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First contribution to debris slope stability analysis of the Sciara del Fuoco (Stromboli island, Italy) via particle numerical modeling

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The Stromboli island is one of the most active volcanoes in the world. Its structural evolution has been characterized by four large sector collapses affecting the NW flank, resulting in the creation of the Sciara del Fuoco horseshoe-shaped depression. Our interest has been focused on local and general stability of the Sciara del Fuoco recent volcanic debris. These loose deposits represent a potential unstable mass that can be mobilized evolving in granular flow. This volcanoclastic material, running along the Sciara del Fuoco into the sea, can form tsunami waves as in the latest landslide events of December 2002 and January 2003. This paper presents the first steps toward the stability analysis of volcanic debris via particle numerical modeling according to the following steps: geotechnical characterization of materials; calibration of the input geotechnical parameters; numerical analysis applied to the Sciara del Fuoco slope. The involved materials have been characterized by a) measure of physical properties by standardised laboratory tests and b) consolidated-drained triaxial compression tests which have given the peak and residual shear strength angle and cohesion respectively: cp'=0, phip'=43°-51° and cr'=0, phir'= 39°-49°. The process of the Sciara volcanic debris slope destabilization has been analysed by the distinct element theory using the particle based numerical code PFC2d. A set of biaxial tests have been simulated by numerical modeling and compared with the experimental triaxial compression tests. The sensitivity analysis has been focused on finding the particle mechanical parameters that better represent the rheology of the volcanic debris at the macroscopic scale.

Specific mathematical relations between mechanical parameters of the single particles and particles assembly have been found as a function of the acting state of stress and taking into account the scale effect. For the debris stability analysis, the initial geological section has been created with an ensemble of independents particles reproducing a simplified volcanic succession constituted of volcanic debris overlying a lava bedrock. The slope has a constant dip, comparable with that of Sciara del Fuoco, and a length of 250m. The micro-mechanical parameters of the volcanic debris have been assigned in accordance with the results of the calibration process, while the lava bedrock is assumed as a rigid block. Different simulations have been performed in defining the destabilizing factors, the critical thresholds, and their effects.