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COUNTER MEASURE OF SCOURING AROUND A BRIDGE PIER

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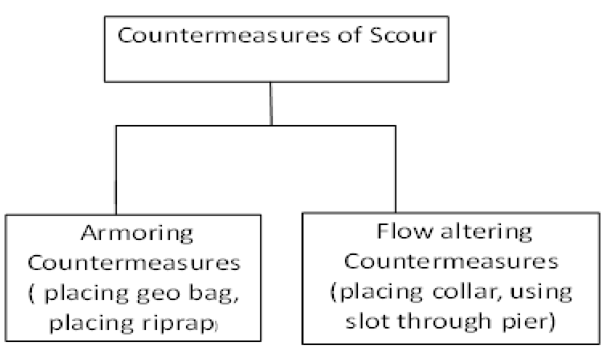
ABSTRACT: *It is essential to control the scouring around pier of bridge for safe economical design. It is found that the performance of any controlling device which is deployed around the bridge piers depends on how the device counters the process of scouring. By placing different parameters such as riprap around the bridge piers, an array of piles in front of bridge piers, a delta wing-like fin in front of bridge piers, partial pier group and tetrahedron frames of stones around the bridge piers, which are reduced the scour depth. Multiple efforts have been made to reduce the scour depth by placing scour countermeasure devices. It is found that failure mechanism related with both armoring and flow alternating counter measure is not very different. It is also noticed that even through adequately design against shear failure, a riprap layer is unsafe to other failure mechanisms which is rendering it ineffective in arresting.*

Keywords: *scour, countermeasure, Riprap, Tetrahedron frames, submerged vanes, controlling device*.

INTRODUCTION:

A countermeasure of scour is an action or process, through which scouring can be prevented or reduced with in safe time limit around the bridge pier. Countermeasure for scour around bridge pier can be grouped into two categories. Armoring countermeasure act as barriers withstanding the shear stresses that occur around the bridge pier. Flow altering devices for pier act to reduce the strength of main features of the flow filed around bridge piers. By placing the riprap around the pier, a collar around the pier, submerged vans, a delta-wing-like fin in front of pier, a slot through the pier tetrahedron frames around pier of bridge reduce the depth of scour. In this study the scour affected areas of bridge piers and some counter measures against scour is provided to stop the scour around bridge pier have been recommended.



LITERATURE REVIEW

There are different past researchers who have studied the scour around bridge pier in different articles which are discussed below.

Moncada.M et al (2009): He found that collar around circular pier and by placing of rectangular slot is controlled the scour depth. It is observed that when the collar is placed at the bed level. The minimum depth of scour is reached. The scour depth is reduced when the collar diameter is increased and the most favorable location to decrease the local scour is obtained by placing the slot near the bed. The scour depth decreases as the slot length increases.

Bhalerao et al (2010): He studied in his paper that layer of riprap stones around bridge pier enhance the ability of bed material around pier to resist the erosion.
Kumar et al (2012): He determines that maximum scour depth depends upon the pier geometry and variations in foundation. In case of compound pier the scour depth is highly sensitive. By using shape variation in foundation and pier geometry, maximum scour depth can be countered and act as scour countermeasure around the bridge pier.

Beg, Beg (2013): H he said that for safe and economical design scour around the bridge is required to be controlled, it is found that efforts have been made to reduce the depth of scour by placing the riprap around the pier, providing an array of piles in front of pier, a collar around the pier, submerged vanes, a slot through the pier and tetrahedron frames placed around the pier.

Akib et al(2014): He found that different countermeasures are generally used in order to protect bridge pier against scouring. The proposed methods can be grouped broadly under two distinct categories which armoring and flow altering countermeasures.

Goswami &Barua (2015): The provision of slot in the pier helps in reducing the strength of the horseshoe vortex due to reduction of effective diameter of the pier. The slot help to pass most of the flow through it and only the balance is left to cause much reduced scour damage. The intensity of scour is greater in the upstream face of the pier than in the downstream face.

Al shukur & Obeid (2016): it is found that rectangular bridge pier have higher scour depth as compare to other shapes because of minimum exposed area. Streamline shape bridge pier is considered the best shape of bridge pier that reduces the maximum scour depth by 60% as compared with rectangular shaped bridge pier. So is ts found that pier geometry is used as countermeasure of scour around bridge pier.

Wang et al (2017): He has published an article on scour around bridge can be classified into two major categories, namely science driven and engineering driven. Engineering driven research focuses on the estimation, monitoring and counter measure of bridge scour and the science-driven research focuses on understanding the scour mechanism. The science and engineering both researches on bridge scour are categorized in four aspects, macroscopic and microscopic mechanism, scour depth prediction carried out by experimental field data. Direct and remote monitoring methods.

