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Best Installation Angle for Immersion Vanes as a Measure for Meander Bank Erosion

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1-Introduction

Investigation of the flow mechanics of a river, the time changes of the river, hydraulic flow simulation and changes in the meander riverbed are some of the most important issues in the field of meandered rivers. River are subject to constant change due to erosion and sedimentation. Understanding such changes for the purpose of organizing and immunizing river against the obtained result is very important. Normally, bed erosion leads to instability of sides and this process is followed by soil mass falling and geometric deformation of the cross section of the river. The outer beach zones are displaced owing to the erosion and is a threat for riverine structures. Because of the presence of eddy flows in the meanders, the riverine erosion in the outer side and sedimentation in the inner side is much more considerable than straight paths. The erosion of the outer side leads to displacement of the arcs of the river and consequently destructs the agricultural lands, technical buildings and infrastructure and reduces the total river flood passing capacity. In order to control erosion and manage sediment in the meanders, two methods of direct protection (concrete quilt, vegetation, riprap, etc.) and indirect protection (flow pattern modifying methods) are used. Selecting the appropriate method to control erosion and sedimentation in meandering depends on environmental conditions (for instance, the implementation of concrete quilts are hampering the growth of vegetation coverage), river hydraulic conditions and economic issues.

Recently, in order to manage the sediment in meanders, direct protection methods (structural methods) are used. The first step toward ensuring that the flow pattern modifying structures can solve the problems, is design of their dimension and the placement approach, whereat these structure are able to create the required changes in the erosion and sediment patterns so that it will reach a stable limit. The immersed vane structure is one of the flow pattern modifying structures which has not been implemented yet. These vanes are similar to submerged vanes in terms of performance where the difference is that the immersed vanes are installed higher than the river bed level. The installation angle of the submerge vanes has a high importance in design since it directly affects their performance in altering the erosion and local scouring near them.

Considering the fact that the immersed vanes structure is installed higher than the river bed level, implementing them is easier and less expensive in deep rivers with constant flow compared to submerged vanes and above all, in angles with high hydrological performance, the structure is not imposed to local scouring. Moreover, there is a possibility of a higher yield in changing the bed pattern. Hence, proper installation of immersed vanes in meanders, which are not implemented yet, are investigated in this study.

2-Materials and methods:

In order to achieve to the aims of this study, a physical model of the Jangiye 180-degree arc located in the down of Ahvaz was built in the library of river models of Shahid Chamran University. The aforementioned arc has experienced different width changes during consecutive years and has caused damages to Jangiye village or nearby palm gardens. The summary of river characteristics of the site of interest is presented in Table (1).

Table. 1. River characteristics

Length of prototype section (km)	Average flow depth (m)	2-year discharge (m^3/s)	Sediment size (mm)
2	7.75	2560	0.1

According to the library condition and the present limitations and choosing the model scales of 300 and 50 respectively for horizontal and vertical dimensions, the physical model is presents in Table (2).

Table. 2. Model characteristics

Length of modeled section (m)	Average flow depth (cm)	2-year discharge (lit/s)	Sediment size (mm)
7	15. 5	2560	2

After constructing the physical model and preparing the experiment requirements, and performing each experiment for 4 hours (the time determined by primary experiments), the summary of the experiments is depicted in Table (3).

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Table. 3. Summary of the experiments

Fr	H(cm)	de	d	α(deg)	Le
0.2	*	*	*	*	*
0.2	3	4H	H	10	16H
0.2	3	4H	H	20	16H
0.2	3	4H	H	30	16H
0.2	3	4H	H	40	16H

In the above Table, Fr is Froude number, H is the height of vanes, Le is the lengthy distance of vanes, α is the insertion angle in degrees, d is the insertion depth of the vanes and de is the distance from the outer bank of the vane. After conducting each experiment, the bed topography was measured using a laser meter and finally using the Tecplot software, the bed topography of the physical model was constructed.

3-Results

Based on the experiments and analyzing them, the results are as follows:

1. In the control experiment and without inserting the immersed vanes, the erosional hole with a maximum depth of 50 mm exited from the 130-degree position near the outer beach and was continued to the end of the data sampling scope.
2. Immersed vane's structure caused fundamental changes in the pattern of erosion and sedimentation in rivers arc.
3. The maximum depth of the erosion hole in two mounting angles of 20 and 40 degrees, is equal to 20 mm whereas compared to the control test (the maximum erosion hole depth of 49 mm) it has 60% reduction.
4. In the mounting angle of 20 degrees, the erosion holes utterly attached to the outer banks, but the erosion hole installed at 40 degrees angle got away from the outer beach.
5. The best installation angle of immersed vanes is 40 degrees. Also, the results of this study is compatible with the results of Avodgard (2008).
6. At the insertion angle of 40 degrees, the length of the erosion hole was 44 cm where compared to the control experiment (160 cm) it has 73% reduction. Hence, by installing immersed vanes at this angle, the minimum possible length of the outer beach with face with erosion is obtained.