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Study the Effect of Groin on the River Flow velocity in the Bend Location (Case study: the small length of Maroon River)

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Abstract: *One of the most important issues related to the rivers is the river erosion in meander location, especially the river beach erosion in the outer bend, that the main reason for that is the existence of secondary streams. The existence of this issue affects the morphology of the river. In this research, using the CCHE2D numerical model, the sediment hydraulic simulation of the Maroon River has been performed and the effect of water speed in the river on the erosion of the river bend, especially the outer bend, and, the utilization of groin on the Maroon River has been investigated as a proposal. The results of this research show that, during the seasonal floodwater and increase of the discharge, the outer beach of the river bend will be eroded and destroyed that this phenomenon could be controlled by the installation of the groin. The installation of groin in the outer bend decreases the shear stress of the river bed by decreasing the flow discharge; therefore, results in the erosion prevention in the outer bend and as a result the beach fixation.*

Keywords: *Groin, Mathematical model, the Water discharge in the river, Erosion.*

INTRODUCTION

The morphological processes are the collection of the factors that interfere with the river to get to a dynamic stabilization and usually are physical, chemical and hydraulic processes that are effective in the confrontation with the geological specifications, geomorphology, and vegetation. Generally, three physical, chemical, and hydraulic factors are effective in the erosion process (Parsa Nia and Agha Majidi, 2016). This problem emerges mostly in the river walls. There are two general methods for its protection, which are known as direct and indirect protection methods.

The direct protection method: in this method, the walls of the river will be tightened to resist against the secondary currents that can result in the wear and erosion of the walls.

The indirect protection method: in the indirect protection method, the water is deflected by some tools and do not let it impact to the wall. Also, the erosion control and rivers stabilization methods are the direct methods that include the gravel, wired lace, articulated concrete veneer, etc. that stabilizes the river wall and indirect protection methods that include the utilization of groin, longitudinal wall, network (mesh) methods, and so on.

The groin that has various names like Epi, Groin, Groyne, Dike, Spur-Dike, Spur and Jetties is a stone, sandy, rock, soil or metallic structure that is constructed with angles in the river beach and in the transversal section. They are hydraulic engineering structures for maintaining the desired water depth, deflecting the main current in the harbor channels and rivers, and preserving river banks (Vaghefi, Safarpoor and Akbari, 2016).

Various studies have been conducted on these structures. Sharma et al. (2012) studied the flow past a spur dike on a rigid bed meandering channel with a trapezoidal cross section, and stated that length of the downstream separation zone alters based on the location of the spur dike. Fang et al (2013) investigated the turbulent flow past a series of groins in a shallow, open channel by large-eddy simulation (LES), and concluded that a rectangular-headed groin produces higher turbulence intensities and larger vortices than a round-headed groin. In 2016 Vaghefi et al (2016) investigated the influence of streamlines variations, the maximum velocity distribution, and the secondary flow strength on bed shear stress distribution along a 180° sharp bend. In another research, they also studied the impact of support structure on flow patterns around T-shaped spur dike in 90° bend channel numerically. They proposed that by enhancement of support structure distance, the power of secondary flow around main spur dike reduces and the length of separation zone increases (Vaghefi, Ahmadi and Faraji, 2015). The historical experience has shown that the utilization of impermeable groin in the bends and arterial rivers was very successful. The main performance mechanism of the groin s is the coast protection, flow deflection from the river and its guidance to the main duct. The result of the flow deflection is the development of a rotational zone with high turbulence around the groin that emerges in the wider state downstream of the groin.

