

EXPERIMENTAL ANALYSIS OF SCOUR UNDER CIRCULAR PIER

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Abstract: *For economical design, scour around the bridge piers is required to be controlled. The execution of any scour assurance/controlling device around bridge piers relies upon how the device counters the scouring procedure. Efforts have been made to reduce the depth of scour by placing the triangular prism on pier at upstream and downstream sides for a bed sample collected from river Ghagghar. The present study deals with minimizing the local scour under a pier. Different possible arrangements have been observed and analyzed to find out the best arrangement. Experiments showed that the arrangements are very effective in reducing scour depth by placing a triangular prism of 2.5 times the diameter of circular pier in the upstream direction near the water surface; it is possible to reduce the clear-water scour by as much as 60%. The study shows that the triangular prism is capable of eliminating scouring to a reasonable extent.*

Index terms: *Soil gradation, Scouring, Local scour, Equilibrium scour depth, Experimental conditions*

I. INTRODUCTION

"Man who overlooks water under bridge will find bridge under water" (Neill 1973). This anonymous reference features the vital impact of running water on the strength of bridges; specifically, its effect on piers that help the bridge. A fundamental driver of concern about the strength of bridge foundations is the event of scour around the piers. Scour at bridge piers might be characterized as a nearby bringing down in the bed rise around the pier. This bringing down is caused by three-dimensional limit layer division at the pier, bringing about disintegration of bed material by the neighborhood stream structure, which is portrayed by an abnormal state of turbulence and vorticity.

Scour is a characteristic wonder caused by the erosive activity of streaming water on the bed and banks of alluvial channels. The nearby stream around a water driven structure, for example, a bridge pier or projection is related with an upgraded residue conveying limit, to such an extent that scour may happen almost a structure notwithstanding when there is no vehicle of dregs from the structure. At a bridge site, scour around bridge piers or abutments may prompt diminished help and thus constitute a potential calamitous risk.

Conventional building strategies for managing local scour issues are not exceptionally modern. These incorporate putting rocks or adaptable mattresses around the pier establishment. In a few occurrences, inflexible collars are appended to the pier to decrease the disintegration potential. The target of this paper is to survey the viability of existing strategies, and to propose and assess new strategies for scour protection.

II. VORTEX FORMATION NEAR A CIRCULAR PIER

As the flow approaches the pier, a stagnation plane is shaped. In view of the vertical velocity profile, a vertical pressure gradient is shaped along the stagnation plane on the pier. This slope delivers a downflow before the pier, which is the primary driver of erosions at bridge piers. It acts like a vertical jet in disintegrating the bed material. The spaces and downflow join to uncover a hole at the main edge of the pier. Here, the approaching flow isolates at the edge of the scour hole, making a course or roller inside the scour hole. The downflow isolates at the base of the scour hole and spirals downstream past the pier. This, together with the ground roller, is what is generally described as the horseshoe vortex. It is extremely effective in transporting unstuck silt particles from the pier.

The horseshoe-vortex is at first little in cross-section and weak as well. With the development of the scour hole, be that as it may, the vortex quickly grows in size and quality as extra liquid achieves a downwards segment and the quality of the down flow increments. The down flow acts to some degree like a vertical stream in eroding the bed. As the scour hole grows, the course connected with the horseshoe-vortex increases, due to its extending cross-sectional territory, yet at a diminishing rate, with the rate of increment being controlled by the amount of liquid provided to the vortex through the down flow in front of the barrel. This thus is controlled by the release of the approach flow; or, for a specific flow depth and width, by the greatness of the velocity of the approach flow. The greatness of the down flow close to the base of the scour hole diminishes as the depth of the hole increments. Thus the rate of erosion reduces.

