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Research Article

Analysis of energy loss in a C-type trapezoidal Piano key weir with outlet key jumps

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Extended Abstract

Introduction

Piano Key Weirs (PKWs) are a type of long-crested weir with a lightweight structure and high discharge efficiency. Due to their high hydraulic performance, they are widely used in dam spillways. However, the high energy dissipation associated with these weirs is crucial to minimize downstream scouring. This study investigates the effect of adding a trapezoidal-shaped PKW with different configurations of end sills (jumps) on energy dissipation and discharge capacity. The research focuses on the impact of varying sill radii and heights on the hydraulic performance of the weir, aiming to optimize energy dissipation while maintaining discharge efficiency.

Materials and Method

The experiments were conducted in a hydraulic laboratory flume with dimensions of 10 meters in length, 0.6 meters in width, and 0.8 meters in height. A trapezoidal PKW with end sills of two different radii (0.15 m and 0.21 m) and heights (0.075 m and 0.14 m) was tested under three flow rates: 0.03, 0.035, and 0.04 m^3/s. The flow depth upstream and downstream of the weir was measured using a needle depth gauge with an accuracy of ±1 mm. The energy dissipation and discharge coefficient were calculated based on the measured hydraulic parameters. The study also employed dimensional analysis to identify the key factors influencing energy dissipation, including the ratio of upstream energy head to weir height (Hu/P) and the ratio of sill radius to sill height (R/h).

Results and Discussion

The results demonstrated that the addition of end sills significantly increased energy dissipation. Specifically, the energy dissipation for the PKW with a sill radius of 0.21 m was approximately 3.8% higher than that of the PKW without sills, while the PKW with a sill radius of 0.15 m showed a 2.5% increase. The average energy dissipation for the PKWs with sill radii of 0, 0.15, and 0.21 m was 54.1%, 55.4%, and 56.2%, respectively.

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However, the discharge coefficient decreased with increasing sill radius and height. The discharge coefficient for the PKW with a sill radius of 0.21 m was 10.9% lower than that of the PKW without sills, while the PKW with a sill radius of 0.15 m showed a 3.9% reduction. The study also revealed that the presence of sills caused the flow to be projected further downstream, which could influence scouring patterns.

Conclusion

The study concludes that the addition of end sills to trapezoidal PKWs enhances energy dissipation, albeit at the cost of a reduced discharge coefficient. The PKW with a larger sill radius (0.21 m) exhibited the highest energy dissipation but the lowest discharge coefficient. The findings suggest that while sills are effective in increasing energy dissipation, their design must be carefully optimized to balance energy dissipation and discharge efficiency. The results also indicate that the trapezoidal PKW with sills outperforms the rectangular PKW in terms of energy dissipation, particularly in configurations without upstream overhangs. Future research could explore the impact of sill geometry and placement on scouring patterns and further optimize the design for practical applications.

Keywords*:* Energy loss, Jump, Output key, Piano Key Weir (PKW), The discharge coefficient