Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 52(7) (2020) 405-406
DOI: 10.22060/ceej.2019.15565.5953

Evaluation and Comparison of the Slots and Collars Performance in Reducing Scouring around Bridge Abutments

Mehdi Osroush[1], Seyed Abbas Hosseini [2,*], Amir Abbas Kamanbedast[3]

[1] Department of civil engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran
[2] Department of civil engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran
[3]Department of water science and engineering, Ahvaz branch, Islamic Azad university, Ahvaz, Iran

ABSTRACT: The bridge failure caused by the local scouring phenomenon around its piers or abutments is a common phenomenon. Therefore, some methods should be used to prevent the destruction of these structures. Slots and collars are among the tools that can be used for this purpose. Therefore, by conducting 49 tests in this research, we will examine and compare the performance of these two tools with new approaches around bridge abutments using an experimental model in different flow conditions. The results show that although the most effective slot model can reduce the dimensions and depth of scour hole by 61%, it cannot postpone the start of the scouring phenomenon and take the scour hole away from the abutment surroundings. However, for the most effective collar and highest Froude number, the scour hole reaches the base point after 120 minutes from the start of the test. In this collar model, the maximum depth of scour hole is shifted to a more distant point from the abutment, and the percentage of reduction in the depth of scour hole at the base point and erodible bed is 96% and 56%, respectively.

Review History:

Received: 2019-01-01
Revised: 2019-02-11
Accepted: 2019-02-09
Available Online: 2019-03-13

Keywords:

bridge abutment
local scouring
Slot
collar
erodible bed

1. INTRODUCTION

Down flows, bow flows, horseshoe vortices, secondary vortices, and wake vortices are considered to be the cause of local scouring phenomenon around bridge abutments [1,2]. To control this phenomenon around pier or bridge abutments, one can refer to the use of slots and collars [3,4]. Using an experimental model and making innovations in the present study, the performance of both slots and collars in reducing scouring around a rectangular bridge abutment with vertical walls will be examined and compared.

2. MATERIALS AND METHODS

In this study, the sediment particles with a diameter of 1.37 mm, geometric standard deviation of 1.15 and a bridge abutment with 9cm * 9cm vertical walls were selected. For recording and measuring the bed topography, a high precision laser bathometer was used. In this study, three Froude numbers were selected: 0.36, 0.31 and 0.28. In all experiments, the flow depth was 7 cm, and the flow was uniform, turbulent, and sub-critical with clear water. The slot width was constantly 0.25 times the length of the abutment. In Tables 1 and 2, different slot and collar models are presented respectively. In these tables, X_s is the position of the slot relative to the nose tip of the bridge abutment, L_a is the length of the abutment, H_s is the height of the slot, y is the depth of flow, Y_s is the position of the slot relative to the sediment bed, L_c is the length of the collar and Bch is the width of the collar.

*Corresponding author's email: abbas_hoseyni@srbiau.ac.ir

3. RESULTS AND DISCUSSION

3.1. Experiments without using a slot or a collar (control tests)

In this part of the experiments, a test is carried out for each Froude number of the flow (a total of 3 tests) for 13 hours. At all stages of this group of experiments, the maximum scour depth occurs at the upstream corner. Therefore, this point is selected as the base point. After 4 hours, for Froude numbers of 0.36, 0.31 and 0.28, the dimensionless scour depth (ds/y) at the base point was 1.54, 0.92 and 0.70, respectively, and at the same period, 95, 97 and 98 percent of the equilibrium scour depth occurred respectively. Therefore, the duration of 4 hours was selected for all tests.

3.2. Experiments results for abutments with a slot

Of the three slot models of S1, S2 and S3 that have the same height, but located at different positions to the bed, the slot model S3, which is closer to the bed surface, has a lower scour depth and better performance. Also, the scour depth of the model S2 is lower than that of the model S1. The slot S4, which extends from the bed surface to the water surface, has a better performance compared to the previous three. On the other hand, the slot S5, with a height equal to the flow depth plus the equilibrium scour depth when not using a slot, has the lowest dimensionless scour depth and higher scour depth reduction percentage compared to those of the four previous slot models.

