ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

NUMERICAL SIMULATION OF THE FLOW PATTERN AROUND THE SPUR DIKE AT A 90 – DEGREE BEND OF THE RIVER

EBRAHIM NOHANI[1*]

1: Young Researchers and Elite Club, Dezful Branch, Islamic Azad University, Dezful, Iran

[*]Corresponding Author's: E Mail: nohani_e@yahoo.com

ABSTRACT

One of the most important issues related to bend channels is the river bank erosion of outer bend side mainly caused by secondary flows. Spur Dikes control the bank erosion and restore the arable lands along the river. Inappropriate implementation and incorrect design may exacerbate the erosion and destruction of farmlands soil. In this study, a 90 – degree bend was simulated using CCHE2D mathematical model. The results showed that CCHE2D software well simulate the flow pattern around the Spur Dike.

Keywords: Spur Dike, Flow Pattern, Erosion, River

INTRODUCTION

Rivers has long been regarded as one of the most basic human water supplies. In fact, great mankind civilizations have been formed to take advantage of water along the rivers. Thus they have played a vital role in human life. However, great floods cause irreparable damages due to having no understanding of rivers nature. Scouring usually occurs as a result of characteristics variations in the channel flow or human activities and actions such as building structures in the river channel or removing materials from its bed [1]. Impermeable Spur Dike is one of the conventional methods for controlling river bank erosion. Its correct implementation and design can also result in recovering and restoring arable lands along the rivers. Local scouring of Spur Dike headland because of narrowed flow cross section and strong vortices is a considerable issue in these structures design. Peng et al. [2] numerically investigated scouring around the Spur Dike and obtained the desired results. Kamanbedas et al. [3] studied and simulated sediment transport using CCHE2D numerical model in Karkheh River. Johnson et al. [4] examined the effect of submerged plates on scouring control around the walls of the vertical abutments. Odgaard et al. [5] evaluated how to carry sediments through submerged plates. Their results showed that the sediments can be removed at high levels. In this paper, the numerical model of the T-shaped Spur Dike is discussed.

MATERIALS AND METHODS

Laboratory information about a flume made of 10 mm thick sheet of Plexiglas at Islamic Azad University was used to study numerical model of flow around the Spur Dike. The flume specifications are as follows: entrance channel length: 5 m, output channel length: 3 m, curvature radius: 2.8 m, internal bend length: 3.85 m, external bend length: 4.95 m, channel width: 0.7 m, channel height: 0.6 m, bend angle: 90°. Flow rates of 21.3, 25.4 and 29.2 liter/s were used. Applied Plexiglas Spur Dikes were long 7, 10.5 and 14 cm, thick 10 mm and high 60 cm in. Flume floor has filled with D_{50} = 1.85mm sand by the height of 20 cm and has both longitudinal and transverse alignment with zero slopes. CCHE2D software was employed to simulate the flow pattern. Taking geometric coordinates of the flume, identifying boundaries of the computational field, meshing, defining different scenarios in terms of Spur Dikes position and initial flow conditions and finally flow pattern simulation using software consist different stages of the procedure. The area was divided into 3 blocks at boundary identification stage. Boundaries include ranges from inlet to Spur Dike area (part 1), Spur Dike area (part 2) and from Spur Dike area to final section of computational field (part 3). An example of the mesh is shown in Figure 2. Spur Dike length (7, 10.5 and 14 cm) and flow rate (21, 25 and 29 liter/s) are variable parameters of simulation. CCHE2D model has three ways including Manning, Wu & Wang and Fan Rhine roughness coefficients to find the roughness coefficient [6]. To obtain Manning roughness coefficient, the relationship Stickler is used for sandy bed considering D_{50} = 1.85 mm as an initial estimate.

$$n = 0.0417D^{\frac{1}{6}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where n and D denote Manning roughness coefficient and average particle diameter, respectively. n = 0.0144 is obtained by placing D = 0.018 into the above equation. Then simulations were performed using 0.01, 0.011, 0.012, and 0.02 coefficients. CCHE2D model exhibits three types of turbulence model namely vortex viscosity, mixing length and k-ε ones. The accuracy of mixing and k-ε models was seen more than vortex viscosity one during some simulations. But since computational complexity of k-ε model was more than mixing length one and there was little difference in two models results, Mixing length turbulence model was selected for all simulations.

