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Case Study: Deposition of Sediments around the Circular Bridge Pier for Uniform Flow

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Abstract—*Scour is the evacuation of residue like sand and gravel from bed surface of flowing or around bridge abutments or piers. Scour is a common soil-structure interaction drawback. Scour within the structures is additionally caused by the consolidated impacts of native, contraction and natural scour. This is thus can cause the undermining of establishments and subsequent fall of the structure. Water typically streams quicker around piers and projections making them defenseless to neighborhood scour. In light of current changes in atmosphere, expanding recurrence of flooding, combined with the expanding extent of these surge occasions, will prompt a higher danger of extension disappointment. In India, bridge scour is one of the three primary driver of extension disappointment. It is the most widely recognized reason for thruway connects disappointment moreover. Scour can even cause issues with the hydraulic analysis of a bridge. The whole scour depth is analyzed by the long-term aggradations and degradation of the watercourse bed and general scour at the bridge and native scour at the pier or abutment. This paper presents a case study on the scour deposition converging angle of 30°, 45° and 75° of the particles which passes through 2.36mm sieve and retained on 1.18mm sieve.*

Keywords*: Scour, abutments, atmosphere*

1. INTRODUCTION

Scour are regularly characterized as the exhuming and expulsion of material from the quaint little inn of streams as a consequence of the erosive activity of streaming water. Scour characterized by [1] as a characteristic wonder caused by the stream of water in waterways and streams. It is the result of the erosive activity of streaming water, which expels and disintegrates the material from the informal lodging of streams and furthermore from the region of extension docks and projections. Bridges Have always been a big challenge for engineers and builders, both in their design stage and in maintain their stability and function over time. Scour happens in three primary structures, to be specific, general scour, constriction scour and local scour. It identifies with the advancement of the conduit and is related with the movement of scour and filling, without impediments. Bridges are typically built at natural river constrictions in order to minimize large spans. Thus, many bridges are built in locations where the flow is undergoing spatial acceleration upstream of the bridge. Scour can be evoked by the channel constriction itself, which can compound the local scour at the bridge pier. A correct understanding of scouring at bridge piers during a narrowing channel will scale back bridge failures. Bridge pier scouring is the process wherein sediment at the foundation of bridge piers is eroded by the river [2]. Scouring in long contraction with different upstream angle (with the same downstream angle) of transition has been analyzed. Both scour pattern and maximum scour depth has been studied. An empirical model based on regression analysis has been established. Scour along long contraction using ANFIS is also soft computing has also been studied. The hypothesis that the linear sum of pier scour and contraction scour in long contraction is equal to the combined effect of pier scour and contraction scour has also been examined.

2. EXPERIMENTAL PROCEDURE

2.1 Experimental Set-Up and Procedure

2.1.1 Flume

A fixed bed masonry flume of 14m length, 0.6m dimension and 0.4 m depth was used for the experiments. The flume receives its water supply from a continuing overhead tank. The water supply into the flume was regulated with the assistance of a valve provided at the inlet of the flume. Honeycomb masonry grid engineered out of tiny sized bricks was provided at the upstream finish of the flume to minimize disturbances getting in the flume. So as to create the flow parallel to the flume wall, flow strengtheners were provided downstream of the masonry grid.

An adjustable gate made from acrylic sheet was provided at the downstream finish of the flume to regulate the depth of flow within the flume. Adjustable rails and a tram were mounted on the 2 rails of the flume to hold the pointer gauge for water surface measures and bed level recording for scour depth measurement. The rails were set horizontal.

The operating section 2.0 m long, 0.6 m wide and 0.6m deep was placed at 6.0 m from downstream of the flume entrance. It had been crammed up with desired sediment to the amount of flume bed. In order to stimulate a similar roughness as in operating section, sediment particles were pasted uniformly on the bed within the portion of the flume upstream and downstream of the operating section. The pier models were placed within the center of this operating section. The Plate shows the layout of the flume.

