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EXTENDED ABSTRACT

Three-dimensional Study of Flow Turbulence Extension around Straight, T and L Shaped Groynes in Open Channles using Physical Model

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Introduction

Rivers have long been considered as one of the most important sources of water supply. Flooding during flood events causes irreparable damage. Therefore, some methods such as the protection of river banks against erosion are considered to control the flood. One of the methods for protecting the rivers and controlling their erosion is the use of groynes. Groyne is a structure that uses rock, sand, etc. to slow down the process of erosion and prevent ice-jamming, which in turn aids navigation . and generates suitable environmental conditions for aquatic organisms in different conditions and in different parts of the river. According to the importance of groynes, a detailed and three- dimensional study of turbulent flow and the intensity of turbulence extension in these structures is of prime importance . In the present research, three- dimensional turbulent flow was completely studied using ADV advanced velocimeter in straight, L- and T- shaped groynes in a straight canal with a rigid substrate and 20% contraction of the groynes in the canal’s width by collecting numerous data points , and the turbulent extension was studied in three- dimensions, which is one of the novel charactersistics of this research.

Materials and methods

The experiments of present research were conducted in a direct channel with the length of 7m, width of 0.5m and height of 0.6m with plexiglass walls and steel shields in hydraulic laboratory of agricultural sciences and natural resources university of khuzestan. The groynes used in this research were made of Plexiglas rectangular planes with thickness of 1cm and in three straight, T- and L-shapes. Flow rate (Q) was considered constant and equal to 30 L/S. Magnetic flow meter was used to measure the flow rate. The flow depth (H) was constant throughout the experiments, and was equal to 15cm.. Geometric characteristics of groynes are presented in Table (1). Hydraulic conditions of the experiments during 3D data handling of flow velocity are presented in Table (2). An ADV velocimeter with frequency of 25 Hz was used to measure the flow velocity. In addition, the time of 180s was used to record velocity data of each point. Vectrino software was used to record the measured data in different times. Then by changing the format and analyzing these data using Excel, related graphs were plotted by Tecplot software.

Discussion and conclusion

In order to study the impact of groyne geometry on the flow structure around it, the flow patterns around the groynes and the graphs of turbulence kinetic energy were plotted in different elevations and then analyzed using the values of flow velocity components measured in 3 dimensions. Fig (1) shows the examples of flow contours at the upstream and downstream of the present research groynes at a level equivalent to approximately 60 percent of flow depth from the bed (Z/H=0.6). Experimental observations showed that a carved wave is formed on the surface of the water and on the cape of groyne due to the collision of the flow with the straight groyne that influence the upstream flow of the groyne and decreases flow velocity in the back of groyne and increases flow velocity in the middle zones, which leads to the establishment of a flow separation plane and the formation of vortices at the downstream of the structure. In the upstream zones of groynes, flow contours are parallel to the walls of channel. They diverge towards the middle zones of the channel due to the separation of the flow and by approaching the groyne.