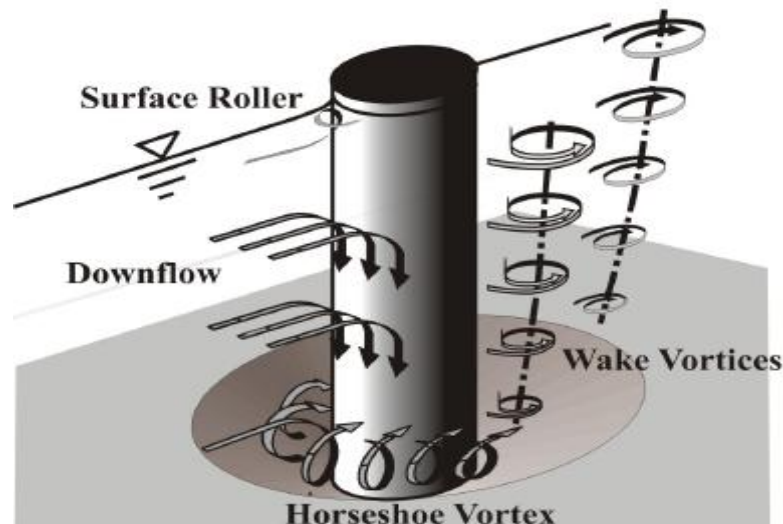


Figure 1: The flow and scour pattern at a circular pier

(Source: Melville B W, Coleman S E. Bridge scour [M]. Water Resources Publications, LLC, Colorado, U.S.A., 2000:550)

III. BED MATERIAL AND ITS PROPERTIES

The bed material was collected from Ghagghar river near sector-3, Panchkula. Figure 2 shows the Location of site with a red dot in Google map.



Figure 2: Sample collection site (Google Map)

SIEVE ANALYSIS OF BED MATERIAL

Table 1: Sieve Analysis

Sieve Size	Percent Finer
4.75mm	91.60
2.36mm	90.52
1.18mm	89.06
600μ	88.02
425μ	87.37
300μ	86.65
150μ	69.02
75μ	23.63
Pan	0.00

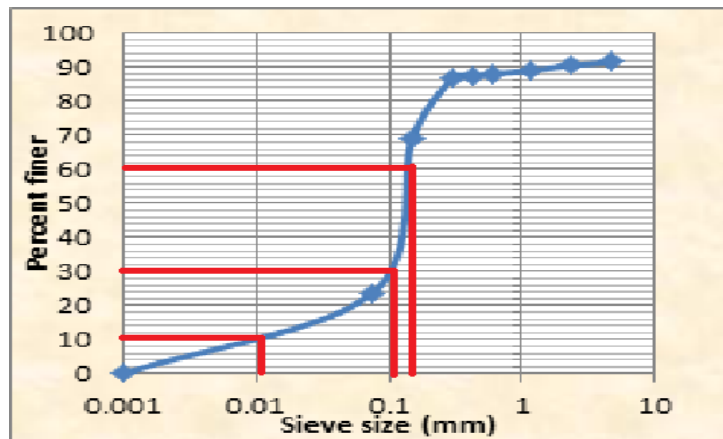


Figure 3: Gradation Curve

Coefficient of Uniformity= 10.5

Coefficient of Contraction = 9.52

This shows a Uniform Sand

IV. EXPERIMENTAL SETUP.

Experiments were performed in a flume of dimension 6 m length, 0.34m width and 0.48m height. The bed material to be used in Experimental study is obtained from river Ghagghar's bed. The depth of bed material in flume was kept at 0.1 m and the quantity of bed material calculated was 0.158 m³.



Figure 4: Experimental Setup

Diameter of circular pier was taken as approximately one-tenth of the width of flume to negate the effect of boundary layer flow. The material of pier used was steel pipe with an external diameter of 33 mm. The triangular prism is of cement concrete with nominal reinforcement of steel wires. Prism size was 2.5 times the diameter of pier from surface of pier. The following two arrangements have been proposed:

Arrangement I

- 1) Water coming from inlet meets the simple circular pier of 33mm diameter at section 1-1 at 1200mm from inlet.
- 2) Then the water interacts with Second pier at section 2-2 1800mm away from first pier. Second pier has a triangular prism attached to it at downward side facing upstream water.
- 3) Lastly the water interacts with last pier at section 3-3 at 1800mm from second pier. The pier also has a prism arrangement downward side but this one is facing the downstream water as shown in figure.

