ISBN: 978-93-83758-09-8

Study of scouring around abutment and its Prevention

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***Abstract*— Failure of bridges due to local scour has motivated many investigators to explore the causes of scouring and to predict the maximum scour depth at abutments. In this paper, a detailed review of the up-to-date work on scour at abutments is presented including all possible aspects, such as parametric behavior around abutment. Apart from dimensions of an abutment and flow character, interference effects between unprotected abutments and protected abutment have been carried out through this study. The whole research work is accomplished with the help of flume. The result of minimum scouring depth equal to 1.72cm and is minimizes by the use of protection device inclined at an angle 75^{o} & projected at a height of 14 cm above the sand bed.**

***Index Terms*—Prevention of scouring around abutment and at the bed.**

I. INTRODUCTION

Bridges across rivers and major drains are considered to be the lifeline of transportation network of a country. A major river bridge assumes significance because apart from being a costly project, its failure may be associated with loss of life and property.

A bridge abutment causes flow acceleration and separation at the upstream face of the abutment as the approximately perpendicular to the structure. This result in the scouring of the bed around the structure locally, Lim (1998). Once a scour hole is formed, the scouring mechanism is dominated by the vortex system and an associated down flow caused by the stagnation pressure gradient which develop ahead of the structure. The down flow acts like a vertical jet impinging and eroding sediment from the bed.

The vortex system and the down flow, along with the turbulence, are the principal causes of local scour. The final shape of the scour hole resembles an inverted cone around the tip of the structure.

Melville (1992) reported that out of 108 bridges recorded in New Zealand between the years 1960-84, 29 were attributed to abutment scour. Considerable contribution to abutment scour has been made by a number of researches (Melville, 1997; Lim, 1997).

An important consideration in designing an abutment is to predict the maximum depth of scour hole so that the foundation of the structure can be sited deep enough to avoid the possibility of undermining. Abutment scour is complicated and has been studied by many researchers in the last few decades. Contributions by Ahmad (1953), Liu et al. (1961), Laursen (1963), and Gill (1972) are among the notable earlier studies. Recent studies include Rajaratnam and Nwachukwu (1983a,b), Froehlich (1989), and Melville (1992). Melville (1992) summarizes comprehensive studies conducted at the University of Auckland by Wong (1982), Dongol (1984), Tey (1984),Kwan (1984, 1988), Kandasamy, et al. (1998). Many equations have been developed in a nearly more than five decades to predict abutment scour depth.

II. SCHEME OF EXPERIMENTATION

Experiments were conducted in the Hydraulics laboratory of the Civil Engineering Department of M.M. Engineering College, Mullana, Ambala.

Flume

A flume having a length of 15m and cross-section 0.6 m wide and 0.75m deep was used to conduct the experiments for the present study. The flume was provided with transparent glass panels for 8m length on both the sides to view the flow conditions and scour phenomenon. It was a re-circulating system maintained with the help of a 15 H.P. pump, 15cm diameter delivery and suction pipe fitted with a valve to regulate the discharge. Photographic view of flume in the figure1.

Figure (1) shows the view of flume

A smooth entry for inflow was provided at the head of the flume. A fine sediment bed of 30cm depth was laid in the flume. A sediment trap was laid downstream of the erodible bed. Tail gate had been suitably improvised to make easy control of velocity and depth of flow and to make surface flow instead of under-sluice flow downstream. Discharge was measured with the help of a pre calibrated orifice meter in the delivery pipe.

Source of sediment and its properties:

Sediment was collected from the course of river Yamuna at Yamuna Nagar (Haryana). Properties of sediments are as follows:-

- Type of sediment = Fine sand
- Median size of sediment, d_{50} = 0.27mm
- Geometric standard deviation, σ_g = 1.60
- $\sigma_g = d_{84}/d_{50}$ or $d_{50}/d_{15.8}$

Abutment Model and Protection Devices:

A definition sketch of the abutment models used during the study as shown in figure 2.

Figure 2 shows the abutment model

For mobile bed studies a wooden model of abutment of square cross-sections 70mm x 70 mm was used for conducting various planned experiments.

The abutment model was used in experiment as shown in table 1 acc to the definition sketch.

Table 1 Configuration of Models of Abutment

Configuration No.	L(in mm)	W(in mm)
1	70 mm	70 mm

The abutment model was placed firmly embedded in sediment at the test section and attached to the side wall of the fume with a commercial adhesive so that it does not get dislocated due to impact of flowing water and also did not allow the water to flow between abutment model and side wall.