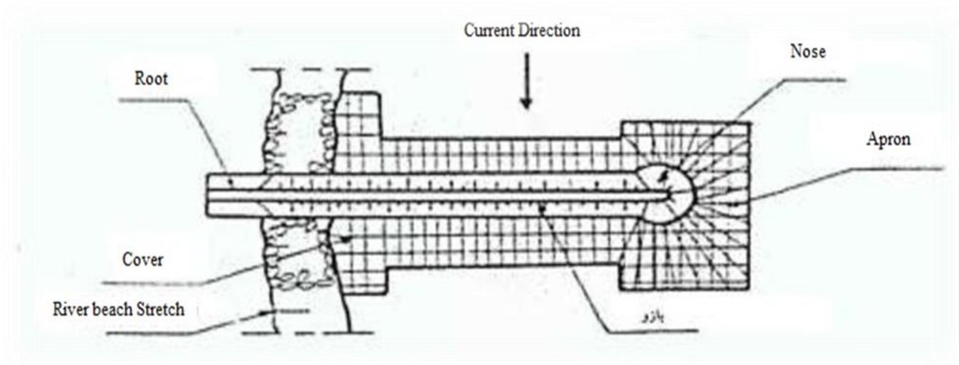

Figure 1: Representation of the various groin components in the plan.

In this study, the effect of the groin in the Maroon River and its effect on the water speed reduction in the riversides and as a result the decrease in the scouring of the ricer wall will be investigated.

Materials and Methods

CCHE2D software

The CCHE2D software was prepared by the Wang, Sam and Gia in the National Center for Computational Hydro science and Engineering (NCCHE), and under supervision of the Mississippi University of America in 1997. In recent years, the mentioned model was gradually developed in such a way that the last version of it (CCHE2D3.2) has various capabilities about the water and sediment simulation. The codes of this program were written by the Fortran 90 programming language. Generally, this collection consists of two separate models. A meshing model and the other one a CCHE2D-GUI model. The mesh generator model with the capability of generating the structured network from the dashed lines generates an environment that makes

the solving of water and sediment problems used in the CCHE2D-GUI possible according to the finite element method. The equations used in this part are bed load transfer equations, suspended load and equations of bed level change. The equations are solved by an efficient element method or exponential difference. The utilized process in the CCHE2D model is schematically shown in the following figure. For preparing the calculation network needed for CCHE2D it is necessary that using the CCHE mesh generator, the calculation range to be limited to an ordered network of the nods with the specified coordinates. The resulted network will be fed to the CCHE2D as a file and the input and output limits will be specified. The model has the capability to use various boundary conditions like discharge hydrograph in the input boundaries, water level hydrograph in the output boundary, also, the simple condition could be used.
This program acts very strongly for calculating the unstable currents problems. This software uses the Partial Differential Equations (PDE) and finite element to solve the simple and complex problems related to the water area.
The water flow simulation is based on the Navier-Stokes in depth-averaged equations. The turbulent shear force is calculated using the Boussinesq approximation and for calculating the turbulent vortex viscosity, three various turbulent models could be used.

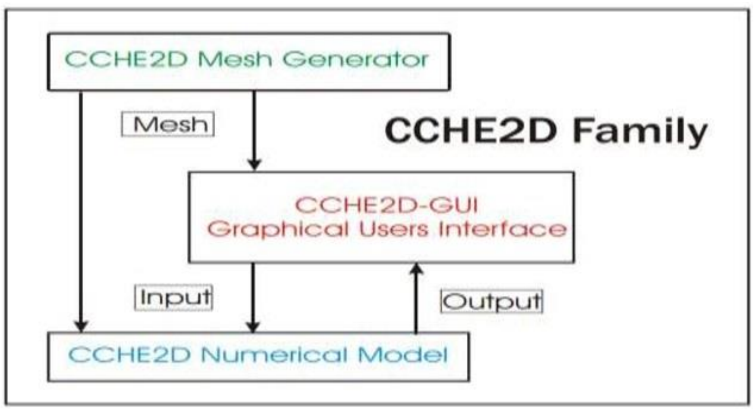

Figure 2: CCHE2D model simulation process.

