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A review for the piano key weir's hydraulic characteristics between modeling and modified based main and auxiliary geometric parameters

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ABSTRACT

The novel technique of hydraulic structures (PKWs), piano key weir, is primarily confined and dispersed. The available gaps must be comprehended in this field of research to provide significant insights into experts and assist researchers in getting them. As a result, a review is done to map the research landscape into a consistent taxonomy. In four main databases: Web of Science, ScienceDirect, IEEE Explore, and Scopus, be conducted a concentrated search for every publication related to (1) Nonlinear weirs, (2) Performance of weirs, and (3) Geometry parameters of PKWs. The classification strategy yielded 82 articles separated into four categories. Then, identify the basic hydraulic characteristics in terms of motivation for utilizing PKW, and recommendations to increase acceptance and use of PKW therefore, the development of the piano key weir still requires modifications to Main (different plan shapes) and secondary (nonlinear parapet wall) parameters to enhance the performance of PK weir.

Keywords: piano key weir, parapet wall, Plan shapes, sischarge coefficient, performance efficiency.

1 INTRODUCTION

Water is essential for life on Earth. As a result, humans have attempted to safeguard and enhance water resources as best they can, such as by constructing dams and sluices on rivers. (Li, Li and Jiang, 2020). In addition, as a result of climate change, high-intensity rainfalls, floods, and droughts have grown more common and severe in many parts of the world. Furthermore, with increasing demands for more reservoir water storage and the ongoing need to improve dam safety, many existing spillways' capacities are already insufficient and in need of upgrading or replacement. Still, weirs, either gated or non-gated, are commonly used as flow control structures in reservoir spillways. (Olyaie, Banejad and Heydari, 2019). But, the low discharge capacity of linear weirs is one of their drawbacks. Besides that, If an increase in reservoir water level is not possible, there are three options for increasing discharge capacity: (1) increasing the weir length (L) up to a specific footprint size by replacing the linear weir with a nonlinear (labyrinth) one, (2) lowering the spillway crest elevation, and (3) increasing the weir width (W) up to a specific footprint size by replacing the linear weir with a nonlinear (labyrinth) one. At those points, Firstly, due to dam geometry or economic constraints, increasing L of a linear weir, and hence W, is typically unfeasible. Then, lowering the spillway crest reduces base-flow reservoir storage volumes, lowering the quantity of stored water available for the reservoir's specific function (e.g., municipal, agriculture, commercial, hydropower). However, where L > W, the use of nonlinear weirs is a realistic and increasingly popular alternative for boosting discharge capacity while ensuring the long-term viability of existing spillway equipment (e.g., spillway channel) (Anderson and Tullis, 2013). Because, vertical walls are used to construct labyrinth weirs, which are more efficient than linear spillways. Therefore, the design of labyrinth weirs is straightforward because of their basic geometry, but they require large footprint sizes, which limits their use when erecting concrete dams. Also, the bottom-approaching flows are subjected to considerable constriction after entering the span between the two vertical sidewalls in this form of the weir, and the upstream and downstream crests are rendered useless. To address the above the piano key weir (PKW) had been developed is a novel labyrinth weir with piano key-shaped openings that slant one by one upstream and downstream. (Akbari Kheir-Abadi *et al.*, 2020). As well as, Piano Key Weirs (PKWs) is considered an excellent technique to increase the discharge capacity of spillway systems (Sangsefidi *et al.*, 2021). It can also, a PKW can be utilized with embankment dams, on the abutment or crest of a gravity dam, or as a run-of-river construction in natural channels. So that, Labyrinth and PK weirs have been utilized to replace physically weak spillways and gated systems and improve operations and maintenance due to their hydraulic performance. (Crookston, Anderson and Tullis, 2018). Consequently,

PKWs are categorized in general based on whether or not they have overhangs. In addition, the upstream and downstream overhangs have caused the sidewalls to incline inwards, resulting in a significant reduction in weir foot length. (Belzner *et al.*, 2017). So that, increased spillway height is often necessary to increase reservoir water storage capacity in dams while redirecting flow in dam upstream channels. Moreover, PKWs have also been used in reservoirs and rivers in conjunction with low-head hydropower or to control and maintain waterways that meet navigational standards in recent years. Lastly, these requirements necessitate the use of different plane shapes and nonlinear parapet walls.

Fig.1. 3D view of the PKW (Belzner *et al.*, 2017))

Fig.2. Type of piano key weir VS. numbers (2006-2020)

2 CONCLUSIONS

A recent disruptive global warm trend has emerged important in the use of piano key weir and its applications in dams and rivers rehabilitation and projects. This trend is still being researched. It is critical to gain insight into this new trend. By surveying and taxonomizing linked works, this article intends to contribute such insights. The many works on PKW can be used to draw certain patterns. Reviews or surveys, research studies on PKW and their application as hydraulic structures, development attempts, and broad design suggestions are essentially divided into four areas. An in-depth examination of the publications aids in identifying and describing the PKW-related issues, benefits, and recommendations. The findings show that based on prior studies, And the addressing of the decreasing discharge in the shape of the rectangle due to flow interference at the opposite sides walls by changing it to a trapezoid despite the efficiency of the rectangle was increasing than the trapezoidal and it is hypothesized that parapet walls may aid in the enhancement of the PKW function. Most of the prior research has focused on PKWs of type A (Fig. 2). Furthermore, studies have paid little attention to the impact of the parapet walls' nonlinearity and, the flow condition (both free and submerged flow), the effects of different plane shapes of PKWs to assessment the optimum performance. Therefore, development of the piano key weir is based on make the modification of the main and secondary geometric parameters, also make improvements to the shape of the inlet and outlet keys. Furthermore, investment the new techniques for modeling the physical model of PKW in lab. instead of used to in past. In addition, for modeling using package software to make the modified on the cross-section PK weir however complicated. These suggestions can help overcome the obstacles that PKW applications face in dams and rivers.

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