2.1.2 Sediment

River sand retained on 1.18mm and passed on 2.36mm sieve was used in all experiments as the sediment. Sand of geometric mean size 1.66mm was used in the present study and has relative density 2.65.

2.1.3 Long Contraction

Contingent upon the proportion of the length of constriction L to the moving toward channel width, channel withdrawals are assigned as long or short. As per [3], a withdrawal turns out to be long when L/b1 ≥1, though [4] thought about it as L/b1 ≥2. In any case, late trial examination of [10], who estimated the stream field by the acoustic Doppler velocimeter (ADV) in channel withdrawals, affirmed that L/b1 ≥1 is sufficient for a compression to be viewed as long.

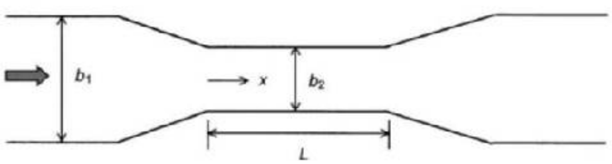

Fig. 1: Plan of Flume for uniform flow

Plate Modes of long contraction without pier; (a) shows horizontal contraction at 45° and (b) shows horizontal contraction at 75°

There are two types of contraction, horizontal contraction and vertical contraction. In horizontal contraction atmospheric pressure prevails where as in vertical contraction flow through contraction is under pressure. Present study is confined only long to horizontal contraction with different upstream transition. Plate shows modes of long contraction made from acrylic sheet used in the present study. Transition at 30°, 45°, 75° and straight portion of 60cm length were used. Downstream transition also was provided at same angle as the corresponding upstream transition.

2.1.4 Pier

Circular cylindrical G.I pipe having diameter 60mm was used as a pier model as shown in plate. The surface of this model was painted to give it a smooth finish. The pier model always protruded well above water surface.

2.1.5 Pier in Long Contraction

Circular cylindrical G.I pipe having diameter 60mm was used as a pier in long contraction. Arrangement for long horizontal contraction with pier is shown in Plate which is made of acrylic sheet of 3.0mm in thickness.

3. RESULTS & DISCUSSION

3.1 Contraction Ratio = 0.3, Converging Angle of Flow = 45°

During the experiments it was observed that scouring commenced almost immediately at the inner corners of the entrance to the long contraction in the form of small circular regions. This is in fact the characteristic of corner vertex that is known to originate from the upstream inner corner of contracted section. The circular scouring regions then rapidly got elongated downstream into the contracted reach of the long contraction while increasing in size both laterally and longitudinally. It was also observed that the position/location of aggradations was dependent on the contraction ratios and it took place at as at some distance from contracted section as shown in Fig. 2.

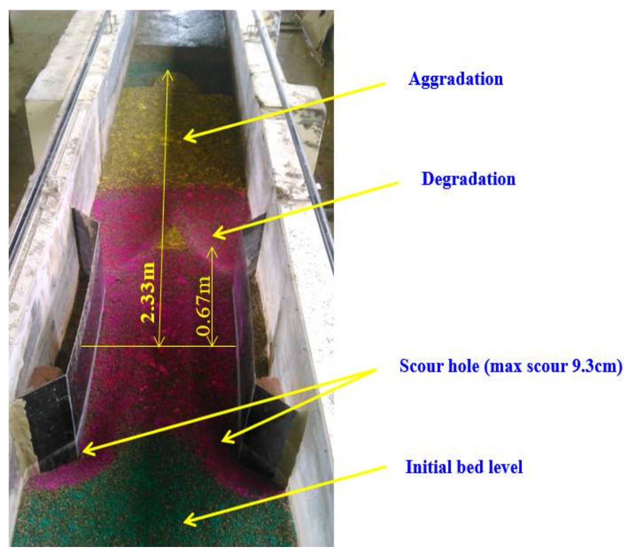

Fig. 2: Shows the plan of bed profile (CR = 0.3, θ = 45°)

The maximum scour depth obtained was 9.30 cm, the value of scour depth at the maximum scour depth location was also noted after a period of 24hrs and its variation with time is shown in Fig. 3.

