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Effective parameters on the amount of bridge scour

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ABSTRACT

Methods for controlling and preventing the scour, according to the studies is defining on the base of scour mechanisms.one of these techniques is mounting collar around the bridge truss. Collar around the base of the bed against vortex systems are protected. Collars are protecting the floor against Vortex system around the bridge truss. In the present study, the rough circular collar with small thickness, were used to reduce scour around the bridge truss. The Collar that has used in the experiments, on the base of the substrate surface was placed at different heights. The results of this study after dimensional analysis by using statistical "SPSS" software the correlation between the dimensionless parameters of scour has showed.

1. Introduction

Bridges are the most important and commonly structures that are used for rivers. Bridges have been used from a long time ago and every year due to floods in rivers many bridges are destroyed just when their existence is so essential. Occurrence of scour around bridge foundations is one of the main reasons for the destruction of the bridges. Therefore it is necessary to protect bridges against scour. In recent years researchers have tried various methods and examined them to protect bridges against scour. Methods to control and prevent scour according to studies is based on scour mechanism .in general scour reduction methods are divided into two groups. The first group are the ways which are used to strengthen the substrate and enhance its resistance against shear stress-induced current, such as the construction of Chinese rock. But the second group of methods are ways that are used around the bridges truss In order to change the flow pattern and decrease the created vortex, Such as creating a groove in the base and mounting collar around the base. Possibility of performance and reliability in any methods of reduce scour is a function of various factors such as performance, cost, maintenance, and awareness of the disadvantages of each method. Thus the basic protection method which has used depends on the desired conditions. Protective plates (collars) are protecting the floor against Vortex system around the bridge truss.

2. Materials and Methods

2.1. Patterns of flow and scour mechanisms

For containing scour is required to at first, scour mechanisms must examine.

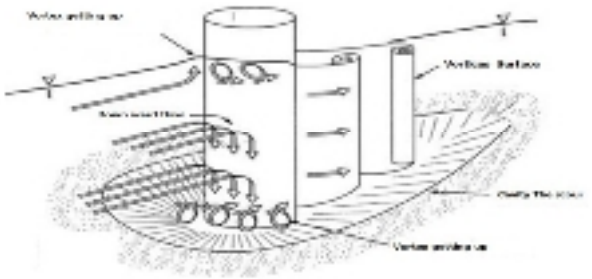

Fig. 1: Flow pattern sand scour around an cylindrical bridge truss

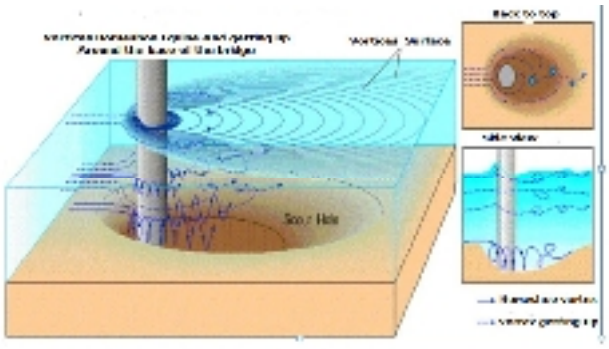

Fig. 2: Mechanism of formation of horse shoe vortices sand vortexes getting up

According to fig.1 after flow collision to the nose of bridge, on stand of bridge as the flow rate of the river water level will become greater more pressure at higher levels will create on the stand and so the

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pedestal pressure gradient is created from the top to down. Which creates a downward flow at the front of stand. Downward flow acts as a vertical jet and after the collision, while digging the river bed are scattered on each side of the bed. Some of this flow which return upward in dealing with the general flow of the river, had to move in the direction of flow and again meets the stand. The swirling flow and its backing into the hole dug will create a vortex that gradually extending on either side of the stand and creates a horseshoe shape which is called horseshoe vortex. Horseshoe vortex formed within the scour hole, Accelerate it's drilling and particles from the substrate that carried downstream by the main flow of the river .because of flow separation on the sides of the stand some vortex will form and its axis is perpendicular to the river bed that has called getting up vortex they. These the vortexes like a tornado isolated the bed's particles, exposed to the flow and transfer the particles from the downstream side of the front and around the stand. Figure 2 is showing horseshoe vortex and getting up formation mechanism very well. Other vortices are formed on the front of stands that has called bow wave or surface vortex is and in shallow streams are important. Scour hole dug by horseshoe vortex continues to increase the volume of water and depreciating Vortex energy.

