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Experimental Estimation of Mean Flow Velocity under Overland Flow

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Precise estimation of mean flow velocity is imperative for the accurate prediction of hydrograph and sediment yield. For overland flow, the mean flow velocities are normally estimated by multiplying the dye or salt based velocity measurements with a correction factor (α). A wide range of correction factors are available in literature, which were proposed under different experimental conditions. The selection of a suitable correction factor has become a main challenge for accurate flow calculations.

Therefore, this study aimed to assess the variability of correction factor (α) with grain size & bed gradient for mobile beds and also to evaluate the dependency of mean flow velocity on flow rate, grain size and slope by regression analysis.

In order to accomplish the objectives, laboratory flume experiments were performed at flow rates from 33 to 1033 x 10^{-6} m^3 s^{-1}, bed gradients ranged from 3^o to 10^o, and median sediment diameters ranging from 0.233 to 1.022 mm. The flow velocities were measured directly with the dye tracing technique (U_{dye}) and indirectly derived from flow depth measurements (U_{depth}). Dye based flow velocity measurements are always considerably higher than depth derived flow velocities, particularly for finest sand due to its steep velocity profile. The derived values of α (U_{depth}/U_{dye}) do not remain constant for all selected grain sizes and increase significantly with the increase of grain size: the derived mean values of α for 0.230, 0.536, 0.719 and 1.022 mm sands were 0.44, 0.77, 0.82 and 0.82 respectively. Hence, due to the substantial variation of α with grain size, no absolute value of α is applicable to all hydraulic and sedimentary conditions. However, the derived mean α values for 0.230 and 0.719 mm sands were found comparable with the α values available in literature for similar grain sizes.

In this study, U_{depth} measurements were considered as the mean flow velocities (U_{mean}). The influence of discharge (Q), slope (S) and median grain diameter (D_{50}) on U_{mean} was studied by regression analysis. The regression analysis depicted the significant influence of Q and D_{50}on U_{mean}, but the effect of slope was found to be almost non-significant. The proposed model was successfully validated with five literature datasets. Therefore, the proposed model could be confidently used to estimate mean flow velocity within the range of conditions for which it was derived i.e. $33 \leq Q \leq 1033$ x 10^{-6} m^3 s^{-1}, and $0.233 \leq D_{50} \leq 1.022$ mm.