Preface

There are ample numbers of examples of slender structure in practice that are subjected to fluid flow. Slender structure is the structure having larger dimension in one direction compared to other two directions. Slender structures significantly disturb the flow around them. When the slender structures are embedded and mounted in erodible bed, erosion and deposition of sediments takes place in channel or river. Most of the bridge piers are slender structure in geometry and constructed in erodible channel bed. When flow passes around these structures the flow pattern and kinetic energy of flow changes. At the point of contact, eddy currents or vortex are formed on either side of the object depending on fluid flow velocity. This formation of vortices creates a local increase in pressure and a local decrease in velocity on one side of the obstruction. Due to changes of flow pattern bed shear stress changes, as a consequence, the erosion and deposition of sediment takes place. Scour hole is formed surrounding of these structures may be uniform or no-uniform. Due to the complexities of both the flow field and the scour mechanism, numerical modeling of the scour process around bridge piers remains a difficult research topic. Prediction of maximum scour depth around bridge pier is necessary for safe design. Channel morphology highly influenced by slender structure in erodible channel.

In view of this fact, the flow characteristics around slender structure are studied extensively in the present research work to get better understanding of flow behavior and its influence on channel morphology both experimentally and numerical modeling.

In the present study an attempt has been taken to find the flow characteristics around slender structures in forms of pier model. All the experimental programs are carried out in the Water Resources and Hydraulics Laboratory of the Department of Civil Engineering, Indian Institute of Technology (Banaras Hindu University), Varanasi, India. Experimental model is developed keeping similarity with erodible sand channel bed in open channel flow. The Ganga sand is used to layout the sand bed of the flume. Pier structures in physical system are modeled by simulation of cylindrical, rectangular and oval shape slender structures.

Maximum equilibrium scour depth around the piers model is observed in clear water flow conditions with erodible channel bed in flume. Effect of shape, size and fluid flow characteristics are experimentally studied for maximum equilibrium scour depth around these structures. From the experimental observation, it is reveal that rectangular pier subjected to water flow produces more scour depth compared to cylindrical shape pier. Flow visualization is carried out during experiments to observe the motion of water surrounding these structures. The movement of sand particles and their deposition pattern in channel bed shows that eddy motion exist around the slender piers. The shape of scour hole is measured after each run of the experiments. The scour hole formation and its movement is schematically explained by plotting contour of this hole. Few studies are also carried out to observe the effectiveness of collar as a preventing device of scouring in erodible channel bed. It is observed that the concentric collar resist the motion of water in vertical direction along the pier body and resist the movement of soil particles, as a result, the maximum depth of scour hole reduces.

An attempt has been also made to study the flow behavior around slender structure that act as obstruction in flow path in rigid boundary open channel by mathematical modeling. The economical depth of flow in channel section is derived analytically for rectangular and trapezoidal cross section with slender structure mounted on rigid channel bed for a given discharge and multiple barriers in flow path. A simple condition is proposed for design of efficient channel section with obstruction in its flow path. Energy of flow in critical flow condition is determined with slender structure in rectangular channel section and compared the energy of flow with the flow conditions in channel section with obstruction and without obstruction.

The flow characteristics around circular and rectangular slender structure in flow path are studied extensively using ANSYS V 14.0 Fluent software. The k-ϵ turbulence model is used to find the flow behavior around slender structure. The time averaged velocity component, turbulence kinetic energy and pressure variation are found at different vertical planes of pier section. Few results are presented to give an over view of the flow field around piers for different flow velocity that passes the slender structure. The influence of multiple barriers in

flow path is studied for rigid-boundary channel section using numerical model. When the numbers of barrier increases at any cross section the interference of barriers may be taken place which depends on the spacing of two consecutive piers and pier diameter.

The effect of slender structure embedded in sand bed of open channel is studied by HEC-RAS modeling keeping similar boundary conditions of present experimental work. The maximum scour depths are found for piers of different shape and size used in experiments by CSU equation used in HEC-RAS software. The experimental results obtained in the present study are compared with the HEC- RAS results and it is found suitable.

Finally, an attempt has been taken to study the change of morphology specifically the changes of river courses of Ganga River near Varanasi and the effect of bridge piers of Viswasundari Bridge on it. The course of River Ganga at Varanasi is studied for last 10 years satellite image that data available in Google Earth after construction of bridge. Sinuosity and morphology are interrelated and it needs attention to study the plan form of a river and its historic change of course. The satellite image reveals that the morphology of the Ganga River has been changed in last few years in terms of sinuosity and silt deposition. The rate of deposition of sand in river course changes in last few years.