SCHOOL OF DOCTORAL STUDIES IN ENVIRONMENTAL ENGINEERING - XVIII Cycle

Claudio Dalrì

Shear induced phenomena in concentrated flowing suspensions

Abstract of the doctoral thesis

Supervisor: **prof. Aronne Armanini**

External Referee: **prof. Christophe Ancey** (Federal Polytechnic of Lausanne)

Mudflows are one of major natural hazard, claiming thousands of lives and millions of dollars in lost property each year in almost all mountain areas on the Earth. The practical interest of such flows is enormous due to the disruptive effects of the propagation of mud front through the incisions of hillslopes and their spreading on the alluvial fans which are located at the foot of mountains and are often densely populated. The constitutive behaviour of such highly concentrated suspensions has been the subject of several experimental investigations (O'Brien 1988, Coussot, 1997). Though the issue cannot be considered as completely settled, however the suggestion has often been made that Bingham or Herschel – Bulkley models may provide a first approximation of the actual mechanical response of these systems.

However, these approaches prevent the possibility of analyzing separately the behavior of the solid phase and the one of the interstitial fluid, and erosional and depositional mechanisms at the bed are neglected, too. Within this frame, equilibrium conditions are supposed not to take place and mudflow is always treated as a rigid-bed flow.

Besides, the rheological parameter are considered as function of concentration and mineralogical composition only. Consequently, the rheology is recognized only as function of material.

Starting from some declarations by Astarita & Marrucci, every macroscopic behaviour should be explained through the knowledge of microstructural state. So this one and its evolution are fundamental subjects to analyse. In particular some chemical and mechanical scientists points out that the microstructure is a shear depend-structure. From this different point of view is logically intending the rheology as a property of the flow.

An experimental stage has been worked out to investigate suspension dynamics with different dispersed-phases under laminar and turbulent flow regimes. In opportune conditions a static equilibrium layer was observed to form on the bottom, over which a free-surface suspension was flowing in uniform conditions. This equilibrium condition on the bed has been focused because of its relevance in natural events such as mudflow or viscous debris flow. Measurements performed in

a new laboratory set-up allowed a description of the velocity field and of the sediment concentration-profile.

A theoretical approach, based on a diffusive model able to consider buoyancy effects and non-Newtonian interstitial fluids, has been adopted and solved for the different experimental runs, applying the proper boundary conditions relevant to the special state of bed-equilibrium. This theoretical effort, underpinned by specific measurements for cases of free-surface suspensions, represents the main novelty of the thesis.