Table 1: slots specifications

Slot model	$\frac{X_s}{L_a}$	$\frac{Y_s}{y}$ *	$\frac{H_s}{y}$ *
Different models relative to the bed			
S1	0	0.5~1	0.5
S2	0	0.25~0.75	0.5
S3	0	0~0.5	0.5
S4	0	0~1	1
S5	0	$\frac{d_s}{y}$~1	$1+\frac{d_s}{y}$
Different modes relative to the nose tip of the abutment			
S'	0.5	*	*
S''	1	*	*
* These parameters are determined after determining the optimal slot relative to the bed			

Table 2: collars specifications of

Test	$\frac{L_c}{L_a}$	$\frac{B_{ch}}{L_a}$
CP1	1	0.25
CP2	1.6	0.6
CP3	1.6	1.2
CF1	1.6	1.5
CP4	2	0.6
CP5	2	1.2
CF2	2	1.5

The average percentage of scour depth reduction for all three Froude numbers is 16, 20, 23, 38 and 47 percent for S1, S2, S3, S4 and S5 models, respectively. Thus, the effect of the S5 model is compared to the nose tip (S'5 and S"5 models in addition to S"5 model). The average scour depth reduction percentage of the three flows in these three slot models (i.e. S5, S'5 and S"5) is 47, 52 and 61%, respectively. This suggests that in slots with the same dimensions and location to the bed, the farther is the slot to the nose tip of the abutment, and the closer it is to the channel wall, the better its performance will be.

3.3. Experiments results for abutments with collar

The results of this section show that, in general, by increasing the length and width of the partial and full collars at the downstream, the scouring around the abutment is decreased, and as a result, the collar performance is enhanced. Such that this change either reduces the scour depth at the base point or, apart from reducing the scour depth at the base point, moves the maximum depth of scour hole from around the abutment to a more distant point. Also, the increase of dimensionless width of the collar (B_{ch}/L_a) from 1.5 to 2 (i.e., the change of collar CP3 to CF1 and CP5 to CF2) has failed to create positive increase in performance of the hole created around the abutment or the sedimentary field. Therefore, increasing the dimensions of the collar from the side of the collar facing the back of the abutment (downstream) cannot improve the positive performance compared to that of the partial collar. Therefore, collar CP5 serves as the most optimal collar. The average percentage of scour depth reduction for all three Froude numbers at the base point and the erodible bed in this collar model is 96% and 56%, respectively.

3.4. Comparison of the performance for slots and collars

The comparison of the performance of the best slot and collar shows that for the abutment with a slot S"5, the scouring occurs as early as the start of the test at the base point. However, in the abutment equipped with the CP5 collar, scouring does not reach the base point until 120 minutes after the start of the test. Therefore, it can be said that the collar causes the scouring around the abutment to be delayed, however, the slot does not have the ability to delay the start of the scour.

4. CONCLUSION

The results show that the slot models located closer to the bed level and the channel wall, with a higher height, are more effective in reducing the dimensions and depth of scour hole. However, the most effective slot, i.e. the S"5 model, is not capable of moving the scour hole from around the abutment. Given the lowered power in down flow and horseshoe vortices in experimental models with collar, increasing the longitudinal and transverse dimensions of the collars reduces the scouring around the abutment. Evaluating the performance of the two collars CP3 and CF1 as well as the collars CP5 and CF2 shows that the presence of the bottom side of the collar located on the back of the abutment cannot improve the positive performance of the collar. Therefore, the CP5 collar is introduced as an optimal collar. Unlike the slot model in which scouring starts around the abutment and the base point, collar can play an important role in postponing the time to bring the maximum scour depth to the base point, moving the scour hole to a point farther away from the abutment, and reducing the scouring development.

REFERENCES

[1] Barbhuiya, A. K., & Dey, S. (2004). Local scour at abutments: A review. Sadhana, 29(5), 449-476.

[2] Kwan, T.F. and Melville, B.W. (1994). Local scour and flow measurements at bridge abutments. J. Hyd. Res., ASCE, 32(5): 661–673.

[3] Grimaldi, C., Gaudio, R., Calomino, F., & Cardoso, A. H. (2009). Countermeasures against local scouring at bridge piers: slot and combined system of slot and bed sill. Journal of Hydraulic Engineering, 135(5), 425-431.

[4] Dargahi, B. (1990). Controlling mechanism of local scouring. Journal of Hydraulic Engineering, 116(10), 1197-1214.

HOW TO CITE THIS ARTICLE

M. Osroush, S.A. Hosseini , A.A. Kamanbedast, Evaluation and Comparison of the Slots and Collars Performance in Reducing Scouring around Bridge Abutments, Amirkabir J. Civil Eng., 52(7) (2020) 405-406.

DOI: 10.22060/ceej.2019.15565.5953