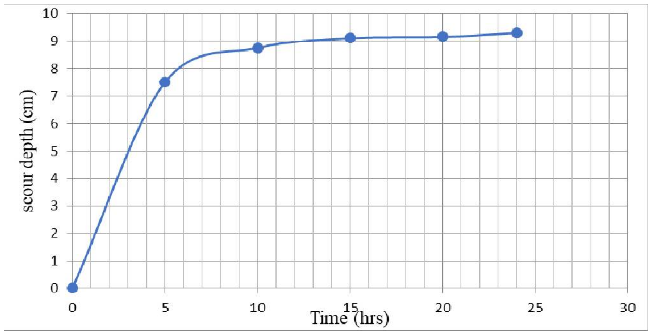

Fig. 3: Variation of scour depth with time (CR = 0.3, θ = 45°)

It can be noted that scour in long contraction achieved equilibrium condition after 12hrs of run as the scour does not change more than 2 mm over a period of 12hrs.

3.2 Contraction Ratio = 0.3, Converging Angle of Flow = 75°

During the experiments it was observed that scouring commenced almost immediately at the inner corners of the entrance to the long contraction in the form of small circular regions. This is in fact the characteristic of corner vertex that is known to originate from the upstream inner corner of contracted section. The circular scouring regions then rapidly got elongated downstream into the contracted reach of the long contraction while increasing in size both laterally and longitudinally. It was also observed that the position/location of aggradations was dependent on the contraction ratios and it took place at as at some distance from contracted section as shown in Fig. 4.

Fig. 4: Shows the plan of bed profile (CR = 0.3, θ = 75°)

The maximum scour depth obtained was 8.24 cm, the value of scour depth at the maximum scour depth location was also noted after a period of 24hrs and its variation with time is shown in Fig. 5.

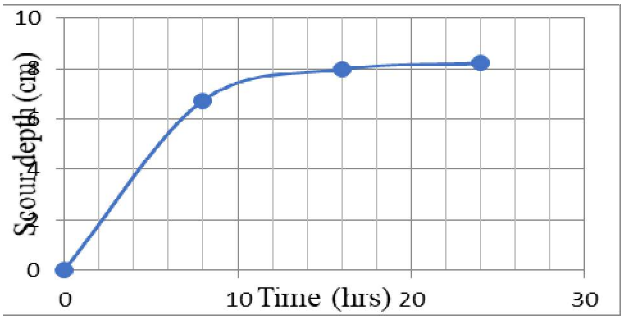

Fig. 5: Variation of scour depth with time (CR = 0.3, θ = 75°)

It can be noted that scour in long contraction achieved equilibrium condition after 16hrs of run as the scour does not change more than 2 mm over a period of 8hrs.

3.3 Contraction Ratio = 0.5, Converging Angle of Flow = 45°

During the experiments it was observed that scouring commenced almost immediately at the inner corners of the entrance to the long contraction in the form of small circular regions. This is in fact the characteristic of corner vertex that is known to originate from the upstream inner corner of contracted section. The circular scouring regions then rapidly got elongated downstream into the contracted reach of the long contraction while increasing in size both laterally and longitudinally. It was also observed that the position/location of aggradation was dependent on the contraction ratios and it took place at as at some distance from contracted section. Variation of scour depth with time is shown in Fig. 6.