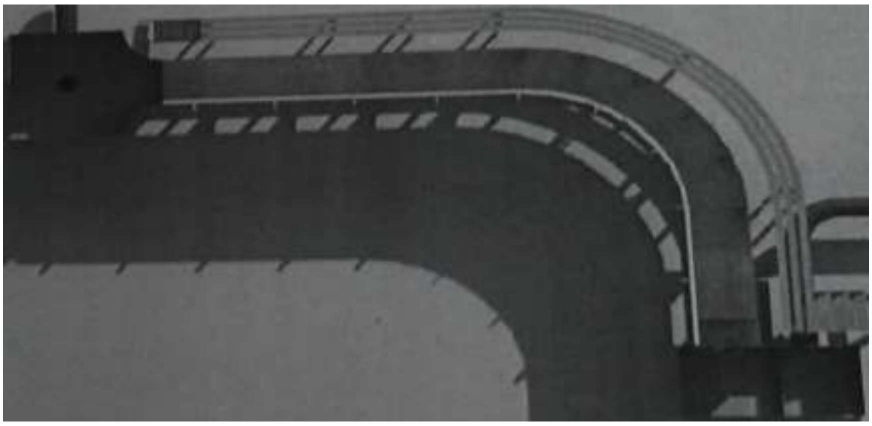

Figure 1: a view of laboratory flume

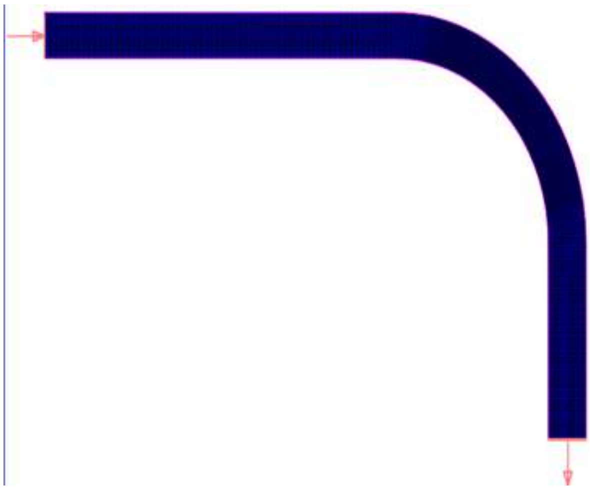

Figure 2- blocks meshing in 90 – degree bend

RESULTS AND DISCUSSION

In this section, the output results of numerical model are discussed. Figure 3 shows a typical Spur Dike with wing span of 10.5 cm at the 5 - degree bend. Considering simulation results, effect range of these Spur Dikes is 46° - 53° from small to large wings. As seen in Table 1, shear stress and speed within effect range so reduces that speed around the Spur Dike has an 80% reduction, resulting in scouring decrease.

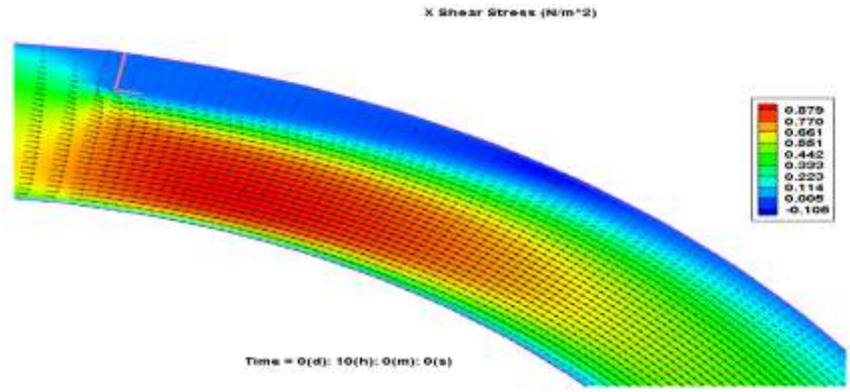

Figure 3: Spur Dike with wing span and flow rate of 10.5 cm and 21.3 liter/s, respectively at the 5 - degree bend

Table 1: The test results of Spur Dike with different wing span and flow rate of 21.3 liter/s at the 5 - degree bend

Spur Dike length (cm)	effect range (degree)	depth variations(cm)	Velocity without Spur Dike(m/s)	Velocity within effect range(m/s)	Froude number Without spur	Froude number within effect range(Fr)
7	46	+0.5	0.235	0.024	0.191	0.013
10.5	50	+0.5	0.235	0.024	0.191	0.013
14	53	+0.5	0.235	0.024	0.191	0.013

An example of the Spur Dike with 14 cm wing span at the 5 - degree bend is shown in the Figure 4. The Spur Dike effect has a 53° - 54° range from small to large wings according to simulation results. Table 2 indicates that there is very low shear stress and speed (about 80%) within the Spur Dike effect range and the flow has a contrary direction in some part of this range. These results reflect the effect range size to prevent bank erosion at the outer bend.

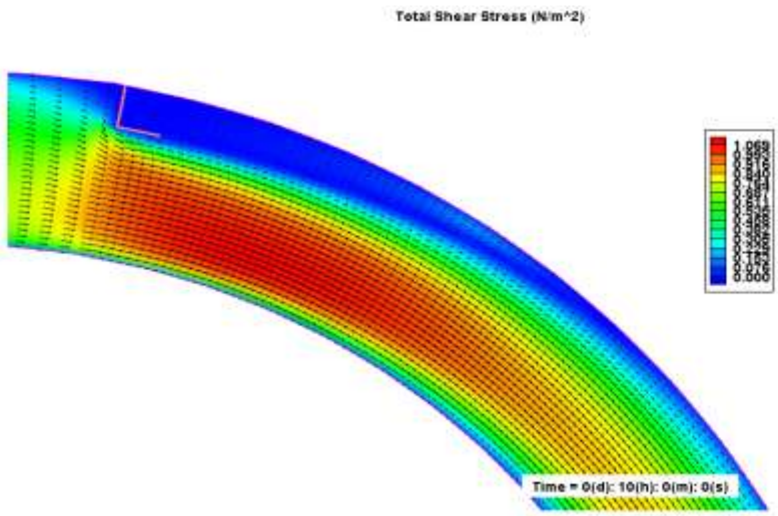

Figure 4: Spur Dike with wing span and flow rate of 14 cm and 25.3 liter/s, respectively at the 5 - degree bend

