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CRITICAL SHEAR STRESS ON CIRCULAR BRIDGE PIER FOR NON-UNIFORM SEDIMENTS

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Abstract :- This paper describes the most reason of local scour area unit typically classified into flow condition, structure, and river bottom material utilized in it and to get the easy essential shear stress for the non-uniform sediments. Scouring is critical issue which affects on the security of bridges. Scouring develops round the pier on the bed channel with non-uniform sediments win the good on scour depth prediction. during this a flume experiment has been conducted to predict the relative parameters of shear stress for varied size of pier diameter and scour depth victimization the non-uniform sediments. From the analysis a relationship between shear stress and it's scour depth is also developed.

***Key Words*:** essential shear stress, scour, non – uniform sediments, pier, scour hindrance, structure, scour depth.

1.INTRODUCTION

Since 1980 over five hundred in USA fails thanks to scouring around bridge pier such scour around pier and pile supported structures and abutments may result in structural collapse and loss of life and property. Associate estimate of the maximum potential scour around a bridge pier is necessary for its secure style. Varied investigations have been done since the late Nineteen Fifties to know the flow and also the erosion mechanisms around bridge piers and to estimate the scour depth and demanding shear stress. Scouring is native lowering of bed stream elevation that takes place around structure in flowing water. Hence for safe and economical style, scour round the bridge piers is needed to be controlled this work is concerned with the flow because it is slowed and tiny deflected round the bridge pier, the bed shear stress distribution, and also the effects of roughness and also the scour hole.

Many scientists have conducted numerous experiments to determine the most depth and diameter of scour hole. A shot has been created to review few previous studies associated with scour. Scour has been the major concern for safety of marine and hydraulic structures. an outsized varied of hydraulic structures failed because the native scour progresses determined the foundations. Recent study by Guney showed that the Local scours around bridge piers affected their stabilities and play a main role in bridge failures. In his study native scours around bridge piers is from unsteady flow has been measured. it had been all over that the most mechanism that drives the formation and evolution of the scour hole around bridge pier is horse shoe vortex motion. Failure of bridges thanks to native scour has inspired several investigators to explore the causes of scouring and to predict most scour depth.

An estimate of the most potential scour around a bridge pier is critical for its safe style. Numerous researchers are performed since the late Fifties to understand the flow and also the erosion mechanisms round bridge piers and to estimate the scour depth. However, the convolution of the three-dimensional (3D) separated flow, its interacted with the transport of sediment and also the ever-changing mobile boundary.Therefore the early researchers largely targeting scour estimation supported dimensional analysis and knowledge correlation of small-scale laboratory experiments (Breusers et al. 1977; Raudkivi 1991) and also the scour prediction strategies developed don't forever manufacture determinable results for field conditions or perhaps for laboratory conditions (Melville 1975; Dargahi1982; Jones 1984). an absence of understanding of the structure of the flow and erosion mechanism looks to be a minimum of partly chargeable for this state.

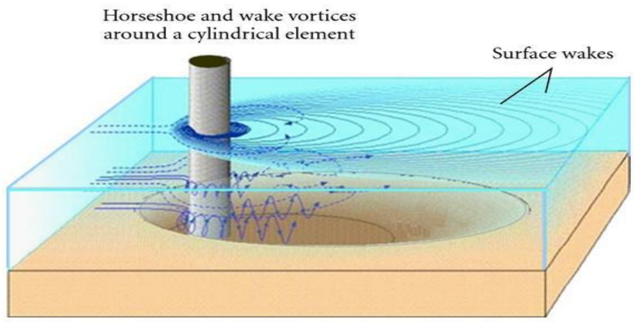


Fig.1 Scouring near bridge pier

Factors moving Scour Depth:

- Various papers are revealed from 1940 on scour depth around bridge piers. Experimental work and theoretical analysis is found that the factors affecting on the scour at bridge pier.

- Incoming Flow is obvious Water Flow or Carries Sediments
- Impact of amendment full of Flow
- Impact of form of Pier Nose
- Impact of Angle of Inclination on Scour Depth
- Impact of gap magnitude relation on Scour Depth
- Impact of Bed Material Characteristics
- Stratification on Bed Slope
- Impact of Flow Parameters
- This issue plays important role in scour depth
- formation. And thanks to this the vital shear stress formation happens. pagination anywhere in the paper. Do not number text heads-the template will do that for you.