In this case scour depth is reached to equilibrium. (Horseshoe vortex, getting up and surface (bow wave) has shown in Fig.1.

2.2. Application of collar to reduce scour

Collar is a page that based on various heights and are usually placed around the base of the bed. This page saver is a smooth surface with small thickness and is effective in reducing scour development. Collar should not be too thick, because large thickness of the collar creates a barrier against the flow

And increases scour. A collar that installed on any surface towards the substrate, is dividing the course into two above and below regions of the collar. Top of the collar as a barrier against the downward flow and thus the horseshoe vortex decreases. Performance of a collar depends on the size and position on the stand. When the collar is mounted on the stand for protecting the scour downward flow is diverted from the bed during the collision collar and preventing the Scour.

Fig. 3: Collar rough end using an in vitro model

Fig. 4: basic model of the bridge with a protective collar around its

Several researchers have studied about collar performance in reducing scour of the stands which are around the bridge that some of them will mention. Chievo (1992) studied about the effect of a protective collar tested to reduce pier scour. And by using collar two times more than a base diameter scour depth was reduced about 20%.

He also stated that the design and proper use of collar can be a good alternative for flagstone due to solve bridge's foundation scour problems. Kumar et al (1999) examined the Effect of collar with different dimensions due to reducing the cylindrical scour of bridge foundation. They used analyze results of the experiments and provided an equation to determine the maximum depth of scour around a cylindrical core that is protected by a collar. Singh (2001) studied about the collar in reducing scour and experimental results Implies that if the distance between the beds' align and align of installed collar increase then the maximum scour depth increases too. Zeraty et al. (2006) also studied about the performance of independent and continuous collar with the stone flag foundations of the bridge. Results showed that the combination of a continuous collar and stone flag led to a reduction in scour depth respectively 50 and 60 percent on the front and back of the base. Also performance of independent collar on one base was better than the performance of continuous collar which was on two bases.

They observed that the performance on a rectangular base is more than two bases on two stretches.

2.3. Introduced and tested models

Experiment shave done in hydraulics laboratory of water engineering department of agriculture faculty of comprehensive Islamic Azad University, of Shuster Branch. Laboratory flume channel with length 15 m, width 40 cm, height 50 cm , that the walls made by Plexiglas. Measuring the flow rate and adjusting the depth has done by a sharp-edged rectangular overflow in downstream of flume channel.

For supplying water from an underground tank with dimensions of 5/2 × 3 × 3 mm (length, width and height) supplied that used municipal water supply for plumbing. Transfer of water from the main tank in a closed channel centrifuges pump with a maximum flow rate of 250-125 cubic meters per hour and a discharge height of 5/19 m have done.

Fig. 5: A view of a laboratory the flume

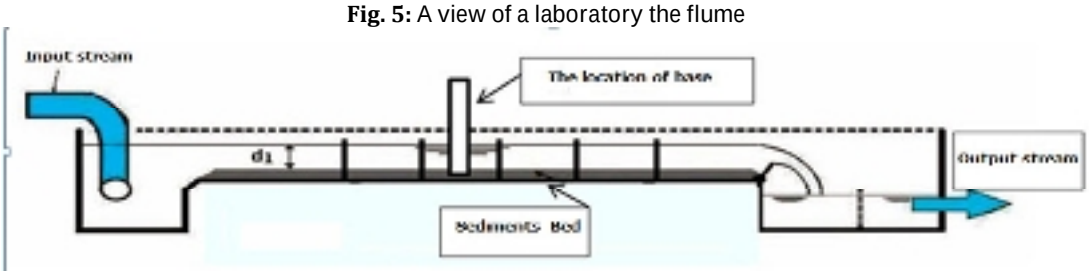

Fig. 6: Plan the flume channel

In order to perform the experiments, the channel was raised 16 cm height a with brick platform. Between platforms that range with 3 meter length that its beginning was located 5 m far from the beginning of the channel has selected the free area for testing and then the platforms have been filled with 16 cm high by non-cohesive sediment. A cylindrical tube made of PVC with a diameter of 5 cm was used as the base model of the bridge. The reason for this selection was that the diameter of the base model In order to avoid the effects of channel walls on scour's depth, channel's width should be at least 8 times more than the diameter of base. Also, in order to eliminate the effect of particle size on sediment bed scour depth, the base diameter should be 50 times larger than the average particle size. Therefore, non-sticky sand particles average with 1.5 mm size was used. Gender of collar selected from Plexiglas sheet with1 mm thickness which made in the circle shape. In order to make a rough collar model , rough attached on the collar naturally with sand and dust and for eliminating the effect of rough on the rate of scour depth particle size a Dimension of the base diameter and the diameter of the collar was considered (5 mm). The base model of bridge that has selected for testing was in a way that provided the possibility of collar's position at different heights on the stand by comparing with align of the bed.

