

# ***Review on Scour Monitoring and Scour Reduction Efficiency of the Slot***

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## ***Abstract***

*Scouring of the river bed material surrounding the bridge pier is a major cause of the failure of the pier. So many researchers have been done on scour depth estimation, but not so much focus is addressed to find the countermeasures. Countermeasures can be used to either strengthen the river bed or to alter the current around the pier. Scour monitoring is a crucial aspect to minimise scouring. The paper studies different methods to monitor scouring. The review focuses on one of the countermeasures to reduce the scouring slot. The scouring varies according to change in the shape, dimension, and position of the slot. Scour monitoring devices can be different according to the site condition.*

**Keywords:** - Bridge, Pier, Slot, River bed, Flow, Countermeasures, Scour, Electrical Conductivity

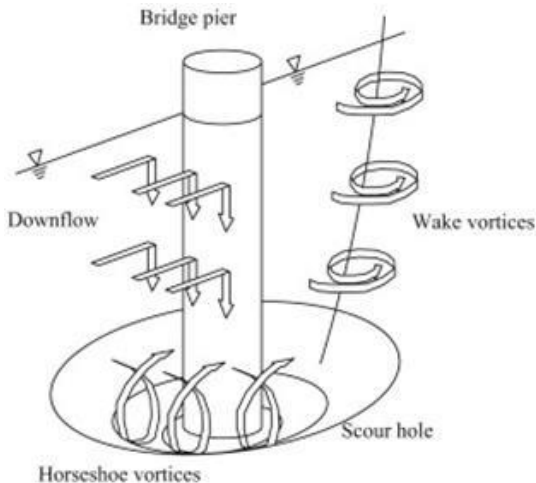
## **INTRODUCTION**

The main issue that the extension structure faces is scouring under the scaffold dock because of the momentum in a waterway. Scouring beneath the extension wharf is the significant reason for connecting disappointments [1]. In one investigation of 500 scaffold disappointments in the United States somewhere in the range of 1989 and 2000, flooding and scour were the reason for 53% of the recorded disappointments [2]. In the United States, the normal expense for flood harm fix of roadways is assessed at \$50 million every year [3]. During a solitary flood occasion in the upstream Mississippi and downstream Missouri waterway bowls, which happen in 1993, at any

rate, 22 of the 28 extensions bombed because of scouring [4]. Wharf scouring occurs when brisk water flows wash away a lot of soil materials adjoining span docks, and this can destroy the structure [5]

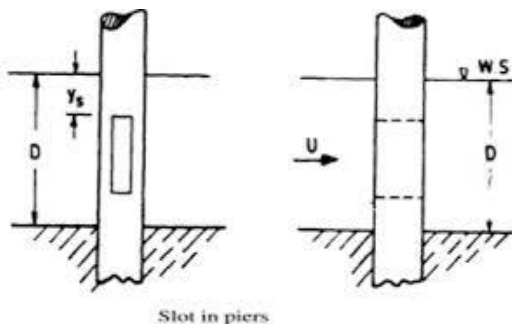
Neighbourhood scour happens around singular extension docks and projections. Descending flow is initiated at the upstream finish of extension docks, prompting exceptionally confined disintegration in the structure's immediate region (see fig 1 [6]). Horseshoe vortices create because of the detachment of the flow at the edge of the scour gap upstream of the dock and in pushing the down-flow inside the scour opening nearer to the

wharf. Horseshoe vortices are an aftereffect of starting scouring and not the essential driver of scouring. Moreover, a partition of the flow along the edges of the wharf brings about a wake vortex [7].



**Fig.1 Flow around circular pier [4]**

Giving the space in the wharf helps decrease the quality of the horseshoe vortex because of the decrease in the powerful width of the dock. Besides, the death of water through the opening lessens the quality of the unfavourable weight angle upstream of the wharf [8].



