

## Hydraulic Type-A Piano Key Weirs with Zigzag Lateral Crest

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### 1. Introduction

According to the related literature, increased velocity approaching has been reported as the most important factor in decreasing discharge capacity in piano key weirs.

Different types of piano key weir geometry, positive effect of installing the nose at upstream attic, elevation of crest height using shield walls, and the semicircular shape of the crest keys have been confirmed to improve the performance of the piano key weirs. In the year 2012, in order to understand the effect of dimensionless geometrical parameters by performing several correlation analyzes, the coefficient of discharge coefficient in free flow and submerged flow conditions on the piano weir crest was calculated. It has been reported that in the case of high discharge experiments, the role of the outlet keys is an influencing factor on the hydraulic efficiency of piano key weirs. The comparison of the significance of the ratio of crest length to width ( $L/W$ ) and weir height ( $P$ ), has showed that the discharge efficiency of a standard rectangular piano key weir by trapping its geometry of 2 to 15% has improved. Also, the effect of trapezoidal piano key weir height on the discharge coefficient was less than the standard rectangular model. Many scholars by simulating three-dimensional hydraulic flow in three geometry models of piano key weirs, showed that in addition to improving the discharge coefficient in trapezoidal geometry relative to the model rectangular and labyrinth, lateral crest have a significant impact on the hydraulic performance of this type of weir.

The study tried to improve discharge capacity and increase the threshold of submergence of piano key weirs in high water heads. Therefore, the effect of zigzagging of the lateral crest profile of these weirs with the aim of decreasing the approaching velocities and increasing the secondary currents (flow deflection) in the crest was investigated.

### 2. Materials and Methods

Tests were performed in a rectangular channel 10 m long, 0.3 m wide and 0.5 m high, with a slope of 0.0012 at the Hydraulic Models Laboratory of Ferdowsi University of Mashhad.

Physical modeling of the two forms was made of standard piano key weir profile (Type A) and zigzag crest with 2.5 shift and made of 1mm thick galvanized steel sheet. The zigzag crest shape of the piano key weir was designed with a sinusoidal height of 5 mm. During the lateral crest,

a maximum of 9 zigzags are modeled with full sinusoidal function (Figure 1).

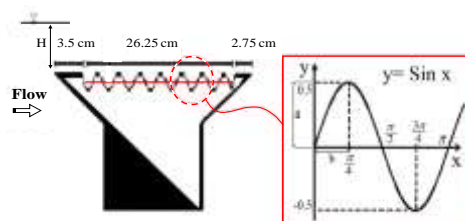


Figure 1. View of Type A Piano Key Weir and Geometric Properties of the Zigzag Crest

In order to increase the accuracy of measurement of hydraulic flow parameters, an accelerometer (ADV) was used. For the ease of analyzing the results, simultaneous impact of 19 parameters on the experimental results was investigated by performing dimensional analysis on the affective variables and obtaining the dimensionless ratios presented in Equation 1. It should be noted that in this study, Pie-Buckingham method was used to perform dimensional analysis.

$$C_d = f \left( \frac{H}{P}, \frac{\rho V_{\text{mean}} H}{\mu}, \frac{\sigma}{\rho V_{\text{mean}}^2 H}, \frac{V_{\text{mean}}}{\sqrt{gH}} \right) \quad (1)$$

### 3. Results and Discussion

The results show that zigzagging of the lateral crest profile of the piano key weirs causes asymmetric jets and much weaker impacts on the outlet keys and increases the transverse and upward velocities by 22 and 16 percent, respectively. The flow in the crest elevation range reinforces secondary currents upstream of the weir. Hence, by incorporating a more effective length of the lateral crest, it increases the deflection and suction current to the outlet keys than the standard crest. Therefore, with the increase in energy loss (increase in water level drop in range (B)), an 11% decrease in the values of the approaching component velocity occurred at the inlet keys. Also, the values of turbulence intensity upstream of the weir over the channel wall and the two flanks of the outlet keys have their maximum values. I have to say; With the zigzagging of the lateral crest profile, the magnitude of turbulence is on average 15% higher than the standard piano key overflow form.

### 4. Conclusion

Examination of hydraulic flow characteristics indicates that the zigzag form is effective on the flow rate coefficient of the piano key weir. Under these conditions, the maximum discharge coefficient occurs at a lower ratio but at a higher numerical value, with the average discharge coefficient increasing by 10% (Figure 2).

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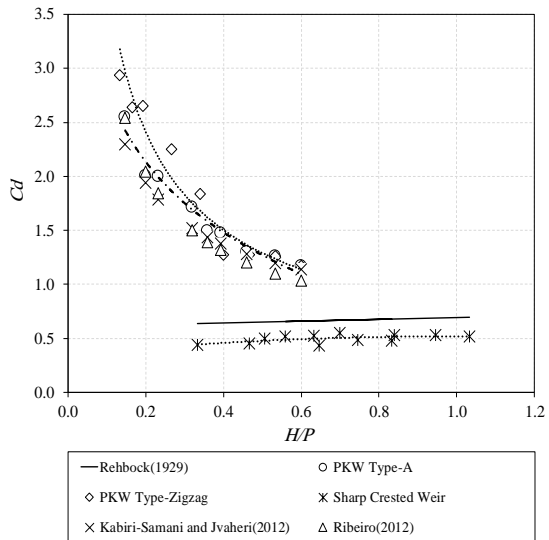


Figure 2. Flow coefficient changes with relative head change of water over weir

Finally, it is worth mentioning that the proposed crest form increases the local submergence limit and improves the discharge transfer efficiency of piano key weir Type-A outlet keys.