Modification in Bridge Column For Scour Reduction

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Abstract- *The removal of sediments from the river beds and get deposited to somewhere else is called scouring. This removal of sediment from river bed were causing huge damage to hydraulic structures. In order to reduce the scouring in Hydraulic Structure, various models have been prepared. The Hydraulic Flume of MAHARISHI UNIVERSITY LUCKNOW, Lucknow has been used for taking various reading of the Column models. In the beginning, the circular Column model is prepared for taking the reading. The diameter of Column model is 10.50cm and the height is 100cm. The circular Column model has been inserted in the sand bed at various location and readings have been taken at various time intervals.*

Three different models have been prepared for reducing the scour depth in hydraulic structure. These models are Slot Model, Collar Model and Column Group Model. In the slot model, the same dimension of pipe is used which is having 10.50cm diameter. ¼ circumferential face has been cut by the middle from both the faces. In the Collar Model, 18.50cm diameter cover has been installed circumferentially from the circumferential face of Column model. It seems like it has covered the bottom of the Column in order to reduce the scour depth. In Column Group model, three Column of 2.80cm has been taken. Two circular plate of 10.5cm has been taken. These two plates are joined from top and bottom of the three Columns. The three Column are located at corners of the plate. These Columns are joined at 1200 angle from the centre of plate.

These three Column models have been placed at various location and readings have been taken at different time interval.

Slot Model- *The diameter of Column model is 10.50cm. The circumferential face has been cut from the middle having 0.25diameter of Column. Scour is reduced by 25% by using this model.*

Collar Model- *The diameter of collar is 18.50cm. It has reduced the scour by 33%.*

Column Group Model- *The most effective model is the Column group model. Scour is reduced by 40% at orientation of 300 by using this model.*

I. INTRODUCTION

1.1 SCOUR

The removal of sediment from the stream beds and stream banks caused by the moving water. It is the process of removal of material from a stream bed by the erosive action of flowing water or scour is used to mean the lowering of the level of the riverbed by water erosion such that there is a tendency to expose the foundations of a bridge and the amount of this reduction below an assumed natural level (generally the level of the riverbed prior to the commencement of the scour) is termed as the scour depth.

1.2 TYPES OF SCOUR

The various types of scour that can occur at a bridge Column are general scour, Local scour and contraction scour. The meaning of scour is lowering of the river bed by the water erosion such that there is a tendency to expose the foundation of the bridge. Scour depth is termed as the amount of reduction below the assumed natural level (generally the level of the river bed prior to the commencement of the scour).

1.2.1 General scour

General scour occurs irrespective of the existence of the bridge and can occur as either long-term or short-term scour. They are broadly classified into Short-term general scour and Long term general scour. Short term general scour develops during a single or several closely spaced floods. Long-term general scour has a considerably longer time scale, normally of the order of several years or longer, and includes lateral bank erosion. The causes of the long-term general scour can be human causes or the natural causes. Human causes: 1. Channel alterations –dredging, channelization, straightening, cut-off formation 2. Stream-bed mining 3. Dam/reservoir construction 4. Land use changes - urbanisation-deforestation, agricultural activities. Natural causes: cut-off formation , land slide, mud Flows, liquefaction, climate changes.

1.2.2 Local scour: Local scour is caused by the interference of the bridge foundation with the flow and includes abutment scour and Column scour. The equilibrium scour depth is attained when the time-averaged transport of the bed material into the scour hole equals that removed from it.

1.2.3 Total scour: Total scour refers to the total depth of scour at the particular bridge foundation, and includes general scour and localised scour.

1.2.4 Localised scour: Scour that is directly attributable to the existence of the bridge and includes contraction scour and local scour.

1.2.5 Clear-water scour: Scour which is caused when approaching flow does not carry any sediment.

1.2.6 Live- bed scour: Scour which is caused when approaching flow carry sediments.

1.2.7 Column- scour: Column scour is caused by the interference of the Column with the flow.

1.3 CONTRACTION SCOUR :

Contraction scour can occur where the foundation and the road approach embankment of the bridge is sited at the natural contraction in the width of the river. The degrees of contraction can be considered in terms of contraction ratio, given by

$$= \frac{1}{2} \qquad (1.1)$$

where w1 and w2 =width of approach(un-contracted) and bridge (or contracted) sections respectively.w2 is the clear opening width at the bridge crossing. The width reduction causes increased scour at a bridge arising from associated increased in the bed shear stress.

