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Post-Failure behaviour of pyroclastic debris flow

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The Campania Region is covered by pyroclastic soils accumulated in the last tens of thousands of years as a result of volcanic activity of Campi Flegrei (Phlegrean Fields) and Somma-Vesuvio. These materials cover the slope of the hilly area of Naples and mountain sides of Appennino. Even if they present significant physical and mechanical differences from site to site, they are posing the same geotechnical problems: they are usually unsaturated and collapse due to the increase of water content after prolonged rains creating simple or complex type of landslides (translational or rotational sliding or falls that lead to debris flows). While the mechanical properties of natural soils are the object of a number of research works, the evolution of the material after failure is much less often studied. Typically the post failure behaviour of this material may be “solid-like” or “fluid-like”, according to causes that are not well-known. The object of this presentation is the study of the rheological behaviour of the “fluid like” material mixtures with fluid mechanics tools. Three natural pyroclastic deposits were sampled and the soils were remixed with distilled water at different solid volume fractions. The behaviour of these mixtures was investigated like a fluid with a vane rotor rheometer and an inclined plane. The main results are that the rheological behaviour is strongly related to the solid volume concentration, but the transition between solid-like to fluid-like behaviour occurs in a small range of solid concentration slightly different for each material tested. In the fluid-like behaviour the material mixtures behave like a yield stress fluid and a classical Herschel-Bulkley model well represents the experimental data. Nevertheless a hysteresis effect, associated with instability of the material behaviour, is observed for the largest solid concentrations. In that case the material starts to flow abruptly beyond a critical stress and rapidly reaches a relatively high shear rate. These results suggest that in the field during the debris flow motion little variation of solid fraction lead to change the behaviour from solid-like to fluid-like and vice versa. The critical shear rate related to low shear stress for lower solid fraction might explain the in situ observed post failure behaviour of pyroclastic debris flow, which is able to flow over very long distances even if over smooth slopes.