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Comparison of Different Configurations of Air-bubble Screens around the Pier to Control Scour

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Abstract

Scouring is a natural phenomenon caused by erosive action of flowing water on the bed. The formation of a scour hole around bridge piers has been the subject of intensive research for many years. Researchers have been introduced a lot of techniques to prevent and reduce local scour at bridge piers. In present study, a new method to reduce scouring around piers has been assessed. A bubble-screen located around the pier are used to counteract the downward flow and avoid the initiation of scour. In addition the capability of bubble-screens in front half of the pier has been assessed and compared with a complete bubble-screen around the pier. Results indicate that the complete bubble-screen is more efficient than the bubble-screens in front half of the pier.

Keywords: Scour; Bridge; pier; bubble-screen.

INTRODUCTION

Local scour around a pier is a result of the interaction amongst the pier, the approach flow and the erodible bed. A main cause of bridge failure is scour around the pier. Bridge failures through out the world, as reported in literature, have attributed general attention to understand the scour process and for developing improved ways of protecting bridges against scour.

The two major countermeasure techniques employed for preventing or minimizing local scour at bridge piers can be classified into two categories: (i) bed armoring countermeasures and (ii) Flow-altering. In the former case, the objective is to combat the erosive action of the scour inducing mechanisms using hard engineering materials or physical barriers such as rock riprap. In the latter case, the objective is to either inhibit the formation of the scour inducing mechanisms or to cause the scour to be shifted away from the immediate vicinity of the pier. Chiew and Lim (2000), Lauchlan and Melville (2001), and Dey and Rajkumar (2007) focused on the first category and using armoring devices for reducing local scour at bridge piers [1,2,3]. Efforts have been made to reduce scour by using submerged vanes [4], a delta-wing-like fin in front of the pier [5], and slot through the pier [6,7].

According to previous studies, local pier scour is directly related to the magnitude of vertical flow (discharge and velocity) parallel to the pier face. Therefore, it should be possible to reduce the scour depth by reducing the magnitude of the vertical flow at the upstream pier face. It could be also blocked by using a barrier placed perpendicular to the pier face. The objective of the present study is to have a first idea on the potential of a new technique that consists in counteracting the vertical velocities impinging on the bed by means of upward velocities induced by air-bubbles rising from a pressurized complete and half collar situated near the bed. This principle was successfully used to attenuate local scour in open-channel bends [8,9]. With respect to "hard" engineering techniques, bubble screens have the advantages of being controllable, ecological (oxygenation), reversible and non-permanent.

Bubble plumes or screens have already been successfully applied in several hydraulic fields at large and small scales such as lakes destratification [10], as a pneumatic barrier against saltwater intrusion [11] or to prevent shoaling in navigation channels [12].

In present experimental study the capability of bubble-screens to reduce scour around the pier has been assessed.