Protection device is composed of plastic fiber and has dimensions 32.53cm × 7cm. As shown in figure 4.

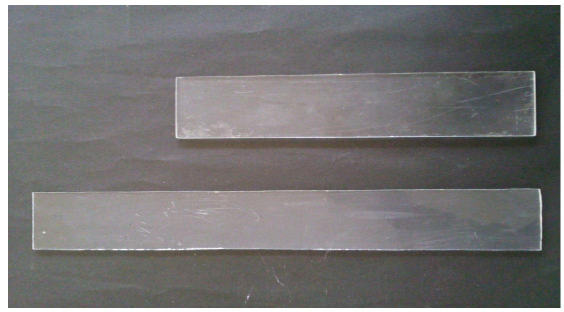


Figure 4 Protection device

Visualization Techniques:

To obtain flow visualization a technique was used, which includes various colored dye. It is a useful tool for the qualitative analysis of flow impression on surface of water. The technique makes use of dye compound and poured around the protection device, which flows with water creating a pattern as shown in the figure given below. The procedure of used technique take only 10 to 15 second to complete it.

Figure 3 shows the visualization

III. RESULTS AND DISCUSSIONS

Present study of project gives the various analysis of scouring phenomenon which is discussed below:

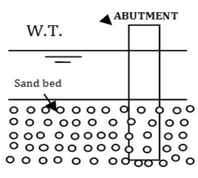
Unprotected abutment:

This experiment was done in the laboratory where the sand

ISBN: 978-93-83758-09-8

bad was leveled first and then taking 9 – 10 reading of bad depth around abutment with measuring scale. Take an average of these readings. The flow velocity was 0.24m/s The whole data regarding this experiment is given in the table 2:

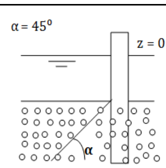
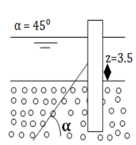
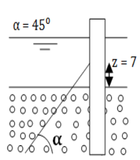
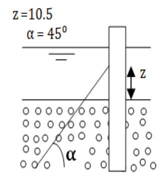
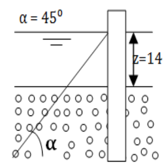
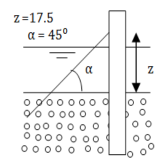
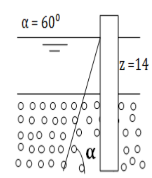
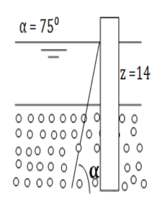
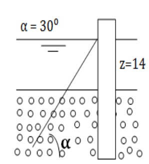
Table 2

Sr. No.	Average bad level (in cm)	Diagram	Flow depth y (in cm)	Scouring depth at abutment's corner y_{sma} (in cm)
1.	46.6		14	9.60

Protected abutment:

This experiment was done in the laboratory where the sand bad was leveled first and then taking 9 – 10 reading of bad depth around abutment with measuring scale. Take an average of these readings. The flow velocity and flow depth was 0.24m/s & 14cm respectively. The whole data regarding this experiment is given in the table 3:

Table 3

Sr No.	Experiment	Elevation ,α & z	Avg. bed level (in cm)	Scouring depth at abutment's corner y_{sma}(in cm)	Scouring depth at device's corner y_{smd} (in cm)
1.	Square protected abutment with inclined strip at an angle 45^0		46.41	5.51	5.51
2.	Square protected abutment with inclined strip at an angle 45^0 & projected at a height of 3.5 cm above the sand bed.		45.9	3.3	3.3
3.	Square protected abutment with inclined strip at an angle 45^0 & projected at a height of 7 cm above the sand bed.		45.83	2.73	5.93
4.	Square protected abutment with inclined strip at an angle 45^0 & projected at a height of 10.5 cm above the sand bed.		45.86	2.96	6.26
5.	Square protected abutment with inclined strip at an angle 45^0 & projected at a height of 14 cm above the sand bed.		45.36	2.34	6.45
6.	Square protected abutment with inclined strip at an angle 45^0 & projected at a height of 17.5 cm above the sand bed.		45.2	2.15	6.30
7.	Square protected abutment with inclined strip at an angle 60^0 & projected at a height of 14 cm above the sand bed.		45.37	1.967	4.767
8.	Square protected abutment with inclined strip at an angle 75^0 & projected at a height of 14 cm above the sand bed.		45.02	1.72	4.12
9.	Square protected abutment with inclined strip at an angle 30^0 & projected at a height of 14 cm above the sand bed.		45.23	3.03	4.13

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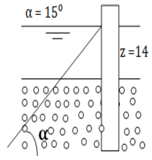
10.	Square protected abutment with inclined strip at an angle 15^0 & projected at a height of 14 cm above the sand bed.		45.4	2.3	2.3

Comparison between unprotected abutment and protected abutment:

Use of protection device decreases the scouring depth near the abutment. The flow velocity and flow depth was 0.24m/s & 14cm respectively. A clear data of scouring depth for varying α and z can be seen through the table given below Table 4 shows the variation in scouring depth due to change in projection 'z', while keeping 'α' as constant.

