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Estimation of scour depth around the bridge pier using different internal openings

Dr. Mrs. N. R. Dhamge[1], Ms. Shalini Kachhi[2]
[12]*(Department of Civil Engineering, K. D. K. College of Engineering, Nagpur/ RTM Nagpur University, India)*

Abstract :- Stability of bridges founded in river-beds depend on 'local scour. An accurate estimation of scour depth below stream- bed during design is important since this determine the foundation levels of the bridge elements such as pier, abutment, guide bank, spur, etc. The present study examines, through laboratory experiments, the effectiveness of internal opening in the protection of bridge piers against local scour. A number of internal opening, having the same circular shape but different dimension and distance from the bed were experimentally studied. The experiments were conducted using different opening for same water flow condition.

Keywords: - Analysis, Bridge pier, Openings in piers, Sand, Scour depth.

I. INTRODUCTION

Scour is the depression left when sediment is washed away from bottom of river. Scouring is defined as erosion of stream bed around any obstruction in flow field. "Man who overlooks the water under bridge will find the bridge underwater". This anonymous citation highlights the detrimental effects that river flow can have on the stability of piers and abutments that support a bridge founded in river. The main cause of concern in stability of bridges founded in river-beds is the lowering of river –bed level caused by river flow around bridge elements such as piers, abutments and spur dikes and is termed 'local scour'. An accurate estimation of scour depth below stream-bed during design is important since this determine the foundation levels of the bridge elements such as pier, abutment, guide bank, spur, etc. The depth of scour below the river-bed level around bridge elements in alluvial streams can be very large depending on flow, pier and sediment characteristics. The foundations of bridge piers should therefore have a great depth below the river-bed (up to 50m) in case of large rivers like the Ganga and the Brahmaputra. Considerable cost would be saved in the construction of bridge foundations if the maximum scour depth is realistically estimated during design.

1.1 Previous study

Garde and Kothyari (1989) describe the phenomenon of scour around the bridge piers in and then enumerate the methods for its prediction. The scour data from prototype bridges are analysed to comments on the relative accuracy of four methods of scour prediction brief comments are made on scour around bridge piers in a clayey bed and gravel bed rivers.El-Razek, El-Motaleb and Bayoumy (2003) showed the openings reduce the maximum depth of scour. Talebbeydokht and Aghbolaghi (2005) show that for wide piers, computed scour depth is more than a measured one; the reason lies in the fact that many equations have been established based on small pier width in laboratory flumes.UmeshKotthyari (2007) describes the limitation of Lacey-Inglis method become apparent when compared with other method in the up to of principal of river hydraulics.Guney, Aksoy and Bombar (2011) reflects the sequence of experiments planned to investigate the evolution of local scours around bridge piers which affect life time and effective service of the bridges. Ackress and Kirby (2002), their objective of the project was to produce a guidance document for engineers engaged in the design, construction and maintenance of structures in the water environment that may be subject to the scour of erodible beds or banks.

This paper examines, through laboratory experiments, the effectiveness of internal opening in the protection of bridge piers against local scour.

II. EXPERIMENTAL SETUP

A laboratory setup was made to measure scour around the bridge piers. The experiment was conducted in circulating flume as shown in fig.1. The flume had a length of 234.84 cm, a width of 60 cm and depth 152.4 cm. Sand bed in the flume was of 188 cm long and 60 cm wide. The sump measured about 188cm long, 60cm wide, and 49cm depth. The water from the sump was pumped out and was circulated over the flume throughout the entire experiment. Sand of Kanhan River was used as the bed material. Sand was sieved using 4.75 micron sieve and was then laid on the bed of the flume. Bed layer of sand was laid for a depth of 15cm. Black stone having dimension 20 mm were kept between two baffle walls to dissipate the energy and to reduce the turbulencein the flow of water and to make the flow steady and laminar. Flume and sump were made up of GI sheet of thickness 0.6 mm as per the design. The pump used was a 0.5 hp low head and high discharge pump running on a single phase and on 220 v. A notch used for the measurement of discharge was of rectangular type. The material of the notch was brass and pre-configured and predetermined coefficient of discharge. The dimension of the notch was 5 cm x 12 cm. The discharge was measured over the notch.

