

Laboratory investigation of effect of flat submerged vanes on scour at bridge piers group and abutment

M. Karimi¹, K. Qaderi^{2*}, M. Rahimpour³ and M. M. Ahmadi⁴

¹Master of science, Department of Water Engineering, Faculty of Agriculture, Shahid Bahonar University of Kerman, Kerman, Iran.

^{2, 3&4}: Associate Professor, Department of Water Engineering, Faculty of Agriculture, Shahid Bahonar University of Kerman, Kerman, Iran.

ABSTRACT

Local scour involves removal of material from around piers and abutments as the flow accelerates around the obstructed flow area. Various methods have been suggested for the control and reduction of local scour around the bridge piers and abutment. Using submerged vanes is one of these methods. Vanes change the regime of bed load movement that led to control place of deposition and erosion. The function of vanes to reduce scour around the bridge piers and sediment movement in the region of vanes due to down flow in front of them are affected by arrays of the vanes. In the present study, Different lay out of arrangements (Parallel rows, two parallel rows, and two zigzag rows) Flat Submerged vanes with the ratio of length to height ($L/H=3$) at an angle of 20 degrees relative to the direction of flow on protection of local scour around abutment and piers group with rectangular debris were laboratory investigation. All experiments conducted in uniform flow with clear water were be done. The results showed that the zigzag arrangement of the two three rows had the greatest effect to protection of local scour around abutment. In this case, vane distance from abutment and the row spacing with the relative spacing is 0/5 and 1.(The distance of the vanes from the abutment was L_a and the distance of the rows was $2L_a$) that reduced the scour depth by 81%.

KEYWORDS

Local Scour, Submerged vanes, layout of arrangement, Bridge Abutment, Protection.

* Corresponding Author: Email: kouroshqaderi@uk.ac.ir

1. Introduction

Bridge failures caused by scour at bridge foundations (piers and abutments) make quite clear the need for further studies in order to predict scour and ways to reduce it.

The various scour countermeasures can be classified into two main groups: bed-hardening methods and flow-altering methods.

During the last decades, different Countermeasures were proposed to protect bridges against local scour. Countermeasures for local scour at bridge piers can be grouped in two categories: armoring devices and flow-altering devices.

Submerged vanes are the hydrofoils which generate helical currents in the flow due to the difference in pressure between the approaching flow side and downstream side of vanes.

Due to the importance of bridges structures, further laboratory investigations are needed to investigate the different aspect of submerged vanes interaction with abutment and piers scouring phenomena. [1, 2, 3 & 4]

So the purpose of this study was to investigate the effect of different lay out of flat submerged vanes arrangements in front of a rectangular abutment and their location to the surface of the sedimentary abutment on bridge group piers scour reduction at the presence of debris.

2. Methodology

The experimental test of this research carried out at the Hydraulic and Water Structures laboratory of department of water engineering, Shahid Bahonar university of Kerman, on a laboratory flume with 8 m length, 80 cm width and 60 cm height, having glass walls and metal bottom. All experiments conducted in uniform flow with clear water, rectangular abutment and debris, Flat submerged vanes and cylindrical piers, with non-cohesive sediment with $d_{50}=0/91$ and $Q=51$ L/s.

The piers model which used in the test are steel cylindrical tubes with an effective diameter of three cm and a rectangular abutment in the form of (12×6 cm) that made of galvanized sheet and debris model was rectangular shape with (19×7 cm) dimensions.

The arrangement of piers positions were in the (2×2) piers group and debris was located on the front piers with a relative depth of 0.3.

The dimensions of submerged vanes with the ratio of length to height ($L/H=3$) at an angle of 20 degrees relative to the direction of flow.

Experiments on scour were in straight channel. Initially the bed surface was leveled, then inlet valve was opened slowly, the discharge increased to a predetermined value so that no scour occurs at the mobile reaches of flume.

The effects of flat submerged vanes in different arrangement submerged vanes on protection of local scour around abutment and piers group with rectangular debris were investigated.

3. Discussion and Results

The results of the experiments are presented in two groups: without collars and with the presence of collars. To investigate the process of scour in presence protective measure, at first it needed a series of experiments without any vanes in front of piers and bridge abutment. At this stage, 9 experiments have been performed. Table (1) show a list of tests and quantitative test results related to scour dimensions.

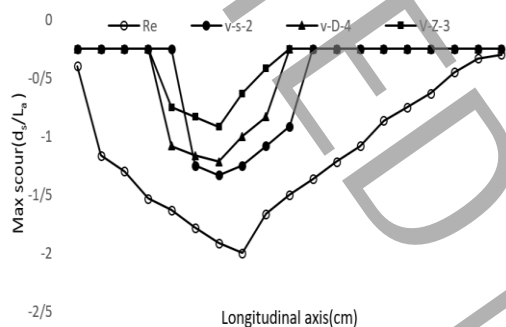
Table1- Percentage reduction of submerged vanes in different arrangements

NO	Symbol	(d_s/L_a) reference	(d_s/L_a) tests	Decrease scour (%)
1	V-S-1	1/3	1	23
2	V-S-2	1/3	0/95	27
3	V-D-1	1/3	0/75	42
4	V-D-2	1/3	0/66	49
5	V-D-3	1/3	0/60	54
6	V-D-4	1/3	0/53	59
7	V-Z-1	1/3	0/45	65
8	V-Z-2	1/3	0/33	74
9	V-Z-3	1/3	0/25	81

Comparisons of results indicate that the vanes with dimension ($L/H=3$) at an angle of 20 degrees position.

The lowest and highest reduction of scour percentage are related to (V-S-1) arrangement with three vanes in a single row arrangement parallel and space between abutment are ($X=6\text{cm}$) with 23% decrease. In (V-Z-3) test with six flat vanes, the arrangement of two rows of zigzags with a distance of 3 cm from abutment ($X=3\text{cm}$) and distance between the rows are ($L_b=6\text{cm}$) with 81% decrease.

Figure (1) shows the longitudinal profile of the hole scour and the sedimentation section in Experiments (RE), (V-S-2), (V-D-4) and (V-Z-3). As can be seen in Figure (1), in the single-order arrangements of the submerged vanes in the test (VS-2) respectively with a 27% reduction in the shallow cavity depth. In the case of two parallel rows in the test (V-D-4) with a reduction of 59% and in the case of vane placement in two-row zigzag arrangements in the test (V-Z-3) with a decrease of 81%.



Longitudinal profile of the bed on the abutment axis in (RE, V-S-1, V-D-4 and V-Z-3) experiments

4. Conclusions

In this research, the effect of flat submerged vanes in different lay out of arrangement on the scour around group circular piers and rectangular abutment were investigated.

Results obtained after harvesting the profile of the entire sedimentary bed surface, in the case of simultaneous establishment of the abutment and piers group by applying a protective measure (submerged vanes) in front of the abutment. It was observed that the protective effect was more on two piers closet to the abutment. The results of the performance of submerged flat in different placement arrangements show a decrease in the amount of scour in the sediment bed surface profile, but this positive performance is not the same in all cases. The results of the experiments showed that the arrangement of the submerged plates in the two-row zigzag arrangement (V-Z-3) had the highest efficiency in the protection of the abutment and bridge piers.

5. References

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