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In Vitro Evaluation of the Composition of Rectangular Panels Connected to the Beach and Horizontal Blade in Controlling Erosion of Convergent 90-Degree Arch

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Abstract

On the river arch, the formation of secondary flow causes erosion in the outer bank and sedimentation in the inner bank. Sediment accumulation in downstream of arches causes decrease in the river width and therefore arces are mainly seen as convergent in nature. Controlling erosion in the outer bank of arches is done in various ways including the use of spur dike structures. In the rigid spur dike, the flow hitting to the structure body creates a downstream flow and causes aggravated scour around the spur dike; therefore, in order to solve and control this problem it is possible to install horizontal panels on spur dikes. In the this study, in ordr to investigate the effect of horizontal panels installed on the thalweg bed, by making a 90 degree convergent arched channel and installating 4 rectangular spur dike in the positions of 30, 45, 60 and 75 degrees in a way in which the panels occupied 15 percent of the channel width and installing horizontal panels with a length of 10 cm and a width appropriate to the spur dike in three positions of 3 cm above the bed, on the bed and 3 cm below the bed, and by considering the sandy bed thickness of 15 cm and the average diameter of sediment equal to 1.15 mm, a total of 15 tests were carried out in different conditions with three discharges. The results of this study showed that the spur dike are generally successful on the movement of the thalweg and installing horizontal panels causes aggravated thalweg, so that in installation conditions at different altitudes of scour depending on the flow conditions and Froude number the effectiveness of spur dike is different.

Keywords: river arch, erosion control, scour, horizontal panels

Introduction

Secondary flows in river arches due to flow rotation and creating a gradient pressure between the outer and inner banks causes the outer bank sediment to be removed and transfer the material to inner bank which leads to the situation in which thalweg in river arches get close to outer bank and continuous erosion in outer bank and marginal land degradation and damages to river facilities. In order to control erosion and isolation of the thalweg from the outer bank depending on hydraulic conditions and the geometry of the arch several methods can be used. Spur dike is one of hydraulic structures effective on stabilizing the river banks.

In recent decades the use of spur dike to stabilize the outer banks of rivers and in the arched path have been considered by hydraulic engineers. Placing spur dike on the way of the flow causes topical scoures at spur dike and changes in the bed of topography. Spur dikes are usually used in two forms of excretion and absorption in engineering works of rivers which based on the angle of its placing to the flow line can distance velocity vector or absorb transported sediment and stablize the outer bank. Usually in the rigid spur dike, the flow hitting to the structure body creates a flow towards the bed and causes aggravated scour around the structure. In order to control downstream flow and prevent scour around the structure horizontal panels can be used according to figure 1. The effectiveness of this panels depends on the flow conditions and geometric dimensions of the panels and the depth in wich they were installed to the river bed.

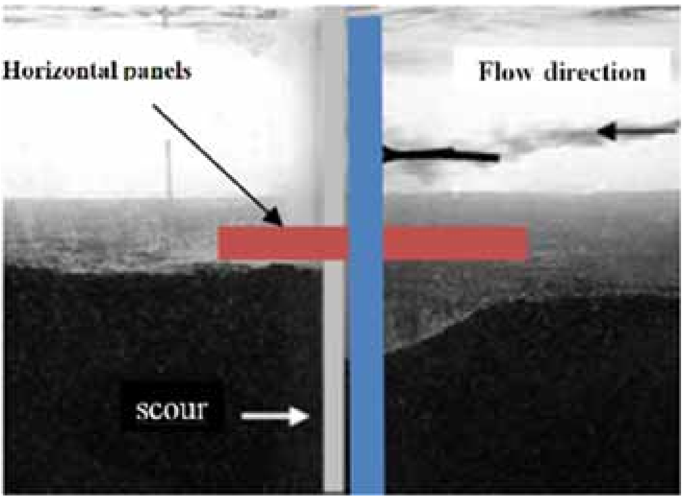

Figure 1: Dividing upstream lines of spur dike to water surface and bed and installing horizontal panel

In the field of applying spur dikes and their effectiveness on controlling erosion of the rivers banks a lot of studies were carried out by different reserchers. The first study on applying spur dikes in arches was conducted by Ahmed (1951) who investigated the depth of maximum scour by changing the variables of discharges, ratio of contraction, spur dike form, position of the settlement in the arches, the angle of spur dike with the flow and sediment characteristics in direct and arched canals. Gill (1972) by changing the radious of the arches curve, the depth of the flow and the diamiter of particles in direct and arched canals showed that the distance between spur dikes depends highly on the radious of arches curve and in arched canals it will be one or two times loner than the length of spur dikes.

