

# Review Paper on Experimental Study and Analysis of Labyrinth Weir

Shruti Shingade<sup>1</sup>, Kunal Shendre<sup>2</sup>, Tushar Shende<sup>3</sup>, Prof. P. R. Khobaragade<sup>4</sup>

Email: -<sup>1</sup> singadeshtruti@gmail.com, <sup>2</sup> kunalshendre1112@gmail.com  
<sup>3</sup>tushar20shende@gmail.com, <sup>4</sup> prafulkhobragade@gmail.com

**Abstract:** *Labyrinth weirs are commonly used to increase the capacity of existing spillways and provide more efficient spillways for new dams due to their high specific discharge capacity compared to the linear weir. In the present study, an experimental and numerical investigation was conducted to improve the rectangular labyrinth weir performance. Labyrinth spillway is the effective and economical solution to increase the discharge by increasing the spillway crest length without an associated increase in structure width. Use of labyrinth spillway is particularly suited to sites where the spillway width and upstream watersurface are limited and larger discharging capacities are required.*

**Keywords:** - *Arched labyrinth weir, Approach flow, labyrinth spillways, Discharge efficiency.*

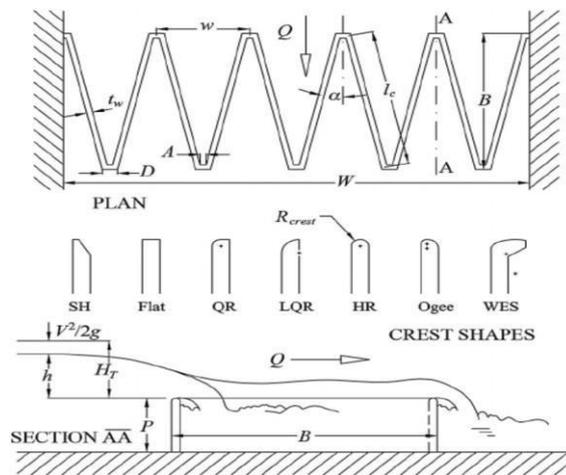
## 1. INTRODUCTION

Most failures in dams occur by water flow passing over the crest. Consequently, the most important factor is the insufficiency of the weir capacity. By increasing the weir crest length or the flow depth, it is possible to control large floods. Since the volume of flow passing through the weir is a function of length and shape of the crest, extensive research has been conducted on the impact of hydraulic and geometric parameters on the discharge coefficient of weirs. One of the most effective ways to increase the weir length is with non-linear designs (such as triangular, trapezoidal, and circular) which are called labyrinth weirs. These types of weirs increase capacity of passive-control spillways and reduce the required upstream head compared to linear weir.

The weir length is an essential parameter that determines the effectiveness of a labyrinth weir on flow. In general, the longer the weir length, the more effective the weir is at producing a longer and wider zone of improved flow over the crest. The length of the weir should be dependent on the channel geometry. Weir height can also influence the effectiveness of a weir. A properly designed weir height can manage the magnitude of discharge passing over the weir. The optimal plan shape weir passes Maximum discharge by keeping the head over the crest constant for same crest length of the various plan form weirs. It is necessary to select from a set of proposed platform weirs, the best (optimal) one for development of an economic unit, the one that ensures the most efficient use of resources. An optimal plan for the development of an economic unit is drawn up on the basis of the solution of a problem which arises while the function of the structure. A specific plan variant can be selected on the basis of the criterion of optimality. The usual problem is to find the platform which is optimal so that it minimizes a certain setback while satisfying constraints.

