Experimental Study on Scouring Around Pier

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Abstract- **Local scour at the bridge pier is the main reason for the collapse of bridge pier founded in alluvial sediments (Melville and Coleman 2000). This process involves two complexities, the three-dimensional flow pattern and the sediment transport. The determination of the scour characteristic is the main topic of interest for the hydraulic engineers. By underestimation of scour depth, it will result in exposure of foundation and ultimately lead to endangering safety of the structure. By overestimation of scour depth, it will lead to uneconomical design.**

Due to the presence of the bridge piers and abutments the three dimensional flow around obstruction would cause vortices and this will lead to deep scour hole around piers. The basic mechanism causing local scour at piers is the formation of vortices (known as the horseshoe vortex) at their base.

No study has been conducted so far to find maximum scour depth in non-uniform cohesionless sediment mixed in various proportions as in our study. To obtain this several experiments have been conducted in non recirculating tilting flume, 6.0 m long, 0.250 m wide and .750 m deep located at LDRP ITR Gandhinagar, Gujarat. Three different sizes of sediment having median size 4.75mm, 0.16 and 1.18 mm are mixed in various proportions.

Index Terms- **Scouring, Local Scour, Flume, Pier, Sediments.**

I.INTRODUCTION

Scour:- It is the removal of bed sediment in a stream due to action of flowing water. In connection with bridges, scour could be defined as the result of erosive action of flowing water excavating and carrying away sediment from the bed and bank of a stream due to interference of structures such as abutments and bridge piers on the flowing water. If the progressive buildup of stream bed in a reach due to sediment deposition it is called as aggradation. If there is a progressive long term lowering of the channel bed due to erosion as a result of deficit sediment supply to the reach it is called as degradation

II. METHODOLOGY

The experiments are conducted in the Hydraulic laboratory of LDRP ITR, Gandhinagar, Gujarat, India.

It has non recirculating flume of 6m in length; 0.25 m wide and 0.75 m deep (see Figure 3.1). The flume has a working section in the form of a recess that is filled with sediment to a uniform thickness of 0.10 m.

At the starting phase of experimental work practice for uniform flow establishment is carried out for different slope by tail gate positioning.

For each slope, three readings were taken by varying valve opening and corresponding readings were recorded i.e. depth, velocity and discharge of flow.

The sand bed recess is 4 m long and is located 0.2 m downstream from the flume inlet section. The recirculating flow system is served by a 30 horse power, variable-speed, centrifugal pump located at the downstream end of the flume. The water discharge is measured by a venturi meter as well as current meter.

A circular bridge pier of 0.075 m diameter is located at 1.2 m (pier 1), 2.4 m (pier 2), 3.6 m (pier 3) downstream from inlet.

Steps to be followed for conducting an experiment:

STEP-1

Fill the hydraulic flume tank with clear water for conducting experiment.

STEP-2

Adjust the slope of hydraulic flume as required for experiment for the experiment by means of Mechanical arrangement.

STEP-3

Mixing of sand. The experiments are conducted in 3 series having different proportions of sediment. For series-1, series-2 and series.

STEP-4

Laying the mixed sediment as per the series of experiment in the hydraulic flume and at the same time pier is placed in its position.

STEP-5

Level the sediment bed in the hydraulic flume and measure it by means of point gauge. While making bed for experiment ensure that level of bed should be same throughout.

STEP-6

Gate opening.

STEP-7

Tail gate positioning is carried out for uniform flow establishment.

STEP-8

Switch on the hydraulic flume.

STEP-9

Initially at the time of switching on the flume, the flow in channel will be non-uniform because of that scour takes place at the extreme nose of circular bridge pier and deposited at the extreme downstream of pier. This scour hole developed during starting of flume will be leveled by supplying sediment in scour hole in required amount and extra sediments deposited at upstream side of pier will be removed carefully without damaging bed.

STEP-10

Now reading time is started as well as supply of sediment is done

STEP-11

While taking readings for scouring the depth of flow (d) will also be measured by lowering the point gauge till it touches the free water surface and depth will be measured and subsequent area (A) will be calculated.

STEP-12

As the velocity of flow for each experiment will be different for different valve and gate opening, it will be measured by lowering the current meter below free water surface till buckets of current meter gets submerged in water.

STEP-13

Now after determining depth and velocity of flow, discharge will be calculated by equation $Q=A \times V$.

STEP-14

Experimental readings will be taken till scouring stops or got same for 1 hour, at that time scour measured at the nose of pier will be considered as maximum scour.

