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Research Article

Experimental Investigation of Effects of Piles on Water Surface Profile in Semi Circular Labyrinth Side Weir with One Cycle

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ABSTRACT

Side weirs are among the most important and useful hydraulic structures in irrigation and drainage systems that are installed on the side wall of the channel to divert excess water of main channels. The flow through the channel beside the side weir is a spatially varied flow (SVF) with decreasing discharge. Labyrinth weirs are special kinds of weirs that are broken in their plans. In this research semi-circular labyrinth side weir has been studied. The main purpose of this research is to study the water surface profiles along the semi-circular labyrinth side weir and piles effects on them in subcritical flow. Results show that the water depth in the upstream end of the side weir is lower than the downstream end and also show that piles direct water flow toward the side weir. It can be also observed that if the piles placed at the downstream end of the weir the flow is more uniform and the head loss is less than the other cases.

Key words: Pile, Semi-circular labyrinth side weir, Subcritical flow, Water surface profile

INTRODUCTION

Side weirs are important and useful hydraulic structures and substantial parts of irrigation and drainage systems that are installed on the side wall of channel. In conditions that water discharge of the channel is more than a certain amount, side weirs divert excess water into relief channel. The flow through the channel beside the side weir is a spatially varied flow (SVF) with decreasing discharge. Probably the first study about side weir discharge coefficient was done by De Marchi (1934). He obtained an equation to compute the discharge coefficient on the concept of constant specific energy. Swamee *et al*. (1994) and Borghei *et al*. (1999) studied rectangular, sharp crested side weirs and gave equations for predicting discharge coefficients. Aghayari *et al*. (2009) have studied the spatial variation of discharge coefficient in broad-crested inclined side weirs. Studies also showed that the hydraulic behavior of side weirs depends on type of weirs, main channel and flow conditions. Emiroglu *et al*. (2010a) studied the discharge coefficient of sharp-crested labyrinth side weirs on a straight channel. Their results showed that the discharge coefficient of the labyrinth side weir is up to 4.5 times higher than that of a rectangular side weir. Emiroglu *et al*. (2010b) used a numerical method to study the discharge capacity of triangular labyrinth side weirs. Kabiri-Samani *et al*. (2011) have studied Hydraulic performance of labyrinth side weirs using vanes and piles. Their study showed that piles and weirs increase side weir discharge coefficient up to 40% and develop its hydraulic performance.

MATERIALS AND METHODS

Experiments were carried out in the Hydraulic Laboratory of Tabriz University, Tabriz, Iran, in a rectangular glass open channel with 8.4m length, 0.4 m width and 0.5m height. A schematic representation of the experimental set-up is shown in Figure 1. The side weirs are installed on the side wall of this channel. Three diameters were considered for semi-circular labyrinth side weirs but the height was 0.15m. Tests were conducted for 11 inlet discharges between 10-60 lit/s and the Froude number between 0.1-0.37; so, the water flow condition in all of the conducted experiments is subcritical flow. The piles that were used in the study were cylindrical and the same height of the side weir. The number and arrangements of piles along the labyrinth side weir were different that in total 14 conditions were created that can be observed in table 1. Schematic plan view of the piles' arrangement is shown in Figure 1.

