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Mechanism of sand slide - cold lahar induced by extreme rainfall

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Along with the increasing frequencies of extreme rainfall events in almost every where on the earth, shallow slide - debris flow, i.e. cold lahars running long distance often occurs and claims downslope residents lives.
In the midnight of 15 October 2013, Typhoon Wilpha attacked the Izu-Oshima, a active volcanic Island and the extreme rainfall of more than 800 mm / 24 hours was recorded. This downpour of more than 80 mm/hr lasted 4 hours at its peak and caused a number of cold lahars. The initial stage of those lahars was shallow slides of surface black volcanic ash deposits, containing mostly fine sands. The thickness was only 50 cm - 1 m. In the reconnaissance investigation, author found that the sliding surface was the boundary of two separate volcanic ash layers between the black and yellow colored and apparently showing contrast of permeability and hardness. Permeability contrast may have contributed to generation of excess pore pressure on the border and trigger the slide. Then, the unconsolidated, unpacked mass was easily fluidized and transformed into mud flows, that which volcanologists call cold lahars. Seismometers installed for monitoring the active volcano's activities, succeeded to detect many tremors events. Many are spikes but 5 larger and longer events were extracted. They lasted 2 -3 minutes and if we assume that this tremors reflects the runout movement, then we can calculate the mean velocity of the lahars. Estimated velocity was 45 - 60 km/h, which is much higher than the average speed 30 - 40 km/h of debris flows observed in Japan. Flume tests of volcanic ash flows by the Forestry and Forest Products Research Institute showed the wet volcanic ash can run at higher speed than other materials. The two tremor records were compare d with the local residents witnessed and confirmed by newspaper reported that the reach of the lahar was observed at the exact time when tremor ends. We took the black volcanic ash and conducted ring shear tests to reveal the mechanism of rapid motion. In the undrained or partially drained tests under pore water pressure test, monotonic loading of shear stress, and constant shear speed conditions, we found that immediately after failure takes place, a big excess pore pressure was generated and accelerating motions had stated in all cases. The reduced shear resistance thereafter was maintained because of the lasting high pore pressure. Even in the partially-drained test, we found once the pore pressure reached almost same with the normal stress and then gradually decreased due to dissipation. Those tests apparently shows that the high mobility and high acceleration of the motion are expected and this could be the key mechanism of the fluidization of initial shallow slides into sand flows, i.e. cold lahars. In the past ring shear test series on volcanic materials from fluidized landslides at El Picaccho of El Salvador, Mt Aso of Kumamto Prefecture, and Nagari Tandikat near Padang, Indonesia, show very similar trends. In all those cases, we expected serious grain crushing during shear, contributed to the generation of excess pore pressure, because those material are deposited recently (in geological time) and suffered no big overburden pressure which means no consolidation and no serious grain crushing ever before. So those volcanic materials are generally susceptible to crushing and expect high mobility when slides are initiated under fully saturated condition.