Results and Discussion

The river discharge in the bend, after installation of the groin:
In the following, the graphical results of the discharge and river bed change in some cross sections will be discussed. Because the bend has the conditions of more credibility and sedimentation, the selected cross sections include some sections before the bend, some on the bend and some after the bend. The shear stress and river bed level, up to the 100 m^3/s of discharges are as follows:

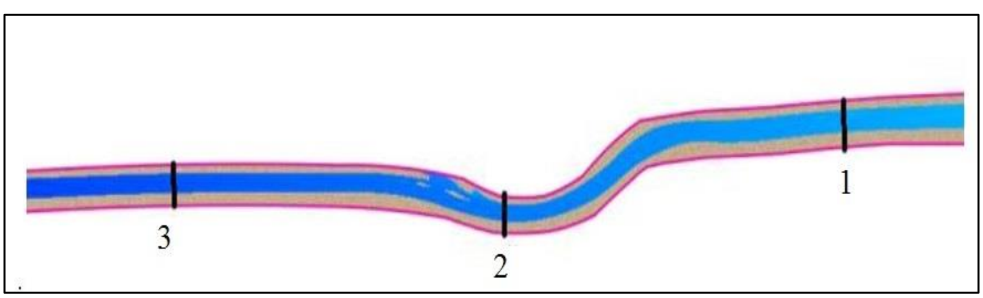

Figure 3: Locating the cross sections in the computational field.

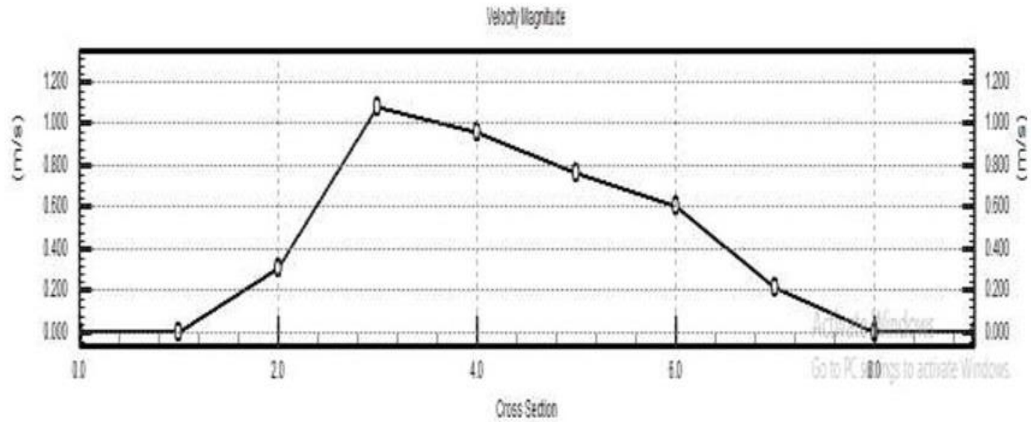

Figure 4: Water discharge in section 1.