1.4 COMPONENTS OF THE SCOUR :

Long term aggradation or degradation, Contraction scour, Local scour (Columns and abutments) =Total scour.

1.5 SCOUR HOLE AND SCOUR DEPTH:

Due to scour, a scour depth is formed around an obstruction and it may be defined as depression left behind when sediment is washed from the riverbed in that area of the structure.
The amount of reduction in the streambed level below the bed level of the river prior to the commencement of scour is referred as the scour depth.

1.6 OBJECTIVE OF PRESENT INVESTIGATION:

The objective of present study is to test the different scour reduction models in the laboratory flume i.e. Slot Model, Collar Model and Column group model have been used.

II. PROCESSOF MODIFICATION

Toward reducing the effect of the downward flow and the vortex formation, proposed specific technique that depends on reducing the flow stagnation in front of the Column . The flow would pass through these openings using the pressure difference around the Column sides. The flow helps releasing the stagnation of the flow in front of the Column as well as reducing the downward flow velocity component. Thereafter tested a Column with a slot in the flow direction as shown in Fig-2.4 and commented that it can reduce the scour depth with 15–30%. For circular Column, the best alignment for the openings is one in the front and connected to the two other openings one on each side of the Column in the same level. Initiated by the urgent needs to reduce the scour holes in front of bridge Columns and its drastic impacts, a comprehensive experimental program to investigate profoundly the effect of this openings technique using several opening sizes 10%, 15%, and 20% of the Column width (w) on the scour characteristics.

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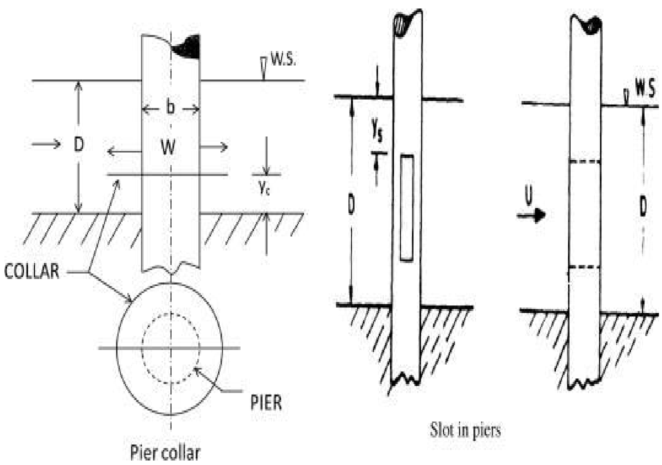


Fig-2.4: Methods to reduce the scour depth around bridge Column.

2.5 REDUCTION AND PROTECTION OF SCOURING AROUND BRIDGE COLUMNS:

Achieving reduction of the effect of the downward flow and the vortex formation, there are several methods as follows:

1. Streamlining the Columns can reduce the scour depth with about 10–20%.
2. Construct barriers upstream of the bridge Columns that consist of a number of piles.
3. Circular collar with 3b to 6b in diameter is placed around the circular Column while its location above the bed is 0.2D which reduces the scour depth with 20–55%.

Based on mechanism of scour, countermeasures to control the local scour at bridge Columns can be grouped in two categories: Armouring devices ,Flow altering devices

2.5.1 Armouring Devices:

Using this device, the streambed resistance is increased by placing the rip-rap and gabions around the Columns.

2.5.1.1 Scour protection using rip-rap:

One of the methods to stop the scouring action of horse-shoe vortex is to provide materials, which cannot be detached from its position. The use of rip-rap stones to deal with Column scour problems is very common in civil engineering. One of the main reasons of the rip-rap failure is the general movement of sediment during severe flood condition.

2.5.2 Flow Altering Device:

Using flow altering devices, the shear stresses on the riverbed around the Column are reduced by altering the flow pattern around a Column which in turn reduces the scour depth at the Column.