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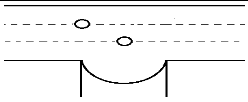
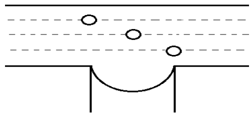
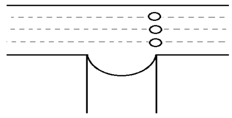
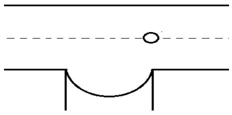
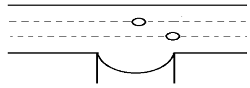
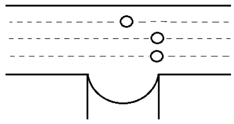
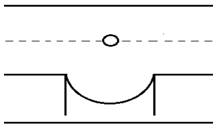
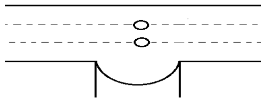
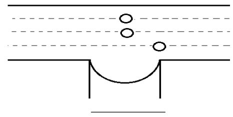
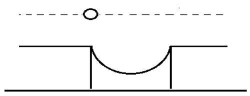
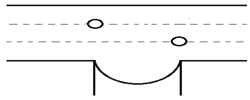
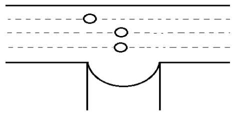
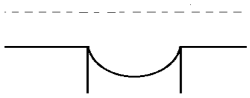
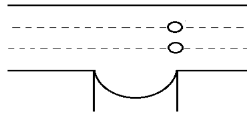
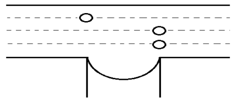
Table 1: Configurations and notations of the tests

Test number	Piles configuration	Test number	Piles configuration	Test number	Piles configuration
C2BO		C3BOA		C3AAA	
C1A		C2OA		C3OAA	
C1O		C2OO		C3OOA	
C1B		C2BA		C3BOO	
SLW		C2AA		C3BAA	

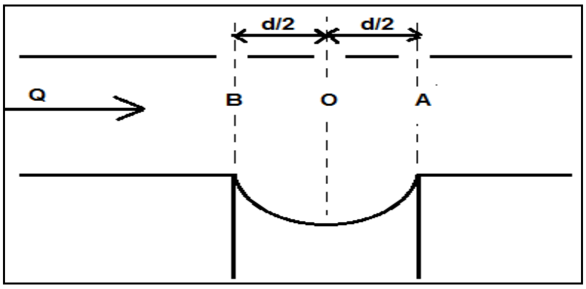


Fig. 1: Schematic plan view of the vanes and pile groups

RESULTS AND DISCUSSION

Side weirs radius effect on water surface profile

Figure 2 shows water surface profiles in the main channel centerlines for three different radius values when the inlet discharge is 35 lit/s. This Figure indicates that by increasing the side weir radius, the water depth along the centerline and the water surface fluctuations decrease.

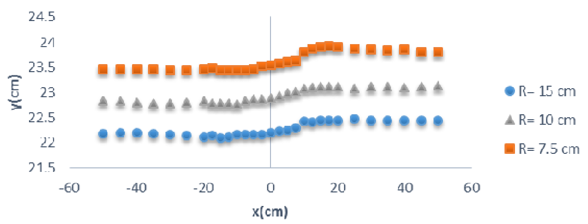


Fig. 2: Side weirs radius effect on water surface profile

Water surface profile in the main channel centerline

Water surface profiles were measured for all of the experiments and side weirs in the main channel centerline. Figure 3 shows these profiles for the side weir with 20 cm diameter for different Froude numbers just for 6 configurations namely SLW, C1A, C2AA, C2OO, C3BOA, and C3AAA. As shown, for the simple side weir (SLW) the water depth in the upstream end of the side weir is lower than the downstream end but these changes are very small and the water surface profiles are almost uniform for different Froude numbers. This situation is observed in all experimental runs which contained piles.

Water surface profile at the distance of 4cm from the side weir

Water surface profiles were also measured at the distance of 4cm from the side weir for all of the experimental runs. As shown in figure 4 (for SLW, C1A, C2AA, C2OO, C3BOA and C3AAA) the water depth in the upstream end of the side weir is lower than the downstream. The water surface profiles along the side weir drop slightly at the upstream end of the weir crest and then the water level rises quickly toward the downstream end of the weir. The figure also shows that piles decrease the water surface fluctuations. Furthermore, it was observed that if the piles placed at the downstream end of the weir, namely C1A, C2AA and C3AAA, the flow is more uniform and the head loss is less than the other cases. Comparison of figure 3 and figure 4 shows that by increasing the distance from side weir, water surface changes decrease.

