Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 53(5) (2021) 443-446
DOI:10.22060/ceej.2020.17252.6501

Investigation of the Cable Performance and Efficiency in Controlling Local Scour of Rectangular Bridge Piers

S. Abbasi*[1], M. Abam[2], M. Heidarpour[3]

[1] M.Sc. Graduated of Civil -Hydraulic Structures., Faculty of Eng., University of Mohaghegh Ardabili, Ardabil, Iran
[2]M.Sc., Graduated of Hydraulic Structure., Faculty of Eng., Islamic Azad University of Estahban branch, Fars, Iran
[3] Professor, Dept. of Water Engineering., Agricultural College., Isfahan University of Technology, Isfahan, Iran

ABSTRACT: In this study, the performance and efficiency of cable in control of local scour around the pier of the rectangular bridge have been investigated by changing the flow collision angle. In this study, three types of piers, namely, (1) round corner rectangular without cables; (2) round corner rectangular with cable with 10 % of pier diameter with a 15-degree twist angle of cable (second type pier); and (3) round corner rectangular with cable with 15 % of pier diameter with a 12-degree twist angle of cable (third type pier), were used with four different flow collision angles, including 0, 5, 10, and 15 degrees. The purpose of this study is to wrap the cable around the pier and changing the flow collision angle from the downstream flow water and then its effect for the reduction of the depth of the final scour measure. In this experimental study, the effect of flow angles on the pier was investigated, so that the first type pier under zero degrees angle was compared with the second and third types parallel to the flow direction. The maximum scour depth in experiments was achieved at the 15-degree angle with the flow direction, and the effect of the cable in reducing the scour depth in this angle for type-2 and type-3 piers was 10% and 22%, respectively. Also, for type-2 piers, in experiments under 5, 10, and 15-degree angles with the flow direction, the scour depth was increased by 3%, 21%, and 37%.

Review History:

Received: Oct. 20, 2019
Revised: Dec. 10, 2019
Accepted: Jan. 01, 2020
Available Online: Mar. 02,2020

Keywords:

Bridge Pier
Collision Angle
Local Scour
Twist Of Cable
Vortex Horseshoe.

1- Introduction

One of the most important factors in the destruction of bridges is the scour around them. Therefore, to prevent and reduce its effects, it is necessary to understand the mechanism of bridge pier failure. The riverbeds are erodible, but the severity of the erosion depends on time. Zarati and Azizi (2001) tested the performance of a half-collar on rectangular piers. Zarrati and Azizi's results showed that the lower the collar installed, the higher the percentage of scouring reduction would increase [1]. Heidarpour *et al.* (2003) investigated the control and reduction of local scour at the pier of the bridge using a hole. Experimental results showed that in cylindrical piers, one and two times pier of the hole close to the water surface did not affect the depth of equilibrium scour of the bridge pier [2]. Day *et al.* (2006) studied the flow-sharing plates with cable with different torsion angles and different diameters relative to the pier diameter. The three piers were tested with different torsion angles and different diameters of cable ratio to the pier diameter [3].

In this study, the performance and efficiency of cable in control of local scour around the pier of the rectangular bridge have been investigated by changing the flow collision angle. The main objectives of this study are (1) Investigation of the effect of change in diameter and angle of cable torsion, and (2) The effect of changing the angle of the collision flow for the pier protection is to reduce the scour depth and increase the time of maximum scour depth.

2. Wavelet transform theory

2- Methodology

Experiments were performed on a rectangular laboratory flume with a total length of 2 m, length of 2 m, width of 2.5 m, and a depth of 0.5 m with a horizontal (without slope) horizontal floor.