2.5.3 Indirect Method

2.5.3.1 Scour reduction using slots:

Scour reduction is achieved by using a slot through the Column, which helps to pass most of the flow through it because of a favourable pressure gradient an balance would be left to cause much reduced scour damage. Column slot with different geometry are shown in the following figure below:

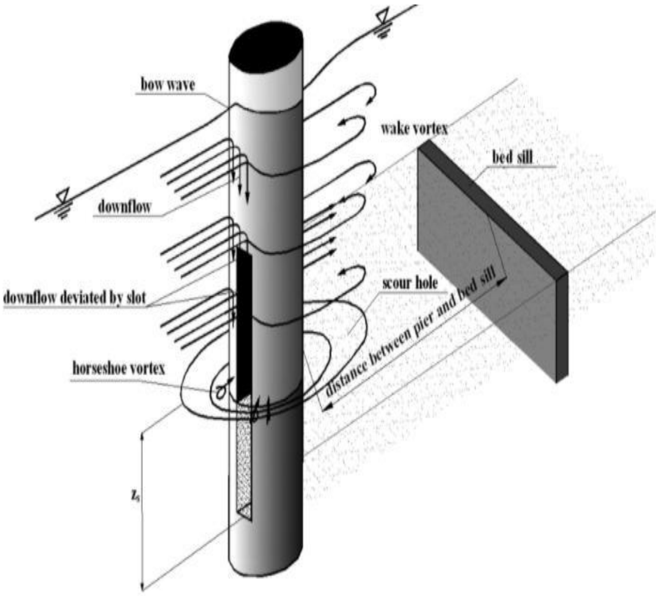
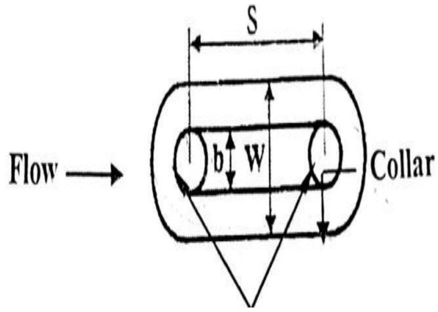


Fig-2.5: Mechanism of Flow at Slot Model

2.5.3.2 Scour reduction using collar:

When a collar is installed around the Column, the direct impact of the down flow on the streambed is prevented which not only causes reduction in the maximum scour depth but also the rate of scouring is also reduced considerably. Reduction in the rate of scouring reduces the risk of Column failure when the duration of flood is low.

Collar around the bridge Column can be arranged in two ways as discussed: Group of two Columns with collar aligned with the flow, Group of two Columns with collar aligned transverse to the flow. These two above condition of collar have been described by the following Fig-2.6.



Circular Column

Fig-2.6: Group of two Columns with collar aligned with the flow.

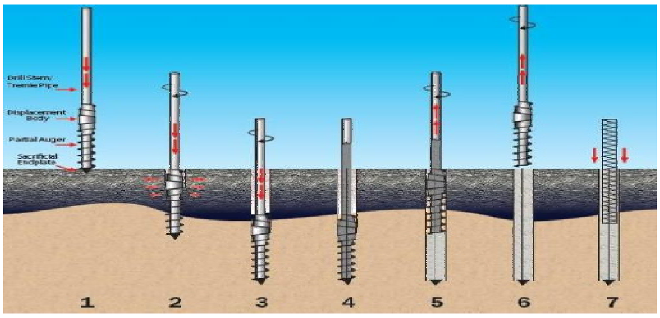


Fig-2.7: Group of two Columns with collar aligned transverse to the flow.

2.5.3.3 Scour Reduction using Sacrificial Piles:

A group of piles located upstream of the Column generates as many turbulent wakes as the number of piles and creates relatively low velocity wake region with interacting individual pile wakes. The net result is reducing the horse-shoe vortex strength and consequent reduction in scour depth significantly. A recent laboratory study of use of sacrificial piles to protect Column against scour is reported by Melville and Hadfield (1999). They concluded that effectiveness of sacrificial piles as a scour counter-measure is dependent on the velocity flow angle and flow intensity. For sacrificial piles produces moderate reduction in scour depth. Finally, it is concluded that sacrificial piles may not be recommended as effective scour counter-measure, unless the flow remains aligned and the flow intensity is small.

2.5.3.4 Foundation Caissons:

Chabert and Engeldinger (1956) investigated a circular Column founded on a circular caisson and concluded that the best system appeared to be a caisson having diameter three times the diameter of Column and the top elevation above half the diameter of the Column below the natural bed. They reduced the scour depth one-third that reached with the Column alone.

