University of Tabriz

Journal of Civil and Environmental Engineering
Volume 52 (2023), Issue 4 (Winter), 215-224

EXTENDED ABSTRACT

The Effect of the an Air-bubble Screen on Flow Pattern and Secondary Flow Strength and Bed Shear Stress in a 90 Degree Mild Bend

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Received: 28 April 2019; **Accepted:** 28 September 2020

Keywords:
3-D velocimeter, Secondary flow strength, Flow Pattern, Bed shear stress, Air bubble screen.

1. Introduction

The complex interactions between streameise flow and curvature- induced secondary flow in bends, bed morphology cause erosion near the outer bank, and deposition near the inner bank, that it can endanger the outer bank's stability and also reduce the navigable width of the rivers. There are several techniques to protect the outer bank, reduce adverse impacts and control bed erosion in bends. Methods used in most parts of the world include submerged groynes, spur dikes, and bandal-like structures. But, meny these Methods have the disadvantage of being fixed constructions on the bed river that caused a threat for navigation. This paper describes a new way that consists in changes the bed morphology with provoking changes in the flow pattern. Dugue, et al. (2011, 2012) studied morph dynamic bends rivers with the Air-bubble screen method. Their results reveal that the air bubble screen is able to modify the flow pattern by shifting the maximum scouring from the outer bank towards the center of the flume and does not endanger its stability anymore. Dugue et al, 2013 studied scour reduction at a 193° bend by an air-bubble screen method. Velocity pattern at 70° bend showed that the bubble-induced flow pattern overcame the secondary flow induced by the outer bank while decreasing the morphology slope. It also showed 50 percent reduction in the maximum scour depth. Shukry (1949) is one of the first researchers in the study of erosion of the outer bank of rivers in a canal with a 180-degree bend with various proportions of the rivers radius to its width. There have been very few investigations about air bubble screen in 90 bend, therefor in this study the effect of the air bubble screen on flow pattern and Secondary flow strength and bed shear stress in 90 degree bend under Froude numbers 0.45 is examine.

2. Methodology

2.1. Experimental study

The all of the experiments were carried out in a 90 degree bend channel with 0.7m width and and 0.8m height, The R/B ratio for the channel bend was 4, at the hydraulic models laboratory of the faculty of water science and engineering of Shahid Chamran University of Ahvaz, Iran. The channel sidewalls were made of plexiglass. The straight channel lengths at the upstream was 5m and downstream of the bend was 3m, (Fig. 1).

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Fig. 1. View of 90 degree bend channel

The flow depth was controlled using a slide gate that was installed at the end of the channel, and it of flow was kept at a constant 0.11m in all tests. The flow discharge was measured using an ultrasonic discharge meter, Digi Sonic E+Model (accuracy of ±0.01 l/s). The flume bed was covered by uniform sand with a mean diameter of d_{50}=1.5mm and a geometric standard deviation equal to 1.22 and the depth of the sediment in the channel was 20cm. In each test after leveling the bed sediments, the gate was completely closed and water slowly entered the channel and the depth and discharge were adjusted. To avoid any disturbance of the velocity meter due to moving sediment, the bed was fixed by spraying a mixture of diluted cement and after a one day the bed surface was hard enough to start the test. The three-dimensional velocity components (u, v, w) were measured using the electromagnetic velocity meter JFE ALEC model ACM3-RS in experiment with and without an air bubble screen. The sampling rate was 20 Hz and the minimum time of sampling was 60 seconds. Therefor, 1200 data points were recorded for each point and for analysis the result, their mean was determined. The Measurements were made in the cross sections 1.5m upstream of the bend and at 0, 15, 30, 45, 55, 60, 65, 70, 75, 80, 85, 90° in the bend. The bubble screen system was formed from a porous pipe with an outer diameter of 1.5cm. The distance between the pores on the tube is 5cm. The air injection rate was also measured by a rotameter. Two 800-watt blowers were also used to provide airflow, which were connected on both sides of the pipe to allow air flow uniformly throughout the pipe (Fig. 2).