2D water surface contours

Figure 5 shows 2D water surface profiles for SLW, C1A, C2AA and C3AAA for semi-circular side weir with 20cm diameter. It can be seen that when the piles are placed at the downstream end of the weir, the flow is more uniform and the head loss, vortices, flow separation and undulation are less than the SLW and other cases with piles arrangements. The location of the separation zone and the reverse flow area depend on the number and positions of the vanes or piles as much as flow discharge and the weir geometric form. Water surface contours also show that when the piles are placed at the downstream end of side weir, flow is directed toward the side weirs.

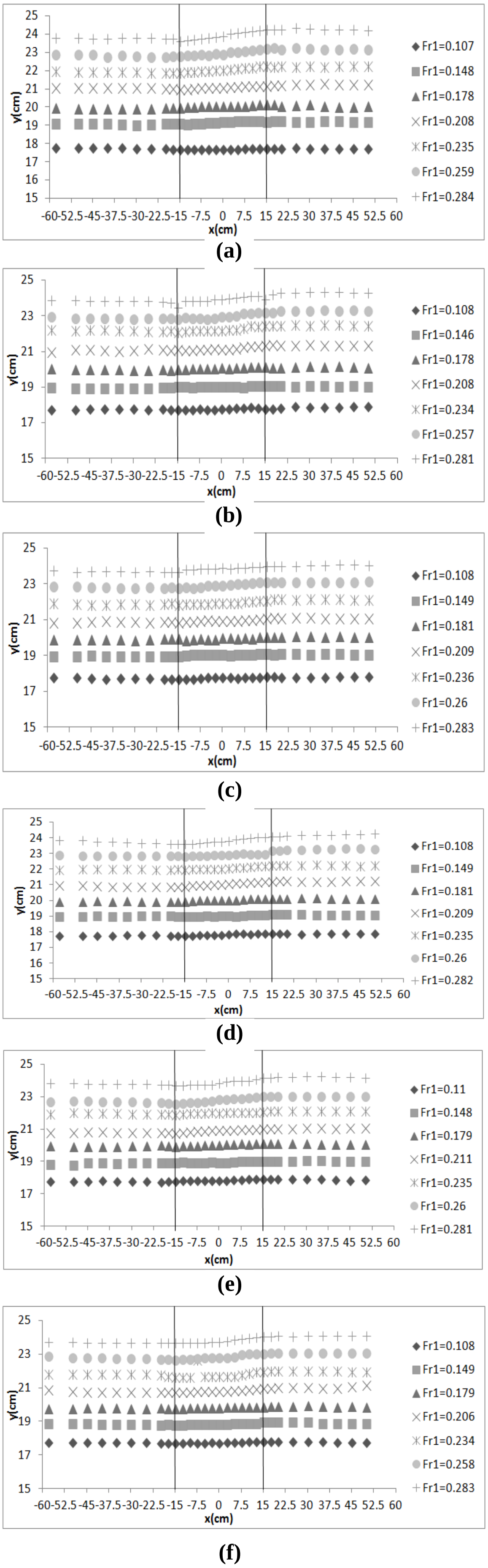


Fig. 3: The water surface profiles along the channel centerline; a) SLW, b)C1A, c)C2AA, d)C2OO, e)C3BOA, f)C3AAA.