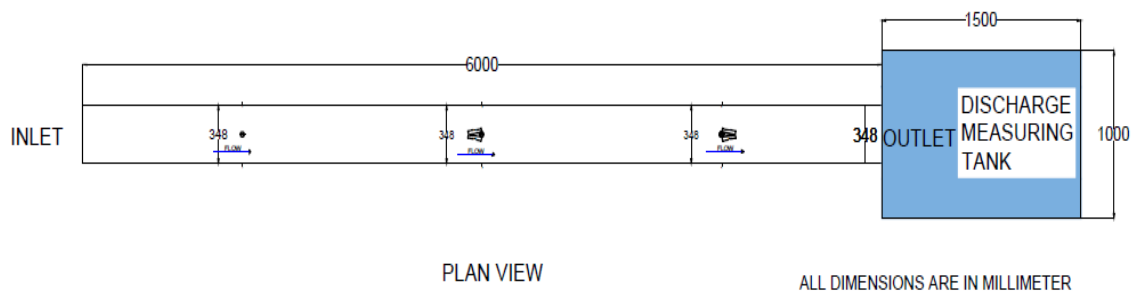


Figure 5: Arrangement-I

Arrangement-II

- 1) Firstly the water interacts with simple circular pier of 33mm diameter at section 1-1.
- 2) Then the water interacts with Second pier at section 2-2 1800mm away from first pier. Second pier has a triangular prism attached to it at downward side facing upstream water.
- 3) Lastly the water interacts with last pier at section 3-3 at 1800mm from second pier. The pier also has a prism arrangement facing upstream but on the upper side as shown in figure 6.

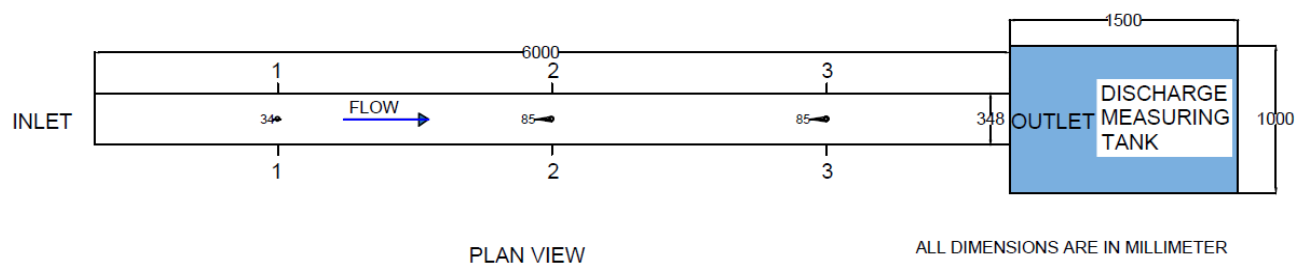


Figure 6: Arrangement-II

V. EXPERIMENTAL RUN

The experiment was run for both the arrangements at 4 different discharges and the value of maximum scour was measured a regular time interval of 15 minutes for 2 hours



Figure 7: Scour Around Pier

VI. EXPERIMENTAL OBSERVATIONS

For Arrangement-1 following values of scour were obtained at different discharge values.

Table 2: Scour values at $Q = 0.0037 \text{ cumec}$

Time (min)	CIRCULAR PIER	PRISM FACING U/S	PRISM FACING D/S
0	0	0	0
15	17	5	12
30	25	7	16
45	29	8	19
60	31	8	21
75	32	9	22
90	32	9	23
105	32	9	23
120	32	10	23

