Local Scour and its Reduction by using Splitter Plate

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Abstract: ***Present study comprises of local scour effect on alluvial bed and its reduction technique using splitter plate. Scour is a natural phenomenon caused due to high velocity of water jet such action results in collapse of the bridge structure and loss of life and property. Protection against scour is too expensive but an attempt should be made to minimize the failure of structures due to local scour. In the present study experiment is carried out using two circular piers having diameter 50mm and 100mm. Sediments were having size d40 and steel splitter plate is used to study the reduction in scour depth.This phenomenon is also applicable for bridge piers resting on rocky foundation.***

Keywords*:* Local scour, alluvial bed, splitter plate, reduction of scour depth

1. Introduction

Scouring is a consequence of the erosive action of flowing water, which removes and erodes material from the bed and banks of streams and also from the vicinity of bridge pier [1]. Scouring lowers the riverbed level and has a tendency to expose the foundations of structure. Such action results in collapse of the structure and loss of life and property. Contraction in the waterways takes place when bridges are constructed in alluvial channel. Contraction in waterway gives rise to scour at the bridge site.

Prediction of scour hole plays important role while designing bridge foundation. Protection against scour is too expensive but an attempt should be made to minimize the failure of structures due to scour. Maximum scour depth and the upstream slope of the scour hole are generally predicted while designing so that risk will be minimized.

Scour can be classified into two type's namely, General scour and localized scour. The scour that occurs near pier, abutment, erosion control device or other structure obstructing the flow is called Local scour. Factors that affects local scour includes width of the obstruction, projection length of the obstruction into the flow, length of the obstruction, angle of attack, velocity of approach flow, size of bed material, depth of flow, shape of the obstruction, bed configuration[2]

Whenever there is a clear water flow it has maximum tendency to erode the bed material as well as to expose the foundation of bridge pier as compare to the sediment transporting flow so care should be taken to minimize the effect of local scour, for that foundation of the bridge pier should be below the Aveg. Scour depth so as to avoid formation of horshoe vortices.[3]

2. Local Scour Mechanism

The basic mechanism causing at piers at the down flow at the upstream face of the pier and formation of vortices at the base. The approach flow velocity is reduced to zero at the upstream side of the pier which results in a pressure increase at the pier face. The associated pressures are highest near surface, where the deceleration is greater and decrease downward. Due to this the pressure on the face of the pier also decreases accordingly forming a downward pressure gradient. The pressure gradient forces the flow down the face of the pier. The resulting down flow creates hole in the vicinity of the pier base [1].

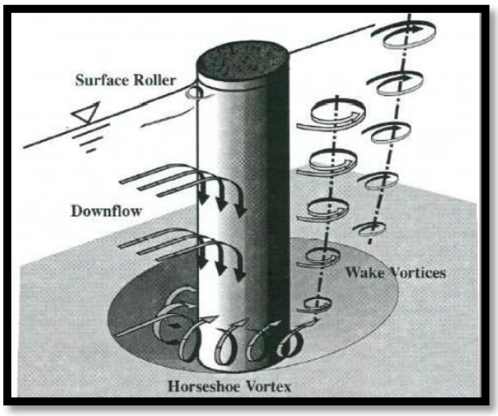


Figure 1: Flow and scour pattern at a circular pier Melville and Coleman 2000[3].

The down flow rolls up as it continues to create a hole and through interaction with the incoming flow, develops into a complex vortex system. Thevortex then extends downstream along the sides of the pier. This vortex shedding is very effective in transporting the dislodged particle away from the pier. Strength of vortex diminishes as the scour depth increases. Also there are vertical vortices downstream of the pier known as wake vortices. The intensity of the wake vorticesis drastically reduced with distance downstream such that sediment deposition is immediately downstream of the pier [4].Due to the formation of horshoe vortices, foundation of the bridge pier may get loosed and there may be chances of collapse of the bridge structure in all over the world.

3. Methodology

- The aim of this study was to find out the Aveg. Depth of reduction in scour hole. Material required and assembly of the Project can be explained as follows.
- Grading of sediment (d_{40} size) on Log Log Paper.
- For this work we have selected hollow circular pier of size 50 mm and 100 mm and length as 300 mm.
- Splitter plate used is of steel material with 5 mm thickness.
- Tilting flume(Width 21 cm) with flow controlling and measuring devices.

4. Experimental Procedure

The experimental procedure of the Project can be explained as follows,

1. Filling of tilting flume with sediment particle(d_{40} size) from the inlet area of the flume up to the length of 125 cm with the depth of sediment 13 cm.
2. Insertion of hollow circular pier (25 and 50 mm dia.) into the sediment particle.
3. Starting of tilting flume with minimum discharge, then after sometime scouring around a bridge pier takes place, the horshoe vortices are formed at the downstream face of the pier, which erodes the bed material and scour hole gets formed.
4. We have taken the run in tilting flume for 50 min for both the sizes of pier during which scour depth increases with increase in time.(Temporal variation of scour)
5. Then for minimization of scour hole we have used steel splitter plate which we have kept it parallel to the flow direction.
6. For the bridge pier with splitter plate, again we have taken the run for the same flow condition for 50 min.(Water depth above sediment is 6 cm)
7. In this way the experimentation was conducted.

