EXPERIMENTAL INVESTIGATION OF THE POINT OF INCEPTION EVOLUTION IN STEPPED CHANNEL

Boutassouna Kheira[a] , Djaid Naima[a] , Gafsi Mostefa[a], Gahmani Ahmed[a] ,Kaouachi Anouar[a], , and Nouis Messad[a]

[a]Research Laboratory of Water Resources, Soil and Environment Department of Civil Engineering, Faculty of Technology Amar Telidji University ; Adress : Boulevard of the Martyrs P.O. Box 37.G, Laghouat 03000,. Email: djaid.dz@yahoo.fr; a.kaouachi@lagh-univ.dz; msgafsi@yahoo.fr; b.boutassouna@yahoo.fr; hydroahmed@hotmail.fr; nouis1989@gmail.com

Abstract:

Most prototype spillways operate at large discharges per unit width, and the water skims as a coherent stream over a pseudobottom formed by step edges. The nappe flow regime is divided into three sub-types, characterized by the formation or absence of hydraulic jumps on the bed of the stairs. The skimming flow regime is sub-divided considering the geometry of the steps and the flow conditions that lead to different configurations of the flow fields near the steps.

We have made an experimental approach in the laboratory of civil engineering at the University of Laghouat (Algeria), in three (03) models: model A (4cm x 7.5cm 4cmx) and model B (8cm x 7.5cm 8cmx), and the third model C size (12cm x 12 cm x 7.5 cm) developed "Plexiglas." Three slopes were studied in this experiment: α = 20 °, 30 ° and $\alpha = \alpha$ = 45 ° for the three models, with flow rates ranging from q = 0.96 l / s / ml up to q = 33.02 l / s / ml. The purpose of this experimental study is the show the effect of rate flow, and the slope of channel in the evolution of the point of inception. Also, we proposed one empirical model for these evolutions cited**.**

Keywords: physical model, point of inception, empirical model, effect of rate flow, and effect of slope of channel.

1. INTRODUCTION

During the last 3 decades, researchers on the hydraulics of stepped spillways have been very active (Chanson 2001). Most prototype spillways operate at large discharges per unit width, and the water skims as a coherent stream over a pseudo bottom formed by step edges. Significant losses and momentum transfers from the main stream to the recirculation zones (Rajaratnam 1990; Chanson 2006) characterize the skimming flows.

For this, we have made an experimental approach in the laboratory of civil engineering at the University of Laghouat (Algeria)**,** in three model, Three slopes were studied in this experiment: α = 20 °, 30 ° and $\alpha = \alpha$ = 45 ° for the, with flow rates ranging from q = 0.96 l / s / ml up to q = 33.02 l / s / ml. The purpose of this experimental study is the show the effect of rate flow, and the slope of channel in the evolution of the point of inception

2. PHYSICAL MODEL

The stepped channels model, on which the experimental tests have been performed, is located in the laboratory of civil engineering at the University of Laghouat (Algeria),

The experimental device consists of a flume made of Plexiglas length 5m, width 0.075 m, and height of the walls is 0.175 m (see photo 1), A channel model stairs made "Plexiglas." This pattern is connect to the glass channel seals, and mastic sealing installation.

Photo 1: Experimental device (Gafsi and Benamamar, 2013a, b)

3. ANALYSIS OF RESULTS

3.1 Evolution of the free surface

The determination of the position of the inception point can deduct the residual energy at the foot of the channel.

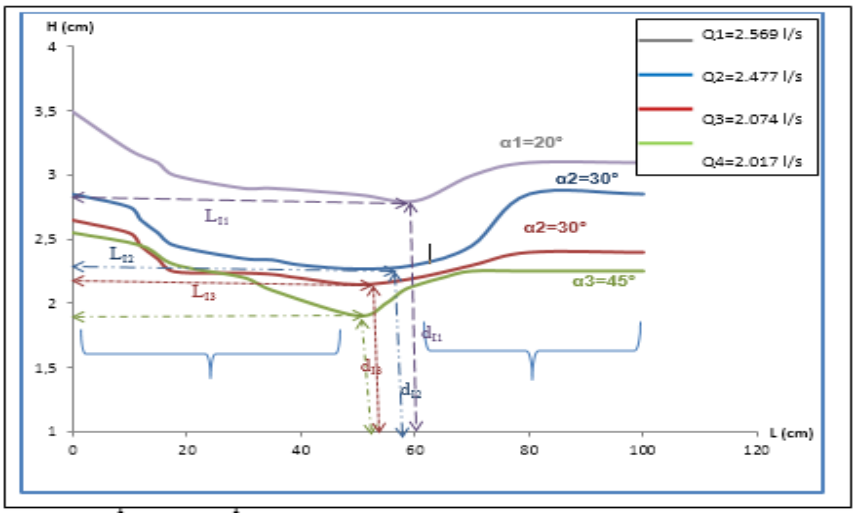
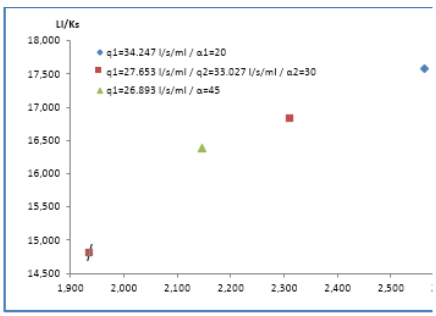