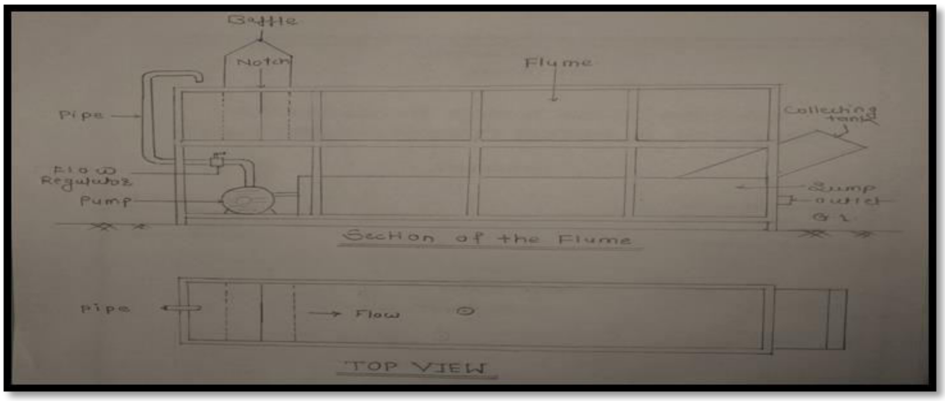


Fig. 1 Section of flume

III. DETERMINATION OF SCOUR DEPTH AROUND BRIDGE PIER

Bridge piers of sizes 10.5 cm and 7.5 cm were used for preliminary investigation regarding scour depth. As scour for 7.5 cm was more hence detailed study was done by providing various openings in the pier. Opening provided in the pier are Straight opening, T- shape opening, Y-shape opening, Double straight opening and plus shape opening as shown in fig 2, fig 3, fig 4,

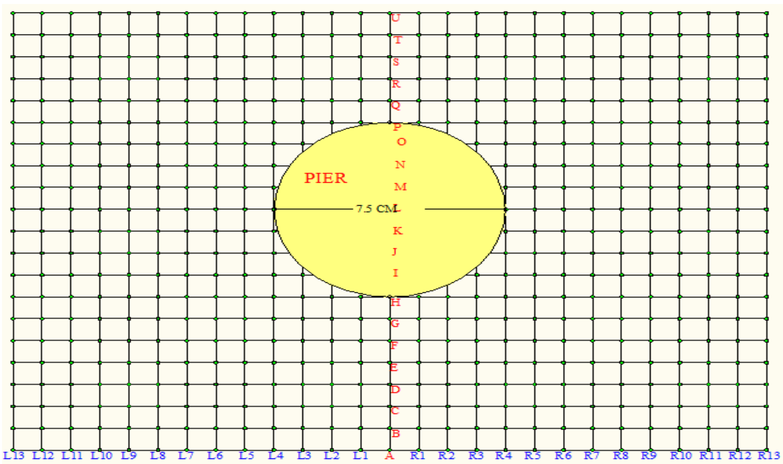
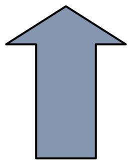


Fig. 2 Observation pattern and pattern for reading for depth of scour

A, B, C, D… J,K,L	Reference points on upstream side
M, N…. Q,R.	Reference points on downstream side
L1,L2,L3…….L11,L12,L13	Left hand side reading
R1,R2,R3…….R10,R11,R12	Right hand side reading



DIRECTION OF FLOW

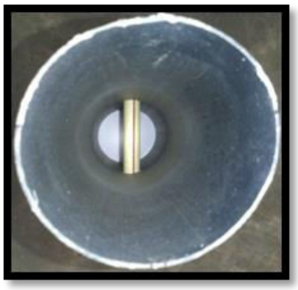


Fig.3 Straight opening

Fig.4 T-shape opening

Fig. 5 ✚ shape opening

Fig.6 T-shape opening

Fig.7 Y-shape opening

Fig.8 Double straight opening

IV. ANALYSIS

Condition 1: Circular pier without opening

For circular pier without opening plotted the section along Y-Y axis and along X-X axis shown in Fig. 9 and fig. 10. These graphs are plotted for the bed depth 15 cm and pier diameter of 7.5 cm. Maximum scour along the X-X axis was found 4.0 cm and along Y-Y axis it was 3.7 cm and minimum scour depth along the X-X axis was 0.2 cm and along Y-Y axis 0.4 cm.