Table 2: The test results of Spur Dike with different wing span and flow rate of 25.3 liter/s at the 5 - degree bend

Spur Dike length (cm)	effect range (degree)	depth variations(cm)	Velocity without Spur Dike(m/s)	Velocity within effect range(m/s)	Froude number Without spur dike(Fr)	Froude number within effect range(Fr)
7	53	+0.6	0.245	0.027	0.195	0.013
10.5	54	+0.7	0.245	0.026	0.195	0.014
14	54	+0.7	0.245	0.026	0.195	0.014

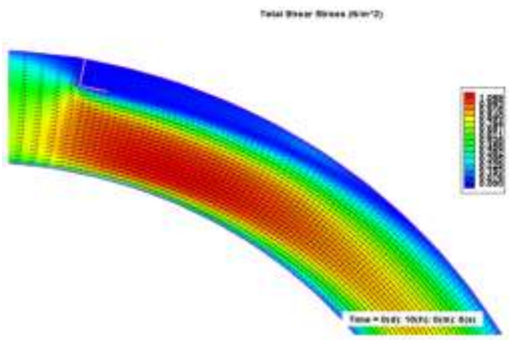

Figure 5: Spur Dike with wing span and flow rate of 7 cm and 29.2 liter/s, respectively at the 5 - degree bend

Figure 5 shows the Spur Dike with a wing span of 7 cm at the 5 - degree bend. Simulation results suggest 50° - 56° effect range for small to large wings. The summary results are also shown in Table 3. The Spur Dike effect on shear stress and speed was high within this range.

Table 3: The test results of Spur Dike with different wing span and flow rate of 29.2 liter/s at the 5 - degree bend

Spur Dike length (cm)	effect range (degree)	depth variations(cm)	Velocity without Spur Dike(m/s)	Velocity within effect range (m/s)	Froude number Without spur dike(Fr)	Froude number within effect range(Fr)
7	50	+0.7	0.261	0.028	0.203	0.016
10.5	53	+0.7	0.261	0.028	0.203	0.016
14	56	+0.65	0.261	0.028	0.203	0.016

So, it can be concluded that the Spur Dikes performance decreases as the incoming flow rate to the river bend increases. However, their effectiveness in reducing shear stress and speed is maintained.

CONCLUSIONS

In this research, the flow pattern around T-shaped Spur Dike was numerically evaluated. The results showed that CCHE2D software is capable to simulate a river bend flow. Results comparison suggests that mixing length turbulence model is more accurate than vortex viscosity one to foresee flow field in the 90 - degree bend. The mixing length turbulence model exhibits a good accuracy for predicting return areas and vortex dimensions. Considering data obtained from the simulation, the shear stress and speed within the Spur Dike effect range have had a large reduction (in some areas close to zero) indicating no scouring phenomenon. Also return and vortex flows can be observed by the direction and size of the speed vectors. It means that model simulation is accurate.

REFERENCES

[1] Ebrahim Nohani., Bejestan, M. s., Masjedi, A. and Kashkuli, H.A. 2012. Experimental Study on the Stability of Riprap at Bridge Piers in a 180 Degree Flume Bend. Contemporary Engineering Sciences, 5(8):381-390.

[2] Peng, J.; Kawahara, Y.; Huang, G. W.; “Numerical Modeling of Local Scour Around Spur Dikes”; 28th IAHR Congress, Graz, Austria; 1999.

[3] Kamanbedas A. A. , Nasrollahpour R., Mashal, M (2013). Estimation of Sediment transport in Rivers Using CCHE2D Model (Case Study: Karkheh River), INDJST, India .

[4] Johnson, P.A., Hey, R.D., Tessier, M., and Rosgen, D.L. 2001.use of vanes for control of scour at vertical wall abutments, journal of Hydraulic Engineering, ASCE, 127:9. 772-778.

[5] Odgaard, A.J. and Wang, Y. (1991), "Sediment Management with Submerged Vanes", II: Application, Journal of Hydraulic Engineering, ASCE, Vol. 117, No.3, pp. 284-301.

[6] Zhang, Y. 2005, "CCHE2D-GUI-Graphical User Interface for the CCHE2D Model, User’s Manual-Version 2.2", Technical Report: No.NCCHE-TR-2005-03, Center for Computational Hydroscience and Engineering, University of Mississippi.