Aim:

Aim of this experimental work is to work out stresses developed round the bridge pier thanks to scouring and determine relation between varied flow parameters.

Objectives:

- To work out the vital shear stress around bridge pier.
- To work out the scouring depth around pier.
- To ascertain a relation between speed of flow and scouring at bridge pier.
- To produce bed scour information.
- To estimate the most scour depth.
- To seek out out conditions for this most scour depth.

Future Scope:

- This analysis is helpful to ascertain adequate depth of foundation for bridge pier.
- Estimation of most scouring is needed to avoid risk of undermining.

Related Terms:

- Vital shear stress - The shear stress acting on the bed at that sediments simply starts to move is termed as vital shear stress.
- Scouring - Scouring is native lowering of stream bed elevation that takes place around pier, abutment in flowing water.
- Early motion - The water exert rubbing force on bed material within the direction of flow, this leads to to particle raise from the bed and just begin to getting the direction of flow this condition is termed as early motion.

LITERATURE REVIEW:

1. **Flow around bridge piers:**
   Ferdous Amed and Nallamuthu Rajaratnam, Fellow, ASCE.
   In this paper researcher conclude that the results of a laboratory study on flow past cylindrical piers placed on smooth, rough, and movable beds. Experimental results are analyzed on the flow in the plane of symmetry, including the frontal down flow and the effects of bed roughness and the scour hole on it. The Clauser-type defect scheme describes the velocity profiles better than the log-law and defect law. Frontal down flows as large as 95% of the approach flows were seen. Experimental results are also analysed on the deflection of flow and bed shear stress field. Bed roughness increased the magnitude of bed shear stress and the area over which the shear amplification was felt and also resisted.

2. **Shear stress at base of bridge pier:**
   Peggy a. Johnson and j. Sterling Jones
   In this paper the experiment on shear stress and scour depth analysed that the magnitude of the vertical velocity in the diving current is a maximum near the surface of the scour hole. They found that the maximum vertical velocity is same to the approach flow velocity and that the shear stress at the bottom of the scour hole is approximately equal to the shear stress of the approach flow at maximum scour condition. A method of determining the approach velocity at which riprap around a bridge pier will fail was developed by Parola (4). In his experiment, Parola set a 4-in. model bridge pier in sand, scoured a hole to a predetermined depth, stabilized both the scour hole and bed surface, and then lined the hole with Y4-in. gravel. He then introduced a flow to the flume, gradually lowered the tailgate, and watched for failure (i.e., movement) of the gravel within the hole. He repeated the experiment for various scour

depths and two pier configurations. Parola found that the effective velocity at the pier was approximately 1.5 times the approach velocity required to cause failure of the riprap for a circular pier and 1.7 times the approach velocity for a rectangular pier. Shear stress is a function of velocity squared; hence the effective shear stress at the pier is on the order of 2.25 to 2. 90 times the shear stress of the approach flow. This indirect approach to "measuring" velocity and shear stress at a pier was the basis for the design of the experiment in this study.

3. **Design method for local scour at bridge piers: B. W. Melville1 and A. J. Sutherland2**

A design method for the determination of equilibrium depths of local scour at bridge piers is presented. The method is based upon curves drawn to experimental data derived mostly from laboratory experiments. The laboratory data include wide variations inflow velocity and depth, particle size and gradation, and pier size, shape, and alignment. Local scour depth estimation is based upon the largest possible scour depth that can occur at a cylindrical pier, which is 2.4D, where D = the pier diameter. According to the method, this depth is reduced using multiplying factors where clear-water scour conditions exist, the flow depth is relatively shallow, and the sediment size is relatively coarse. In the case of nonrectangular piers, additional multiplying factors to account for pier shape and alignment are applied.

