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Nine years of study of the Piano Key Weir in the university laboratory of Biskra "lessons and reflections"

A. Ouamane

Laboratory of Hydraulic Planning and Environment, University Mohamed Kheider, Biskra, Algeria

ABSTRACT: Since more than nine years studies and tests were carried out in association with Hydrocoop-France for developing a new shape of labyrinth weir. This new design was baptized in 2003 Piano Key Weir (PK-Weir). Studies and general tests which were realized during these nine years allowed a better understanding of this type of weir behavior and their geometrical shape optimization, so two geometrical forms were adopted (Model A and B).

This paper presents a synthesis of the results of these studies and recommendations on the geometry of the PK-Weir and the adopted experimental procedure. Two examples of weirs similar to the PK-Weir constructed in Algeria are exposed.

1 GENERALITIES

The labyrinth weirs are characterized by a crest with broken axis in plan, so that the length of the crest is longer than the width of the weir and occupies the same side space as a linear weir. The objective of this design is to increase the discharge capacity by unit of width for a given hydraulic head. The labyrinth weir is the ideal structure to discharge strong floods with low heads, in situations where the maximum head is limited. This type of weir represents an adequate alternative when the width of the weir is limited by the topography and/or the design flood is important.

The first analysis of the hydraulic performance of a labyrinth weir is attributed to Hay and Taylor (1970). It is considered as a base of the labyrinth weir design and was issued concomitantly with criterion and procedure to determine the discharge on a labyrinth weir (Darvas, 1971), (Magalhaes, 1985), (Houston et al. 1982).

2 EXPERIMENTAL STUDY OF THE LABYRINTH WEIR

Since 1995, various research works within the field of spillways were committed to the laboratory of hydraulics of Biskra University (Algeria). These works concerned theoretical and experimental studies of morning glory weirs, stepped weirs, labyrinth weirs and PK-Weirs.

The experimental study of a labyrinth weir showed that the flow over the weir is characterized by two opposite napes overtopping the lateral walls of the weir. When increasing the hydraulic head, the two opposite flows meet and a central jet appears with a disturbed flow around the corners, whose length evolves proportionally with the length of disturbance.

The connection between the length of disturbance ld and the relative head H^*/P was defined to be a linear relation of the shape: $ld/lc = a \times H^*/P + b$, wherea and b are a constant for every corner. The relevant parameters are defined on Figures 1 and 3.

The connection between the relative length of disturbance ld/lc and the relative length of the central jet ljc/lc corresponds to a unique straight line whatever the corner (Fig. 2).

$$ljc/lc = 0.6 \times ld/lc \qquad (1)$$

This relationship shows that the length of the central jet ljc is closely linked to the evolution of the disturbance that affects the flow over a labyrinth weir.

The effect of the height of the labyrinth weir upstream (P) and downstream (D) was studied for the three configurations (P = D, D/P = 1), (P < D, D/P > 1), (P > D, D/P < 1) showed on Figure 3.

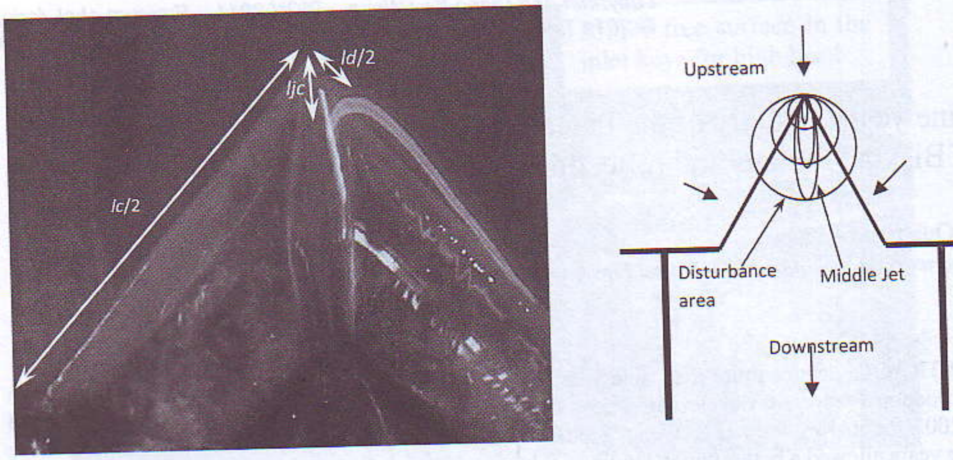

Figure 1. Disturbance flow on the labyrinth weir.