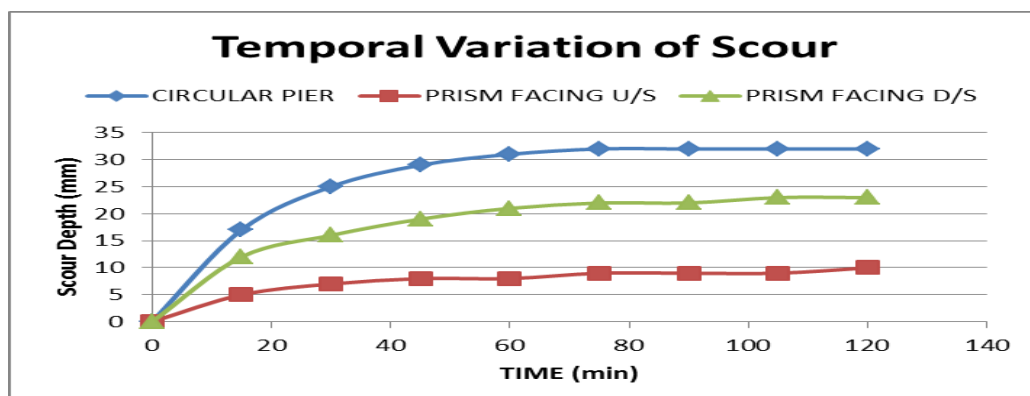


Figure 8: Scour values at $Q = 0.0037 \text{ cumec}$

Table 3: Scour values at 0.0027 cumec

Time (min)	CIRCULAR PIER	PRISM FACING U/S	PRISM FACING D/S
0	0	0	0
15	19	8	13
30	24	9	16
45	26	10	18
60	27	10	19
75	29	10	19
90	30	10	19
105	30	10	20
120	31	10	21

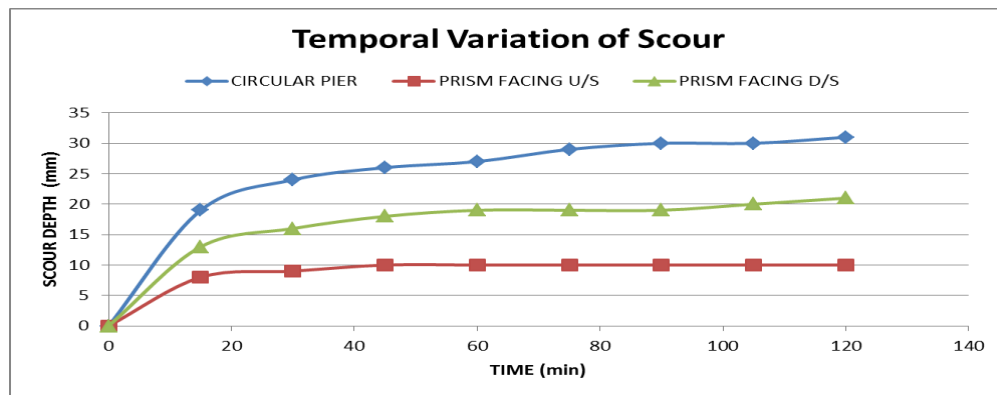


Figure 9: Scour values at Q = 0.0027 cumec

Table 4: Scour values at 0.011cumec

Time (min)	CIRCULAR PIER	PRISM FACING U/S	PRISM FACING D/S
0	0	0	0
15	31	10	22
30	38	14	31
45	41	16	33
60	44	17	35
75	45	18	36
90	45	18	36
105	46	18	36
120	46	18	37