**Fig.2 Slotted Bridge pier [8]**

The opening assists with passing a large portion of the course through it and just the equalisation is left to cause a lot of diminished scour harm. [9]

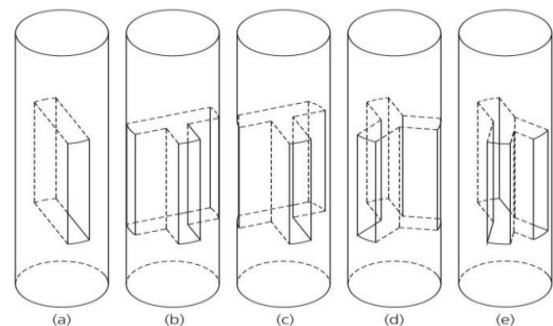
The most far-reaching checking plan set up as a major aspect of any board's public extension resource is to attempt visual reviews. These assessments are typical in designing and are

utilised to distinguish auxiliary abnormalities, for example, breaking and different harms [10]. Concerning scour, visual reviews include using jumpers to assess the state of establishment components and gauge the profundity of scouring utilising fundamental instrumentation [11]. Two specific drawbacks related to this investigation technique incorporate the way that assessments can't be completed during seasons of flooding when the danger of scouring is the most elevated, and the greatest profundity of scouring may not be recorded as scouring gaps will, in general, be filled in as flood water dies down [12].

### COMPARATIVE SLOTTED BRIDGE PIER STUDIES

Lately, a few investigations have been thought about the Slotted connect dock in various exploration papers. Scouring decrease may change as per the position, shape, and length of the opening.

As the state of this space changes, the decrease of scouring changes. On the off chance that we use Y and T moulded spaces as a countermeasure to decrease scouring, results are discovered as Y formed openings were discovered more successfully than T formed spaces slot.



**Fig. 3 Three-dimensional line drawings of: (a) straight slot; (b) slot T1; (c) slot T2; (d) slot Y1; (e) slot Y2**

Greatest scour decrease productivity was appeared by two specific spaces, one having a diminished downflow edge of y moulded opening and one straight opening individually 33% and 38%. An expansion in the left point of y formed space diminishes the presentation as it expands the vitality misfortune and scouring. As far as volume decrease of scouring, Y moulded space with a little point between leave discovered to be more proficient as a 59% decrease in volume and for the straight opening decrease in the volume of scouring is discovered to be 53%.[13]

The current examination demonstrated that collars and openings might altogether diminish profundities at connect wharves. The trials performed permit makes the accompanying determinations. The arrangement of space decreases the scouring to an incredible degree. When the opening is given beginning from water surface to downwards decrease of scouring was somewhere in the range of 48% and 85%, while when it is provided starting from the stream bed to upwards, it was somewhere in the field of 60% and 88%. In this manner, the space Position is a particular that straightly affects the scour profundity, with the best situating close to the bed [14].

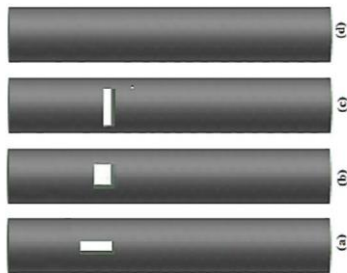
The space measurement additionally influences the decrease of scouring. Suppose we give stature "D" width"  $D/4$ " in a roundabout wharf, where "D" is the distance across the extension dock. The outcomes show that when space is inserted under the waterway bed keeping the stature as D, scour profundity will be diminished about 20.34% to 39.73% in the front of the wharf and diminishing in scour volume is 46.84% to 75.74%. [15]

The scouring profundity changes as indicated by the situation of the space. Scouring is least when space started from the beginning of the waterway bed and is more when the opening situation is over the stream bed level. In an examination of scouring in space arrangement, a decrease of scouring profundity was more in an opening having a length in run zero to double the measurement of the dock which is discovered 23.8% decrease and in space having a length equivalent to the distance across of the wharf and beginning above stream bed level is discovered 12% decrease. Results show that scouring profundity is affected by the proportion of the average speed of the waterway to the edge speed of silt, and scouring diminishes as the proportion decline. [16]

An opening penetrated close to the underlying bed surface doesn't impact the water level; at a short length upstream to the opened chamber, the stream goes amiss through space; nonetheless, such a redirection may marginally stray the methodology stream at a more drawn out separation towards the bed more than on account of an undrilled chamber; in an opened chamber, the disturbance power in the stream wise course increments extensively in the closeness of the chamber front, while it increments somewhat the symmetrical way; in any case, it decreases in the span wise heading; close to space, a striking increment of tempestuous force happens; in any case, it might diminish for profiles farther from the cylinder.[17]

An opening is demonstrated to be compelling in lessening scour, especially if space reaches out into the bed. Nevertheless, space is incapable if the methodology stream has a high obliquity concerning the opening widths to build a plan

relationship. The slot has indicated an expansion in proficiency whenever implanted in the waterway bed. The opening productivity diminishes as the point between the space and the stream increases, and the space is inadequate when the opening crosses over to the stream. [18]



