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Effects of rigid stems on sediment transport

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Abstract

The vegetation is an important factor of quality of the river ecosystem, given its capability to contribute to the chemical, biological and physical quality of water. On the other hand, the presence of vegetation in riverbed modifies flow structure, flow resistance, sediment transport and morphology. Each single modification has been largely studied, but the knowledge on the mutual relationships are still limited.

This project faces a part of these still-unknown aspects by considering the case of rigid and emergent vegetation and the relationships with sediment transport, flow field, flow resistance and bed forms at small scale. The thesis is based on experimental approach coupled with theoretical analysis.

In particular, the research contributes with a rational approach to the formulation of sediment transport capacity of a vegetated riverbed as a function of hydrodynamic conditions, types of sediments, dimension and distribution of plants. The validity of the ballistic approach is proved by the comparison with a large number of experimental results obtained in a laboratory channel, in which the vegetation was modeled with cylindrical and rigid elements. The experimental results were carried out for different flow conditions, arrangement of cylinders and cylinder dimensions. For the tests, three different sediments were used, at different densities and grain sizes. The comparison allows the determination of some empirical parameters related with the velocity of movement of particles, characteristics of sediments and plants incumbrance.

A partially rational approach for the determination of the empirical parameters comes from the analysis of the flow field through the cylinders. The experimental data highlight bed areas in which the contribution to the sediment discharge is smaller, and bed areas in which is larger, with respect

The flow field analysis shows also the physical mechanisms which rule the formation of bed forms induced by plants. Height and length of vegetation bed forms are measured and related with the density of vegetation, with the plant diameters and with the average distance between the cylinders interaxis. In particular, the

experimental data show the linearity between length of bed forms and average distance between stems.

Finally, measurements of the drag force exerted by the cylinders to the flow were carried out by means a load cell fixed to the cylinders in staggered configuration. The measurements were done in a channel with fixed bed, both plane and with bed forms. The experimental measurements of drag show that the drag coefficient depends on the density of vegetation and on the presence of bed forms. This dependence is confirmed by comparing the indirect measurements of the drag coefficient with the measurements done with the load cell and fixed bed. The indirect measurements were done in the flume with mobile bed and sediment transport, for both the staggered and random distribution of cylinders.

The direct measurements in the different experimental setup and the comparison between direct and indirect measurements put in evidence that the vegetation bed forms give a contribution to global resistance that, in particular cases, is comparable with the contribution due to the rigid stems, demonstrating that to consider negligible their effect can be sometimes a rough approximation.