## 2. LITRETURE REVIEW: -

Labyrinth weir head-discharge relationships have been described by various empirical equations. These relationships vary based on 9 different definitions of the discharge coefficient, the characteristic weir length, and the upstream driving head (e.g., the inclusion of the velocity head component  $V^2/2g$ , described in the following). In the present study, a standard form of the weir equation, Eq. (1), was selected with the centerline length of the crest (Lace) as the characteristic weir length:



Several earlier labyrinth weir studies resulted in published design methods; a selection is presented and discussed. Hay and Taylor (1970) presented parameter guidelines, based upon research by Taylor (1968), for sharp-crested triangular and trapezoidal labyrinth weirs. Discharge rating curves for  $h/P < 0.6$  were pre-sented in terms of a labyrinth-to-linear weir discharge ratio (based on a common channel width,  $W$ , and  $h$ ), requiring discharge information for a linear weir ( $\alpha/490^\circ$ ) of equivalent weir height ( $P$ ), wall thickness ( $two$ ), and crest shape. The Bureau of Reclamation (USBR) conducted model studies to aid in the design of Ute Dam (Houston 1982). Discrepancies between their experimental result sand the recommendations by Hay and Taylor (1970) were attributed to different definitions of upstream head [ $h$ , Hay and Taylor (1970)];

The labyrinth weir is a complex structure and the flows over labyrinth weirs are three-dimensional. The labyrinth weir has many parameters affecting discharge capacity. Labyrinth weirs seem a complex structure. This structure consists of a large set of parameters. Many studies relating to labyrinth weir geometry have described the impact of various parameters on rates of flow and discharge efficiency when passing over these types of weirs. Labyrinth weirs were utilised as regular structures for flow and also help control aeration, drop structures, and energy dissipation. The trapezoidal and triangular-shaped labyrinth weirs give better hydraulic performance than the rectangular shape of the labyrinth weirs, and these types of weirs can be applied in many various field applications. Thus, there is great interest in their design and construction. Enhancing weir hydraulic performance usually needs physical model experimentation because many dimensional parameters influence the capacity of discharge over the labyrinth weirs. The reviewed previous studies on labyrinth weirs and revealed the most important variables of a labyrinth weir, such as the total head to the height of the weir ratio, sidewall angle, and magnification of length ratio.

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The results demonstrated that some parameters still need further investigation. Also, energy dissipation over the labyrinth weir needs further investigation with different weir geometry. Furthermore, the results showed that common design equations did not take into account all parameters affecting labyrinth weir performance, including geometries, flow condition, site conditions, and scale effect. In addition, machine learning techniques need further study.

Flow Characteristics of Arced Labyrinth Weirs (2022) by AlSaadi et al.

This study investigated the flow characteristics over arced labyrinth weirs.

The study was conducted experimentally in a laboratory flume. The results of the study showed that the arced shape of the weir had a different to the Approach Flow Conditions (2020) by Li et al. significant impact on the flow characteristics. The arced shape reduced the turbulence of the

flow and increased the discharge capacity of the weir.

- Numerical Simulation of Flow over Labyrinth Weirs with Different Crest Shapes (2021) by Chen et al. This study used numerical simulation to investigate the flow over labyrinth weirs with different crest shapes. The study used the CFD software ANSYS

Fluent to simulate the flow over labyrinth weirs with triangular, trapezoidal, and rectangular crest shapes. The results of the study showed that the crest shape had a significant impact on the flow characteristics over the weir. The triangular crest shape had the highest discharge capacity, while the rectangular crest shape had the lowest discharge capacity.

- Experimental and Numerical Investigation of Flow over Labyrinth Weirs with

### 3. CONCLUSIONS:

To develop a better understanding of the effects of PK weir geometry on discharge efficiency, and to evaluate the hydraulic performance of a recommended PK weir design found in the literature, a laboratory-scale sectional model was tested. The head-discharge relationship proposed by Lempérière (2009) [Eq. (2)] was evaluated for various PK weir geometries and upstream head definition (piezometric or total head). The influences of various geometric parameters on the PK weir discharge efficiency were also evaluated [e.g., the inlet-to-outlet key width ratio ( $W_i=W_o$ ), adding a parapet wall, installing noses beneath the upstream overhangs, different crest shapes (half-round and flat top)]. The appropriateness of using superposition to account for the changes in discharge efficiency associated with multiple PK weir geometry modifications was investigated. Finally, a discharge