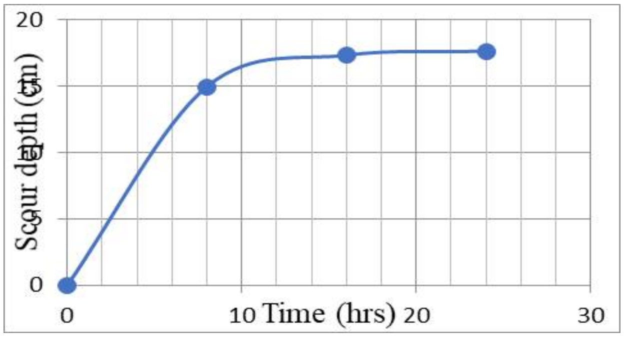

Fig. 6: Variation of scour depth with time (CR = 0.5, θ = 45°)

It can be noted that scour in long contraction achieved equilibrium condition after 13hrs of run as the scour does not change more than 2 mm over a period of 11hrs.

3.4 Contraction Ratio = 0.5, Converging Angle of Flow = 75°

During the experiments it was observed that scouring commenced almost immediately at the inner corners of the entrance to the long contraction in the form of small circular regions. This is in fact the characteristic of corner vertex that is known to originate from the upstream inner corner of contracted section. The circular scouring regions then rapidly got elongated downstream into the contracted reach of the long contraction while increasing in size both laterally and longitudinally. It was also observed that the position/location of aggradations was dependent on the contraction ratios and it took place at as at some distance from contracted section as shown in Fig. 7.

Fig. 7: Shows the plan of bed profile (CR = 0.5, θ = 75°)

The maximum scour depth obtained was 11.50 cm, the value of scour depth at the maximum scour depth location was also noted after a period of 24hrs and its variation with time is shown in Fig. 8.

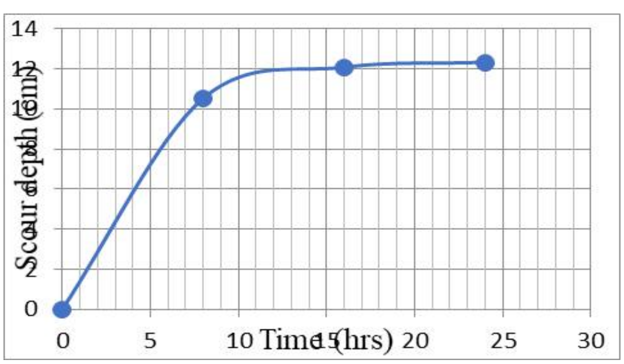

Fig. 8: Variation of scour depth with time (CR = 0.5, θ = 75°)

It can be noted that scour in long contraction achieved equilibrium condition after 12hrs of run as the scour does not change more than 2 mm over a period of 12hrs.

4. CONCLUSION

The primary objective of this study is to examine the effect of long horizontal constriction with and without bridge pier. Detailed studies have been carried out by conducting numbers of experiment with different contraction ratios and different converging angles of flow. Scouring is a leading cause of bridge failure. This study aimed to reduce this by gaining a better understanding of the mechanisms behind scouring. In particular, the study examined the case of combined constriction and pier scour. Currently the practice in industry is to determine the scour depth from the pier and constriction separately and use the linear sum to predict the amount of total scour for a case in which both types of scour occur. The two main objectives of this thesis were Study of scour around long horizontal constriction with different contraction ratios and different converging angles of flow and Study of scour around the bridge pier with horizontal constriction with different contraction ratio and different converging angles of flow.

For the contraction ratios tested this study which ranged from 0.3 to 0.5 it was found that when in the case of simultaneous pier and constriction scour, the linear sum of the two components is greater than the amount observed in a case where both are present. In case of long contraction only it was found that clear that the maximum equilibrium scour depth has been found with converging angle of 30° and contraction ratio 0.5 and Least equilibrium scour depth was found with converging angle of flow of 75° and contraction ratio 0.3.In case of combined pier and contraction it was found that the maximum equilibrium scour depth occurs with converging angle of flow of 30° and contraction ratio 0.5. Least scour depth was found with converging angle of 30° and contraction ratio 0.3 The result of increasing contraction ratio is to increase the scour depth at the contracted section of the flume. Equilibrium scour depth increases with decrease in converging angle of flow, irrespective of contraction ratio.

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