In the present study, a constant flow discharge of 23 liters per second, adjusted by the graduated valve, was used. To eliminate the effect of canal walls on the depth of local scours of bridge foundations as defined by Radikivi and Ettema (1983), The minimum channel width to pier width ratio should be 6.25 [4]. Radikivi and Ettema (1983) concluded that the start of local scours around the foundations occurs at a velocity equal to half the critical velocity at the threshold of sediment particle movement and less than critical speeds, clear water scours conditions occur [5]. Therefore, all of these experiments were performed at the critical condition of 0.9 (0.9 Vc). In the present study, more than 90 percent of the

*Corresponding author's email: salimabbasi@student.uma.ac.ir

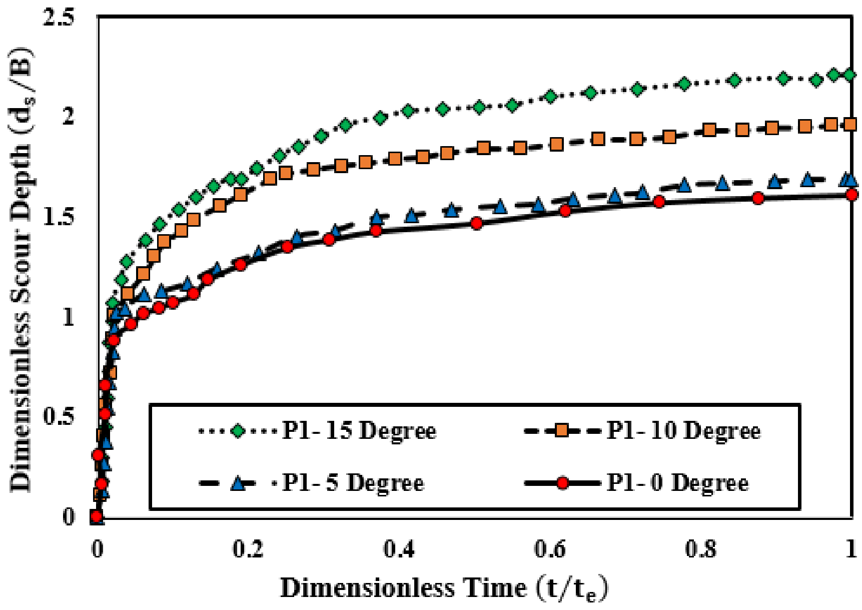

Fig. 1. Time development scour of the first type of pier under zero, 5, 10, and 15-degree angles with the flow direction

scour depth occurs within the first 8 hours, therefore, each test was performed within the first 8 hours. Data collected by Chiew (1992), Chiew (1995), and Ettema (1980) under clear water and live bed conditions where ky (balanced scour depth) equals scour depth at specified depth The flow is more than 4 times the pier diameter ratio to the scour depth this value is also taken into account in the present study [5, 6, 7].

3- Results and Discussion

At the first moment of scouring initiation, the depth of scouring (Fig. 1) is very close to each other and there is little change in the angle of impact to the pier flow. According to observations, this type of pier coincides at zero and 5 ° angles and is located 90 minutes from the beginning of the scour with very little distance until the equilibrium time is reached. Over time, the activity of the takeoff vortices also declined sharply, so that most of the activity of the vortex was limited to moving and transporting particles driven by the vortex.

After 90 minutes, the pier curves will be subjected to a 15-degree slope higher than the other curves and as the angle of impact increases, the scour depth will increase. This can also be deduced from the research by Melville and Sutherland (1988). Increasing the collision angle to the pier causes the pier to become wider and ultimately increases the power of the vortex. Therefore, as the angle of impact increases, the scour depth also increases, so that in this study, the experiments were performed on the first type pier at angles of 5, 10, and 15 degrees relative to the pier at zero angles. The degree of increase was 4%, 20%, and 35%, respectively.

It can be seen from Fig. 2 that the angular deviation of the pier flow from zero to 5 ° does not have much effect on the final scour depth. In Experiment 10 and 15-degrees, as the first type piers under these angles, the slope continues completely until 90 minutes after the onset of scouring, after which the pier has a steeper slope of about 15 degrees until about 3 degrees. The hours continue to run parallel to each other again. Second type pier under 5 ° angle with flow direction compared to pier type 12% depth reduction, pier type 10 ° with angle 10% with flow direction lower 10% final depth of scouring and angle of 15 ° In the direction of flow, they have the highest scour depth, and the effect of cable in reducing the scour depth for this angle for pier type 2 is 10%.