Mesbahi (1992) conducted different experiments in arches and concluded that building spur dikes in arches makes the depth of scour holes deeper. Giri et al (2004) experimentally and numerically stimulated the flow field around the spur dikes. Forghani et al (2007) conducted experimental study of two dimentional flow pattern and scour on direct spur dikes in an arch of 90 dgrees. Fazli et al (2007) investigated the scour changes and the way in which erosion hole was made around direct spur dikes located in the arch of 90 dgrees and concluded the more the position of the spur dike settlement goes to the end of arches, the more will be the amount of scour. Mousavi and Barani (2008) studied the use of physical model in investigation of the effects of spur dikes in controlling sediments and reducing erosion in the arch of 90 dgrees of the rivers. In this study in a physical model, the effects of Permeable and impermeable spur dikes on maintaining staibility of the bank in outer bend of an arch of 90 degrees in a canal were studied and compared. Therefore, the physical model which includes a channel with the width of 73 cm and a height of 45 cm and a length of 115 cm along with two penstocks and arches with the angles of 135, 90, 45, and 180 degrees built in Bahonar Martyr University of Kerman were used. The results show that the permeable spur dike with more bars are more effective on maintaining the outer bank of arches. Spur dikes with less bars lead to reduction of erosion in central part of the canal and the nose of the spur dike is better protected. Vaghefi et al (2008) experimentally studied the flow pattern on T shape spur dike in an arch wit 90 degree angle and concludedthat by increasing the length of spur dike, reducing the length of the spur dike wing, increasing the Froude number and changing the position of spur dike to the arches downstream the erosion hole dimensions will be increased. Previous studies show that the major studies were done in arched canals in the lab with fixed width; while in the nature, rivers have variable width and are more convergent. Tis study was carried out to investigate the effects of spur dikes on controllig erosion in the arches with 90 degrees and convergent angle and also controlling the scour hole and its effects on the location of the thalweg by horizontal paels connected to spur dike.

Materials and methodology

The studies done by researches on the flow of water and sediments in water arches and apllying spur dikes show that the parameters like the width of the arches, the curve radious, the shape and dimensios of the spur dikes, the size of sedimental particles, the depth of the water flow, the discharge of the flow in main canal, the angle of positioning of spur dike in compare to cross flow are the effective geometric and hydrolic factors on the rate of applying spur dikes to avoid erosion from external walls of river arches and the amount of sediments on the river bed and their performances. In order to study and carry out the research the effective parameters on the scour conditions were first extracted by the use of dimentional analysis. The parameters include geometrical, hydraulic parameters and fluid properties determined according to equation 1 after classifying and preparing parameters without dimentions.

$$\phi(x,y) = F\left(\frac{b}{B},\frac{h}{H},\frac{ds}{d},\theta,\alpha,\mathrm{Fr}\right) \tag{1}$$

In the above equation, ø (x,y) is the location of thalweg, the ratios of b/B are the ration of the length of spur dike to the the width of canal and the ratio of h/H is the ratio of depth of putting horizontal panels to the water depth in canal before the arch and ds/d is the ration of erosion depth to water depth and ɵ is the position of putting spur dike in the arch and α is the angle of putting the spur dike to the flow. In order to achieve the goals of the study, the required facilities including canals and measuring facilities were first built in the hydrolic lab according to figure 2.

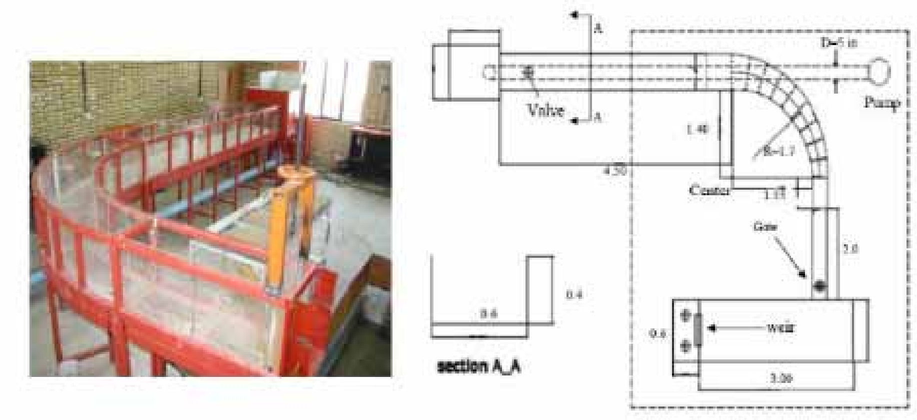

Figure 2: Plan and image of used experimental canal

Experimental canal consists of three parts. The first part is with the length of 4.5 meters, width of 60 cm and depth of 40 cm and direct; the second part is an arched canal with a central radius of convergent arch of 170 cm, the beginning width of 60 cm and ending width of 30 cm; the third part is a direct canal with the length of 2 meters and width of 30 cm and at the endthere is a regulating openining. Water facilities include pumps and 5-inche pipes and the valve controlling flow. The sharp-edged trapezoidal overflow was used to measure the discharge as shown in Figure 3.