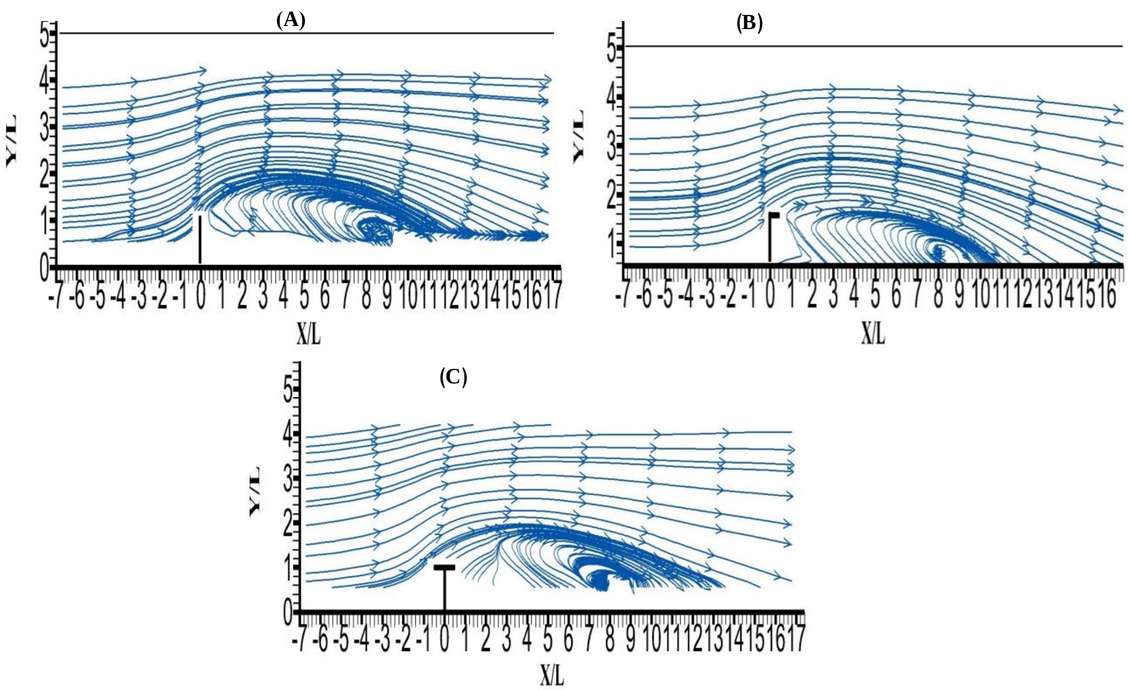

Fig. 1- Comparison of flow lines around the groyne at the level of 60 percent of flow depth from the bed:(A, B, C) present study

Dimensionless length of flow shear plane (Xr/L) and maximum transversal distance from main separation zone (Yr/L) are presented in Table (1). For the studied groyne near the flow surface in every horizontal plane, the value of velocity component is considered as zero in the direction of flow in the channel's wall. According to Table (1), transversal distance from flow separation zone in T-shaped groyne is lower than straight and L-shaped groyne and the established vortices at the downstream of straight groyne have more longitudinal and transversal range compared to two other groynes. In addition, this value is higher in the L-shaped groyne than the T-shaped groyne. Therefore, it can be noted that the longitudinal range of downstream vortex of the groyne decreases by increasing the wing length of the groyne.

Table 1- Dimensionless and lateral length from vortices zone nearby the surface flow

Groyne	Yr/L	Xr/L
Straight Groyne	2.4	11
T-shape Groyne	1.8	9.9
L-shape Groyne	2.2	9.5

Distribution of turbulence kinetic energy ($\mathrm{TKE} = 0.5[\overline{u'^2} + \overline{v'^2} + \overline{w'^2}]$) was considered for three studied groynes in 9 and 0.6 level from the bed. At a level close to the bed, a turbulent zone is formed in the cape of the groynes, which begins from upstream of the groyne and extends to the downstream with an angle of about 45° along the flow separation layer. Turbulence intensity of this zone in straight groyne is higher than two other groynes. The attributed to the formation of horseshoe vortices in the cape of groyne. In addition, the expansion and strain of TKE are consistent with flow separation plane, and its expansion at the downstream of straight groyne is 4.95 percent and 16.45 percent higher than L- and T-shaped groynes respectively. This phenomenon is attributed to the formation of downstream vortices of L- and T-shaped groyne. In addition, the distribution of kinetic energy in upper layer is higher than the layer close to the bed.

Conclusion

Present research studied the structure of three dimensional and turbulent flow around the straight, T- and L- shaped groynes in a direct channel with smooth bed using vectrino 3D velocimeter that is one of the most advanced Acoustic Doppler Velocimeters (ADV). The results showed that the established vortex at the downstream of the structure is further developed in upstream of the flow. The maximum flow turbulence intensity (TKE) is along the shear layer and in straight groyne, and its expansion at the downstream of straight groyne is 4.95 and 16.45 percent higher than L-and T-shaped groynes, respectively.

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