INVESTIGATION OF FLOW PATTERN AT SCOURED ABUTMENT IN NON-UNIFORM GRAVEL BED

GORDON GILJA [1], MANOUSOS VALYRAKIS [2], PANAGIOTIS MICHALIS [3], DAMIR BEKIĆ [4], NEVEN KUSPILIĆ [5], EAMON MCKEOGH [6]

[1] *University of Zagreb, Faculty of Civil Engineering, Croatia, ggilja@grad.hr*

[2] *University of Glasgow, School of Engineering, United Kingdom, manousos.valyrakis@glasgow.ac.uk*

[3] *University of Zagreb, Faculty of Civil Engineering, Croatia, pmichalis@grad.hr*

[4] *University of Zagreb, Faculty of Civil Engineering, Croatia, damir.bekic@grad.hr*

[5] *University of Zagreb, Faculty of Civil Engineering, Croatia, kuspa@grad.hr*

[6] *University College Cork, School of Engineering, Ireland, e.mckeogh@ucc.ie*

Abstract

Presence of scour at abutments significantly influences flow pattern in their vicinity, increasing turbulence and inducing vortexes in the flow field. Size of scour hole depends on flow parameters and is proportional to flow augmentation. Scour hole equilibrium depth is achieved under long-term exchange of high and low flows, but greatest scour hole depth occurs during high flows. Hydrographic surveys deployed for flow field measurement are influenced by high flow conditions, making acquisition of reliable results uncertain and survey procedure dangerous. For this reason, survey is mostly conducted during low and mean flows, when water depth is shallow and flow velocity slower. Survey conducted this way may not be representative of flood induced hazard on bridge safety as bed-load material can be deposited in scour hole during low flows and conceal its final depth. Therefore, the quantification of final scour hole depth generally involves coupled hydrodynamic and sediment transport models for a range of hydrological events covering both high and low flows and comparison of results to measured data.

Sediment transport process associated with scour is especially complicated to describe in gravel bed rivers. Application of empirical relations developed for gravel-bed rivers can result in sediment transport scour depth estimation using flow data as input, but cannot give estimate of turbulence characteristics that are primary generator of local scour t abutments. Continuous long-term water levels and discharge measurements are rarely readily available on smaller streams, so probability of occurrence for significant high flow events can be challenging to calculate. Therefore, most reliable results can be achieved using physical modelling in laboratory conditions.

Research has been conducted on scoured bridge abutments of a single span masonry arch bridge in south Ireland. Riverbed material is sand-gravel mixture, with coarse cobbles armouring the riverbed and hiding finer grains. The numerical and physical sediment transport model are established based on detailed bathymetry data surveyed along a rectangular grid of 50cm spacing. Aim of the research was to determine critical conditions for sediment incipient motion under which mass movement of bed material occurs and resulting flow pattern in the bridge profile. Flow field investigation on physical model is conducted under two flow regimes: fixed bed and mobile bed. Flow velocity profile is measured on 4 verticals (from left to right: A, B, C, D) at profile immediately upstream (BUS) and downstream (BDS) of the bridge.

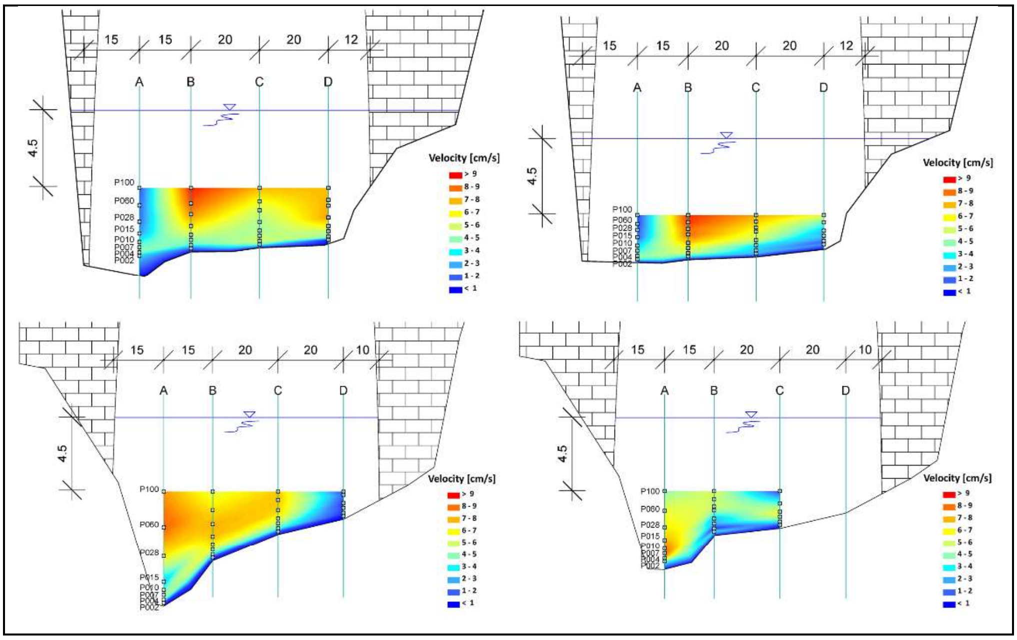

Figure 1. Contour plot generated for flow field at BUS for fixed bed (a) and mobile bed (b); at BDS for fixed bed (c) and mobile bed (d)

Complex flow field characteristics extracted from measurements justify use of physical model for investigations of abutment scour and resulting flow field in steep streams. Physical model results correlate well with numerical model results. Abutment scour is shown to be related with local flow field, making it difficult to estimate using conventional empirical methods. Accurate determination of incipient motion for bed-load material provides important information needed for assessment of structural risk associated with flood events.

Keywords: abutment scour, sediment transport, physical model,

Acknowledgement

The authors wish to acknowledge the financial support of the European Commission, through the Marie Curie action Industry-Academia Partnership and Pathways Network BRIDGE SMS (Intelligent Bridge Assessment Maintenance and Management System) - FP7-People-2013-IAPP- 612517

View publication stats