Table 4

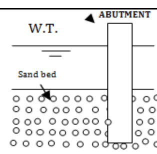
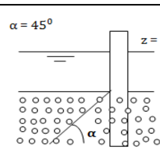
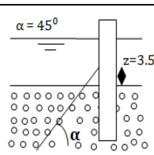
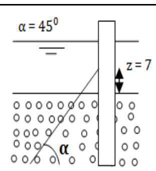
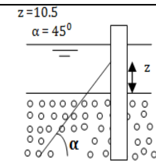
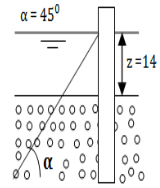
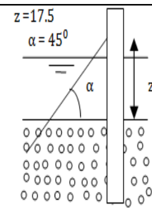
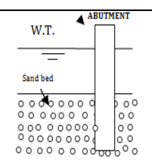
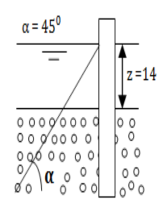
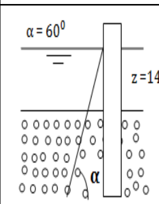
Sr No.	**Experiment**	**Elevation ,α & z**	**Avg. bed level (in cm)**	**Scouring depth at abutment's corner y_{sma} (in cm)**	**Scouring depth at device 's corner y_{smd} (in cm)**
1	Un protected abutment		46.6	9.60	
2	Square protected abutment with inclined strip at an angle 45^0		46.41	5.51	
3	Square protected abutment with inclined strip at an angle 45^0 & projected at a height of 3.5 cm above the sand bed.		45.9	3.3	
4	Square protected abutment with inclined strip at an angle 45^0 & projected at a height of 7 cm above the sand bed.		45.83	2.73	5.93
5	Square protected abutment with inclined strip at an angle 45^0 & projected at a height of 10.5 cm above the sand bed.		45.86	2.96	6.26
6	Square protected abutment with inclined strip at an angle 45^0 & projected at a height of 14 cm above the sand bed.		45.36	2.34	
7	Square protected abutment with inclined strip at an angle 45^0 & projected at a height of 17.5 cm above the sand bed.		45.2	2.15	

Table 5 shows the variation in scouring depth due to change in elevation 'α', while keeping 'z' as constant.

Table 5

Sr No.	**Experiment**	**Elevation ,α & z**	**Avg. bed level (in cm)**	**Scouring depth at abutment's corner y_{sma} (in cm)**	**Scouring depth at device 's corner y_{smd} (in cm)**
1	Un protected abutment		46.6	9.60	
2	Square protected abutment with inclined strip at an angle 45^0 & projected at a height of 14 cm above the sand bed.		45.36	2.34	
3	Square protected abutment with inclined strip at an angle 60^0 & projected at a height of 14 cm above the sand bed.		45.37	1.967	4.76

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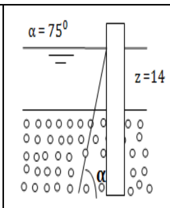
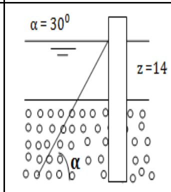
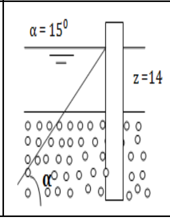
4	Square protected abutment with inclined strip at an angle 75^0 & projected at a height of 14 cm above the sand bed.		45.02	1.72	4.12
5	Square protected abutment with inclined strip at an angle 30^0 & projected at a height of 14 cm above the sand bed.		45.23	3.03	4.13
6	Square protected abutment with inclined strip at an angle 15^0 & projected at a height of 14 cm above the sand bed.		45.4	2.3	2.3

A graphical representation of scoring phenomenon is also shown below:

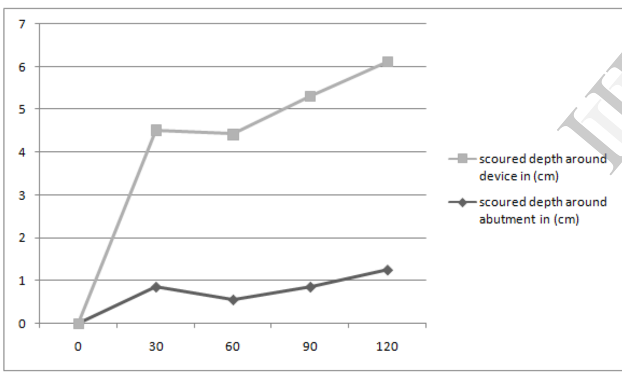


Figure 5 Shows the effect of scoured depth

The above graph shows the a relation between scouring depth of abutment & protection device and reading was taken at regular interval of 30 minutes and the whole experiment was taken into consideration for five hours.

IV. CONCLUSION

In the present study an attempt had been made to minimize the scouring phenomenon around abutment using protection device having certain dimensions. It is mainly an experimental study under uniform flow conditions.
Following are the main conclusions of this experimental study:

- From the experimental study, it has been concluded that scouring depth is most minimizes by the use of protection device inclined at an angle 75⁰ & projected at a height of 14 cm above the sand bed. Other parameters like width of abutment and depth of flow do not affect scour significantly.
- This condition of protection device gives us a minimum scouring depth equal to 1.72cm which proved to be beneficial among all the experiments done in the laboratory.

REFERENCES

[1] Breusers, H.N.C. and Raudkivi A.J. 'Scouring', Hydraulic Structures Design Manual No. 2. Balkema Rotterdom Brookefied, The Netherlands, 1991.

[2] Chang, F, and Devis, S., 'Maryland SHA Procedure for Estimating Scour at Bridge Abutment'. Proceeding of ASCE, 1998.

[3] Gill, M.A. 'Erosion of Sand Beds around Spur Dikes', Journal of Hydraulic Engineering, ASCE 98(9), 1587-1602.

[4] Laursen, E.M. and Toch, A, 'A Generalized Model Study of Scour around Bridge Piersand Abutments'. Proceeding of ASCE, 1953

[5] Lim, S.Y. and Cheng, N.S., 'Protection of Live Bed Scour at Bridge at Abutment'. Journal of Hydraulic Engineering ASCE 124(6), 635-638, 1998.

[6] Lim, S.Y., 'Equilibrium Clear- Water Scour around an Abutment'. Journal of Hydraulic Engineering, ASCE 123(3), 237-243, 1997.

[7] Melville, 'Pier and Abutment Scour: Integrated Approach'. Journal of Hydraulic Engineering, ASCE, 123(2), 125-136, 1997.

[8] Melville, 'Bridge Abutment Scour in Compound Channels'. Journal of Hydraulic Engineering, ASCE 121(12), 863-868, 1995.

[9] Melville, 'Local Scour at Bridge Abutment'. Journal of Hydraulic Engineering, ASCE 118(4), 615-630, 1992.

[10] Molias, A, Kheireldin, K, and Baasheng, WV, 'Shear Stress around Vertical Wall Abutment'. Journal of Hydraulic Engineering, ASCE, 124(8), 822-830,1998

[11] Rajaratnam, N. and Narach Ukwa, B.A., 'Flow Near Grain – like Structure'. Journal of Hydraulic Engineering, ASCE, 190(3), 463-480, 1983.

[12] Setia, Baldev. 'Scour around bridge piers; Mecanism and Protection'. Ph.D. Thesis, Department of Civil Engineering, Indian Institute of Technology, Kanpur, India, 1997.

[13] Sturm, T.W. and Januja, N.S., 'Clear Water Scour around Abutments in Flopplains'. Journal of Hydraulic Engineering, ASCE, 120(8), 956-972, 1984.

[14] Zaghloul, N.A., 'Local Scour around Spur dikes'. Amsterdam, The Netherlands, 123-140, 1983.

[15] Gangadharaiah, T.; Setia, Baldev; Muzzammil, M. (2000), 'Flow Visualisation in Hydraulic Engineering'. International Symposium on Recent Advances in Experimental Fluid Mechanics, Indian Institute of Technology, Kanpur, 18-20, 2000.

[16] Singh, C.P., Effect of Collar Sleeve Combination on Scour around a Circular Pier'. M.Tech. Thesis Submitted to Kurukshetra University, Kurukshetra, 2000.

[17] Bhatia, U K & Setia B., Wake Vortex Propagation around a Wing Wall Abutment, Journal of Engineering and Technology, Volume 1. No. 1. Issue 1, January - June, 2011, pp 47-51