EXPERIMENTAL INVESTIGATION OF BRIDGE PIER SCOURING WITH RIP RAP ENCLOSED IN MESH

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Abstract- Bridge pier scouring poses a significant risk to the stability and safety of transportation infrastructure, necessitating effective countermeasures to mitigate its impact. This study presents an experimental investigation aimed at evaluating the effectiveness of rip rap enclosed in mesh for reducing scour depth around bridge piers. Scaled models representing bridge piers were constructed in a laboratory flume, and rip rap enclosed in mesh was installed around the piers. Controlled experiments were conducted to simulate varying flow conditions and sediment transport processes. Data on water flow velocity, sediment transport rates, scour depth, and rip rap stability were collected and analyzed. The results demonstrate that the use of rip rap enclosed in mesh significantly reduces scour depth compared to unprotected scenarios. Taking Oblong pier as reference before installing riprap value of scouring was 0.83 which later was reduced to 0.62. Furthermore, the overall scouring that was reduced is 74.5%. Insights gained from this study contribute to the understanding of scour processes and the effectiveness of rip rap with mesh in mitigating bridge pier scouring. Practical recommendations are provided for the design and implementation of rip rap protection systems to enhance the resilience of bridge infrastructure against hydraulic scour.

Keywords- *Bridge, Mesh, Rip rap, Scouring*

1 Introduction

The erosive action of running water causes bridge pier scouring, which is a serious risk to the structural integrity and stability of bridges worldwide. As shown in figure 2. [1] Scouring can undermine the foundations of bridge piers, leading to structural instability and potential collapse, with potentially catastrophic consequences. [2] Consequently, there is a pressing need for effective scour mitigation measures to safeguard bridge infrastructure and ensure public safety.[3] Among the various scour countermeasures, rip rap – loose stone or concrete rubble – has long been utilized to protect bridge piers from scour erosion. Rip rap functions by dissipating flow energy and resisting erosive forces, thereby reducing scour depth around bridge foundations. However, traditional riprap placement techniques may not always provide optimal protection, as sediment migration and instability can compromise its effectiveness. To address these limitations, researchers and engineers have explored innovative approaches to enhance rip rap performance. One such approach involves enclosing rip rap within a mesh framework, which serves to contain the stones and prevent sediment displacement. By changing flow patterns and improving the riprap's structural stability, the mesh promotes sediment deposition and lessens scour. The purpose of this project is to conduct an experimental investigation into the efficacy of riprap contained in mesh as a bridge pier scour countermeasure.[4] By subjecting scaled models of bridge piers to controlled flow conditions in a laboratory setting, this research aims to assess the effectiveness of rip rap with mesh in reducing scour depth and enhancing stability. The findings of this experimental study are expected to contribute valuable insights into the performance of rip rap enclosed in mesh as a scour mitigation measure. [5] These insights will inform the design and implementation of effective scour protection strategies for bridge infrastructure, ultimately enhancing resilience and safety in transportation systems. Scouring around bridge piers significantly threatens bridge stability and can cause tragic failures if not addressed effectively. [8]

2 Research Methodology

A comprehensive experiment was conducted at the Water Resources & Hydraulics Engineering Laboratory of the University of Engineering and Technology, Taxila, focusing on mitigating bridge pier scour. The experiment utilized a 20-meter-long glass-sided flume equipped with adjustable features to control water flow characteristics precisely as shown in figure 1. A model pier resembling real-world designs was placed within distinct test sections of the flume, each evaluating different pier protection strategies.[6] These tactics comprised conventional riprap, bare piers, and several mesh-enclosed riprap designs with different mesh qualities. Instruments such as point gauges and depth sensors were strategically placed to quantify scour depth around the pier in each section.[7] The main experiment comprised operating water flow for a predefined amount of time, mimicking flood occurrences or observation periods, and monitoring the scour depth surrounding the pier during that time.[9] After the experiment, thorough analysis compared scour depth and patterns across sections, focusing particularly on the effectiveness of mesh-enclosed rip rap in reducing scour compared to traditional methods. This research aims to provide valuable insights into enhancing bridge safety and longevity through improved pier protection techniques.[10]