efficiency/weir footprint comparison between trapezoidal labyrinth and PK weirs was made. Based on the results of this study, the following conclusions were drawn. The optimal range of  $W_i=W_o$  for maximizing discharge efficiency is likely within the approximate range of 1.25–1.5; however,  $W_i=W_o > 1.5$  configurations were not tested. Installing noses beneath the upstream apex overhangs of the PK weir produced a hydraulically more efficient inlet (reduced flow contraction, reduced energy loss, and potentially modified critical flow section location) and increases discharge efficiency. Raising the crest elevation, in this case with a parapet wall, increased discharge efficiency. This was likely due to the increase in inlet and outlet key volume resulting in a decrease in inlet key entrance energy loss and a corresponding reduction in outlet key local submergence. Improved crest shapes (half-round) result in significant gains in discharge efficiency at low heads relative to the flat-top crest; as  $H_t$  increases, however, the gains in efficiency gradually decrease. The appropriateness of using superposition to account for the changes in discharge efficiency associated with multiple PK weir geometry modifications was investigated. Finally, a discharge efficiency/weir footprint conclusions

#### 4. REFERENCE

- [1] Anderson, R. M. and Tullis, B. P. of Labyrinth Weirs. (2012) Comparison of Piano Key and Rectangular Labyrinth Weir Hydraulics. *J. Hydraul. Eng.* 138:358-361.
- [2] Bilhan, O, Emiroglu, M. E., Kisi, O, (2010) Use of artificial neural networks for prediction of discharge coefficient of triangular labyrinth sideweir in curved channels. *J. Advances in Eng. Soft.* 42(4), 208-214.
- [3] Carollo, F., Ferro, V., and Pampalone, V. (2012). Experimental Investigation of the Outflow Process over a Triangular Labyrinth-Weir. *J. Irrig. Drain Eng.*, 138(1), 73–79.
- [4] Crookston, B. M., and Tullis, B. P. (2011) “The design and analysis of labyrinth weirs” 31st Annual USSD Conference. San Diego, California, April 11-15, Pages: 1667-1681.
- [5] Crookston, B. M., and Tullis, B. P. (2012a) Arced labyrinth weirs. *J. Hydraul. Eng.*, 138(6), 555–562.
- [6] Crookston, B. M., and Tullis, B. P. (2012b) Discharge efficiency of reservoir-application-specific labyrinth weirs. *J. Irrig. Drain. Eng.*, ASCE, 138(6), 773–776.
- [7] Crookston, B. M., and Tullis, B. P. (2012c) Labyrinth weirs: Nappe interference and local submergence. *J. Irrig. Drain. Eng.*, 138(8), 757–765.
- [8] Darvas, L. (1971) Discussion of performance and design of labyrinth weirs, by Hay and Taylor. *J. Hydraul. Eng.*, ASCE, 97(80), 1246–1251.
- [9] Emiroglu, M. E., Kaya, N., and Agaccioglu, H. (2010). “Discharge capacity of labyrinth side weir located on a straight channel.” *J. Irrig. Drain. Eng.*, ASCE, 136(1), 37–46.
- [11] Hay, N., and Taylor, G. (1970) Performance and design of labyrinth weir. *J. Hydraul. Eng.*, 96(11), 2337–2357.
- [12] Houston, K. (1982) Hydraulic model study of Ute dam labyrinth spillway. Rep. No. GR-82-7, U.S. Bureau of Reclamation, Denver.
- [13] Houston, K. (1983) Hydraulic model study of Hyrum dam auxiliary labyrinth spillway. Rep. No. GR-82-13, U.S. Bureau of Reclamation, Denver.
- [14] Khode, B.V., Tembhurkar, A.R. Porey, P.D. and Ingle R.N. (2011) Determination of Crest Coefficient for Flow over Trapezoidal Labyrinth Weir. *World Applied Sciences Journal* 12 (3): 324-329.
- [15] Khode, B. V., Tembhurkar, A. R. P. D. Porey and R. N. Ingle, (2012) Experimental Studies on Flow over, Labyrinth Weir. *Journal of Irrig. Drain Eng.* ASCE, 138:548-552.