Pier and abutment scour

Collaboration between:

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Generalized entrainment criterion

This research intends to generalize the Shields' entrainment criterion for bridge hydraulics. Two related problems of sediment hydraulics are addressed:

- Inception of sediment transport for nearly uniform flow of both uniform and non-uniform sediments for two different sediment densities, and grain sizes ranging from sand to gravel, and
- generalized inception conditions if elements are inserted in a plane sediment bed.

The Shields' criterion is formulated with basic quantities involving gravity, viscosity and densities of the two-phase flow. The results of the analysis relate to the viscous, the transition and the fully turbulent regimes. The transition regime is verified with extended laboratory experiments. Then, these conditions are used as a basis for formulating a general stability criterion for loose bed hydraulics, and compared to detailed experiments involving pier and square elements located either at the channel side or at its axis. In addition, a generalized densimetric particle Froude number is introduced that accounts for both uniform sediments and mixtures. The engineering application of the present results is straightforward, given that basic parameters of hydraulics, sediment and fluid are involved.

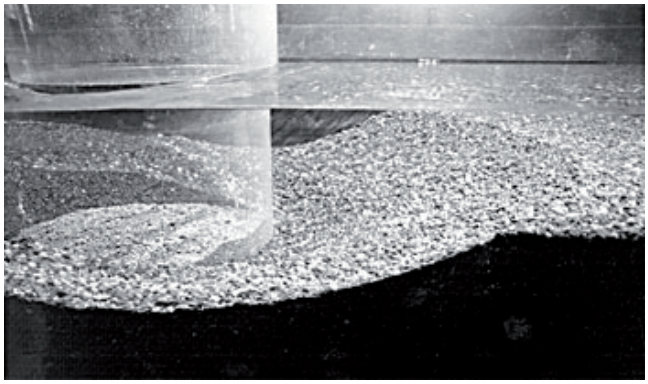

Fig. 1: Scour phenomena in a rectangular channel for a sediment mixture.

Scour related to bridge hydraulics received much attention in the past decade, including its relation to flood hydrology and hydraulic processes in addition to steady flow. New research on bridge pier and abutment scour is presented based on a large data set collected at ETH Zurich, Switzerland (Fig.1). In total six different sediments were tested, of which three were uniform. Also a large variety of scour elements were considered, from 1 to 60% of the channel width, and flow depths ranging from 1 to 40% of the channel width. Using similarity arguments and the analogy to flow resistance, an equation for temporal scour evolution is proposed and verified with the available literature data. The agreement of the present scour equation with both the VAW data and the literature data were considered sufficient in terms of river engineering accuracy, provided limitations relating to hydraulic, granulometric, and geometrical parameters are satisfied. These limitations are discussed and refer particularly to effects of viscosity, which were excluded in the present scour equation.

Keywords:	bridge piers, abutments, scour, data collection, sediment transport, entrainment
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