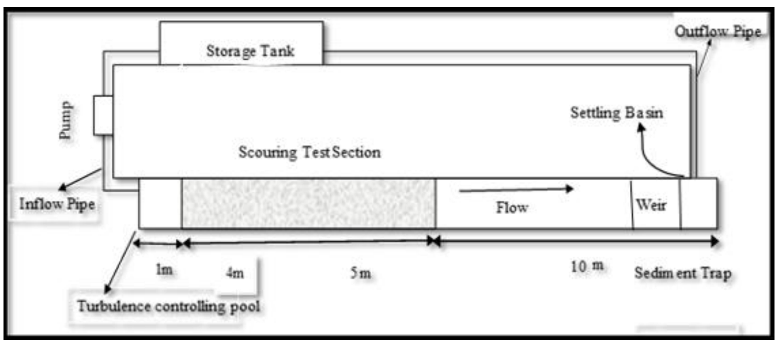

Figure 1. Schematic Diagram

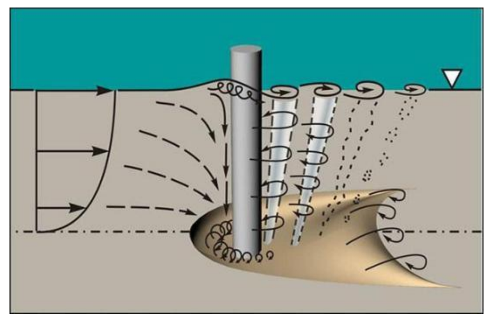

Figure 2. Local Scouring

3 Results

All the experiment was performed in clear water flow conditions, which means that the velocity of the flow was less or equal to the threshold velocity or critical velocity [Vc], in clear-water scouring conditions maximum scouring occurs at the threshold peak, where '*h*' is the flow depth, '*T*' is the time in hours, '*Q*' is the discharge, S is the separation distance, from the upstream submerged rip rap, *ysf* is the maximum scour at the upstream face of pier. Table: 1 shows the hydraulic parameters of the present experimentalstudy. As the figure 3 and 4 shows the relation between V/Vc and ds/D with mesh where 5 and 6 figure shows without mesh relation. As, V represent velocity and Vc is the critical velocity and ds represent the scouring depth and D is the dia of the pier in table 1. Rather of depending on weirs and other expensive techniques, we might choose a more economical course of action with easily accessible resources. Because it substantially lowers scouring at just a percentage of the expense, this alternate approach is preferred.

Table 1Experimental Values

					Without Mesh			With Mesh		
Shape	**Discharge 'cm^3/s'**	**Bed Depth 'cm'**	**V/Vc**	**Fr**	**Dia 'cm'**	**ds**	**ds/D**	**Dia 'cm'**	**ds**	**ds/D**
	22	15	0.47	0.019	6	5	0.833333333	6	5	0.625
	27	15	0.59	0.024	6	5.4	0.9	6	5.4	0.675

Oblong	32	15	0.71	0.029	6	5.9	0.983333333	6	5.9	0.7375
	38	15	0.84	0.034	6	6.4	1.066666667	6	6.4	0.8
	42	15	0.95	0.038	6	6.7	1.116666667	6	6.7	0.8375
Circle	22	15	0.47	0.019	6	5.3	0.883333333	6	5.3	0.6625
	27	15	0.59	0.024	6	5.7	0.95	6	5.7	0.7125
	32	15	0.71	0.029	6	6.2	1.033333333	6	6.2	0.775
	38	15	0.84	0.034	6	6.7	1.116666667	6	6.7	0.8375
	42	15	0.95	0.038	6	7	1.166666667	6	7	0.875
Square	22	15	0.47	0.019	6	5.5	0.916666667	6	5.5	0.6875
	27	15	0.59	0.024	6	5.9	0.983333333	6	5.9	0.7375
	32	15	0.71	0.029	6	6.4	1.066666667	6	6.4	0.8
	38	15	0.84	0.034	6	6.9	1.15	6	6.9	0.8625
	42	15	0.95	0.038	6	7.2	1.2	6	7.2	0.9