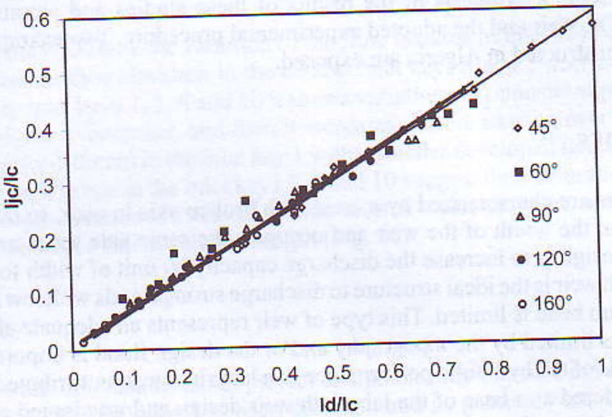

Figure 2. Relative length of the central jet according to the length disturbance at the corner.

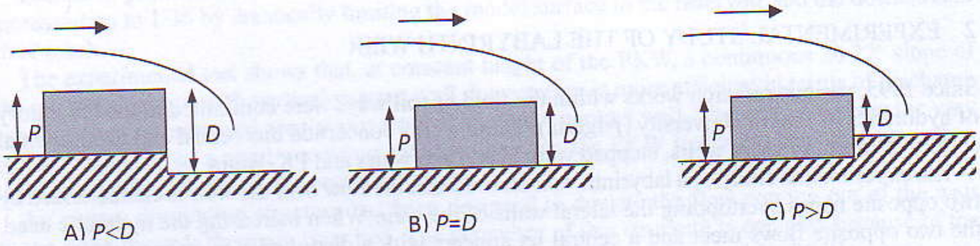

Figure 3. Schematic diagram of labyrinth weir with various cases of slab levels upstream and downstream.

The results revealed that no improvement of the performance of the labyrinth weir can be obtained by raising the downstream slab higher than the upstream one ($D/P < 1$). However, when the downstream height of the weir is superior to the upstream one ($D/P > 1$) the performance is improved.

Studies conducted on four models of labyrinth weirs, of triangular, trapezoidal, rectangular and trapezoidal upstream rounded shapes (Fig. 4), showed that the most recommended shapes, as far as hydraulics and economics are concerned, correspond to the trapezoidal upstream rounded and the trapezoidal shapes.

To a certain extent, it is more convenient to increase the number of cycles for a given width of the labyrinth weir. This reduces the longitudinal length of the weir and therefore the concrete volume of the slab between the sidewalls of the weir.

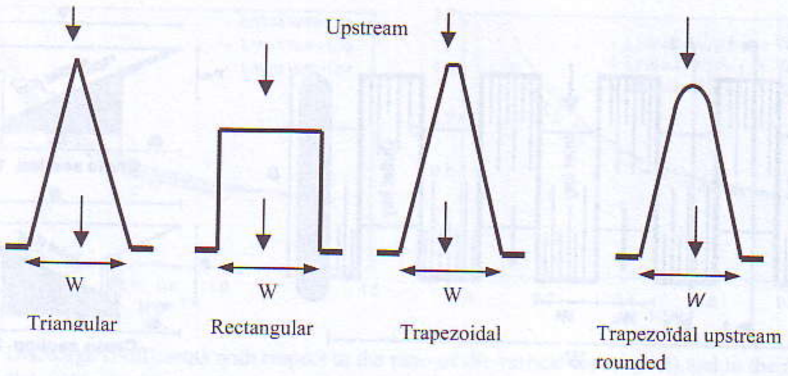

Figure 4. Schematic plan view of the experimented models of labyrinth weirs.

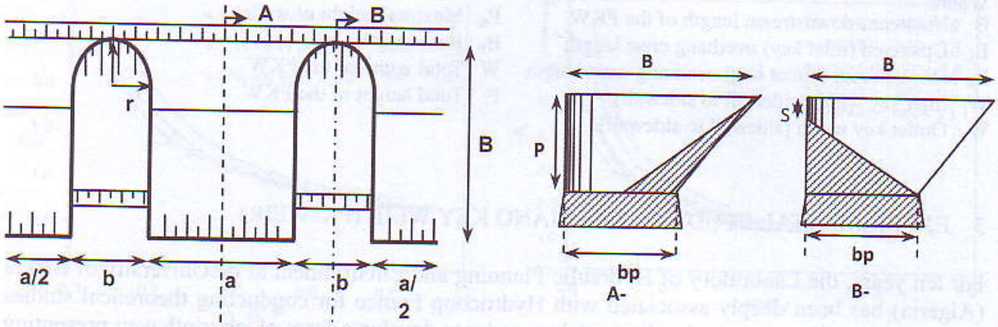

Figure 5. Schematic model of labyrinth weir with downstream overhang and inclined slab.

Figure 6. Flow on the labyrinth weir with downstream overhang and inclined slab.

Generally, the labyrinth weirs are designed with vertical walls; but, it is possible to design a portion of the crest weir in overhang by inclining the downstream frontal wall (Figs. 5 and 6).

This layout represents an economic shape which allows reducing the base of the weir and consequently, the construction of this type of weir on a concrete dam becomes possible. The advantage of this type of weir lies in its base length which is reduced, according to the layout with overhang, and the aeration of the flow downstream.