4. **Bridge pier scour model with non-uniform sediments: By Shaghayegh Pournazeri, Fariborz Haghighat**

Pier scour is a core problem affecting the safety of bridges. For given hydraulic and geometric conditions, perfect determination of scour with nonuniform sediments is important, but this need has not been fulfilled. The purpose of this research was to develop a three-dimensional model for scour prediction and to verify the model using laboratory measurements. The model allows for selective transport of non-uniform sediments, particle hiding and bed-level change in response to scour and deposition. The development of scouring around a circular pier on a mobile channel bed with nonuniform sediments was successfully predicted and scours depth prediction agreed well with the measurements. It was found that scour patterns emerge from the lateral sides of the pier and migrate towards its upstream nose. Upstream of the pier, strong down flow and vortex motions develop and effectively remove sediments from the foot of the pier; at equilibrium, the bed-surface slope almost reaches the angle of repose of sediments.

5. **Indian practice on estimation of scour around bridge pier: By Umesh Kothari**

Well-base foundation is mostly provided in road and Railway Bridge in India over large and medium size river. The age old Lacey-Inglis method is used for estimation of design of scour depth around bridge element such as pier, abutment, and guide bank. Codal provisions are seen to produce large scour depth around a bridge element resulting in bridge substructure that lead to increase in construction cost. New railway and Road Bridge are required to build in large number in near future across several rivers to strengthen such infrastructure in country. It is strongly felt that provision in the existing code of practice for determination of design scour depth required immediate review. The present paper provide critical note on the practice followed in India for estimating the design scour depth.

EXPERIMENTAL PROGRAM:

- Knowledge assortment
- Materials and testing:

❖ Concrete
❖ Sediments
  ➢ Sieve analysis
  ➢ relative density
  ➢ Density of sediments

- Casting:

Pier was casted well before electrical phenomenon of experiment.

- Experimental arrangement:

The experiment was conducted in tilting flume of dimensions 10m length, 0.6m wide and zero.4m exhaustive. The flume is given baffle walls at body of water and outlet chambers. The circular form pier was made from M20 grade concrete, having length three hundred metric linear unit, diameter seventy metric linear unit. The pier was placed at center of section so bed material (sieved sand) was placed around it. The flume was unbroken horizontal whereas doing the experiment and flume was given gate to regulate discharge of flow and maintain the uniformity. The depth of scour was measured with purpose gauge. conjointly rate is measured by taking various readings (runs).

- Parameters:

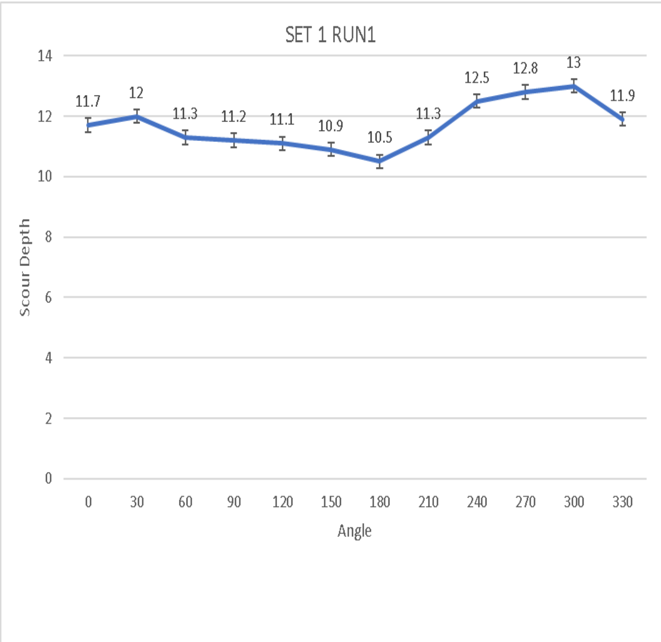
Shape of Pier - Circular pier

- Velocity of Flow

1) V1

2) V2

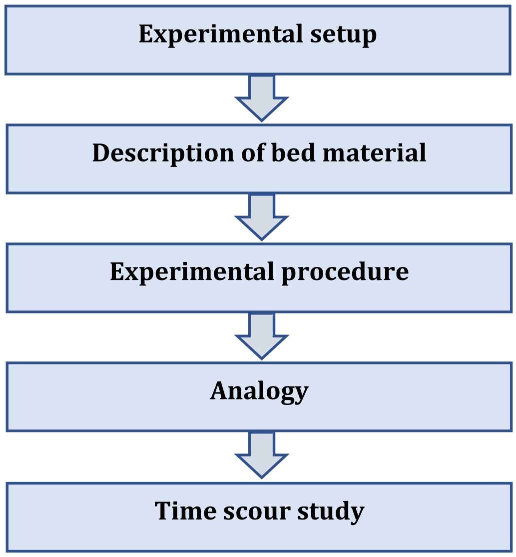
3) V3



EXPERIMENTAL WORK DONE BY RESEARCHERS:

The aim of the experiment is to study Critical shear stresses and measure scour depth around circular bridge pier for non-uniform sediments. The experiment was performed in clear water condition and at standard temperature and pressure condition.

- **Experimental Flow Chart:**



- **Experimental setup:**

The experiment was performed in tilting flume of dimensions 10m length, 0.6m wide and 0.4m in depth. The flume is provided with baffle walls at inlet and outlet chamber which were used to keep flow of water steady and calm. A section of 2.5m length and 150mm depth was prepared by using acrylic sheet. The pier was fixed at center of section and then bed material (sieved sand) was placed around it.

The flume was kept horizontal while performing the experiment and flume was provided with gate to handle discharge of flow and maintain the uniformity. The depth of scour was measured with point gauge.

- **Description of bed material:**

The bed slope material of non-uniform sediments was used for the experiment. Having specific gravity 2.7 and size which ranges from 150 microns to 4.75 mm. Bed materials was washed thoroughly with clean water to remove silt and organic material. After that the sieve analysis is done for the specific sample of sand and we get following curve (graph).

- **Experimental procedure:**

1. Preliminary runs were dispensed to calculate the discharge of water through flume by meter technique.

2. Then speed of the flow was measured by analytical technique and it had been compared with theoretical speed.

3. Section was ready and bed material (sieved sand) was placed around pier.

4. Bed material was compacted and was leveled.

5. Then the flume section was stuffed with water slowly, in order that entrapped air was removed.

6. At that time the frame is ready with thread arrangement thereon. This arrangement is employed to take reading at numerous angles and at different positions.

7. This frame was placed over prime of the flume to take angular readings of scouring.

8. Valve was fastened at position to stay steady flow condition for a run.

9. Steady flow was maintained for couple of minutes and rate was measured.

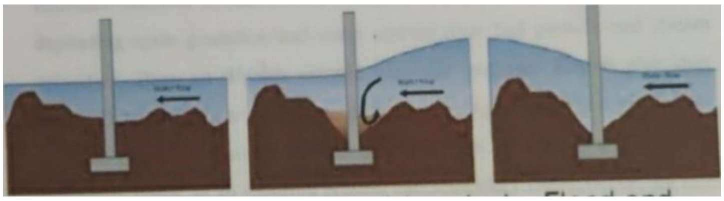
10. Scouring impact happens and therefore the scour hole depth was measured victimization purpose gauge.

11. Same procedure was recurrent for various runs for AN interval of few time for one set keeping a similar rate.

12. Four sets of 4 totally different velocities were taken to live scouring at totally different velocities.

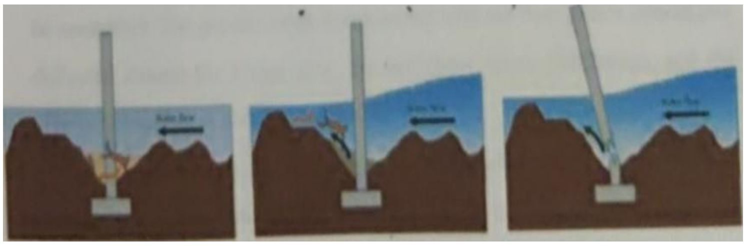
13. Same procedure was adopted to hold out numerous runs.