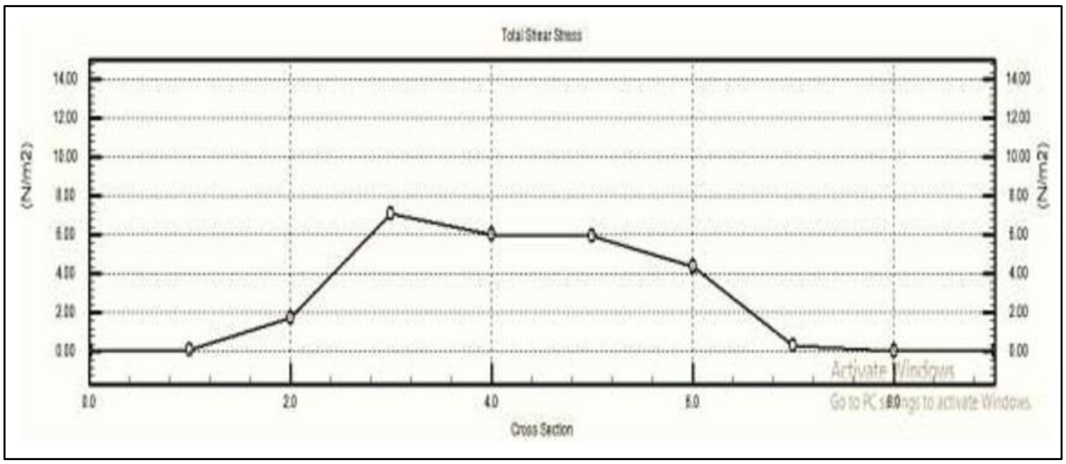

Figure 5: Shear stress in section 1

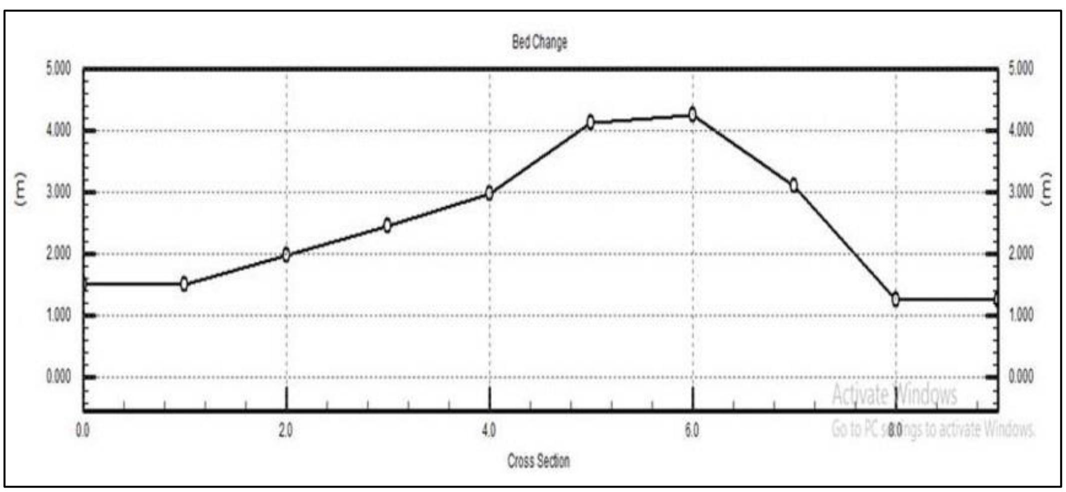

Figure 6: Bed change in section 1.

According to Figure (4) and Figure (5) in section 1, the average discharge is about 0.45 m/s and the average shear stress is about 3.5 N/m, which is lower than the critical shear stress (τ_c) that has resulted in the sedimentation and is clearly specified in Figure (6).

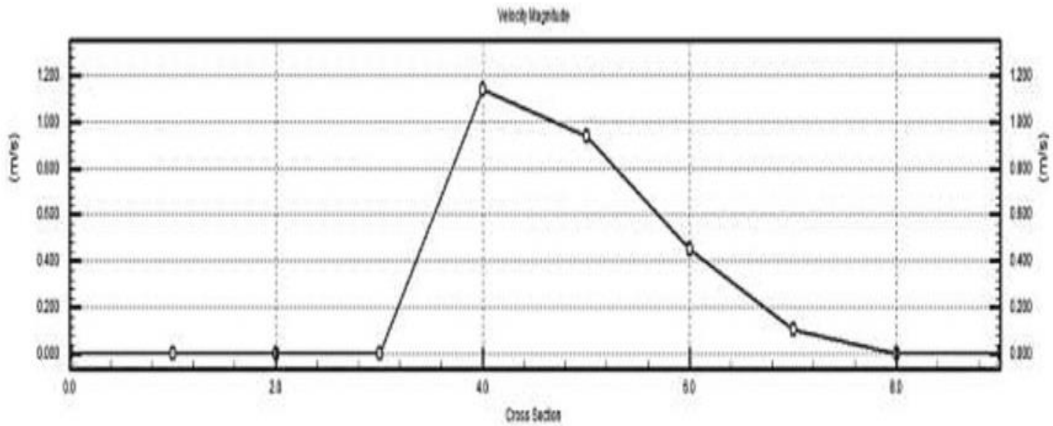

Figure 7: Water discharge in section 2.

