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Experimental Study Of Scouring AroundVarious Shapes Of Bridge Piers

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ABSTRACT - Scour around bridge piers is a challenging problem faced by bridge engineers. Scour is caused by the horse-shoe vortex differs according to the arrangement of piers. The flow pattern is different for a group of piers and a solid pier thereby creating different scour patterns. In this paper, the scour investigated in a laboratory flume. The experimental flume is 2.2m long, 0.23m wide and 0.2m deep with a re-circulating facilities. The results obtained showed that scour volume is considerably reduced around a single solid pier compared to the combinations of piers. Further, the flow becomes complex due to the combination of piers.

Keywords: **bridge failure, pier scour, scour dynamics, scour measurements, scour estimates.**

1. **INTRODUCTION –** The term Scouring is the erosive action of water carrying away sediments from river bed and riverbanks, and around piers and abutments of a bridge. This phenomenon is considered as the main cause of bridge failure in the United States: nearly 60% of bridge collapses are caused by this hydraulic problem. The erosion caused by flowing water resulting in removal of sand, earth, or silt from the bottom of the river is called Scour. The scour around obstruction in waterway is called local scour. The scour due to contraction of waterway is called contraction scour. Due to continuous flow of water over a long period of time, the occurring scour is called degradation or aggradations. Scour is one of the leading causes of bridge failure. The scour removes the bed materials around the foundation of the bridge which results in exposure of the foundation and endangers the stability of the bridge. The flat surface of flume of 2.2m long, 0.23m wide and 0.2m deep with a constant slop of zero was used for experiments. The walls and bottom of the flume were made of Plexiglas. The rectangular flume was made into three sections: inlet section, outlet section and test section in the middle. There is a mild steel tank at the upstream end of the flume. Water was re-circulated into the flume from the sump using pump. The tank was connected to the inlet section of the flume using a bell mouth arrangement. If the width of the road/railway above is more, elongated piers or multiple piers would be needed to support the super structure. Hence the flow and scour features around such elongated and multiple piers should be understood for design of a supporting structure. The shape of pier, the angle of inclination between the pier axis and the flow direction, the arrangement of piers with respect to the flow direction are someof the many factors that affect the scour pattern around piers.

2. **OBJECTIVE**

i. Piers are substructures located at the ends of bridge spans at intermediate points between the abutments. The function of the piers is as follows: to transfer the superstructure vertical loads tothe foundation and to resist all horizontal and transverse forces acting on the bridge.

ii. A pier is a raised structure that rises above a body of water and usually juts out from its shore, typically supported by piles or pillars, and provides above-water access to offshore areas. Frequent pier uses include fishing, boat docking and access for both passengers and cargo, andoceanside recreation.

iii. One way of reducing pier scour is to combat the erosive action of the horseshoe vortex by armoring the riverbed using larger size materials such as stone riprap. Another approach is toweaken the down-flow and thus the formation of the horseshoe vortex using collar.

3. LITERATURE REVIEWAshish Malik et.al (2020) [2]

For economical design, scour around the bridge piers is required to be controlled. In the present study, an attempt has been made to minimize scour depth by placing a triangular prism on the downstream side of a circular pier (35 mm dia) with one of its noses facing the direction of flow and other facing opposite to the direction of flow. Three different bed samples collected from Gagger, PatialkiRao and the Kotla super-passage have been placed in a rectangular flume. Discharge values were varied from 0.0015 to 0.0186 m3/sec. Results are compared for observed scour-depth for upstream (U/S) and downstream (D/S) piers with and without protection. Arrangement with a triangular prism of 2.5 times the diameter of the circular pier in the upstream direction of the flow is very effectivein reducing scour depth.