Fig. 2. Porous tube installed in the bend

3. Results and discussion

3.1. Effect of air bubble screen on velocity distribution variations and Secondary flow strength and shear stress

Flow pattern at transverse sections of 0, 30, 85 degrees, as well as the vector pattern of transverse and vertical (v, w) velocities for testing without air bubble screen are shown in Fig. 3. in figure at 0° in beginning of the bend, the max velocity (u), is formed near the inner bank of channel at a distance of 5 cm from it. According to Rozovskii (1957), the effect of secondary flow is also exist in the before the bend. At 30° to 85°, the max velocity region is located adjacent to the outer bank which causes erosion in this area. The contrast between the centrifugal force and the force induced by the lateral pressure gradient another cell of secondary current is generated anti-clockwise from the beginning of the bend to an section of 85 degrees. Shukry (1950), Blanckeart and Graph (2001), Bahrami Yar Ahmadi and Shafaei Bejestan (2015) reported of existence of a rotating cell which is generated due to the contrast between the centrifugal force and the force induced by the lateral pressure gradient in their laboratory channel. Due to Fig. (3-d) to (3-f) show the flow pattern for the test with air bubble screen system that two types of re-circulating flow at the channel observe. The anti-clockwise cell is created by centrifugal force and the existence of a pressure gradient between the outer and inner bank, and clockwise cell is generated by the operation of air bubble screen. It was found that with the air bubble screen, the minimum velocities created near the outer bank for all angles along the bend, and the maximum velocity area is transferred from the outer bank to the center of the channel. According to result the experiments air bubble screen caused the secondary flow power to be decreased in an average of 35% in comparison with the reference experiment and this reduction was due to the increasing of lateral velocity in the second half of the bend. As well as, the results showed that the application of the bubble screen resulted in a reduction of the maximum bed shear stress and the location of maximum shear stress with a ratio of 1.4 in the second half of the arc is moved away from the outer wall. These elementary experiments show the potential of air bubble screen to influence and modify the flow pattern and bed topography.

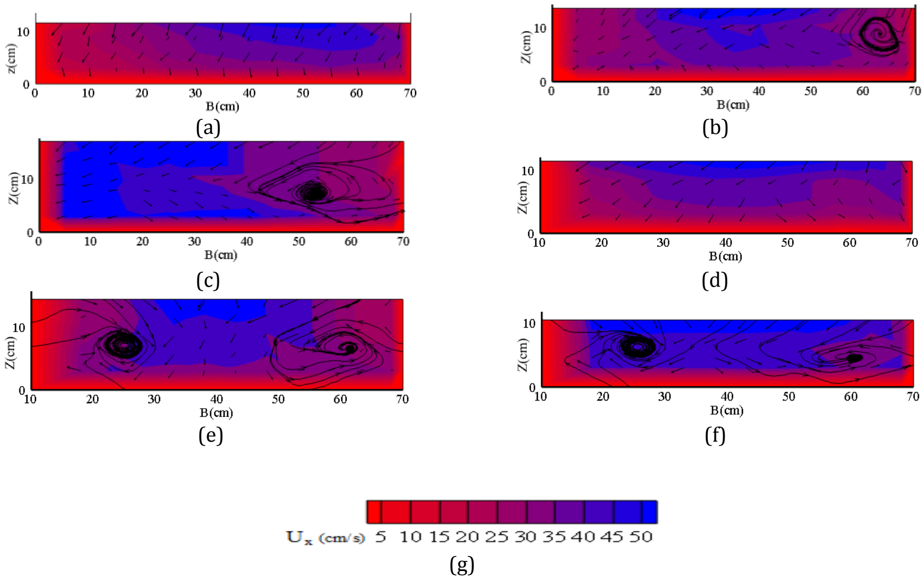

Fig. 3. View of Secondary flow pattern and velocity distribution in different sections;for reference test: a) 0°, b) 30°, c) 85°, and with air bubble screen, d) 0°, e) 30°, f) 85, g) Longitudinal velocity

4. Conclusions

In this research, the effect of aeration structure on the flow pattern and secondary flow power and bed shear stress pattern in a 90 degree mild bend has been studied. All of the experiments were carried out under the clear water conditions. According to result experiments, the air bubble screen system was able to shift the maximum velocity lines and shear stress from the outer bank to the middle of the channel.The results show the potential of the bubble screen as a method to modify the flow pattern and morphology in a variety of applications in and open Channels and Especially Shallow rivers.

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