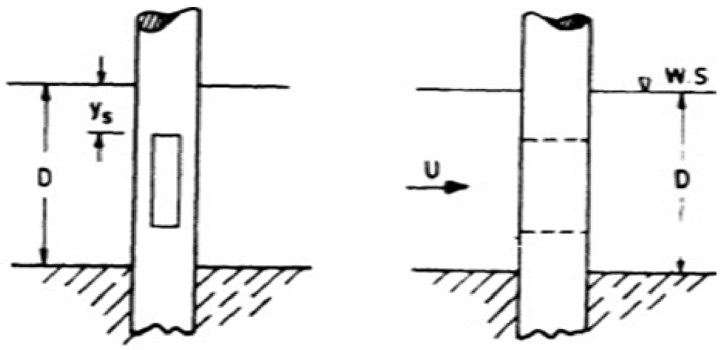
Muhd Khalid et al (2018): He has studied that for safely evaluation of bridge, the bridge pier scouring take an important role, scour prediction around bridge pier in cohesive sediment for uncorrelated and correlated variable has been implemented by first order reliability method. It is found that the reliability index is directly propositional to safety factor but safety factor is inversely proportional to failure probability. The safety of piers is influenced by the probability distribution of random variable. Froude number of pier is one of the parameter of bridge pier failure. The clay fraction and moisture content are resisting factor on reliability.

METHODOLOGY:

While the bridge pier sufficiently goes deep into the bed and to take care of anticipated maximum scour depth, the grip length requirement is quite expensive, some attempts have been made to reduce the scour either by some modification of the pier, or some addition to It or by increasing the ability of the bed to resist the scour. It is very important to estimate the maximum scour depth precisely around piers of bridge. A large depth pf foundation is required for bridge piers to overcome the effect of scour which is a costly proportion of the bridge.

1.By using slot method:

Slots on the piers have proved significantly to reduce the local scour around bridge piers, since some water passes through the slot, the down flow impinging on the bed is reduced. The width, length and location of the slot are significant parameters. The provision of slot is to reduce the power of the horseshoe vortex includes create a conduit for passing the flow through the pier of the bridge.



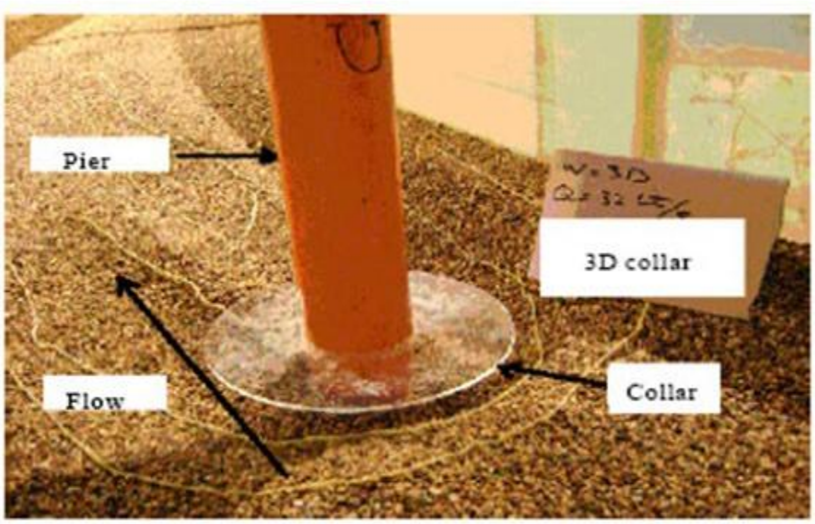
Slot in piers

2.By placing riprap:

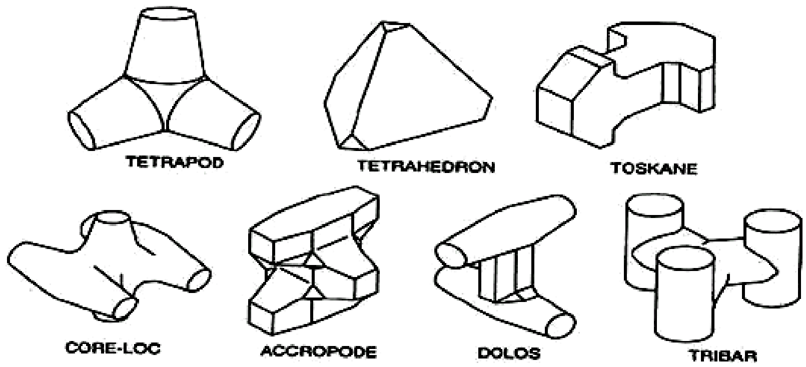
The figure 3 of riprap around bridge pier is an effective method of reducing scour around it. The cover and thickness of riprap layer are important things which directly effecting the stability.

