ABSTRACT

Local scour around bridge abutments in alluvial channel bottoms is an unavoidable problem. Accurate prediction of the scour depth and pattern is essential for safe and economic design of the bridge foundation. Overestimation of the local scour leads to uneconomic design while underestimation of the local scour leads to unsafe design. The local flow field around bridge abutments is a complex phenomenon. It is three-dimensional separated vorticial turbulent flow. The local scour pattern around abutments depends on the bridge abutment shape, local flow field, type and properties of the erodible bed. Extensive studies have been conducted on abutment scour in the past few decades. Most of the available studies focused on estimating the maximum or the equilibrium scour depth in non-cohesive sandy soil. Until recently, few investigations are available to estimate the equilibrium scour at bridge abutments in cohesive soil. Experimental study of local abutment scour in cohesive soil is a difficult process due to the complex erosion characteristics of the clay and the difficulty in scaling the properties of the cohesive soil. Few general-purpose formulas are presently available to predict the equilibrium local abutment scour in cohesive soil. These formulas are considered to be in the initial stage.

The present study has the following two major goals. The first is to study the flow field around a vertical bridge abutment for sandy soil and clayey soil. The second is to develop scour prediction formulas to predict scour pattern at a vertical bridge abutment for sandy soils and for clayey soils. The study also aims to investigate the difference between the scour pattern for sandy soils and that for clayey soils. All experiments are carried out for clear water range. Vertical wall abutments are used with three different sizes. Two sets of experiments are conducted. The first set consists of twenty four experiments for non cohesive soil (medium sand with D_{50}=0.38mm). The second set consists of forty experiments for cohesive soil (Kaolin clay mixed with silica with various clay contents, varied compactions, and varied liquidity indexes) and is divided to three subsets. In the first subset, the effect of the clay content percentage in the mixture is investigated by varying the percentage of clay in the mixture. The compaction and liquidity index are kept almost constant. In the second subset, the effect of the compaction percentage of the mixture is investigated by varying the compaction percentage of the mixture. The clay content and

liquidity index are kept almost constant. In the third subset, the effect of the liquidity index of the mixture is investigated by varying the liquidity index of the mixture. The compaction and liquidity index are kept almost constant.

Specific formulas are developed for cohesive soils to predict the equilibrium scour pattern around the bridge abutment (maximum scour depth and its location, geometry, scour volume, scour width, lateral profile, side slope, longitudinal profile and longitudinal slope of the scour hole) in terms of the dominating factors that affect and control scour process (Froude number, clay content, compaction, liquidity index, and vertical-wall abutments dimensions). Also, a specific formula is developed for cohesive soils to predict the development of scour depth with time. A computer program is developed to get the equilibrium scour pattern around the bridge abutment and the development of scour depth with time. The flow field around bridge abutment with all its features (vortices, down flow, and circulation) is investigated through detailed 3-D velocity measurements performed with the Acoustic Doppler Velocimeter (ADV) for non cohesive soils as well as for cohesive soils. The data presented in this study is useful for the development and validation of a flow field model, which can be used for the estimation of scour depth at bridge abutments.