The third type (Fig. 3) pier at an angle of 5 ° with an 18% decrease in flow direction compared to the first type. Also, in experiments at a 10 ° angle with the direction of flow of the third type compared to the first type, the final depth of scouring decreased by 17%. All experiments have the highest scour depth under a 15-degree angle with the flow direction and the effect of cable on reducing scour depth for this angle for the third type is 22%. Table (2) shows the percentage reduction of the final depth of the pier at the final depth of scouring compared to the first type of pier at different flow angles.

Comparison of Figs. 1 to 3 showed that increasing the cable diameter can decrease the initial scour depth and the maximum depth. However, this increase in diameter must be in such a way that it has no operating limit and can be used. In the third type pedestals using a cable with a diameter of 15% of the pier diameter and having a lower torsion angle at angles of 5, 10, and 15 ° than the pier at a zero angle, the depth by 3%, 20%, and 27% increases. It shows that, concerning the above-mentioned materials, the third type has less depth of rising than the first and second type with a 15-degree angle. In this case, the final depth of scour at the base of the third type, which is parallel to the flow direction, shows a 17% decrease, respectively.

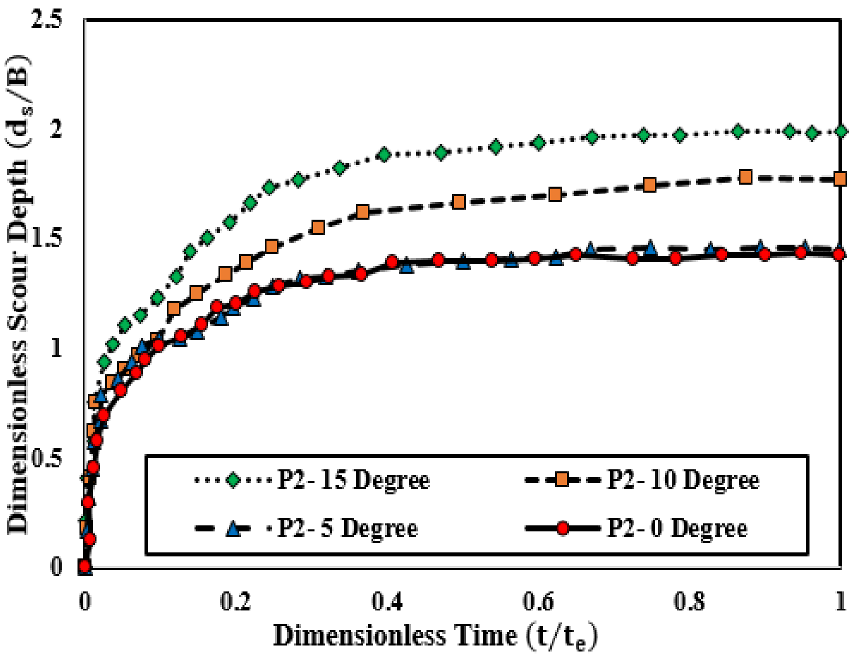

Fig. 2. Time development of scouring the second type of pier under zero, 5, 10, and 15-degree angles with the flow direction

