Discussion of "Hydraulic Design and Analysis of Labyrinth Weirs. I: Discharge Relationships" by B. M. Crookston and B. P. Tullis

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Introduction

The discusser would like to thank the authors for presenting discharge coefficient data for nonvented trapezoidal labyrinth weirs with quarter-round and half-round crest shapes for sidewall angles of 6, 8, 10, 12, 15, 20, and 35°. Different sets of weir models having weir height $P = 15.24$ cm and $P = 30.48$ cm are studied by the authors.

The work by the authors in accomplishing the regression equations applicable to discharge coefficients is really appreciated. These accurate equations are applicable to the trapezoidal labyrinth weirs that have sidewall angles of 6, 8, 10, 12, 15, 20, and 35° with head to weir height ratio of $0.05 \leq H_t/P \leq \sim 0.8 - 0.9$. The regression equations presented by the authors are selected over polynomial relationships because of their improved data representation ($R^2 \geq 0.99$) and extrapolation performance (they remain well behaved up to $H_t/P \leq 2.0$). It worth noting that for other wall angles between 6 and 35°, the interpolation procedure should be employed to obtain the discharge coefficients. The application of the linear interpolation technique for determining the values of the discharge coefficients for intermediate values of the sidewall angle seems to be inappropriate because of the nonlinearity of the discharge coefficient curves. However, in practice it is very suitable to have a single equation applicable to any sidewall angle between 6 and 35°. Thus, the discusser would like to introduce unified regression-based equations for discharge coefficients (based on experimental data presented in original paper), which are valid for any sidewall angles between 6 and 35°. For this, the head to weir height ratio (H_t/P) and sidewall angle (α) are considered as independent variables in the proposed equations for discharge coefficients. It should be noted that the thickness and the crest curvature of the weirs may influence the flow pattern and cause different values of the discharge coefficient (Azimi 2013). This investigation attempts to find a generalized and unified equation for the discharge coefficient of the labyrinth weir. The proposed equation renders the authors' study more valuable and will be accurate and easy to use in practical situations.

General Regression Model for Discharge Coefficient (C_d)

Vatankhah and Eslahi (2013) and Gupta and Singh (2013) presented generalized equations for the discharge coefficient of the trapezoidal labyrinth weir with a head to weir height ratio in the range of $0.12 \leq H_t/P \leq 0.7$. Vatankhah and Eslahi's regression equations are valid for the trapezoidal labyrinth weirs that have sidewall angles between 8 and 90° and Gupta and Singh's equations are valid for sidewall angles between 8 and 30°.

In this study, the following general model is proposed for the discharge coefficient of trapezoidal labyrinth weirs

$$C_d = (k_0 + k_1 \eta^{k_2 \eta^{k_3} + k_4})[k_5 + k_6 (\sin\alpha)^{k_7}] + (k_8 + k_9 \eta^{k_{10}} + k_{11} \eta^{k_{12}})^{k_{13}} [k_{14} + k_{15} (\sin\alpha)^{k_{16}}]^{k_{17}} \quad (1)$$

in which $\eta = H_t/P$ and constant coefficients k_i ($i = 0, 1, \ldots, 17$) are determined via the optimization procedure. This general form is obtained using regression analysis based on the practical ranges of the corresponding experimental variables ($0.05 \leq \eta \leq \sim 0.8–0.9$ and $\alpha = 6$, 8, 10, 12, 15, 20, and 35°). The value of $\alpha = 90°$ was not accounted for when developing the generalized equation because it corresponds to a linear weir, not a labyrinth weir. To determine k_i, the sum of absolute percentage error, $|PE|$, ($|PE| = 100 \times |1 - C_d / C_{d\_experimental}|$) is minimized as an objective function using the Solver toolbox of Microsoft Excel. $C_{d\_experimental}$ stands for the experimental value of discharge coefficient from

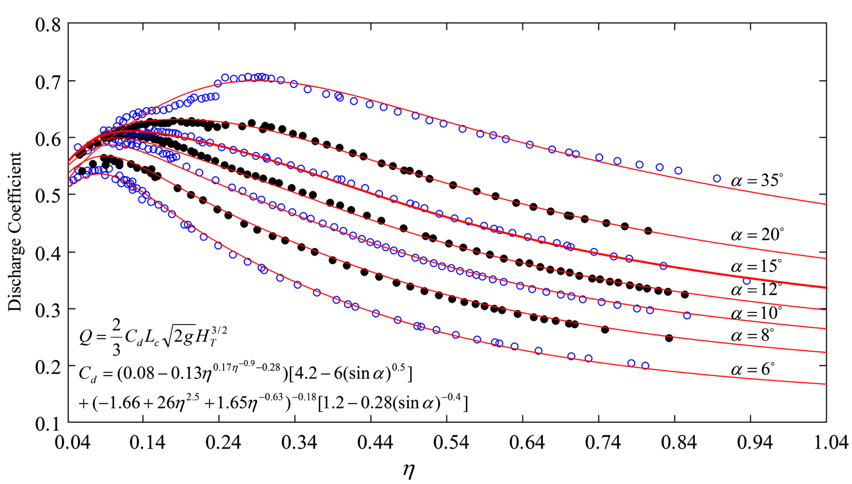

Fig. 1. Variation of discharge coefficient of quarter-round trapezoidal labyrinth weirs with head to weir height ratio (η) for different sidewall angles