The moving bed of sand with an average diameter of d50 = 1.15mm and a thickness of 15 cm was considered. The duration of each test was considered 120 minutes (at this time erosion changes of the bed was almost fixed). Spur dikes are made of plexiglas with a thickness of 6 mm and a height of 35 cm and the length was to occupy 15%of the cross section and were installed at positions of 30, 45, 60 and 75 degrees and to install horizontal blades the plexiglas panels with the thicknes of 5 mm and length of 10 cm and width according to the spur dikes length were considered. Horizontal panels were installed at three positions so that the depth of their placement was considered 20 percent of water depth over the bed and in a situation on the bed.

Figure 3: Experimental modl and the overflow of measuring discharge

Of course, to do any test, first canals were full of water by very low rate of discharge after adjusting the sediment surface and putting spur dikes and horizontal blads then the discharge gradually was increased at the same time the end openinig was opened until the desired depth and the flow rate was obtained And then it took 120 minutes to do the test and after stopping the flow and allowing the water drainage in the sand sand bed level was removed. In order to remove it lasor meter with the capability of moving on the arch path with the accuracy of 0.1 mm was used. Also, the network of taking data along the arched canal was considered every 2.5 degrees and in the width of the canal 2 cmm. 15 tests were done in 3 discharges and 5 conditions (without spur dike, with spur dike and installing 3 cm horizontal blades on the sand bed, with spur dike and installing horizontal blade on the sand bed, with spur dike and installing 3 cm horizontal blades below the sand bed) whose results are as follow.

Discussion and conclusion

The dta from 15 tests in 3 discharges and 5 different conditions were evaluated and analyzed after gathering. The comparison of the effects of the height of installing horizontal blades (3 cm over and below the bed and installing over the bed) in the conditions of the 3 discharges were presented in the figures 4, 5, and 6. As it is obvious, in discharge of 5.47 liter on second the effect of the height of installing horizontal blades on the place of different thalweg and in some points installing over the surface of the bed was more effective. The more discharges, the less effects of the place of installing blade; so that in the condition of installing below the bed surface show regular and better effects. In the condition of installing below the surface bed, the bed level was less affected by erosion.

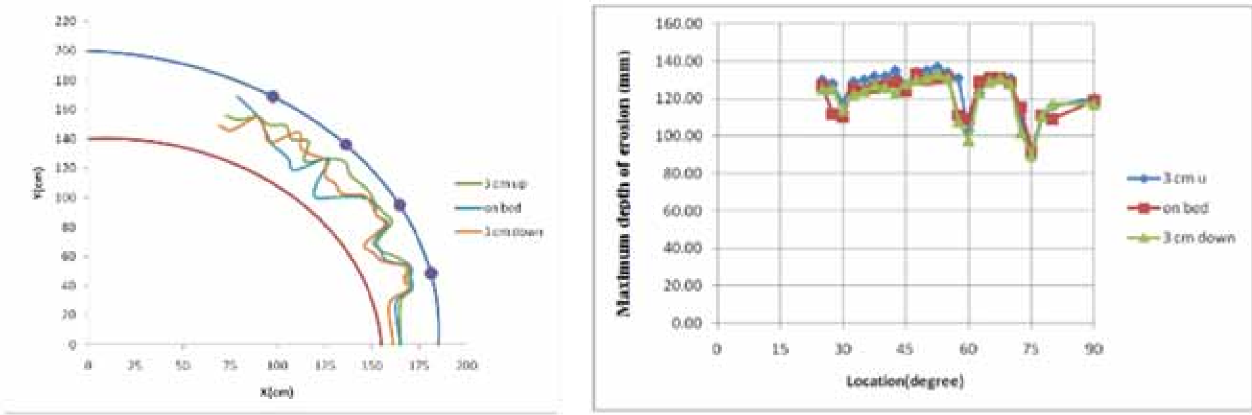

Figure 4: Position and changes of maximum erosion depth in thalweg in the condition of spur dike in 3 condition s to installing horizontal blads in the discharge of 5.47 liter on second.