Abdulnaseer Kashmoola et al. (2019) [1]

Comparison of experimental study was carried out between bridge piers to find out the efficient bridge pier to countermeasures the local scour. In addition, the present study is to provide a new method to reduce scour depth in front of bridge pier. The idea of this method is dependent on change the position of two piers (normal pier (10-4) cm and straight aero foil shaped pier) with respect to flow direction (named after here as opposite bridge pier and opposite aero foil pier). The down flow deflected away from the front the opposite piers and the horseshoe vortex becomes small and does not affect the piers. In the present study five piers (normal pier (10-4), opposite pier (4-10), straight aero foil, opposite aero foil and circular) were tested under live-bed condition with flow intensity 58 l/sec. for duration 3 hrs. Comparison between five bridge piers was carried out to find out the efficient bridge pier to countermeasures the local scour and the paper experimentally examined the application of a new method of placing the pier in the opposite direction of flow to reduce local scour on bridge pier.

Vijayasree B.A. et al. (2016) [6]

Scour around bridge piers is a challenging problem faced by bridge engineers. Scour is caused by the horse-shoe vortex formed due to the presence of the pier obstructing the flow. The behavior of horse-shoe vortex differs according to the arrangement of piers. The flow pattern is different for a group of piers and a solid pier thereby creating different scour patterns. In this paper, the scour around bridge piers of different arrangements with same aspect ratio is investigated in a laboratory flume. All three arrangements studied have an aspect ratio (L/B) of 5. The experimental flume is 7.5 m long, 0.3 m wide and 0.6 m deep with a recirculating facility. The results obtained showed that scour volume is considerably reduced around a single solid pier compared to the combinations of piers. Further, the flow field becomes complex due to the combination of pier The flow field becomes complex around a group of piers due to the interference of horse-shoe vortex formations of individual piers. In the twin circular pier arrangement, the scour at the downstream pier is due to a combined effect of wake vortices caused by upstream pier and the horse-shoe vortices at the downstream pier. In the three circular pier arrangement, scour occurs at the second and third pier due to the combined effect of wake vortices caused by the upstream pier and the horse-shoe vortex at the pier behind it. This results in complexity of flow in front of pier 2 and pier 3. The horse-shoe vortex loses its strength around the solid pier and reduces the scour geometry parameters
The arrangement of pier plays a significant role in the characteristics of scour hole formed around it. When the arrangement of piers were changed from twin circular pier to three circular piers and oblong pier, the scour volume reduced by 21.5% and 55.63% respectively. A single solid pier produces less scour compared to group of piers of equivalent aspect ratio at upstream end, mid-section and downstream end of pier compared to the other two arrangements of same aspect ratio. When considering the arrangement of a bridge pier, solid pier is a better option compared to group of piers of equivalent aspect ratio. When considering the cost of materials, the solid pier may appear to be uneconomical, but it compensates on the cost of scour protection needed.

Luigia Brandimarte et.al (2011) [3]

Scour at hydraulic structures is one of the main issues engineers have to face at various stages of the structure life: during design, operation and maintenance. Scour at bridge piers is the main cause for bridge failure and might represent a potential threat to the civil population. The scientific community has made enormous advances in understanding the scour process dynamics and has explored different approaches to estimate the maximum expected scour depth at bridge piers. These advances provide tools for supporting engineers in the design phase of adequate bridge foundations

S Kang et al. (2010) [5]

In this "High-resolution numerical simulation of turbulence in natural waterways" found the development in an efficient in versatile numerical model for carrying out high resolution simulations of turbulent flows in natural meandering stream with arbitrarily complex bathymetry. In this the numerical model solves the 3D, unsteady, incompressible Naiver-Stokes and continuity equations in in generalized curvilinear coordinates. This method also can handle the arbitrary geometrical complexity of natural streams by using the sharp interface curvilinear immersedboundary also known as CURVID method of Ge and Sotiropoulos.
I found the potential of the model as a powerful tool for simulating energetic coherent structures in turbulent flows in natural river reaches is demonstrated by applying it to carry out LES and URANS in a 50-m long natural meandering stream at resolution sufficiently fine to capture vortex shedding from centimeter scale roughness elements on the bed. And the accuracy of the simulations is demonstrated by comparisons with experimental data and the relative performance of the LES and URANS models is also discussed.