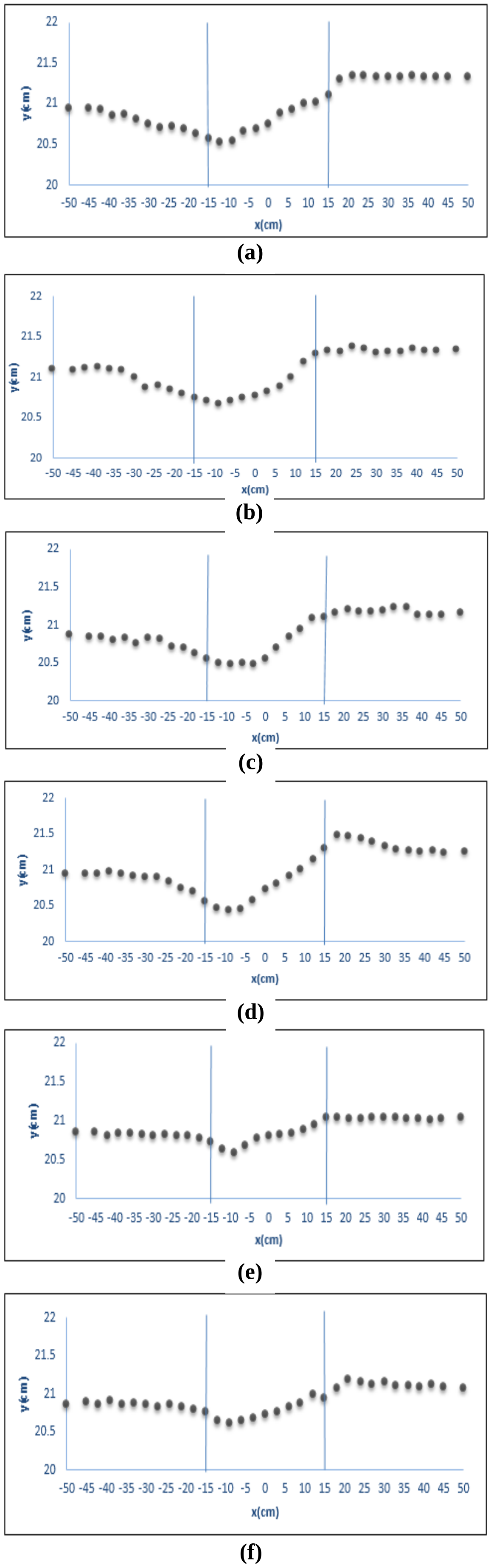


Fig. 4: Water surface profile at the distance of 4cm from the side weir; a) SLW, b)C1A, c)C2AA, d)C2OO, e)C3BOA, f)C3AAA.

