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Effects of sediment clustering on flow resistance in steep coarse-bed streams

Anshul Yadav and Sumit Sen
Indian Institute of Technology Roorkee, Department of Hydrology, ROORKEE, India (ayadav@hy.iitr.ac.in)

The flow velocity and discharge estimation are important in fluvial geomorphology and other wide variety of scientific purposes in river research applications. However, in steep coarse-bed streams dominated by large sediments and irregular channel beds, the conventional equations fail to consider the additional losses, leading to the overestimation of flow velocity. In such cases, the science of flow resistance, particularly during low relative submergence (y/D_{84}), and active transport conditions, needs to be revisited. Since the poorly sorted sediments on the channel bed also increases the resistance in the flow (Yadav et al., 2021). This work examined the effects of geometric standard deviation (σ_g) of the bed material on flow resistance in steep streams using the dataset reported in the literature and conventional flow resistance equations. The flow resistance estimates in poorly sorted sediments were observed to be unreliable for the non-uniformity () range 7.5-10 for all the equations, however relatively better flow velocity estimates were observed for σ_g greater than 10. This distinct response of flow resistance equations for σ_g ranging between 7 to 10 was probably due to additional losses occurring due to armouring and formation of sediment clusters and reticulate structures in this subset of the data. The dimensionless shear stress (τ^*) exerted on the channel bed for the dataset with σ_g between 7.5 to 10 was in agreement to develop sediment clusters as suggested by various researchers. Furthermore, when the geometric standard deviation exceeds 10, the unbiased flow velocity estimates using the conventional flow resistance equations indicate the reduced resistance in the flow field. This behaviour may be attributed to the smoothing of bed or change in bed conditions either due to disintegration of bedforms and sediment clusters at higher discharge or structural instability.

Keywords- Flow resistance, sediment sorting, non-uniformity, sediment clusters, armouring, shear stress

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