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Measurement of turbulent flow field along a bridge abutment

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Change of riverbed morphology under stresses imposed by flow on erodible boundaries can scour piers and abutments positioned in the riverbed, thus exposing their foundations to flow and rendering them susceptible to destabilisation. Therefore, scour is considered to be one of the most important hazards regarding bridge safety with catastrophic consequences, and novel methods and frameworks for its monitoring are needed (Bekić et al. 2017, Valyrakis et al. 2015). Scour holes developed next to the bridge elements create variations in riverbed geometry throughout the bridge profile as a result of sediment erosion and deposition. This variation in riverbed geometry directly influences three-dimensional flow and vortex systems next to the bridge elements, and can further contribute to development of scour.

Measurement of turbulent flow field next to abutments has not been yet extensively investigated as the flow field at piers. Approaching flow upstream of the bridge is generally one-dimensional in the downstream direction, and becomes three-dimensional at the abutment that protrudes into flow field. Rajaratnam and Nwachukwu were the first to measure the shear stresses at the upstream abutment corner and found them to be up to 5 times higher than the approach shear stress. These findings were backed up by several other researchers, measuring amplification of the average bed shear stress in the range between 1.6 and 3.63 times near the nose of an abutment in comparison to free flow upstream. This increase in shear stress resulting in higher values than critical for sediment size, combined with increased turbulence and vortex structure, may be considered as the primary cause of scour at abutments.

The subject of this study is to shed light to the nature of the flow field next to the bridge abutment. Three-dimensional turbulent flow field along a stone masonry arch bridge abutment that resulted in the development of local scour hole is investigated. Scaled model experiments are conducted in a sufficiently wide and long (1.8x12m) laboratory flume on scoured bathymetry frozen using glued sand to physically represent in sufficient detail the scoured riverbed bathymetry. Experiments have been carried out under different flow conditions using acoustic Doppler velocimetry. For each of the different flow rates, flow velocity has been measured on 6 ensembles, 4 in the bridge profile and 2 upstream at the bridge approach section, and each ensemble consisted of 8 velocity measurement points. Measured flow field is represented using the measured velocity data through vector and contour plots. From the measured data Reynolds and boundary shear stresses were also calculated.

References

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