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EXTENDED ABSTRACT

Experimental and Numerical Investigation of the Effect of Transition Length on Energy Losses in Gradual Transitions Open Channels Under Subcritical Flow

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Introduction

'Transition' is a short hydraulic structure used to change the cross-sectional shape or flow shape. Transitions are commonly used both in the open-channels and natural waterways. The task of a transition is to connect a narrow channel at the upstream to a wider downstream channel or vice-versa. This, creates a disturbance region of turbulent flow causing energy losses. In general, the structure of a transition prevents the formation of wave and other turbulencies. In this case, the energy loss, due to the change in the amount of the momentum, will be minimized.

Methodology

In the present study, a rectangular-to-trapezoidal transition with a gradual expansion is designed according to the method proposed by Swamee and Basak (1992). In this process, an equation is written for the width of the bed, and by optimizing the proposed equation, the parameters of the equation are obtained. Using a trial and error scheme, the best transition equation can be obtained in terms of different transition lengths. Achieving the objectives of this study, experiments were carried out in the Hydraulic Laboratory of Gorgan University of Agricultural Sciences and Natural Resources. The laboratory equipment consistes of a main flume with a length of 11 meters,and the width of 1 meter, with a useful height of 0.08 meters. The length and width of the upstream rectangular channel are 3 and 0.25 meters, respectively. The length of the transitions is variable and the length and width of the bottom of the trapezoidal channel floor are 3 and 0.4 meters, respectively. The lateral slope is considered as a one-to-one trapezoidal channel. The measurement of the flow rate is performed using an ultrasonic flow meter embedded in the water transfer tube and controlled by a sharp-crested weir in the downstream channel. The water flow level was fixed by an adjustable gate located at the end of the flume. A depth gauge is used for measuring the water level with a 0.1 mm accuracy level. The Pitot tube is used to measure flow velocity at water level. In order to study the distribution of flow velocity along the transition, the depth and flow velocity values are measured at different stages while calculating the efficiency and energy loss factor during the transition.

The flow velocity data are gauged along the depth of flow and near-water levels at the 0.20, 0.4, 0.6, and 0.8 times of water depth and near the bed at the beginning, middle, and end of the transition. Experiments were performed for five different discharges including 10, 15, 20, 25, and 30 liters per second. Subsequently, a numerical model is used to examine all flow pattern characteristics. Given that in the laboratory model the secondary flow, flow separation, and other parameters are not measurable it was necessary to use numerical model.

In this study, the Fluent software package with the RSM turbulence model is selected and used. The longitudinal velocity and the flow depthwere gauged in both models in order to adapt the experimental model and its numerical model and validate it. The models are verified using the error (E) and the root mean square error (RMSE) of the numerical simulations. For the length of one meter and discharge of 20 liters per second, the RMSE and E rates obtained from the comparison of the results of the water surface profile at a Froude number of 0.32 were 0.3 and 1.60 respectively and at a Froude number of 0.55, were 0.45 and 1.80 respectively.

Results and Discussion

There is also a good match for the velocities obtained from the numerical model and the experimental results. The RMSE error obtained from the comparisons at the input, middle and output sections are 4.60, 5.95, and 4.20 per-cent at the Froude numbers of 0.32 and 4.96, 6.23 and 4.58 per-cent at the Froude number of 0.55.

To calculate the transition efficiency, the depth and velocity data were gauged at different sections. Therefore, the depth of velocity flow is obtained from the numerical and laboratory models. Observations indicate that, for all inlet discharges, the flow depth increases along the length of the transition. The maximum and minimum gradients of the water surface occur at the Froude numbers of 0.70 and 0.32, respectively, indicating that the change in the gradient of the water surface during the transition is directly related to the Froude number. Accordingly, the Froude number increases as the slope of the water level increases.

In this study, it has been shown that increasing the length of the transition increases the hydraulic efficiency, so that by a 50 percent transition length increment, the total hydraulic efficiency increases up to 20.38 per-cent. By increasing of the L / b0 ratio, the energy loss factor decreases so that by increasing this ratio from L / b0 = 2 to L / b0 = 6, the energy loss coefficient decreases by 31.93 per-cent. Also, with an increase in discharge from 10 liters per second to 30 liters per second, the energy loss ratio increases by 1.65 times.

Conclusions

The results of this research showed that increasing the Froude number increases the length and width of the flow separation region. The length of the separation zone created for the Froude numbers of 0.32, 0.47, 0.55, and 0.63 are 0.41, 0.56, 0.63, and 0.85 meters, respectively. Furthermore, for the same Froude numbers, the separation widths are 0.1, 0.14, 0.16, and 0.22 meters, respectively.

Observations showed that the shear stress is decreased along the inlet section to the midpoint section of the transition while increasing near the end of the transition. The maximum shear stress of the bed occurs at the inlet section. Moreover, increasing the Froude number results in an increase in the shear stress of the bed.

References

1- Hosseini, S. M., and J. Abrishami. 2014. *Hydraulic open channels*. Imam Reza University Publishers, thirty-first edition. In Persian.

2- Abbott, D. E., and S. J. Kline. 1962. Experimental investigation of subsonic turbulent flow over single and double backward facing steps. *Journal of Basic Engineering* 84, 317.

3- Alauddin, M., and B. C. Basak. 2006. Development of an Expansion Transition in Open Channel Sub-Critical Flow. *Journal of Civil Engineering*, 34(2): 91-101.

4- Basak, B. C., and M. Alauddin. 2010. Efficiency of an Expansive Transition in an Open Channel Subcritical Flow. *DUET Journal*., Dhaka University of Engineering & Technology: 27-32.

5- Fluent 6.3.26 User Manual, Fluent Inc, 2006.

6- Haque, A. 2008. *Some Characteristics of Open Channel Transition Flow*. Msc Thesis, Civil Engineering, Concordia University.

7- Henderson, F. M. 1966. *Open Channel Flow*. Prentice-Hall, Inc., Upper Saddle River, NJ 07458.

8- Howes, D. J., Burt, C. M. and B. F. Sanders. 2010. Subcritical contraction for improved open-channel flow measurement accuracy with an upward-looking ADVM. *Journal of Irrigation and Drainage Engineering*, 136: 617–626.