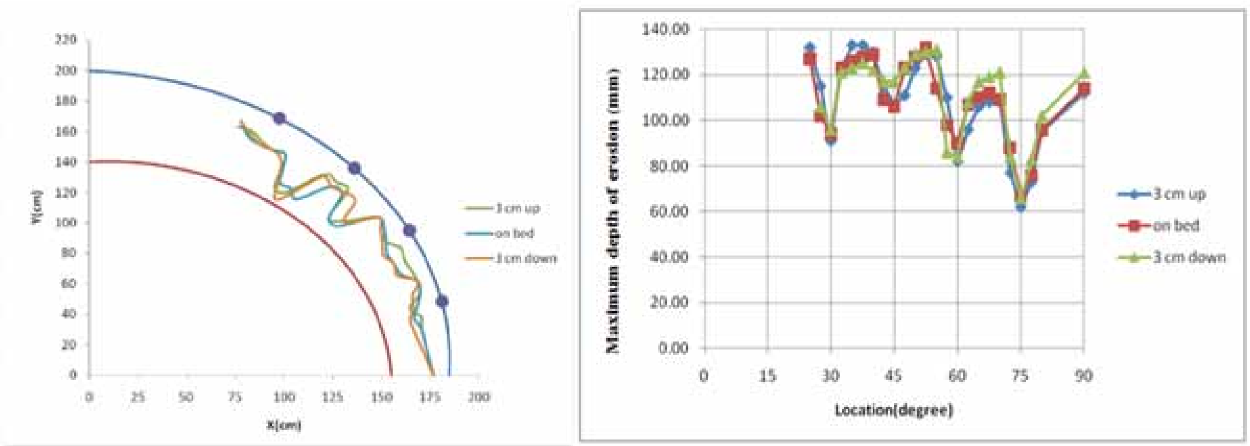

Figure 5: Position and changes of maximum erosion depth in thalweg in the condition of spur dike in 3 condition s to installing horizontal blads in the discharge of 10.04 liter on second.

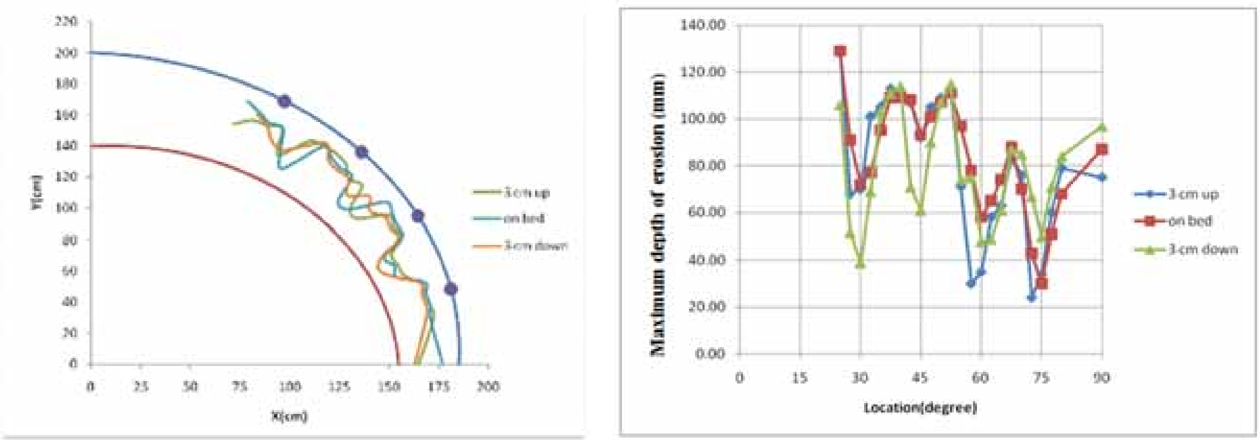

Figure 6: Position and changes of maximum erosion depth in thalweg in the condition of spur dike in 3 condition s to installing horizontal blads in the discharge of 18.45 liter on second.

Conclusion

This study was done to investigate the effects of height of installing horizontal blade on rectangular spur dike located on the convergent arch of 90 degrees and the following results were achieved:

- Spur dikes generally affect the location of thalweg;
- Installing horizontal blade has effects on distancing the location of thalweg from the arch of outer bank;
- Installing horizontal blade under sedimental bed had regular and better effects in compare to the two conditions mentioned and on the bed and on the location of thalweg.

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