**Fig. 4 Pier with different slot shapes and without slot**

Between all the openings at any height from the bed level, the base profundity of scouring happened in space No. 3. They are expanding the width of the space benefits more than expanding the stature. The game plan of the adequacy of space measurements on scouring decrease in the scaffold wharves is opening No. 3 (width more noteworthy than tallness), space No. 2 (width indistinguishable from tallness), and opening No. 1 (a width littler than stature). In an expansion to the opening's size, those spaces introduced close to the bed surface result in the greatest scour profundity identified with different rises. The wharf was opened from the bed level to the stream level, and with rising the current speed, the scour profundities were diminished. The scouring profundities for spaces close to the water level were not exactly the other opening areas. In this way, among all the models watched, space No. 3 ends up being more effective at the third level lessening the scour profundity by 20%. It ought to be noticed that the spaces on the docks don't regularly ensure to bring about lessening scour

profundity. Explicit investigations will be completed on each case, taking the docks' components and the spaces' setup into account. [19]

## SCOUR MONITORING USING DEPTH MEASURING INSTRUMENT

Given the significance of the scouring issue, the scope of instrumentation has been created to scour gap advancement. These instruments can be extensively arranged as follows: single-use gadgets, heartbeat or radar gadgets, covered or driven bar systems, sound-wave devices, fiber-Bragg grinding gadgets and electrical conductivity gadgets. They are portrayed independently in the accompanying sub-segments.

### 1. Electrical conductivity device

Gadgets utilise the distinctions in the electrical conductivity of different media to decide the area of the water-residue interface. They take a shot at the guideline of estimating an electrical flow between two tests. If the material between the tests changes, the capacity for a current to be drawn will likewise change. This marvel can be utilised to demonstrate the presence and profundity of scouring. A case of a gadget that utilises this innovation is the electrical conductivity test [20]

### 2. Fibre – Bragg grating

Fibre-Bragg grinding sensors are a type of piezo-electric gadget [21]. These sorts of sensors work dependent on the idea of estimating strain along implanted cantilever poles to produce electrical signs, which can show the movement of scouring along the pole. It has been discovered that the move of the Bragg frequency has a straight relationship with the applied strain in the hub heading [22]. An inserted pole that turns out to be somewhat presented because of scouring will be

exposed to hydrodynamic powers from the progression of water that actuates bowing in the uncovered bar. This bowing permits the strain sensors to identify that the pole is free. If few strain checks are situated along the bar, the movement of scouring might be observed. These gadgets perform especially well in observing the adjustment in scour profundity with time at their introduced area and are moderately modest to create. Their answer, nonetheless, relies upon the dividing of the sensor exhibit along the bar. It can likewise be profoundly delicate to vibrations of the help structure utilised, with vibrations happening because of streaming water or traffic excitation from the scaffold. A few surveys of the viability of the methodology report that there is little contrast between covered and uncovered sensors because of this wonder [23].

### 3. Driven buried rod devices

Covered or driven bar frameworks include the attractive sliding collar, the "Scuba mouse", the Wallingford "Tell-Tail" gadget, and mercury tip switches. These instruments deal with the guideline of a manual or mechanised gravity-put together physical test that rests with respect to the streambed and moves to descend as scour creates. The gravity sensor is normally situated around a covered or driven pole framework in the streambed. It must be adequately huge to forestall infiltrating the streambed while in a static state. A distant detecting component is normally used to distinguish the adjustment inside and out of the gravity sensor. On account of an attractive sliding collar, the area of the collar comparative with its unique position is dictated by the conclusion of attractive switches along the inflexible bar. As the streambed disintegrates, the sensor moves along

the bar, and its attractive nature makes these switches close. The information can be physically or naturally read. On account of programmed perusing, adaptable links can be appended to the framework, which passes on attractive switch terminations back to an information obtaining unit. This gadget gives a generally direct strategy to scour profundity movement; be that as it may, there are a few weaknesses. In the manual readout mode, the sensor requires a framework as metal tubing that can be helpless to harm from garbage impacts, especially during seasons of hefty flood stream. Scour profundities must be distinguished in the immediate region of the gadget, so a few gadgets might be needed to catch the valid (global) effect of scouring. The gadget utilises a gravity sensor, and in that capacity, it stays at the most minimal profundity of scouring after each flood occasion [24]. This implies it might need to be reset, which can be expensive and tedious and gives no data on scouring opening re-filling. [4].