2.5.4 Other Methods of Scour Protection:

Among other methods available in literature, a few are discussed here. They are submerged vanes (low vanes), slanting vanes on the front face of the Columns and armouring using different type of artificial material. Stone Gabion with Geo-textile filter, Use of Tetra-pods as Artificial Rip-Rap, Concrete Filled Fabric Mats.

III. RESULTS AND DISCUSSION

In this experimental procedure, as the main objective is to reduce the scour depth as much as possible and make the structure economical. For each set of run twelve readings were taken. Among the all Column model tested in the laboratory, maximum scour depth reduction was observed for a Column group. The value of De/Ds is practically constant at an average of 0.74, as against 0.80 by Chiew (1992) . Thus observed value of scour depth reduction is verified and found to be correct.

The different Column models, slot models, collar models and Column group models whose readings are shown below.

Table-4.1 Column Model.

Location=Middle of flume Pressure1=2.4kg/cm2 Pressure2=2.2kg/cm2 Flow depth=2.6cm			
Run	*Time(minutes)*	*Scour Depth(cm)*	*Column Diameter(cm)*
1.1	*15*	*2.20*	*10.50*
	45	*2.40*	
	75	*2.60*	
	120	*2.70*	
	165	*2.80*	
	225	*3.00*	
	285	*3.10*	
	345	*3.20*	
	405	*3.40*	
	475	*3.50*	
	535	*3.60*	
	600	*3.80*	

Table-4.2 Slot Model.

Location=Middle of flume Pressure1=2.4kg/cm2 Pressure2=2.2kg/cm2 Flow depth=2.6cm			
Run	*Time(minutes)*	*Scour Depth(cm)*	*Column Diameter(cm)*
1.2	*15*	*1.90*	*10.50*
	45	*2.00*	
	75	*2.10*	
	120	*2.20*	
	165	*2.30*	
	225	*2.50*	
	285	*2.70*	
	345	*2.90*	
	405	*3.00*	
	475	*3.10*	
	535	*3.20*	
	600	*3.30*	

Table-4.3 Collar Model

Location=Middle of flume Pressure1=2.4kg/cm2 Pressure2=2.2kg/cm2 Flow depth=2.6cm Collar diameter=18.5cm			
Run	***Time(minutes)***	***Scour Depth(cm)***	***Column Diameter(cm)***
1.3	*15*	*1.60*	*10.50*
	45	*1.70*	
	75	*1.80*	
	120	*1.90*	
	165	*2.00*	
	225	*2.20*	
	285	*2.30*	
	345	*2.40*	
	405	*2.50*	
	475	*2.70*	
	535	*2.80*	
	600	*3.00*	

Angle=00

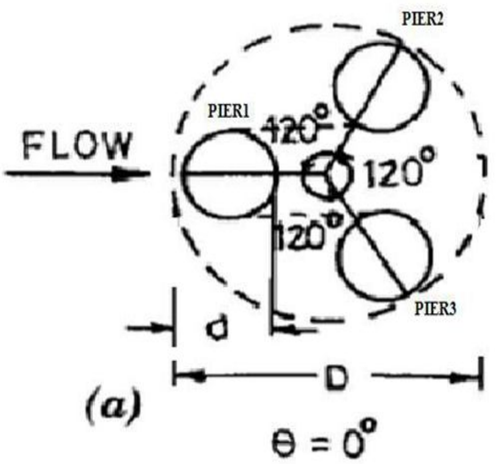


Fig-4.1: Column Group at 00

Table-4.4 Column Group

Run	***Time(minutes)***	***Column 1***	***Column 2***	***Column 3***	***Column Diameter(cm)***
1.4	*15*	*1.40*	*1.30*	*1.30*	*2.80*
	45	*1.50*	*1.40*	*1.40*	
	75	*1.60*	*1.50*	*1.50*	
	120	*1.80*	*1.70*	*1.70*	
	165	*1.90*	*1.80*	*1.80*	
	225	*2.00*	*1.90*	*1.90*	
	285	*2.10*	*1.90*	*1.90*	
	345	*2.20*	*2.00*	*2.00*	
	405	*2.30*	*2.10*	*2.10*	
	475	*2.40*	*2.20*	*2.20*	
	535	*2.50*	*2.30*	*2.30*	
	600	*2.60*	*2.40*	*2.40*	

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