Collar with double diameter of the base and by locating at heights (Zero ,

And the base diameter D) Half the size of the base diameter D / 2

Were tested by comparing with substrate Align. In Fig.9 Schematic picture of the base model and the collar used in the experiments has shown.

In order to achieve maximum scour depth, all experiments were performed in clear water conditions. The duration of testing that has done by a long-term equilibrium experiments were carried out for 12 hours on the bridge truss without a collar. According to the Fig.8 it was observed that approximately 98% of scouring occurs in first 3 hours Therefore, in all experiments the equilibrium time was 3 hours.

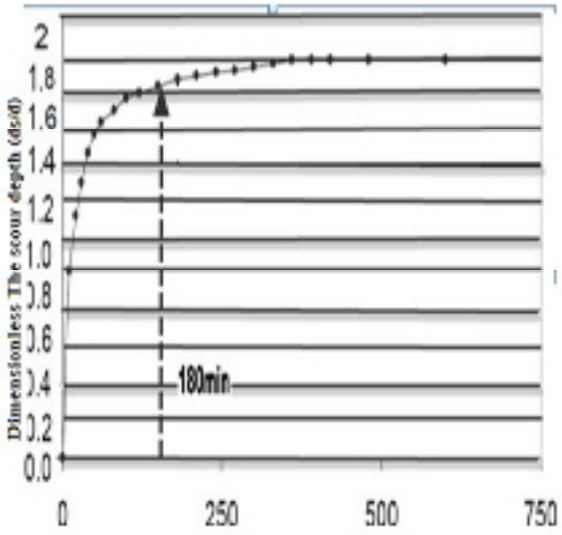

Fig. 8: The equilibrium time testing

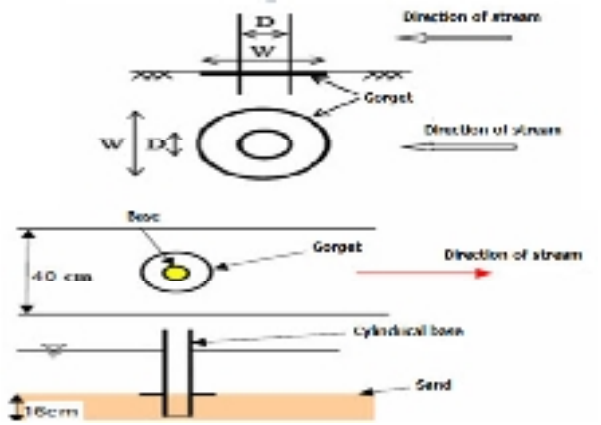

Fig. 9: Plan cylindrical base and a circular collar around it (w =diameter of the collar and D =diameter)

2.4. The Scenario of experiments

Planning to conduct experiments in this study were basis so that All the experiments by a single bridge truss in the middle of the flume and two collar types (smooth and rough) in diameter twice the size of base on three levels (1 - on the surface of the sand bed 2- the distance by half the diameter of a sand bed level 3 - the distance between the base diameter

of the sand bed) and for a uniform grain size (D95) of the threshold rate have measured and calculated.

Table 1 shows the testing program which have carried out.

Dubai(threshold of sediment particles moving (lit / s)	Grading	Alignment Collar	Diameter of collar	Type of collar	Figure	Name of test
11	D_{95}	The surface	2D	Rough		Experiment with a rough collar
11	D_{95}	–	–	No Collar		Control experiment without collar

3. Discussion of results

In all experiments after adjusting the rate and depth of flow, immediately around the base vortices formed and scour began to occur in high speed. After Scour whole formation the sediments derived from the cavity and have shifted toward downstream, shortly after the start of the experiment, sediment transport under the influence of secondary flow downstream to the scour whole and two or more small grooves around the base was formed.

3.1. A simple model testing (no collar base)

In Fig.8 the time of scouring change in no collar base state in 12 hours has shown. Results indicate that scour rate was higher in the first moments and it's drastically will reduced with the development and progression of scour holes. According to figure it can be seen that after 3 hours of starting tests, the scour hole almost reaches to equilibrium. The variation of scour depth test is changing only 1mm from this time until the end of the experiment. Therefore, the equilibrium time became 3 hours to scour for other tests. In this case, scouring is starting from the front, washing Sediments from the front and gathering into a heap on back of Stand. These ridges gradually spread to the downstream.