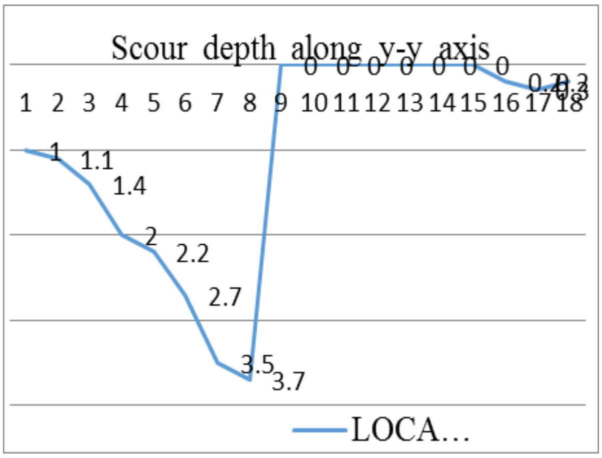


Fig.9 Scour depth section at Y-Y axis for circular pier

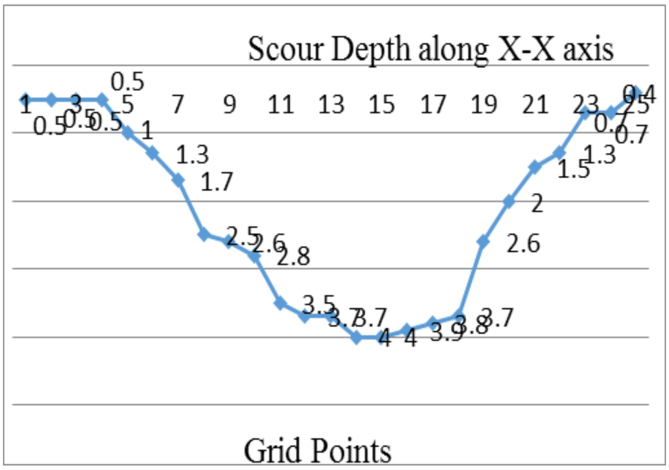


Fig.10 Scour depth section at X-X axis for circular pier

Condition 2- Pier with straight opening

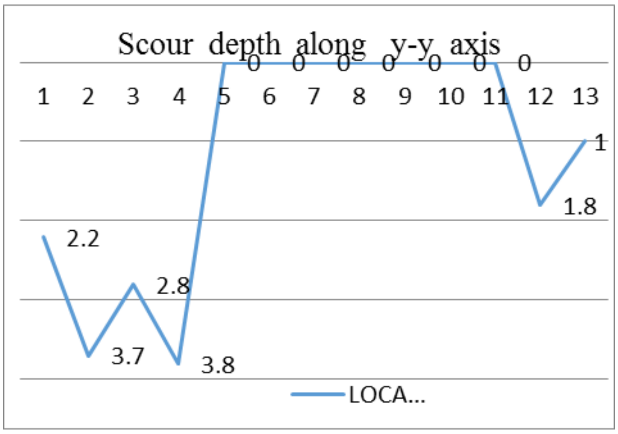


Fig.11 Scour depth section at Y-Y for straight opening pier

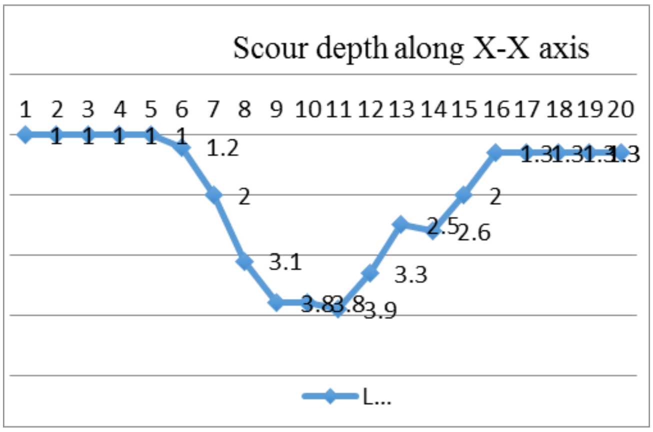


Fig.12 Scour depth section at X-X for straight opening pier

Condition 3 - Pier with T-shape opening

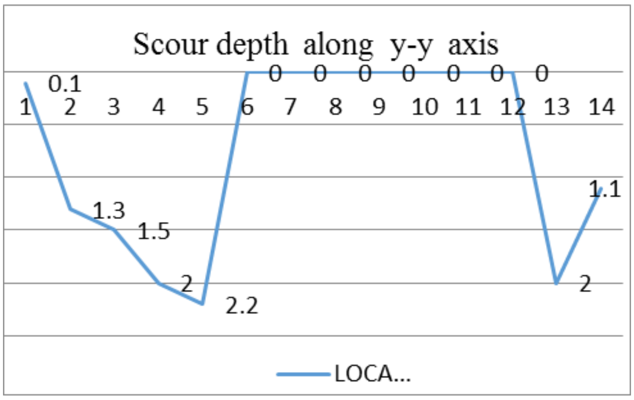


Fig.13 Scour depth section at Y-Y for T-shape opening pier

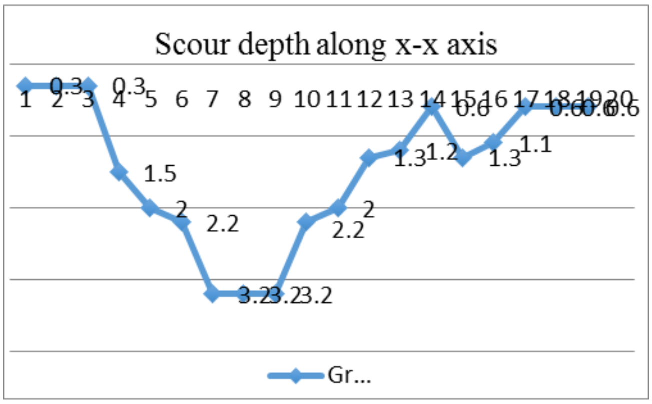


Fig.14 Scour depth section at X-X for T-shape opening pier

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Condition 4- Pier with double straight opening