Rajkumar V Raikar et al. (2005)[4]

An experimental investigation on scour at circular and square piers uniform and non-uniform gravels. Because they are clear water scour at limiting stability of gravels is presented it is observed that the equilibrium scour depth increases with decrease in gravel size. The variation of equilibrium scour depth with gravel size it can influence of gravel gradation on scour depth with prominent in non-uniform gravels. To prevent of the scale to represent the time variation of scour depth of uniform and gravel it can also be gravels of scales increases with increase in pier Froude number and gravel size. It decreases with increase in geometric standard deviation of particle size distribution of gravels.

4. APPARATUS AND MATERIALS:

Distance measurement system using ultrasonic waves and interfaced with arduino. We know that human audible range is 20hz to 20khz. We can utilize these frequency range waves through ultrasonic sensor HC-SR04.The advantages of this sensor when interfaced with Arduino which is a control and sensing system, a pro per distance measurement can be made with new techniques. As large amounts are spent for hundreds of inflexible circuit boards, the Arduino will allow business to bring many more unique devices. This distance measurement system can be widely used as range meters and as proximity detectors in industries. The hardware part of ultrasonic sensor is interfaced with Arduino. This method of measurement is efficient way to measure small distances precisely. The distance of an obstacle from the sensor is measured through ultrasonic sensor. After knowing the speed of sound the distance can be calculated.

- **Arduino UNO:**
  The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc and initially released in 2010. The board is equipped with sets of digital and analog input/output pins that may be interfaced to various expansion boards and other circuits.

- **Ultrasonic Senser:**
  The HC-SR04 ultrasonic sensor uses sonar to determine the distance to an object. This sensor reads from 2cm to 400cm (0.8inch to 157inch) with an accuracy of 0.3cm (0.1inches), which is good for most hobbyist projects. In addition, this particular module comes with ultrasonic transmitter and receiver modules.

- **Potentiometer:**
  Potentiometer is a device used to measure the internal resistance of a cell, to compare the e.m.f. of two cells and potential difference across a resistor.

- **LCD:**
  A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

- **Battery:**
  9-volt battery, is an electric battery that supplies a nominal voltage of 9 volts. Actual voltage measures
  7.2 to 9.6 volts, depending on battery chemistry. Batteries of various sizes and capacities aremanufactured; a very common size is known as PP3, introduced for early transistor radios.

- **Hydraulic Flume Apparatus:**
  This flume is used for determining hydraulic jump, open channel flow and nappe profiles. Also, it helps in determining calibration of vent beuri flume. Under experts' supervision, offered flume is manufactured with the aid of advanced technology by utilizing high quality components.

- **Sand:**
  Particle Size Distribution D50 is also known as the median diameter or the medium value of the particle size distribution, it is the value of the particle diameter at 50% in the cumulative distribution. It is one of an important parameter characterizing particle size.

- **Piers:**
  Pier is a support for a bridge, a structure built out into the water for use as a landing place or walk or to protect or form a harbor. We are using 3 different types of piers namely circular , Hexagonal and Octagonal to examine with 3 different type of discharge.

5. METHODOLOGY TO BE ADOPTED:

- **Experimental setup and procedure:**
  Experimental conducted in a Hydraulic Flume at the Fluid Mechanics laboratory axis institute of technology and management (AITM).

These are the various procedures which are to be involved in this project work to make this project asuccessful outcome.

- **Types of Piers:**

(a) Circular Pier
(b) Hexagonal Pier
(c) Octagonal Pier

- Circular Pier Discharge (@15min) Discharge (@30min) Discharge (@45min)
- Hexagonal Pier Discharge (@15min) Discharge (@30min) Discharge (@45min)
- Octagonal Pier Discharge (@15min) Discharge (@30min) Discharge (@45min)

6. Expected Outcome:

Bridge scour is the removal of sediment such as sand and gravel from around bridge abutments or piers. The local scour around the piers of the bridge is one of the main causes of the bridge failure. The local scour of river water is a catastrophic effect on the engineering structures. It leaves them under dangerous,maintenance prone conditions and occasionally leads to loss of life.

- The flow will become complex around a group of piers due to the interference of horse-shoevortex formations of individual piers.
- The arrangement of pier plays a significant role in the characteristics of scour hole formedaround it.

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