5. Experimental Photographs

This pilot project was conducted in two parts in part one two sizes of pier were used (25 and 50 mm) and in second part both the piers were composed with splitter plate, following Photosnaps gives the exact idea of experimentation.

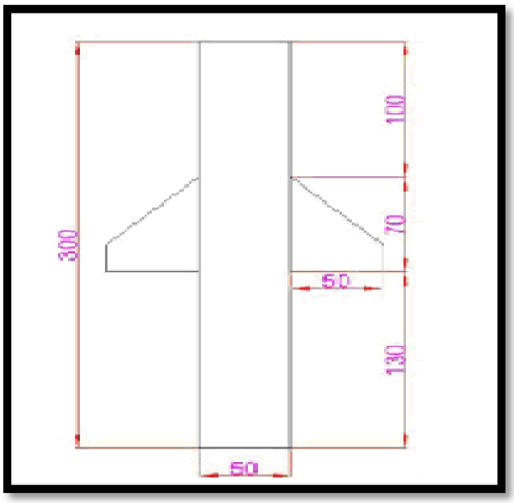


Figure 2: Auto Cadd details of splitter Plate

Figure 3: Tilting flume where experiment was conducted.

Figure 4: 25 mm pier with scour hole formation without splitter plate.

Figure 5: 50 mm pier with scour hole formation without splitter plate.

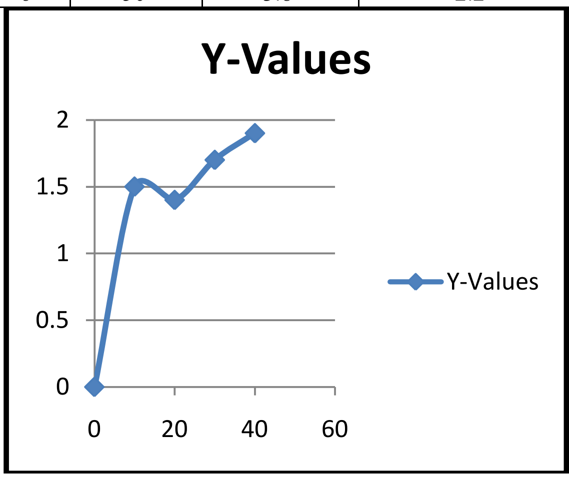
Figure 6: Splitter plate with 5 mm thickness.

Figure 7: Splitter plate with pier assembly (25 mm dia.) is kept parallel to flow direction, due to which scour hole minimizes.

6. Observation table and Graph

Table 1: 25 mm Diameter Circular Pier Reading

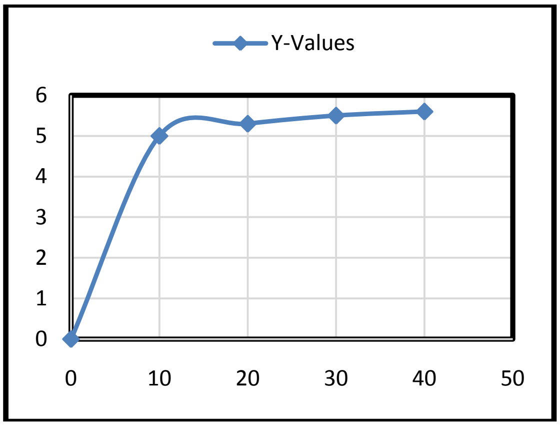
Sr No	*Time in min*	*Depth of scour (cm)*	*Depth of scour with splitter plate*
1	00	00	00
2	10	2.00	1.5
3	20	2.2	1.4
4	30	3.00	1.7
5	40	3.5	1.9
6	50	3.8	2.2



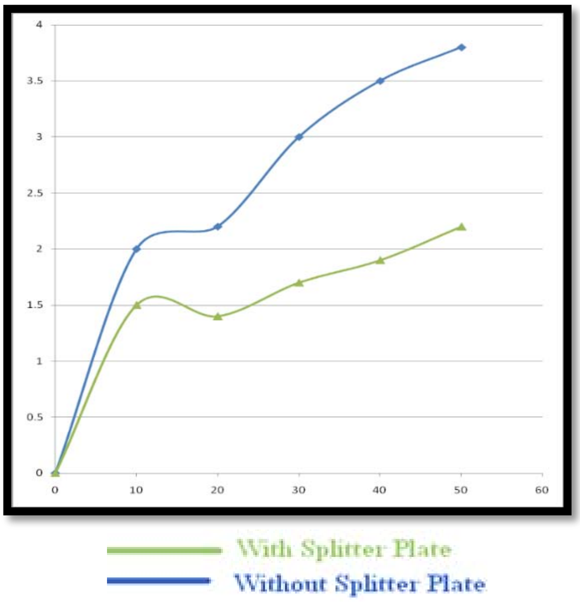
Graph 1: Scour depth Vs. Time for 25 mm Dia. Pier.