14. Readings were noted down and analyzed for developing relation between velocities, scour depth, pier dimensions.



Normal Heavy Flood (erosion) Flood end

Fig 2 Failure of bridge due to scouring



Debrts fill hole Light flood (erosion) Collapse

Fig 3 Mechanism of bridge failure

- **Analogy:**

To determine shear stresses we tend to used formula given by Peggy A. Johnson and J. Sterling Jones. [2]

$$T = \frac{pV^2}{[5.75\log(12.27\frac{V}{K})]^2}$$

Where,

τ = Shear stress around pier

V = rate of flow

d = flow Depth

Ks = Mean diameter of sediment

- **Time scour study:**

Then it absolutely was ascertained that primarily scouring depth rises significantly. For now amount rate of particle taken away was a lot of. because the time goes on this rate get weakened and eventually maximum scour depth is obtained. The total runs performed were varied and knowledge and results were collected. The extend of scour hole is not rely on rate and depth of flow. The extend and depth of scour hole isn't associated with any of those parameters.

3. CONCLUSIONS:

The results of AN experimental study of the flow and bed shear stress by numerous researchers within the field around circular cylinders same that the various varieties of bed conditions are emerged. The down flow rate in front of the pier goes the maximum amount as ninety fifth percentage of the approach rate within the scour hole before diminishing. The relative magnitudes of shear stress at the base of a bridge pier as a operate of pier diameter and scour depth. The results conjointly conclude that the shear stress at the bottom of the pier decreases as scour depth will increase. because the scour depth continues to increase, the shear stress approaches the bed shear stress upstream of the scour hole. The model has successfully been applied to predict the flow around a circular pier and therefore the development of a scour hole. The determined scour depth at equilibrium agrees well with measurements reportable by river et al. (2004). For reliable determination of pier scour with a sediment mixture, it's applicable to contemplate selective transport and relative exposure of sediment particles. The results of this study were supported AN experimental method within which the shear stress at the base of the scour hole was measured indirectly. There are blessings and disadvantage in exploitation such a technique. One vital advantage is that no instrumentation was required within the scour hole; therefore there was no interruption of the flow pattern round the pier or within the scour hole. On the premise of those results, it can be ended that the shear stress at the bottom of a pier increases with increasing bridge pier diameter; but, the increase isn't a linear one. The shear stress increases nonlinearly with increasing pier diameter, as does the depth of scour. Once a relationship between the shear stress magnitude relation and also the equilibrium depth of scour is determined, then the indirect shear stress measurements might become a laboratory expedient for conducting pier scour experiments.

Limitations:

1. Excessive internal stresses beyond the specified magnitudes stipulated in the codes.

2. Excessive deflection or displacement, adversely affecting the finishes and causing discomfort to the users of the structure.

3. Excessive local damage due to cracking or spalling of concrete which impairs the efficiency or appearance of the structure.

4. Limit state of vibration critical in foot bridges, suspension bridges under dynamic effects of wind loads.

REFERENCES:

[1] Ferdous Ahmed and Nallamuthu Rajaratnam, “Flow Around Bridge Piers”, journal of hydraulic engineering, 1998.

[2] Peggy A. Johnson And J. Sterling Jones “Shear Stress At Base Of Bridge Pier” transportation analysis record 1350 PP.

[3] Previous study on “Critical shear stress around bridge pier for non-uniform sediments” by students of civil Engineering, BVCOEL, Pune.

[4] Shaghayegh Pournazeri Fariborz Haghighat S. Samuel Li, “A bridge pier scour model with heterogenous sediments”, Proceedings of the establishment of Civil Engineers, October 2014.

[5] D. goop Sheppard, “Large Scale And Live Bed native Scour Experiments”, Sunshine State department of transport, September 2003.

[6] R J Garde, U C Kothyari, “Scour Around Bridge Piers”, PINSA 64, a, no 4, July 1998.

[7] report of federal main road administration’s turner Fairbank main road centre (TFHRC) J. Sterling Jones mechanics laboratory in response to state transportation departments.

[8] Peter R. Wilcock, “Methods For Estimating The Critical Shear Stress Of Individual Fractions In Mixed-Size Sediment” water resources analysis, vol. 24, no. 7, July 1988.

[9] Vincenza C. Santoro, Pierre Y. Julien, Everett V. Richardson, Steven R. Abt, “Velocity Profiles And Scour Depth Measurements Around Bridge Pier”.