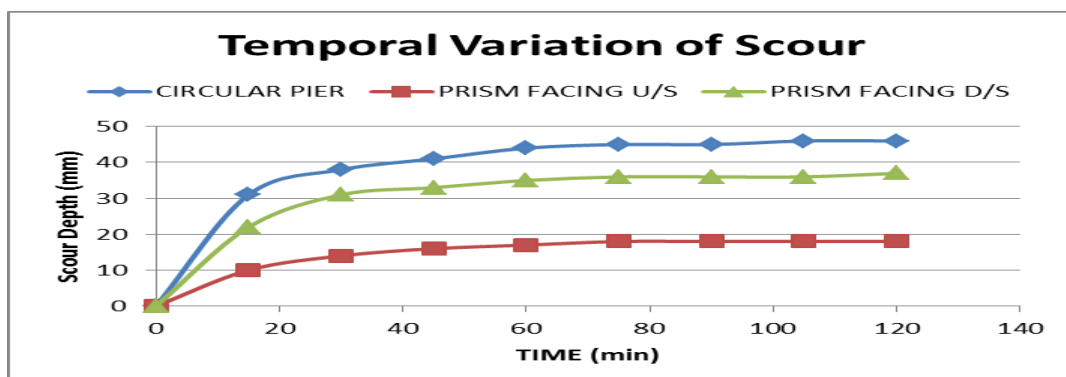


Figure 10: Scour values at Q = 0.011 cumec

For Arrangement-II following values of scour were obtained at different discharge values.

Table 5: Scour values at 0.00087cumec

Time (min.)	Circular Pier	Prism downward	Prism Upward
0	0	0	0
15	14	7	12
30	18	8	17
45	21	9	20
60	23	9	21
75	24	9	22
90	24	10	22
105	24	10	22
120	24	10	22

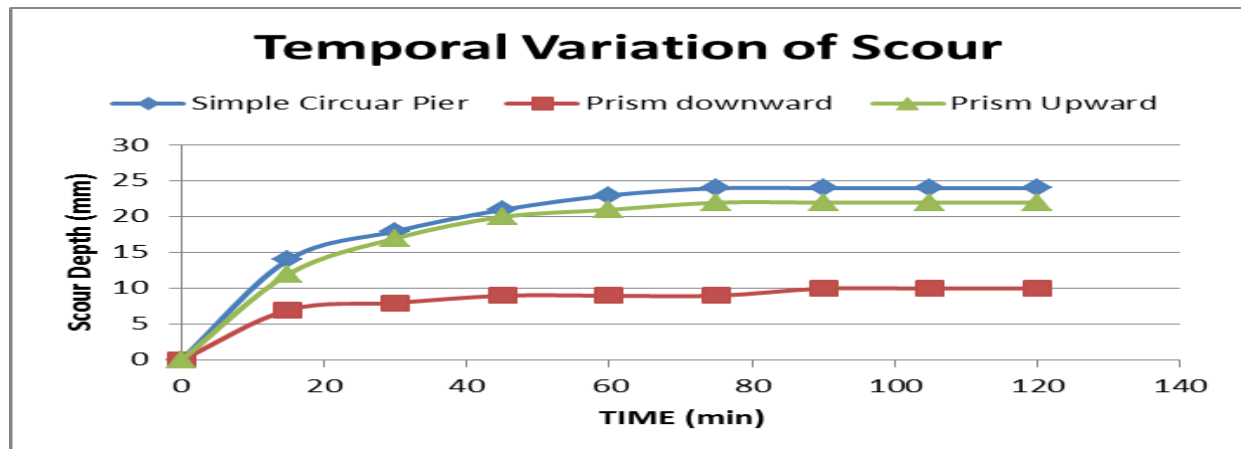


Figure 11: Scour values at Q = 0.00087 cumec

Table 6: Scour values at 0.0033cumec

Time (min.)	Circular Pier	Prism downward	Prism Upward
0	0	0	0
15	17	8	15
30	25	9	23
45	29	10	27
60	31	10	28
75	32	10	28
90	33	10	29
105	33	10	29
120	33	10	29

