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Calculation of local scour at bridges over large Croatian rivers

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Local scour is phenomenon associated the most with bridge piers in sand-bed and gravel-bed rivers. Depth and extent of local scour hole reach their maximum during flood events as a response to extreme flow depth, velocity and shear stress, potentially posing a threat to the bridge stability. At the same time, extreme flow conditions resulting with maximum scour hole present challenge for flow and bathymetry data collection as they impose restrictions on the measuring equipment. Scour hole depth and extent recorded during low flows can greatly differ from the conditions that are representative for bridge stability estimation due to the backfill effect. Focus of this research is on testing the applicability of the available empirical equations on scouring around piers of 7 bridges over large Croatian rivers: Danube, Drava, Sava and Kupa. All analysed bridges have one or more piers positioned within the main river channel directly interacting with flow oscillations, and therefore are suitable for evaluation of existing scour equation applicability on field data. Potential scour depth estimation for each bridge is calculated using empirical equations and compared to the depth of scour hole obtained from field measurements. Using calculated and measured data in comparison with foundation type and depth potential threat on bridge stability is evaluated. For every bridge measured data consisted of detailed bathymetry in the bridge opening and its vicinity complemented with cross-sectional riverbed geometry on adjacent river reach. Flow field survey conducted in parallel with bathymetric survey was used for calibration of hydraulic model. Flow conditions were simulated using HEC-RAS flow modelling software for 100-year flood estimated from long-term gauging station data. For calculation of scour depth 1D hydraulic design module within the HEC-RAS was set-up using previously calculated flow environment in the bridge opening. Site specific conditions enabled evaluation of calculated results across span of discharges and resulting flow depths, velocities and Froude numbers, as well as pier shapes, sizes and alignments. Based on the results it can be concluded that CSU equation implemented through HEC-RAS cannot be used for all analysed flow and river channel conditions to reliably predict scour depth. Scour depths calculated using CSU equation show strong correlation with measured values for sand-bed river channels, while for gravel-bed rivers significant differences of calculated and measured values are present.