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SOME CONSIDERATIONS ON DEBRIS FLOW RHEOLOGY

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The debris flow is often considered to be a mixture of viscous slurry, consisting of finer grain sizes and water, and coarse particles, thus the flow curve is more complex. Recent developments in the rheological study of water - debris mixture have demonstrated that the behaviour of such mixtures can be classified into many different categories according to the clay fraction content. For a lower clay fraction (as in this case), granular fluid models are employed (Iverson, 2003). For a higher clay fraction, yield stress viscoplastic fluid models are generally used (Coussot, 1997).

In order to evaluate the rheological curve of the pyroclastic deposits, rheometer tests were carried out using the *Dynamic Stress Rheometer* at the Department of Engineering of Materials and Production (DIMP) of ‘Federico II’ University of Naples. The tests were carried out in the configuration with parallel plates with controlled stress and temperature. Although this geometry is less precise in terms of the velocity of imposed deformation (there is no uniform rotational velocity inside the cylinder of the material subjected to flow), it has the advantage of being simpler to use, making it easier to charge the instrument. This rheometer makes it possible to establish the curve of flow directly with a single test (the *shear rate sweep test*). The upper and lower limits of the deformation velocity are set and the instrument gives constant readings of the value of the viscosity.

The tests were carried out only on fine particle-water suspensions of the analysed soils due to the size of the instrument used, with varying volumetric concentrations of the solid substance (C_v). In general, it can be seen that the mixture behaves like a non-Newtonian fluid. For concentrations equal to 30% (corresponding to a porosity of 70%), the behaviour of the mixture is pseudoplastic (shear thinning) since the apparent viscosity decreases with the shear rate. The flow curve is well described by a Herschel & Bulkey model. With the increase in water content (or the reduction in the solid volumetric concentration), a change in behaviour can be observed: in particular, for concentrations of 20%, the apparent viscosity increases slightly with the shear rate, displaying behaviour typical of non-Newtonian dilatant fluids (shear thickening). The experimental results were compared with the flow curves for several clay suspensions with different sandy fractions (Coussot and Piau, 1995). It was observed that as the sandy fraction increases, so too does the threshold τ, while the parameters n and k remain almost constant. Coussot and Piau (1995) showed that the addition of free particles to a clay-water mixture gives suspensions with higher apparent viscosity. The flow curve level increases with added sand concentrations according to O'Brien and Julien (1988) and Major and Pierson (1992). If the solid fraction is not too large, a Herschel Bulkley model may be fitted to data and the suspension yield stress increases almost exponentially as a concentration of sand.

As a first approximation, pyroclastic deposits can be considered as yield stress fluids. However, because the parameters of their constitutive equation change significantly during flow as a result of solid - fluid exchanges, descriptions of flow dynamics remain speculative.