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Flow structure over square bars at intermediate submergence: Large Eddy Simulation study of bar spacing effect

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A b s t r a c t

Turbulent open-channel flow over 2D roughness elements is investigated numerically by Large Eddy Simulation (LES). The flow over square bars for two roughness regimes (k-type roughness and transitional roughness between d-type and k-type) at a relative submergence of $H/k = 6.5$ is considered, where H is the maximum water depth and k is the roughness height. The selected roughness configurations are based on laboratory experiments, which are used for validating numerical simulations. Results from the LES, in turn, complement the experiments in order to investigate the time-averaged flow properties at much higher spatial resolution. The concept of the double-averaging (DA) of the governing equations is utilized to quantify roughness effects at a range of flow properties. Double-averaged velocity profiles are analysed and the applicability of the logarithmic law for rough-wall flows of intermediate submergence is evaluated. Momentum flux components are quantified and roughness effect on their vertical distribution is assessed using an integral form of the DA-equations. The relative contributions of pressure drag and viscous friction to the overall bed shear stress are also reported.

Key words: wall roughness, Large Eddy Simulation, double averaging.