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Scaling approach for physical modelling of pier scour

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Physical modelling of local scour around bridge piers is challenging due to the three different similarity criteria that need to be satisfied for the complete similitude of the model and the prototype. To achieve the complete similitude, geometry, flow and sediment material in the model scale need to be scaled simultaneously. Aim of this paper is to calculate the scale parameters of the physical model used for scour assessment next to piers protected with riprap. The scale parameters are calculated individually for each prototype – two bridges located on the Drava River and one on the Sava River. Hydrological conditions are determined by analysis of flood wave amplitude and duration from the nearby hydrological station adjacent to the pilot bridge. Experiments will be conducted with different pier shapes and sizes, as well as with two different materials representing the riverbed – same density as prototype and lower density material. Range of discharges used for simulating various flow conditions are selected to be compatible with the flume pump capacity. To calculate required thickness of sediment trap layer in the hydraulic flume, expected scour depth is estimated. Sensitivity analysis of 13 empirical equations was conducted due to differences in hydraulic and geometric conditions of each prototype [1]. Bathymetric survey was the basis for establishing a numerical model, and its results were input parameters for empirical equations. Finally, scour depths were estimated as the average of all equations results except those results that turned out to be inadequate. Scaling affects the time parameter of the scouring process, and therefore an adequate time scale is calculated to achieve full development of the scour hole with respect to flow conditions. Finally, as a result of the flume restrictions, advantages and disadvantages of the physical model distortion are discussed.

[1] Cikojević, A., Gilja, G., Kuspilić, N.: Sensitivity analysis of empirical equations applicable on bridge piers in sand-bed rivers, Proceedings of International Symposium on Water Management and Hydraulic Engineering, Skopje, Republic of North Macedonia, pp. 100-108, (2019)

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