Numerical investigation on flow transformation of sand-rich debris flow into turbidity current

*Yuichi Sakai[1], Hajime Naruse[2]

1. Utsunomiya Univ., 2. Kyoto Univ.

Debris flows induced by a subaqueous landslide may experience flow transformation into turbidity currents through its flow passage. Thus, a debris flow that is initially sand-rich drastically change flow properties due to the preferential settling of fluidized sands in a flow to form a deposit. In contrast, clay particles included in a debris flow are ejected upward and generate a turbidity cloud over the debris flow. However, generation processes to create a turbidity cloud have remained unclear due to the lack of quantitative evaluation.

This study numerically investigated the generation of turbidity currents by flow transformation of subaqueous debris flows. A two-layered layer-averaged model was used to express the flow transformation. In this model, the lower layer represents a debris flow, and the upper layer corresponds to a turbidity cloud. The debris flow layer is approximated as consisting of fluidized sand and pore fluid composed of homogeneous water and clay. The sand in this debris flow layer is gradually deposited according to their settling rate. We considered two mechanisms generating turbidity clouds from initial sand-rich debris flows, which are (1) shear mixing at the surface of a debris flow and (2) release of pore fluid from debris flows. The rate of generation of suspension by shear mixing was formulated to be proportional to the relative velocity between two layers as reported in the previous study. In modeling the rate of generation of suspension by the release of pore fluid, we coupled the release rate of the pore fluid with the deposition rate of sands, assuming that the contractive motion of settling sands squeezes the pore fluid to the upper layer.

Numerical experiments for flow transformation of sand-rich debris flow were conducted, in which debris flow descended a uniform slope. We compared two cases: one incorporated only the process of shear mixing, and the other considered both shear mixing and release of pore fluid. As a result, the latter case considering the release of pore fluid reproduced the behavior of the flow head reported in the literature better. In contrast, the generation of turbidity clouds only by the shear mixing process was inefficient because the relative velocity between the upper and lower layers became smaller after the development of turbidity clouds. The mechanism by the release of pore fluid was remained effective in the whole duration of flows so far as sands deposited from debris flow. Thus, our experimental results imply that the contribution of mechanisms generating suspension varies depending on the development stage of the turbidity current.

Keywords: Sediment gravity flow, Turbidity current, Debris flow, Flow transformation, Numerical model