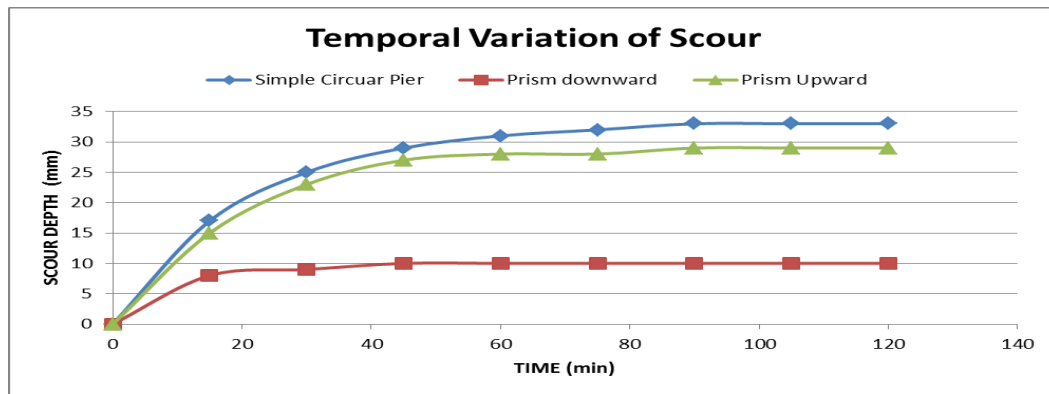


Figure 12: Scour values at Q = 0.0033 cumec

Table 7: Scour values at 0.0086cumec

Time (min.)	Circular Pier	Prism downward	Prism Upward
0	0	0	0
15	34	16	29
30	40	21	36
45	44	24	39
60	45	25	41
75	46	25	42
90	46	25	42
105	46	25	42
120	46	25	42

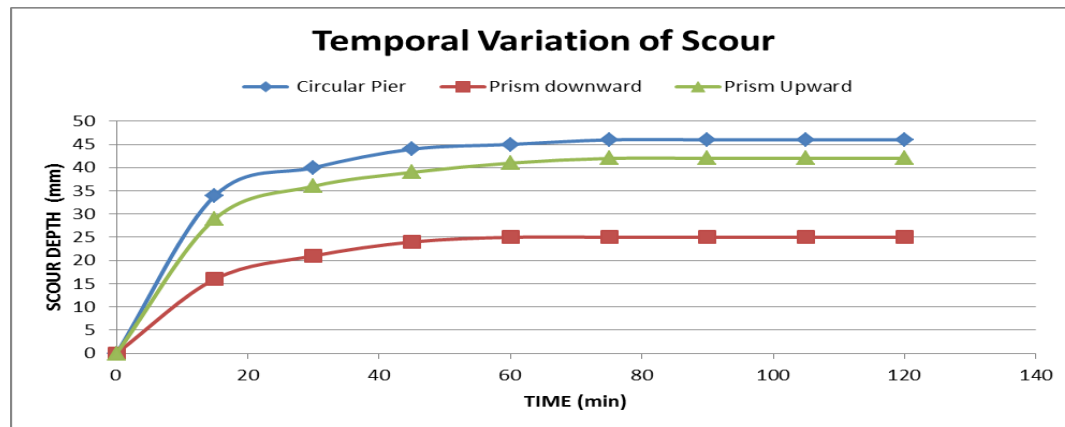


Figure 13: Scour values at Q = 0.0086 cumec

VII. RESULTS AND DISCUSSION

1. After running several experiments at different discharges it was found that the middle pier with downward prism was giving the least local scour depth and hence most efficient. The reduction in scour depth in the middle pier was of the order of 50-70%.
2. The pier with prism downwards and prism facing downstream gave somewhat satisfactory results with a scour reduction of the order of 25-35%.
3. The pier with prism upward gave unsatisfactory results with the efficiency of only 10-15% .

VIII. CONCLUSION

At the point when a pier is put in flowing water, the local flow pattern is modified, expanding the sediment transport limit of the flow. Designing strategies for managing potential nearby scour issues typically include putting riprap material around the pier foundation for safeguard against scour. The present study explored the impact of a triangular prism in various arrangements on a circular bridge-pier. Experiments showed that the arrangements are very effective in reducing scour depth by placing a triangular prism of 2.5 times the diameter of circular pier in the upstream direction near the water surface; it is possible to reduce the clear-water scour by as much as 60%. A same sized prism placed in downstream direction near the water surface can reduce the clear-water scour depth by as much as 25-35%. When the prism is in upstream direction and on upper half of pier shows a minimal reduction of scour when compared to the scour of simple circular pier. The study shows that the prism is capable of eliminating scouring to a reasonable extent.

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