Geophysical Research Abstracts
Vol. 17, EGU2015-5511, 2015
EGU General Assembly 2015

A new Parameter to Determine Degree of Fragmentation of Rockslides

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When a rock slope fails, the consequent transport of materials depends on the bulk state of the rock mass. For example, if the rock mass collapses and disintegrates into a granular material, appropriate transport models need to consider the physics of granular material to determine the rock mass transport and final travel length. In contrast, should the failure occur on a well-defined failure zone and the block have sufficient cohesion, the rock mass can be considered as an elastic block. However, were the block to experience high stresses during its travel, for example from impacting the ground after free falling, it may still fragment and turn into a granular material. Determination of which systems immediately collapses, which remain intact and which is likely to fragments during transport is of key importance to choose appropriate transport models.

To do this requires a quantitative description of which systems will undergo fragmentation and which will not. To simplify matters somewhat, we only consider the question whether or not the material experiences enough stresses during its travel for fragmentation to occur. Fragmentation of a rock mass is determined by numerous variables such as its intact rock strength, pre-existing fracture density, size and geometry, as well as the topography of the slope. However, as it is not yet understood how these variables interact, such a description is still lacking. Here we suggest such a description for a special case of a cuboid sample traveling over a slope break.

We perform a series of tests using a newly developed analogue rock material of which the bulk material cohesion can be controlled. In the tests, a cuboid shaped sample of the analogue material is released down a slope of 45° at a height of 0.7 m and impacts on a horizontal plate. The tests show that the degree of fragmentation depends on aspect ratio, kinetic energy and material strength of the samples.

To collapse of the data from all three variables, we characterize a sample proneness to fragmentation by a parameter (S_{eff}) consisting of the estimated peak tensile stress in a samples normalized by its bulk cohesion. The peak tensile stresses in the sample is estimated from elastic thin plate theory (Kirchhoff's theory) modified with a factor $(h/l)^2$ due to the samples non-negligible thickness, where h is the thickness and l is the length of the sample in the direction of travel.

Combining the experimental test results and the new parameter S_{eff}, we determine thresholds of the parameter value which discriminate whether fragmentation occur, as well as between intermediate and high degree of fragmentation. Since S_{eff} is determine solely from initial conditions, this new parameter can be used to predict the degree of fragmentation. To test the applicability of our new parameter, we calculate the value of S_{eff} for the Seymareh rock avalanche and find that its value predicts it to be within the range of highly fragmented materials, as expected.