Figure. 1: Determining the coordinates of the point inception in Model A.

With L_I: distance to the channel crest, d_I: water depth at the point of inception.

The visual observations of the flow in the model A, indicated that the position of the free surface profile showed a trend slightly wavy; waning along canal

3.2 Effect of rate flow



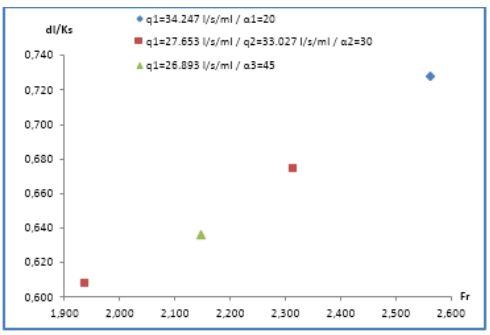


Figure 2. Evolution of LI/Ks as function of number Fr in Model A

Figure 3. Evolution of dI/Ks as function of number Fr in Model A.

Figures 2 and 3, shows that the flow rate increases; the length of the inception point away to the foot of channel.

3.3 Effect of slope of channel

Figures 4 and 5 show that variation of the Li/ks and di/ks follows a decreasing function depending on the slope of the channel (for a given flow rate); For a given flow rate, the increase in the slope of the channel moves the point of inception of the upstream channel (figure 4 and 5).

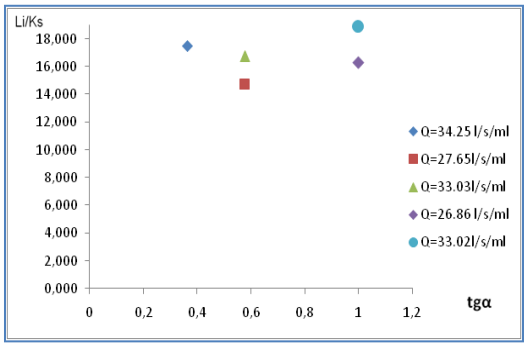


Figure. 4: Variation of Li/K as a function of tan (α)

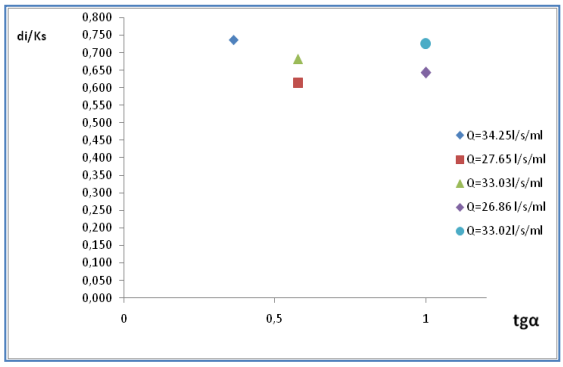


Figure. 5: Variation of di/Ks according to tan (α)

3.4 Determination of empirical correlations for the point of inception

3.4.1 Effect of rate flow

The Figure 6 and 7, shows respectively the variation of the ratio Li /Ks and di/Ks as function a number Froude. Their empirical functions are:

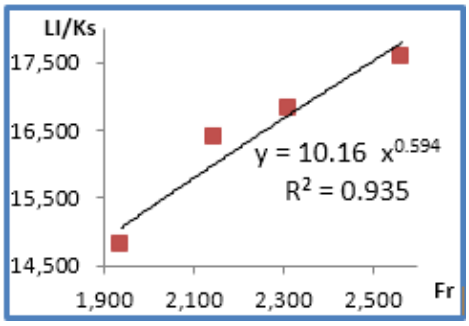


Figure. 6: Proposed of empirical correlation of LI/Ks as function a number of Froude in model A

