



Dimensional analysis of natural debris flows

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Debris flows occur when masses of poorly sorted sediment, agitated and saturated with water, surge down slopes in response to gravitational attraction. They are of great concern because they often cause catastrophic disasters due to the long run-out distance and large impact forces. Different from rock avalanches and sediment-laden water floods, both solid and fluid phases affected by multiple parameters can influence the motion of debris flows and govern their rheological properties. A dimensional analysis for a systematic study of the governing parameters is presented in this manuscript. Multiple dimensionless numbers with clear physical meanings are critically reviewed. Field data on natural debris flows are available here based on the fifty years' observation and measurement in the Jiangjia Gully, which is located in the Dongchuan City, Yunnan Province of China. The applications of field data with the dimensional analysis for studying natural debris flows are demonstrated. Specific values of dimensionless numbers (e.g., modified Savage Number, Reynolds number, Friction number) for classifying flowing regimes of natural debris flows on the large scales are obtained. Compared to previous physical model tests conducted mostly on small scales, this study shows that the contact friction between particles dominates in natural debris flows. In addition, the solid inertial stress due to particle collisions and the pore fluid viscous shear stress play key roles in governing the dynamic properties of debris flows and the total normal stress acting on the slope surfaces. The channel width as a confinement to the flows can affect the solids discharge per unit width significantly. Furthermore, a dimensionless number related to pore fluid pressure dissipation is found for distinguishing surge flows and continuous flows in field satisfactorily. It indicates that for surge debris flows, the high pore fluid pressures generated in granular body dissipate quite slowly and may influence particle contact behaviour significantly.