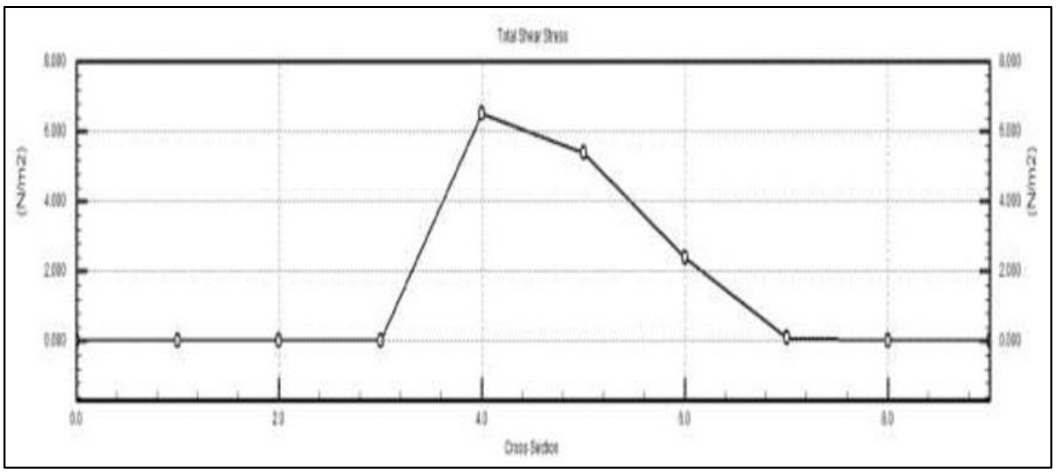

Figure 8: Shear stress in section 2.

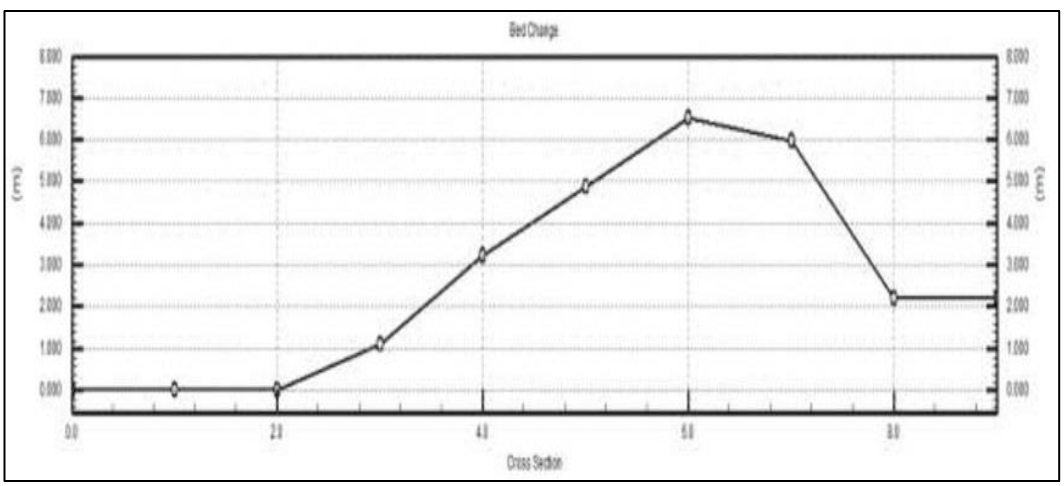

Figure 9: Bed change in section 2.

According to Figure (7), Figure (8) and Figure (9) in section 2, the average discharge is about 0.45 m/s and the average shear stress is about 3.1 N/m, that is lower than the critical shear stress (τ_c) that has resulted in the sedimentation and is clearly specified in Figure (9).

