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Modelling of Collisional Bed Load at High Bed Shear

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Sediment-laden turbulent flow at high bed shear in an open channel with a mobile bed is discussed. The bed surface is plane, fully mobilized (bed Shields parameter between 0.4 and 2.0 approximately) and interacts with a developed transport layer in which transported sediment grains are supported by mutual collisions. The transport layer occupies a considerable part of the flow depth. The distribution of grains across the transport layer exhibits a steep gradient of local granular volumetric concentration between the top of the layer (the local concentration is virtually zero) and the bottom of the layer (the local concentration approaches the bed concentration). This affects behavior of flow carrying the collisional load.
We discuss a granular-rheology based modelling framework for predicting the bed-load flow rate at conditions given by channel geometry and carrying liquid flow conditions. The flow rate is related with relevant flow parameters through granular constitutive relations which describe the collisional character of distributions of local granular quantities as granular normal stress, shear stress, concentration and velocity across the transport layer. The modelling framework offers alternative constitutive relations based either on the phenomenological approach (principles of dense granular flow rheology) or on the kinetic-theory approach. The alternative approaches are evaluated by means of our experimental results obtained for intense bed load of lightweight model sediment in a laboratory tilting flume.