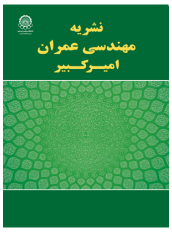

Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 53(7) (2021) 695-696
DOI: 10.22060/ceej.2020.17729.6654

Laboratory Investigation of Effect of Flat Submerged Vanes on Scour at Bridge Piers Group and Abutment

M. Karimi, K. Qaderi* , M. Rahimpour, M. M. Ahmadi

Department of Water Engineering, Shahid Bahonar University of Kerman, Kerman, Iran

ABSTRACT: Local scour involves the 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 bedload movement that led to control places 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 downflow in front of them are affected by arrays of the vanes. In the present study, different layouts 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 the protection of local scour around abutment and piers group with rectangular debris were investigated. All experiments conducted in uniform flow with clear water were being done. The results showed that the zigzag arrangement of the two-three rows had the greatest effect on the protection of local scour around the abutment. In this case, the vane distance from the abutment and the row spacing with the relative spacing is 0/5 and 1, respectively, (the distance of the vanes from the abutment was La and the distance of the rows was 2La) that reduced the scour depth by 81%.

Review History:

Received: Jan. 15, 2020
Revised: Feb. 25, 2020
Accepted: Jul. 14, 2020
Available Online: Aug. 21, 2020

Keywords:

Local scour
Submerged vanes
Layout of arrangement
Bridge abutment
Protection

1. INTRODUCTION

Bridge failures caused by scouring at bridge foundations (piers and abutments) make quite clear the need for further studies 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 into two categories: armoring devices and flow-altering devices.

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

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

So the purpose of this study was to investigate the effect of different layouts 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.

*Corresponding author's email: kouroshqaderi@uk.ac.ir

2. METHODOLOGY

The experimental test of this research was carried out at the hydraulic and water structures laboratory of the 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 were 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 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 is made of galvanized sheet and debris model was a rectangular shape with (19×7 cm) dimensions.

The arrangement of piers positions was 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 scouring were in a straight channel. Initially, the bed surface was leveled, then the inlet valve was opened slowly, the discharge increased to a predetermined value so that no scour occurs at the mobile reaches of the fl ume.

Table 1. 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

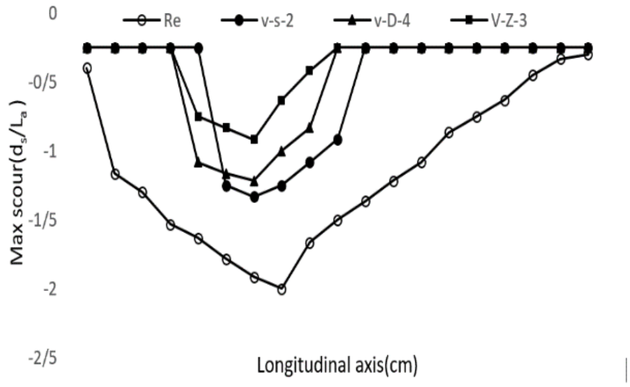

Fig. 1. Longitudinal profile of the bed on the abutment axis in (RE, V-S-1, V-D-4, and V-Z-3) experiments.

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

3. RESULTS AND DISCUSSION

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 the presence of protective measures, 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 shows a list of tests and quantitative test results related to scour dimensions.

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 scouring percentage is related to (V-S-1) arrangement with three vanes in a single row arrangement parallel and space between abutment are (X=6cm) with 23% decrease. In the (V-Z-3) test with six flat vanes, the arrangement of two rows of zigzags with a distance of 3 cm from abutment (X=3cm) and distance between the rows are (L_b=6cm) with an 81% decrease.

Fig. 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 Fig. 1, in the single-order arrangements of the submerged vanes in the test (VS-2) 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 the case of vane placement in two-row zigzag arrangements in the test (V-Z-3) with a decrease of 81%.

4. CONCLUSION

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

Results were 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 closest to the abutment. The results of the performance of submerged flat in different placement arrangements showed a decrease in the amount of scour in the sediment bed surface profile, but this positive performance was not the same in all cases. The results of the experiments revealed 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.

REFERENCES

[1] Odgaard, A. J., & Mosconi, C. E. (1987). Streambank protection by submerged vanes. *Journal of Hydraulic Engineering*, *113*(4), 520-536.

[2] Odgaard, A. J., & Spoljaric, A. (1986). Sediment control by submerged vanes. *Journal of Hydraulic Engineering*, *112*(12), 1164-1180.

[3] Odgaard, A. J., & Wang, Y. (1991). Sediment management with submerged vanes. I: Theory. *Journal of Hydraulic Engineering*, *117*(3), 267-267.

[4] Wang, Y., & Jacob Odgaard, A. (1993). Flow control with vorticity. *Journal of Hydraulic Research*, *31*(4), 549-562.

HOW TO CITE THIS ARTICLE

Karimi M. , Qaderi K. , Rahimpour M. , Ahmadi M. M. , Laboratory Investigation of Effect of Flat Submerged Vanes on Scour at Bridge Piers Group and Abutment , Amirkabir J. Civil Eng., 53(7) (2021) 695-696.

DOI: 10.22060/ceej.2020.17729.6654