Table 2: 50mm Diameter Circular Pier Reading.

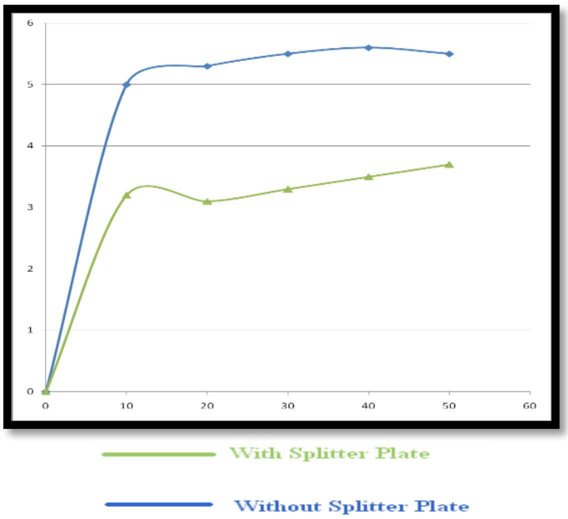
Sr No	*Time in min*	*Depth of scour(cm)*	*Depth of scour with splitter plate*
1	00	00	00
2	10	5	3.2
3	20	5.3	3.1
4	30	5.5	3.3
5	40	5.6	3.5



Graph 2: Scour depth Vs. Time for 50 mm Dia. Pier.



Graph 3: Combine Graph of 25mm Pier with & Without Splitter Plate. (Scour Depth vs. Time)



Graph 4: Combine Graph of 50mm Dia. Pier with & Without Splitter Plate.

7. Conclusion of the Study

The findings of the study can be concluded as,

- Scouring is a time dependent process. Ie. Scour depth goes on increasing as time increases, This phenomenon is also called as temporal variation of scour.

- Vortex formation is the main cause of scouring of bridge pier.
- As the diameter of pier increases scour depth also goes on increasing.
- Maximum depth of scour is observed on the upstream face of the pier.
- Scour depth goes on increasing if the flow is along the perpendicular direction to the splitter plate.
- So in this experiment the position of splitter plate is parallel to the flow direction.
- Due to the use of splitter plate vortex shedding may get avoided (Flow gets separated) so reduction in scour depth takes place.
- Scour depth vs. time graph is like stress strain curve which Obeys Hooke's law. After few minutes depth of scour hole remains constant which is called as Equilibrium scour depth.
- Due to the use of Splitter Plate Average depth of scour reduces up to 61%.

8. Future Scope

- This type of study can be applicable to the bridge pier foundation which rest on rocky strata. (Hard rock or for Deccan trap basalt).
- In our Maharashtra region no. of bridges or footings of bridge pier may failed due to hard rock scouring, so we may protect it by keeping position of splitter plate parallel to the flow direction so that vortex shedding may get avoided and scour depth may get minimized.
- Following Photosnaps shows the adverse effect of hard rock scouring, at Chaskaskaman dam site (Rajgurunagar, Pune, Maharashtra) where bridge pier foundation was resting on Sheet jointed Basalt but due to the formation of vortex shedding the footing of bridge pier may got exposed, which is a serious issue in tail channel portion of Chaskaman dam.
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Figure 8: Scouring on Hard Rock

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Author Profile

Priyanka Muke received Bachelor degree in Civil Engineering (B.E Civil) with Distinction from Imperial college of Engineering and research from Pune University in 2012 and perusing Masters in Hydraulics from Sinhgad collage of Engg, Vadgaon, Pune. She has published two papers in International journal and having keen interest in scour of Alluviam River as well as scouring of Basaltic rock for Maharashtra region. At present she is working on live case study project based on Residual energy and its adverse effect on erosion of tail channel for Bhama Askhed and Ghod dam of Pune Maharashtra.

Tushar Bhosale received Bachelor degree in Civil Engineering (B.E Civil) in 2012 and Masters in Hydraulics in 2014 from Savitribai Phule, Pune University.He is having teaching experience of 3 yrs .and having five different publication in National and International conferences on his name and having keen interest in open channel hydraulics as well as the ground water hydrology .He is involved in testing and consultancy work at various firms. At present he is working as a Hydraulic modeller at Jacobs-Ces Pune.