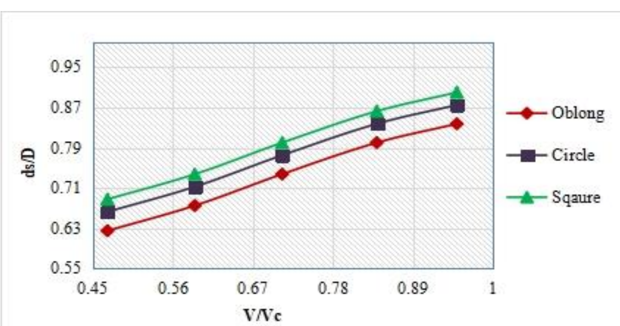

Figure 3. Graph with Mesh

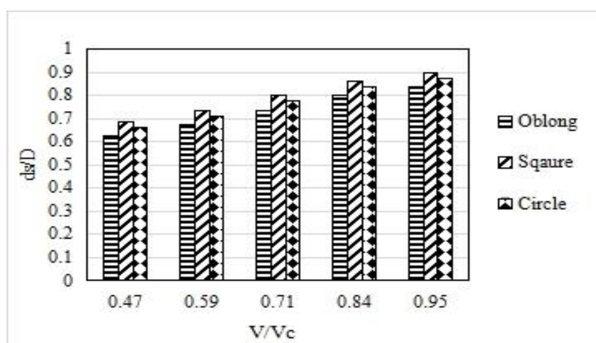

Figure 4. Graph with Mesh

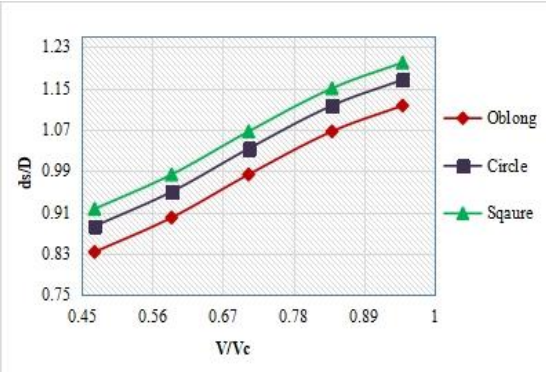

Figure 5. Graph without mesh

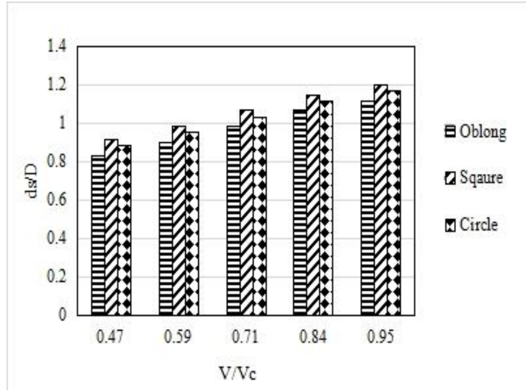

Figure 6. Graph without mesh

4 Conclusion

Using riprap that is covered with mesh greatly decreased scouring. After three distinct forms were tested (oblong, round, and square), the oblong design produced the best results. Both pre-and post-installation investigations show that the oblong pier greatly reduces scouring to the maximum degree. Using figure 3, 4, 5 and 6 we can see that before rip rap installation, scouring in the oblong pier measured was 0.83, but it dropped to 0.62 after installation, the lowest figure achieved across all shapes. When the findings before and after rip rap installation are compared, a 21% reduction in scouring is seen. Furthermore, using rip rap encased in mesh reduces scouring by 74.5%. This highlights the tremendous usefulness of rip rap, especially when paired with mesh reinforcement, in reducing scouring.

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