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Experimental Investigation of the Effect of Collar on Local Scour around Oblong-Shaped Bridge Pier

Z. Taheri, M. Ghomeshi*
Faculty of Water Sciences Engineering, Shahid Chamran University of Ahvaz, Khuzestan, Iran

ABSTRACT: The failure of the bridge caused by local scour, the importance and necessity of studying the prediction of scour depth and ways of reducing it. One of the important method to reduce the effects of erosion factors is to use a thin plate around the bridge pier called collar. Collar dimensions and the position have great effect on reducing local scour around bridge pier. In this research, collar with four forehead length (lca) equal to B, 2B, 4B and 9B (B is width of the pier) are examined. The collars were installed in four levels equal to: on the bed, 0.12B under the bed, 0.5B and B above the bed. The experiments have been conducted with three Froude Numbers equal to 0.13, 0.16 and 0.19 in clear water condition. The experiments have been done on a flume with the length of 6 m, width of 73 cm, and a depth of 60 cm with a slope near zero in Hydraulic Laboratory of Shahid Chamran University of Ahvaz. The results showed that increasing dimensions of collar will increase the efficiency of performance and the best dimension lca (length of oblong collar in the front of the pier) were B and 2B. The best position to install the collar were on the bed and 0.12B under the bed. In these situations the collar had 100% and 88% efficiency in respectively reducing the scour depth.

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1.INTRODUCTION

Scour in fact means the particle displacement by the flow from a place to another location. One of the types of disinfection is local scour due to the local effect of the structure on the flow pattern. Dargahi [1] with a check on the collars concluded that the collar should not be too thick, since the large thickness of the collar itself created a barrier to the flow and increased scouring. Sanoussi and Habib [2] studied the effect of steep and rounded nose in local scour and showed that the depth of scouring decreases when the nose is sloping. The results of Defanti et al. [3] showed that flow conditions effect the collar efficiency in reducing the depth of scouring, and also stated that collars have better performance at lower flow velocity.

2. METHODOLOGY

The experiments were carried out in a flume with the length of 6 m, width of 73 cm and the slope of the bed near zero at the Hydraulic Lab of Shahid Chamran University of Ahvaz. According to Chiew and Melville's [4] advice, in order to eliminate the effect of channel walls on scour depth, the diameter of the pile should not be greater than 10% of the channel width. Therefore, from the oblong pier with width of 2.5 cm were used. Also according to Chiew and Melville [4], in order to prevent the effect of the particle size on the scour depth, the ratio of the diameter of the pier to the average diameter of the sediment particles should be more than 50 and to eliminate the non-uniformity of the sediments on the reduction of scour, the standard deviation of the particles should also be less than 1.3. Therefore, the average diameter of the selected particles was 0.5 mm and the standard deviation of the particles was 1.18. The collar thickness was 3 mm, the width of the collars according to Tanaka and Yano [5] was three times the width of the pier and the length of the front collars was equal to B, 2B, 4B and 9B (B= pier width). Collars were installed in four positions including, 0.12B under the bed, on the bed surface, 0.5B and B above the bed around oblong bridge pier. To determine the time of experiments, a test with a maximum flow rate of 20 L/s was performed without the presence of collars in long time. The result showed that over a period of 4 hours, more than 90% of scour depth occurred. So, the time of experiments was considered to be 4 hours. Table 1 shows the hydraulic conditions of the experiments.

*Corresponding author's email: m.ghomeshi@yahoo.com

3. RESULTS AND DISCUSSION

3.1. Investigation on collar dimensions

As the collar dimensions increased, the maximum depth of scour decreased. The collar with l_{ca} is 9B reduced the

Table 1. Hydraulic conditions of the experiments

Re	Y(m)	Fr	$\frac{V}{V_c}$	V_c (m/s)	V (m/s)	Q (L/s)
27300	0.13	0.19	0.91	0.23	0.21	20
23400	0.13	0.16	0.78	0.23	0.18	17
19500	0.13	0.13	0.65	0.23	0.15	14

scour by 73%. The collar with l_{ca}=2B and 4B reduced the scour by 38%. The collar with lca=B reduced the scour by 31%.

3.2. Investigation on collar height position:

The collar on the surface of the bed reduces the depth of the scour by 100%. In the level of 0.5B and B above the bed surface, due to the height of the bed surface and the intensification of the downstream flow and the horseshoe vortex, scour increased to bed surface. At the level of 0.12B below the surface of the bed, only the sediments on the collar surface were washed, which was considered to be self-defeating and had 88% efficiency.

3.3. Collar function in different Froude Numbers:

By decreasing the flow rate and decreasing the intensity of vortex flows around the pier, the maximum depth of scour was reduced and the spatter cavity decreased. The collar efficiency at the level of 0.5B above the bed and with l_{ca}=B in the Froude Number of 0.13, 0.16 and 0.19 was 56, 36 and 31 percent, respectively.

4.CONCLUSIONS

The results showed that the increasing dimensions of collar will increase the efficiency of performance and the best dimension l_{ca} (length of oblong collar in the front of the pier) were B and 2B. The best position to install the collar were on the bed and 0.12B under the bed. In these situations the collar had 100% and 88% efficiency in reducing the scour depth.

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