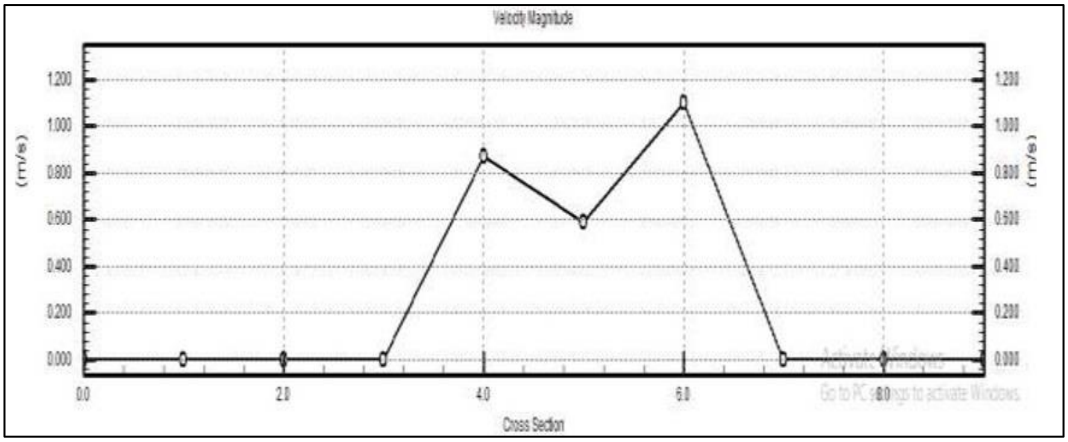

Figure 10: Water discharge in section 3.

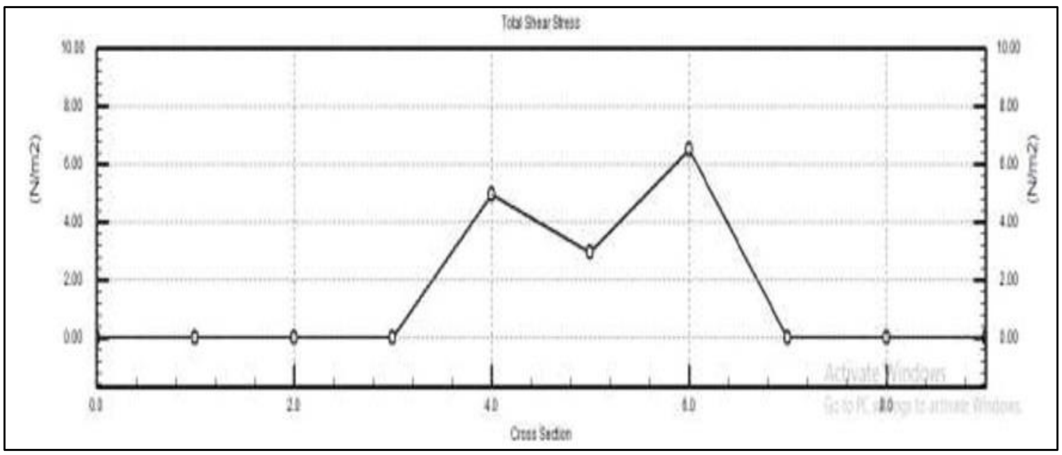

Figure 11: Shear stress in section 3.

