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# How do macro-roughness elements affect bed-load sediment motion?

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Experimental results are here presented for bed-load particle motion in the presence of macro-roughness elements (MREs). Experiments were performed at the Hydraulics Laboratory of the Politecnico di Milano using plastic particles (size of 3 mm) as bed-load sediment that was fed into a rectangular-section, pressurized duct. The bottom of the duct was covered with a number of MREs, represented by concrete semi-spheres (diameter of 35 mm) that were not mobilized by the hydrodynamic conditions used. The experiments thus mimicked the transport of fine sediment in the presence of immobile boulders, that is one possible idealized representation of the granulometric variability found in natural water courses. The work is part of a project devoted to the characterization of particle kinematics for different roughness of the bed, undertaken within a long-term cooperation with the Environmental and Industrial Fluid Mechanics group at the University of Aberdeen (UK).
Different flow conditions were tested. For each, MREs were placed in two different arrangements, corresponding to triangular grids with variable side length (130 mm and 100 mm). Colour of sediment was appropriately chosen (white grains over black background) to enable bed-load particles to be tracked by an image processing software (Streams, developed by the University of Canterbury, New Zealand). Particle kinematics was described using typical quantities: path length and tortuosity, path-averaged and instantaneous velocity components in the stream-wise and transverse directions, duration of motion events. The collected database was considerably wide, in terms of both measured particle paths and instantaneous velocity values.
Results are discussed in terms of the measured kinematic properties and also comparing the sediment motion to that obtained for the same hydrodynamic conditions and in the absence of MREs. A discussion is made about comparability of the different scenarios, as the presence/absence of the MREs creates different relationships between the bulk flow properties (e.g., discharge) and the friction velocity, whose scales of spatial variability are also much different.