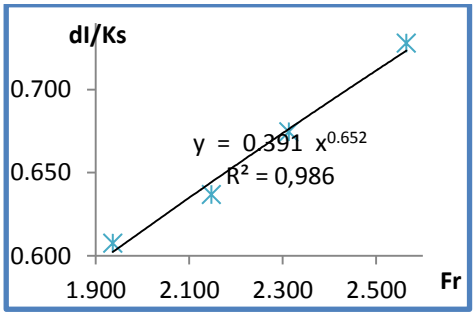


Figure. 7: Proposed of empirical correlation of di/Ks as function a number of Froude in model

3.4.2 Effcet of slope of channel

The evolutions curves of the experimental points plotted in figures 9 and 10 allowed us to obtain respectively the empirical correlation of di /Ks and Li/Ks as a function of the slope of the channel (tg α) namely:

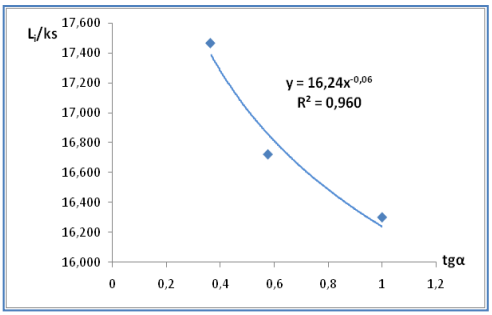


Figure. 9: Proposed of empirical correlation of Li/Ks as function at the slope of the channel (tg α).

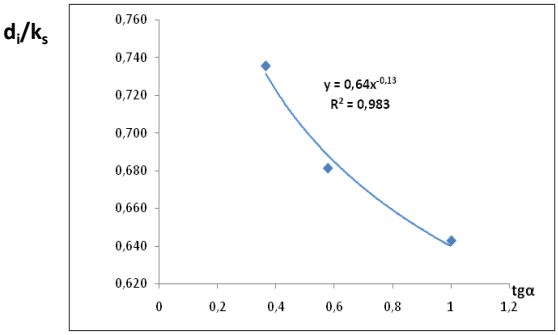


Figure. 10: Proposed of empirical correlation of di/Ks as function at the slope of the channel (tg α).

4. GENERAL CONCLUSION

- The water became white and you could appear rollers trapped in hollow steps. With the advent of the white water, the thickness of the layer increases sharply. In this area, there is more homogeneous fluid, but a water-air mixture. The flow is then disrupted and the surface level at a point varies constantly;
- The point of inception of pseudo-bottom of stepped channel is characterize by a concentration of the air. It is located more upstream than a smooth channel, because, in stepped channel, there is a greater increase of the thickness of the turbulent boundary layer and a high level of turbulence near the bottom;
- The point of inception of pseudo-bottom is located slightly upstream of the position where the depth of water increases to the point two phases generated item surface;

References

Amador, A., Sánchez-Tembleque, F., Sánchez-Juny, M., Puertas, J., and Dolz, J. (**2004**). « Velocity and Pressure Field in Skimming Flow in Stepped Spillways ».

Chanson, H. & Toombes, L. (2002). « Air- Water Flows down Stepped chutes: Turbulence and Flow Structures Observation». International of Multiphase Flow, volume 27, N°11, pp. 1737-1761.

Gafsi Mostefa, Benmamar Saadia, Djehiche Abdelkader, and Kerbache Khadidja (2012). Influence of the Flow Rates and the Channel Slope in the Energy Dissipation on Flows in the Stepped Channel. Wulfenia Journal (ISSN: 1561-882X), Vol 19, No. 11;Nov 2012, pp 385-393.

Djaid,et Boutassouna (2013) « étude de l'effet du la pente sur les caractéristiqueshydraulique des écoulements dans les canaux a motifs périodique ». Thèse de master, université Ammar Telidji de Laghouat, 99 pages.

Ohtsu, I.; Yasuda, Y. and Takahashi, M. (**2004**). " Flow Characteristics of Skimming Flows in Stepped Channels ", Journal of Hydraulic Engineering, ASCE, Vol. 130, No. 9.

Stephenson, D. (**1991**). « Energy dissipation down stepped spillways ». Water Power & Dam Construction, volume 43, N°9, September.