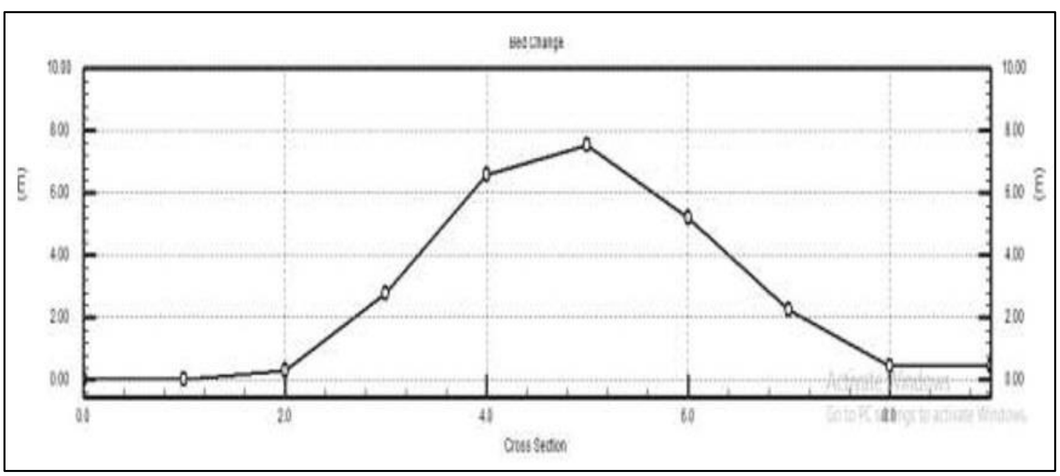

Figure 12: Bed change in section 3.

According to the Figure (10), Figure (11) and Figure (12) in section 3, the average discharge is about 0.55 m/s and the average shear stress is about 3.2 N/m, that is lower than the critical shear stress (τ_c) that has resulted in the sedimentation and is clearly specified in Figure (12). Also, the sedimentation was in the order that has resulted in the formation of the island on the river surface.

In the discharges higher than 200 m^3/s, up to 1000 m^3/s, the results in cross-section 2 are as follows:

Table 1: Flow speed and Froude number change according to the discharge increase in the outside bend of the river.

Simulation	Discharge (m^3/s)	The flow speed in an outside bend (m/s)	Shear stress in an outside bend (N/m^2)	Froude number in an outside bend (Fr)
1	200	0.74	2.26	0.09
2	400	1.6	10.5	0.2
3	600	1.97	15.9	0.25
4	800	2.5	24.8	0.3
5	1000	3.2	40.7	0.38

According to the simulation results in table (1), it could be observed that with the increase of the discharge from 200 to 1000 m^3/s, the flow speed has increased from 0.74 to 3.2 m/s and the Froude number has increased from 0.09 to 0.38 that is higher than the critical speed and shear stress (τ_c) that leads to the erosion process and morphology change of the river and also results in the destruction of constructed facilities at the beach. Therefore, in order to prevent this phenomenon, as a proposal, the utilization of groin in the outside beach bend was proposed in order to prevent the erosion that after its implementation, the following results were obtained:

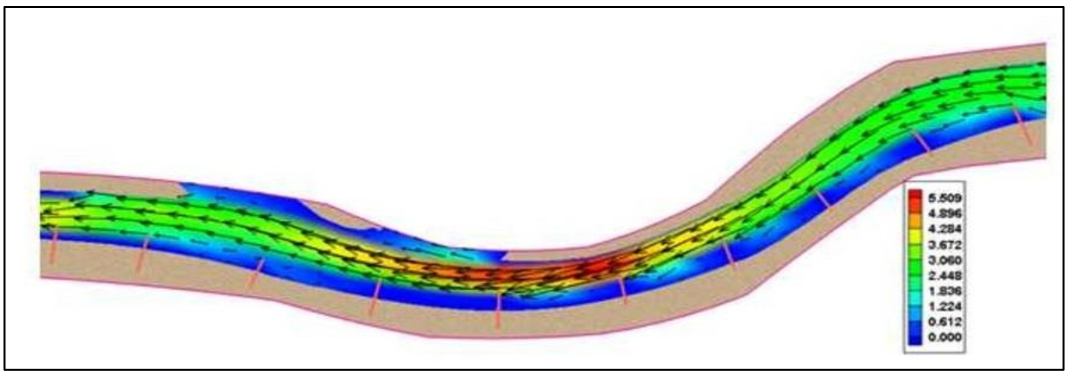

Figure 13: The utilization of groin in the outside part of the River bend.