III. EXPERIMENTAL RESULTS

At the starting phase of experimental work practice for uniform flow establishment is carried out for different slope by tail gate positioning.

For each slope, three readings were taken by varying valve opening and corresponding readings were recorded i.e. depth, velocity and discharge of flow.

Slope	Gate Opening (cm)	Depth (cm)	Average Velocity (m/sec)	Average Discharge (m^3/sec)
0.00153	6.0	11.60	0.4472	0.0129
	6.0	11.78	0.4346	0.0127
0.00250	6.5	11.86	0.4244	0.0125
	6.5	11.82	0.4244	0.0125
0.03750	6.0	10.30	0.4654	0.0119
	6.0	11.21	0.4438	0.0124

TABLE 1: SLOPE MEASUREMENTS

4.75 mm (percentage by weight)	**1.18** mm (percentage by weight)	**0.6** mm (percentage by weight)
Material 1	Material 2	Material 3
50	40	10
40	50	10
00	50	50

TABLE 2: MATERIALS

Run Number	Depth of flow (cm)	Velocity of flow (m/s)	Discharge of flow (m^3/s)	Run duration (min)	Pier 1 Scour in cm	Pier 2 Scour in cm	Pier 3 scour in cm
1A	11.0	0.298	0.0081	40	6	7	5.8
1B	12.2	0.317	0.0096	25	4	6.6	6.1
2A	13.1	0.325	0.0106	60	6.9	4.6	5.2
2B	13.8	0.48	0.0165	50	5.3	5.7	3.8
3A	11.0	0.382	0.0105	60	7.2	5.1	6.6
3B	13.3	0.338	0.0112	55	8.3	7.9	8

TABLE 3: EXPERIMENTAL RUN

MINUTES			0	5	10	20	25	30	35	40	45	50	55	60
SCOUR IN CM	RUN 1A	PIER 1	0	1.6	1.7	2.1	2.8	3.1	5.4	6				
		PIER 2	0	1	1.5	2.7	3.3	5.1	6.8	7				
		PIER 3	0	1.1	1.6	1.9	2	3.2	5.8	5.8				
	RUN 1B	PIER 1	0	1.8	3.6	3.9	4							
		PIER 2	0	2.4	4.7	6.6	6.6							
		PIER 3	0	2	3.9	5.4	6.1							
	RUN 2A	PIER 1	0	1.5	2.7	2.9	3.8	3.9	4.2	4.4	5.8	6.3	6.9	6.9
		PIER 2	0	0.3	0.9	1.2	2.1	3.5	3.6	3.8	4.2	4.5	4.6	4.6
		PIER 3	0	1.2	1.7	2.2	2.6	3.8	4.4	4.9	5	5.1	5.1	5.2
	RUN 2B	PIER 1	0	0.6	0.7	1.2	1.5	1.9	2.6	3.4	4.8	5.3		
		PIER 2	0	0.8	1.9	2.5	3.3	3.8	3.9	4.3	5.7	5.7		
		PIER 3	0	0.9	1	1.3	1.7	1.7	2.3	3.3	3.8	3.8		
	RUN 3A	PIER 1	0	0.2	1.1	2.5	2.9	3.6	4.4	7	7.1	7.1	7.2	7.2
		PIER 2	0	0.9	1.6	2	2.6	3.6	4	4.1	4.5	4.8	5.1	5.1
		PIER 3	0	1.5	2.4	2.9	3.6	4.4	4.8	5.3	6	6.3	6.3	6.6
	RUN 3B	PIER 1	0	0.4	2.9	3.6	4.8	5.4	6.1	6.9	7.6	7.9	8.3	
		PIER 2	0	2.5	3.6	5.5	6.1	6.3	7.5	7.9	7.9	7.9	7.9	
		PIER 3	0	1.2	1.8	2.2	4.3	5.4	6.6	7.2	7.9	8	8	

TABLE : SCOUR DEPTH

FIGURE 1 : PIER OF 75 mm

FIGURE: 2 EXPERIMENTAL FLUME

IV. CONCLUSION

1. The depth of scour is highly dependent on time. The depth of scour increases as the time increases until equilibrium state.
2. The rate of change of scour depth decreases as time elapses and tends to be zero as the scour approaches its equilibrium state.
3. The present experimental results show that there is a relation between depth of scour and pier diameter where the depth of scour increases with increase of pier diameter for the same sediments size and discharge.
4. There is a relation between the size of the sediments and maximum scour depth with decreasing the mean size of the sediments the maximum scour depth increases.
5. Our experimental results show that the deposition is not occurred at high discharges.

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