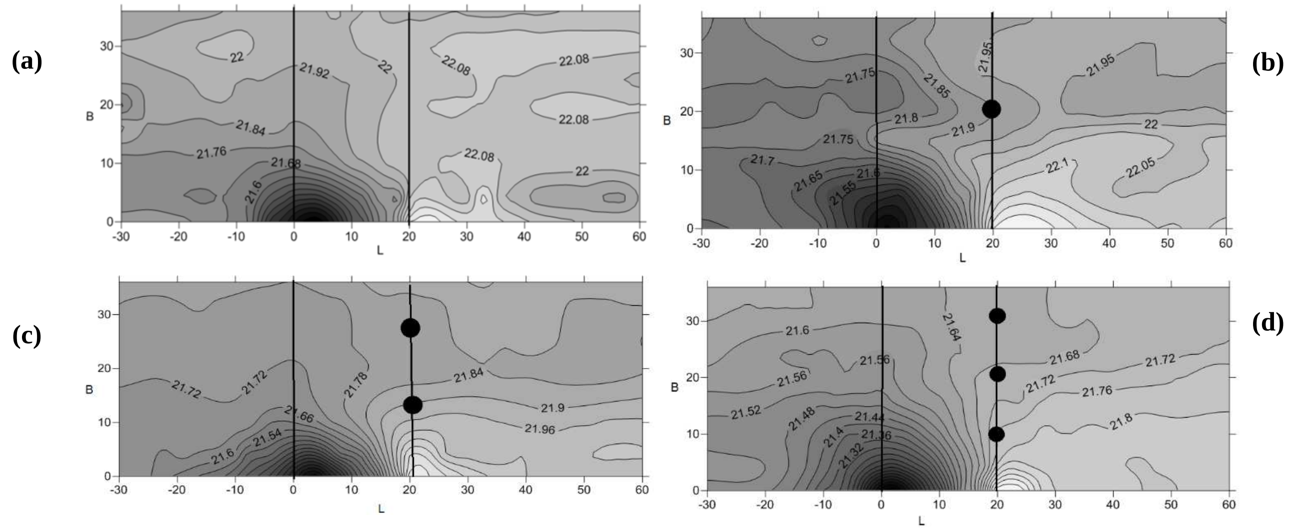


Fig. 5: 2D Water surface contours; a) SLW, b)C1A, c)C2AA, d)C3AAA.

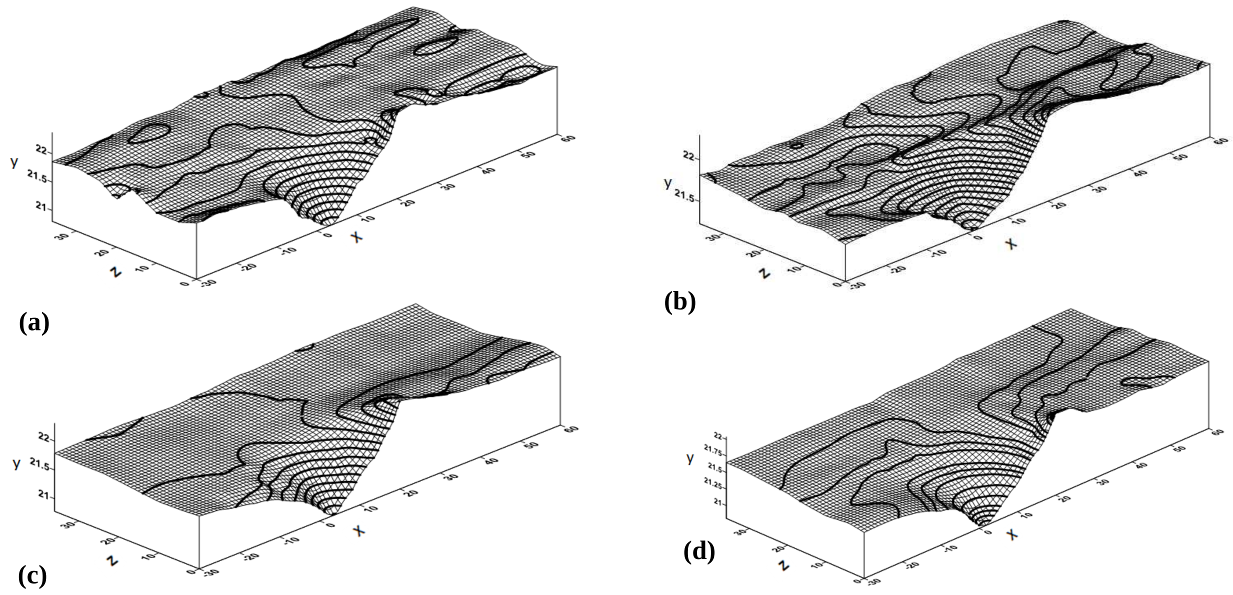


Fig. 6: 3D Water surface contours; a) SLW, b)C1A, c)C2AA, d)C3AAA.

3D water surface contours

3D water contours show the water surface change more evident than 2D contours. As shown in figure 6, when the piles are at the downstream end of side weir, compared with SLW, water surface is more uniform and undulation is less. This uniformity increases by piles number increasing.

Conclusion

In present study, the effect of piles on the water surface profiles of semi-circular labyrinth side weir was investigated. The results show that piles increase water surface uniformity, decrease its undulation and decrease the head lost. It also observed that the piles effect on water surface are more when they are placed at the downstream end of side weir and by increasing the piles number this effect increases too.

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