Mercury tip switches can be utilised on a determined or covered pole to scour. This deal with the rule that when a steel pipe is foreshadowed into the ground, switches situated along the pole overlay facing the line, hence shutting the circuit. If the streambed materials disintegrated, the switches open accordingly, breaking the circuit. Because of its effortlessness, this gadget gives a powerful method to recognise scour near the sensor establishment region. They are diminishing the sensor switch exhibit separating permits the precision to be improved. Detriments related to this instrument incorporate how mercury is utilised in the sensor, demonstrating unsafe to the earth whenever delivered [24]. Likewise, the sensor can't

demonstrate that scour gap re-filling has happened because the switches can't close again once opened. It can notwithstanding give a decent gauge of the greatest scour profundity created.

#### 4. Single-use devices

Single-use gadgets comprise buoy out gadgets and fastened covered switches that can distinguish scour at their establishment areas. [24, 25] that can scour at their areas of the establishment. These gadgets are introduced vertically in the riverbed, almost a dock or projection of scouring of intrigue and work on the rule that when the profundity of scouring arrives at the establishment profundity of the gadget, they essentially coast out of the dirt. When the gadget changes from a vertical direction to a level one (after coasting out), an electrical switch triggers, which can show to an information procurement framework that the gadget is no longer in the ground and that the scour profundity has arrived at its height. Fastened covered switches regularly have three status markers: "in position", "coasted out", and "not operational [25]. Although these are exceptionally straightforward mechanical gadgets, they have a few certain impediments. They require the costly establishment and have just a solitary use before they should be re-introduced and can demonstrate that the scour profundity has arrived at the gadget's situation. Accordingly, they give no additional data on the greatest scour profundity came to. Tethered buried switches should likewise be straightforwardly hard-wired to an information securing framework and, as such, are powerless to trash harm. Buoy out gadgets have a limited measure of put away force, which implies they must be supplanted in the long run as a major aspect of typical support strategies. However, float-out gadgets and fastened

covered switches are generally dependable bits of gear because of their characteristic straightforwardness and can satisfactorily demonstrate when the profundity of scouring has arrived at their establishment profundity [4]

#### 5. Pulse or radar devices

Pulse or radar gadgets use radar signals or electromagnetic heartbeats to decide changes in the material properties when a sign is proliferated through a changing physical medium [26]. This regularly happens at a water-dregs interface, and along these lines, this kind of gadget can distinguish a profundity of scouring at a specific area. Time-space reflectometry (TDR) is a technique that utilises changes in the dielectric permittivity constants between materials to decide a profundity of scour at a particular area [27]. This technique was initially evolved by electrical specialists keen on identifying discontinuities along force and correspondence lines [28]. Estimating tests are introduced into the dirt at an area of scouring of intrigue. A quick rising advance drive is sent down a cylinder that decides the interface between the water and the dirt, henceforth the profundity of scouring. They work dependent on the rule that when the engendering wave arrives at a region where the dielectric permittivity changes (for example, the water-sediment interface), a bit of the vitality is reflected in the beneficiary. They can consequently be utilised to watch the variety of scouring profundity with time [29]. The strategy requires long tests to be introduced into the waterway bed at the area of intrigue, which can be costly and tedious. The estimation exactness is influenced by fluctuating temperature in the channel, with relative blunders of the request for 5% being revealed in certain

examinations. In any case, checking the divert temperature notwithstanding the TDR wave form can relieve this effect. [30]

## CONCLUSION

Scouring reduction varies if the slot dimensions or position is changed. The slot is found most efficient if the angle between slot and current is 0-20 degrees. The Y-shaped slot is found more effective than the T-shaped slot, and if the angle between two branches of Y is less, the scouring reduction is 53-59%. If the slot is provided at the river bed level, the reduction of scouring is in the range of 48-88%. The dimension of the slot is also important for scour reduction. If the width of the slot is in the range 0-2 times the pier diameter, the scour reduction is 0-23.8%, and if the height of the slot is kept as the pier diameter, then scour reduction is 46-75%. Different types of monitoring devices are used according to the site condition. Single-use devices are not preferred mostly because it is one-time use and does not give the maximum scouring depth. A more effective device is fibre Bragg grating as it gives maximum scour depth and real time continuous monitoring.

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