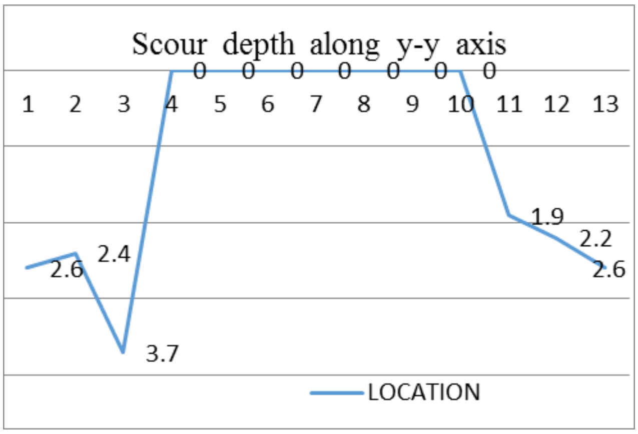


Fig.15 section at Y-Y for double straight opening pier

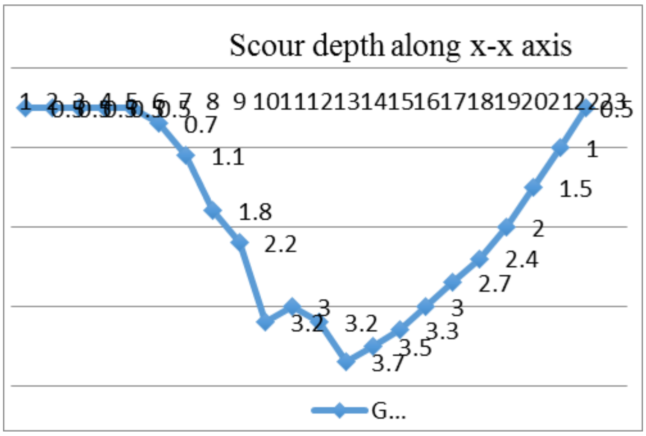


Fig.16 section at Y-Y for double straight opening pier

Condition 5- Pier with + (plus) shape opening

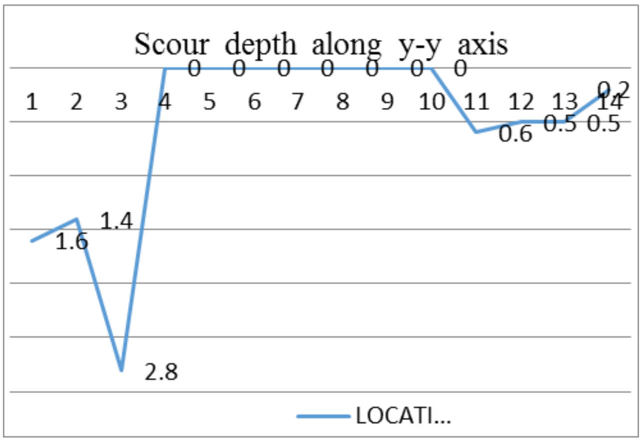


Fig.17 section at Y-Y for + (plus) shape opening pier

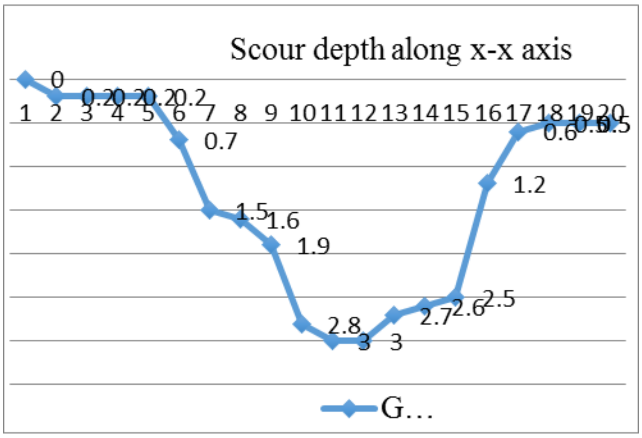
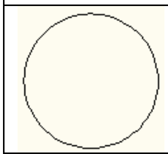
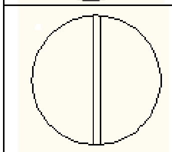
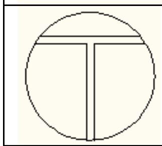
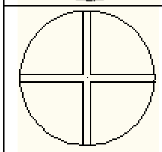
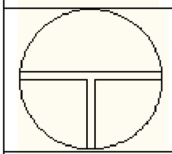
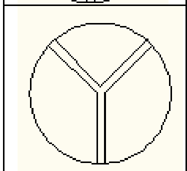
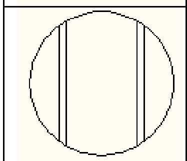


Fig.18 section at X-X for + (plus) shape opening pier

Table 1 Result analysis of all pier for bed depth = 15cm

BED DEPTH - 15 cm						
Figure	Case	Opening	Depth of scour range (cm)	Peripheral scouring (cm)		Maximum scour (cm)
				X-X	Y-Y	
	I	Circular pier without opening	0-4	16.5	9.2	4.0
	II	Straight opening	0-3.9	12.6	9.2	3.9
	III	T- shape opening	0-3.8	15.2	8.8	3.8
	IV	+- shape opening	0-3.0	19	11.5	3
	V	T-shape opening	0-3.2	18.85	11.2	3.2
	VI	Y-shape opening	0-3.9	14.45	11.6	3.9
	VII	Double Straight shape opening	0-3.7	18.2	7.4	3.7

V. CONCLUSION

Maximum scour depth in case of solid one, which reaches the value at 4 cm. Depth of scoured material in case of pier provided opening to the circular pier, which reaches the value at 3cm. Depth of scoured material also can reduce by increasing the diameter of pier but it also increases the economy of project, so internal opening can be minimize the economy of project as well as reduces the scour depth. The use of internal opening through the bridge pier will reduce the effect of scour and prevent the pier to fail against the excess the flow of water. From this experiment it has been concluded that in the considered cases of the different internal opening with respect to the flow of water the scour has been reduced to maximum in case of plus shape opening. Further it can be said that the larger the diameter of the internal opening the lesser is the scour experienced. Finer particles around the pier can result in increased amount of scour. From this experiment it has been concluded that following parameters also influence the scour depth: diameter of pier, bed depth, sand type, width of channel, opening diameter, time of run and type of flow.

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