3.Collar use as countermeasure:

The impact of direct down flow is prevented when the collar method is installed around the pier shown in figure 4, similarly the scour depth and rate of scouring are reduced considerably. Hence the reduction of rate of scoring reduces the risk of pier failure when the duration of flood is low.



4.By placing artificial riprap:
Artificial materials like tetrapods, toskanes and dollos given in the figure may be stacked around bridge pier. They interlock themselves by creating good bond between them. Their performance as scour protection device is good. There is large variety of concrete that are used as an armor layer. There are four groups to be mentioned, elements of many different shapes that are used like riprap (Tripods,Dolos etc) blocks that are placed regularly and elements that are mutually connected.

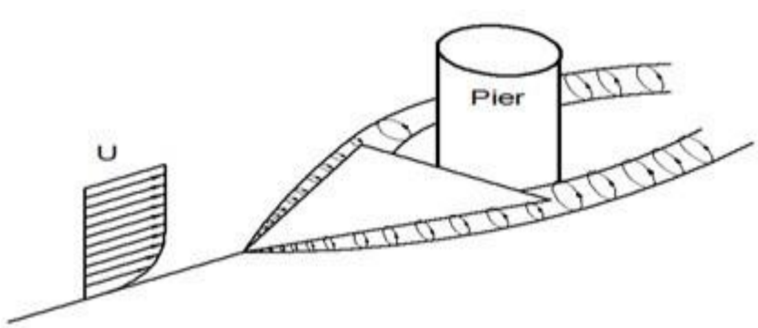


Tetrapods and related units.

5.Method for estimating diameter of toskane/dollo:
It is developed by Ruff and fother in 1995, where D_p = Diameter of toskane/dollo, Dp= pier width, U_1= 1.5 $C_1C_SC_HU$ (C1=coefficient of pier location, Cs=Coefficient of pier shape, Ch=coeffiecient of the level of the top surface of the toskane layer, U=approach flow velocity) h=approach flow depth, s= Density of block. F_r= $(U_1)\div(gh)^{0.5}$ $(D_e)\div(h)$={ (0.255 F_r)÷(S-1)}X[{($D_p)^{0.5}$}÷{$(h)^{0.5}$}]

Counter measure against scour at bridge pier makes proper foundation depth. It is important that even through the riprap stones themselves are capable of resisting scour i.e. it is heavy enough to resist shear erosion, failures can take place. Artificial riprap like tetrapods may be stacked around bridge pier. They interlock themselves by creating good bond between them. Their performance as scour protection device is good. Apart from japan there are very few examples of the use of artificial riprap as bridge pier countermeasure. Artificial riprap is an alternative riprap where it does not exist with proper dimensions or it is very costly.

6.By Using submerged vanes as scour countermeasures:
Submerged vanes, various vanes, rectangular plates were held at an angle in the horizontal direction of flow. Above sketch showing dimensions and layout plan in front of bridge piers is shown in figure 6.



DISCUSSION:

It is elucidated from the given study that limitations on the use of slot through piers is very dangerous when choking of the slot space taken place by debris and floating materials. They also reduce the strength of pier structure. Hence they cannot be considered as good scour protection device. Effectiveness of collars depends on collar dimension position of the collar relative to the bed. In riprap layer which is thick and if it is disrupted partially armoring with the bigger stones it takes place and prevents complete disintegration of layer. It also increases the cover of riprap layer and the stability against failure. Riprap blanket being flexible is not weakened than the circular collar in reducing the depth of scour due to having sharp edges. By using square collar the power of horseshoe vortex become lowered.

CONCLUSION:

It is concluded from the given studied article that the amount of riprap materials near the bridge is not easily available therefore the flow altering devices should economical. The strength of horseshoe vortex is reduced when slot is provided in the pier and horseshoe vertex is reduced due to the reduction of effective diameter of the pier. It is found that passage of water through the slot reduces the intensity of adverse pressure gradient upstream of the pier. The slot helps to pass most of the flow through it and only the balance is left to cause much reduced scour damage. The floating debris helps to block the slot. In addition to this it is difficult to construct the slot in pier. When the flow approaching piers changes its direction then sacrificial piles may become ineffective. A thin collar plate skirting around bridge piers which are placing at or below the bed level are diverted the down flow and shields the streambed from its direct impact. It is therefore a very effective mean of protection against scour has been observed. The application of collar around rectangular and single cylindrical pier has been tested. However scanty information is available in literature about the application of collar on group of piers.

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