Table 2: The results of the flow seed change in the river outside the bend area

Test	Groin	The distance of the groin s from each other (m)	Discharge (m^3/s)	The flow velocity in the groin area (m/s)	Shear stress in the groin area (N/m^2)	Froude number in the groin area (Fr)
4	No groin	-	200	0.74	2.26	0.09
5			400	1.6	10.5	0.2
6			600	1.97	15.9	0.25
7			800	2.5	24.8	0.3
8			1000	3.2	40.7	0.38
12	With groin	90	200	0.11	0.13	0.02
13			400	0.14	0.17	0.03
14			600	0.18	0.2	0.03
15			800	0.22	0.24	0.03
16			1000	0.26	0.27	0.03

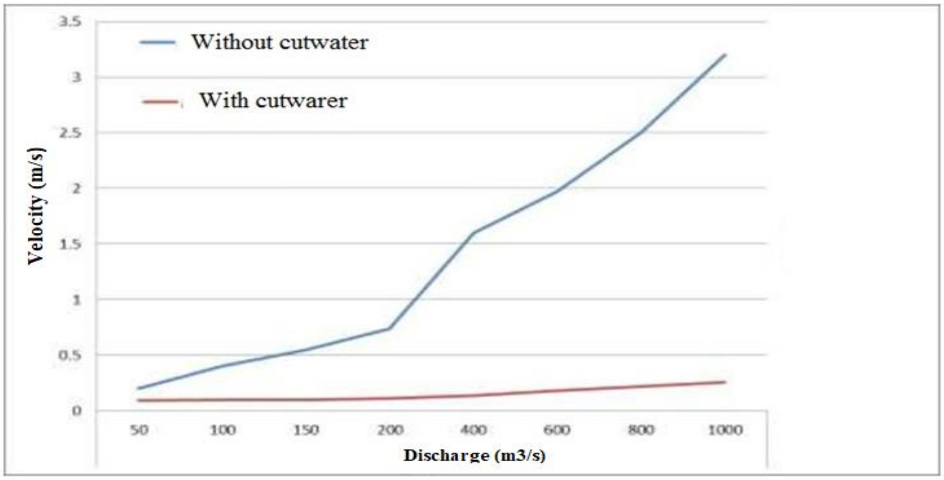

Figure 14: the results of the flow speed (in the outside bend, in the groin area) in the river simulation.

Conclusion

In the meantime of seasonal floodwater and increase of the discharge higher than 200 m^3/s, due to the increase of the flow speed, the shear stress imposed on the river bed, the erosion phenomenon will happen that results in the destruction of the outside beach of the river bends that this phenomenon could be controlled by the installation of the groin. According to the obtained results, by installing the groin in the outside bend, the water speed decreases that this results in the erosion phenomenon decrease in the river bend.

Reference

1. Fang, H.W., BAI, J., HE, G.J., Zhao, H.M. (2013), "Calculations of non-submerged groin flow in a shallow open channel by large-eddy simulation" Journal of Engineering Mechanics, Vol. 140, No. 5, pp. 4001–4016.
2. Parsa Nia, M., Agha Majidi, R., 2016, Sediment control in Maroon River using the CCHE2D software, M.Sc. thesis, Azad Islamic University, Esfahan Branch.
3. Sharma, K., Mohapatra, P.K. (2012), "Separation zone in flow past a spur dyke on rigid bed meandering channel" Journal of Hydraulic Engineering, Vol. 138, No. 10, pp. 897–901.
4. Vaghefi, M., Ahmadi, A., Faraji, B. (2015), "The effect of support structure on flow patterns around T-shape spur dike in 90° bend channel", Arabian Journal of Science and Engineering, Vol. 40, No. 5, pp. 1299–1307.
5. Vaghefi, M., Akbari, M., Fiouz, A.R. (2016), "An experimental study of mean and turbulent flow in a 180 degree sharp open channel bend: secondary flow and bed shear stress", KSCE Journal of Civil Engineering, Vol. 20, No. 4, pp. 1582–1593.
6. Vaghefi, M., Safarpoor, Y., Akbari, M. (2016), "Numerical investigation of flow pattern and components of three-dimensional velocity around a submerged T-shaped spur dike in a 90° bend", J. Cent. South Univ., Vol. 23, pp. 2984–2998.