3.2. Stand experiment with a circular rough collar

Fig.11 has shown the amount of scour depth with a circular rough collar (W=2D) at different levels positions in the three-level cervical.(1-zero,2- half of stand's diameter 3- stand's diameter) .The results show that the impact of rough collar as often as position level of collar is lower has more effect on scour reducing . The reason is that it's actually collar avoiding the downward stream and prevents to make the strong horseshoe vortex. Also

Roughness causes the depletion of layer boundary circle which is created under the collar. As the collar is mounted on lower level, less flow influence under it and therefore generated a weaker downward flow. The best situation for a rough collar is that the collar is placed on a sand bed level.

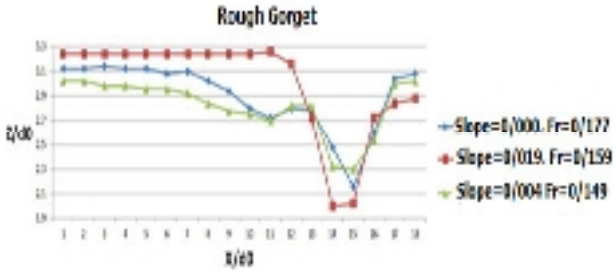

Fig. 10: the changes of Scour's depth, on the base of slope changes and the rough collar descend which has placed the flush on the surface of the sand bed.

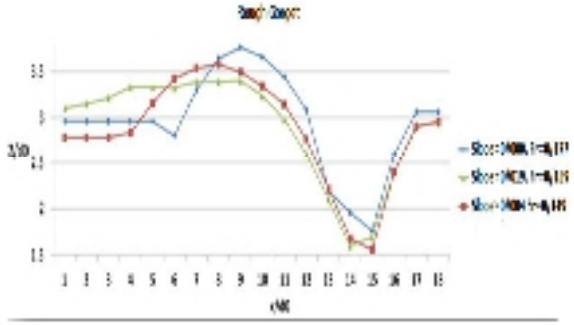

Fig. 11: the changes of Scour's depth, on the base of slope changes and the rough collar descend which has placed the flush half the size of a sand bed

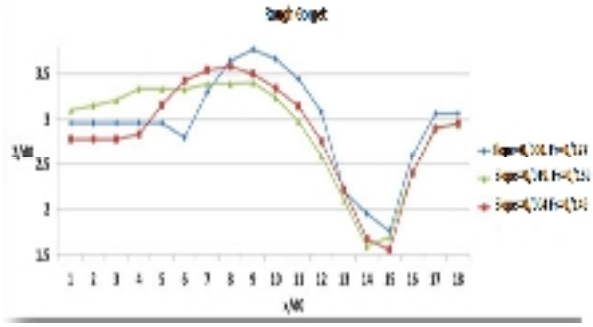

Fig. 12: the changes of Scour's depth, on the base of slope changes and the rough collar descend which has placed the flush of sand's diameter above the bed

3.3. Correlation coefficients and significant output of SPSS software conclusions

1) By comparing with the control experiments which have conducted by the collar rough it can be concluded that the use of a collar is effective on reducing the scour's depth and decreasing the scour's depth. However, reducing the amount of

depth in different levels of exposure of rough collar was not equally.

2) According to the results of the comparison of the level of exposure, rough collar on the basis of best practice to minimize scour depth, rough collar positioned on the surface of the sand bed. Collar placed on a sand bed level for all tested scenarios the best place to minimize scour depth was observed.

3) When the collar is mounted on the base, downward Horseshoe vortex during the collisions to collar will misalign and reduces the scour depth.

4) Correlation with a slope of the Froude is (-0.981) and its significant is less than 0.05 (0.001). So we can say that there is a significant inverse relationship between the Froude number and slope.

5) Correlated with the Froude number with $\frac{h}{d_0}$ (rough collar high located) is (-0.987) and its significant is less than 0.05 (x 0.001).

6) Correlated with the Froude number with $\frac{Z}{d_0}$ (the height of scour) is (-0.080) and its significant is more than 0.05 (- 0.839). So we can say that there is a significant inverse relationship between the Froude number and $\frac{Z}{d_0}$

7) Correlated with the Froude number with the Reynolds number is (0.001) and its significant is less than 0.05 (o.oo1). So we can say that there is a significant inverse relationship between the Froude number and Reynolds number.

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