} \ (m^3/s/m) \qquad (2.1)$$

$$Cd_{pk} = f\left(\frac{L}{B}, \frac{bo}{ai}, \frac{H}{ai}\right) \qquad (2.2)$$

$$\text{Where, } \frac{L}{B} = \frac{a+b+2w}{a+b+2t} \qquad (2.3)$$

As discuss by Leite Riberio At. El. (2012) [12] a Piano key weir behaves like linear weir cause of upstream head increase. Consequently, a discharge enrichment ratio (r) between Piano key weir discharge (Q_{pk}) and rectangular Sharpe crested weir discharge (Q_w) has been define,

$$r = \frac{Cd_{pkw}}{Cd} \qquad (2.4)$$

In equation (2.4) considering Cd constant, the discharge enrichment ratios are is function of the C_{dpkw}. The Piano key weir discharge co-efficient (Cd_{pkw}) is the function of dimensionless geometry and hydraulic parameters as shown in equation (2.2).

Once the discharge enhancement ratio is calculated for a given value of H and W. Several type of Piano key weir can be envisioned. From Fig. 2.

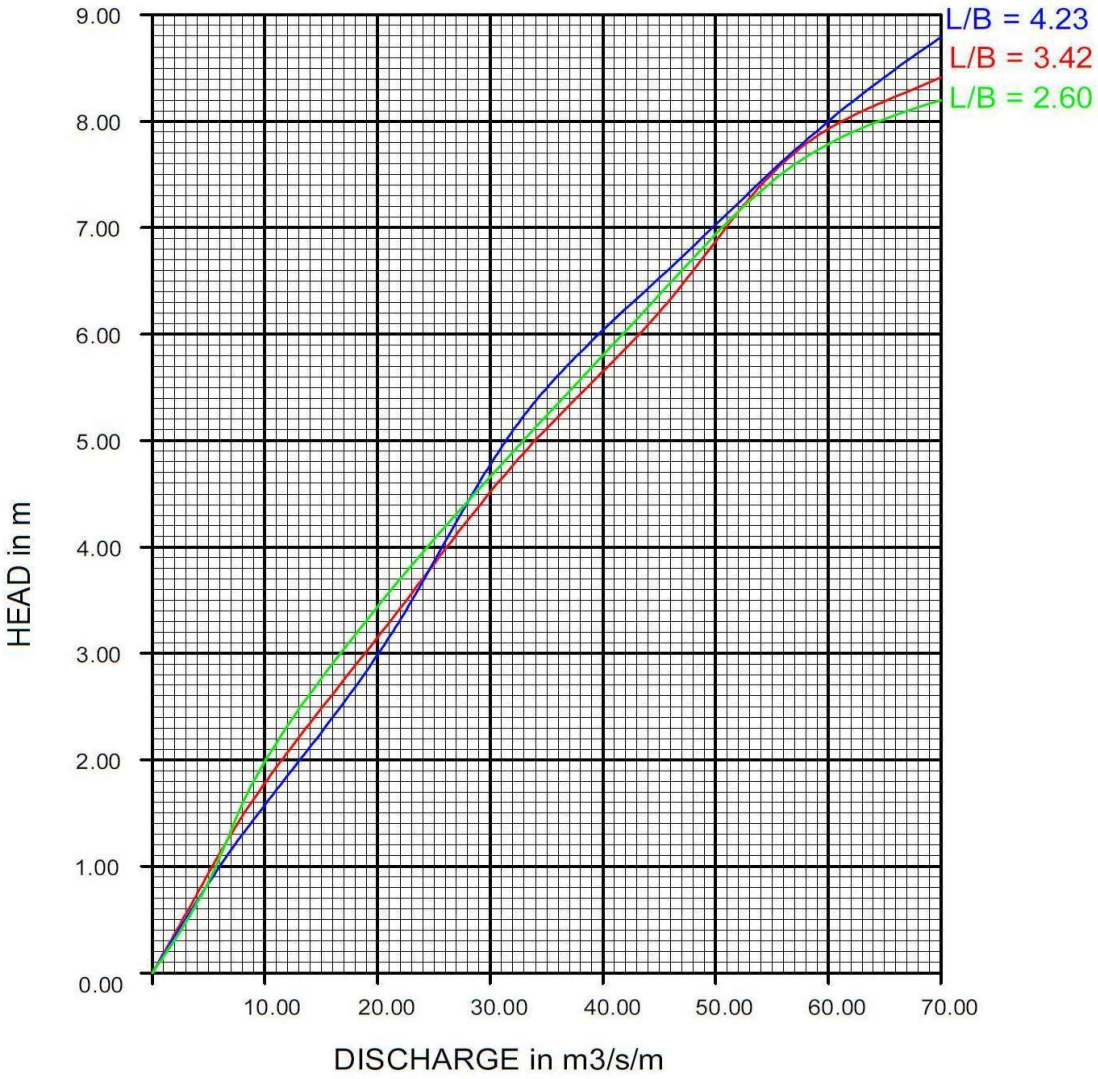

Figure. 2 Discharge v/s head for different L/B ratio

After choice of ratio L/B, the width of the inlet key can be obtain.

3. CONCLUSION:

The significant conclusions that can be drawn from this study are,

- The piano key weir is very useful for low head. With increasing hydraulic head, its efficiency decrease rapidly.
- The crest length ratio (L/B) is the most significant parameters on the discharge coefficient.
- The ratio of outlet key to inlet key (bo/ai) gives maximum Piano key weir performance when its value is 1.2.
- The effect of upstream overhang length on the Piano key weir efficiency is also significant.
- For Piano key weir design there is no excellent solution for the discharge vs. head in the hydraulic point of view.
- The downstream energy dissipation system should also be considered.

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