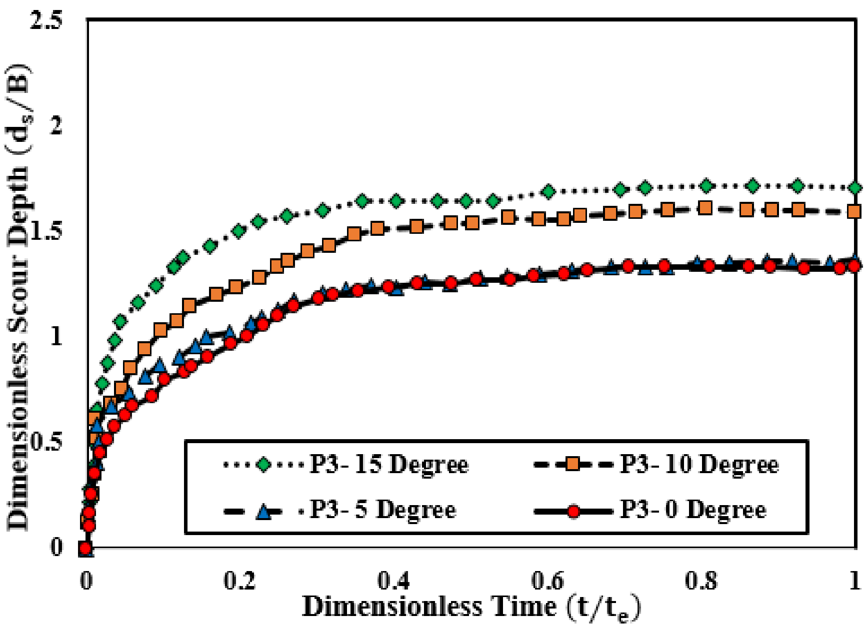

Fig. 3. Time development of scouring the third type pier under zero, 5, 10, and 15 degrees with the flow direction

4- Conclusion

Based on the results, increasing the cable diameter can decrease the depth of primary and final scour. This is due to the decrease of downward flow and weakening of the uplift eddies. Tightening the cable around the pier of the bridge to 10% and 15% of the pier diameter significantly reduces the scour pit angles of 15° and 12°, respectively. Reducing the angle of twisting of the cable around the pier reduces the depth of scouring. That is, if the cable steps are close to each other, the number of cables available will increase, reducing the depth of scouring. Increasing the angle of impact to the pier of the bridge increases the depth of scouring. An angle change of more than 10 degrees is not recommended.

The percentage of final depth increase with the impression of the collision angles on the pier with a 5 ° flow angle for the first to third pier types has a 4, 3, and 3% increase in depth ratio to the pier with zero degrees collision angle, respectively. Also at pier 10-degree angle of flow for first to third type baseboards increase by 20, 21, and 20% depth compared to the pier with zero-degree angle collision angle and 15-degree collision angle for pier type to the third showed a 35, 37, and 27.5% increase in depth relative to the pier with zero degrees of collision angle, respectively. The percentage of final depth reduction at the final depth of scouring relative to the first type at the collision angle of zero degree flow is 12% for the second type and 17% for the third type. Also, for a 5-degree flow angle of 12% for the second type pier, and 18% for third type pier, 10% for second type pier 10% and 17% for third type pier, 10% for 10-second type pier angle, and the third type, it was 22%.

References

[1] A. Zarrati, M. Nazariha, and M. Mashahir, Reduction of Local Scour in the Vicinity of Bridge Pier Groups Using Collars and Riprap. Journal of Hydraulic Engineering, 2006. 132(2): p. 154-162.

[2] M. Heidarpour, Z. Khodarahmi, and S. Mousavi. Control and Reduction of Local Scour at Bridge Pier Groups Using Slot., in: Proceedings, XXX IAHR Congress, Thessaloniki, Greece, August. 2003.

[3] S. Dey, B.M. Sumer, and J. Fredsøe, Control of Scour at Vertical Circular Piles under Waves and Current. Journal of Hydraulic Engineering, 2006. 132(3): p. 270-279.

[4] A.J. Raudkivi, and R. Ettema, Clear-Water Scour at Cylindrical Piers. Journal of Hydraulic Engineering, 1983. 109(3): p. 338-350.

[5] Y.M. Chiew, Scour Protection at Bridge Piers. Journal of Hydraulic Engineering, 1992. 118(9): p. 1260-1269.

[6] Y.M. Chiew, Mechanics of Riprap Failure at Bridge Piers. Journal of Hydraulic Engineering, 1995. 121(9): p. 635-643.

[7] R. Ettema, Scour at Bridge Piers. 1980.

HOW TO CITE THIS ARTICLE

S. Abbasi, M. Abam, M. Heidarpour , Investigation of the Cable Performance and Efficiency in Controlling Local Scour of Rectangular Bridge Piers. Amirkabir J. Civil Eng., 53 (5) (2021) 443-446

DOI: 10.22060/ceej.2020.17252.6501