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Sudden pore pressure rise and rapid landslide initiation induced under extreme rainfall conditions - a case study

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Since July 19 to 26, 2009, western Japan had a severe rainstorms and caused floods and landslides. Most of the landslides are debris slide - debris flows. Most devastated case took place in Hofu city, Japan. On July 21, extremely intense rainstorm caused numerous debris flows and mud flows in the hillslopes Some of the debris flows destroyed residential houses and home for elderly people, and finally killed 14 residents. Debris flow distribution map was prepared soon based on airphoto interpretation. Japanese Meteorological Agency runs nation-wide ground-based rain gauge network as well as radar rain gauges, which provide hourly to 10 minutes precipitation distribution real-time with spatial resolution of about 5 km. Distribution of daily (cumulative) precipitation of July 21 shows (1) The cumulative precipitation from 6 am – 12 am of the day was evaluated that their return period could be 200 - 600 years statistically. In 2009, another extraordinary rainfall, of which intensity was evaluated as less than 100 years more more, caused floods in another city claiming many residents lives on the way to evacuation area. Those frequent extraordinary extreme rainfall is not concluded as the consequence of global warming nor climate change, however, those frequency of extreme rainfall events affecting societies are obviously increasing in Japan, too.

As for the Hofu city case, it was proved that debris flows took place in the high precipitation area and covered by covered by weathered granite sands and silts which is called “masa". This sands has been proved susceptible against landslides under extreme rainfall conditions. However, the transition from slide - debris flow process is not well revealed, except authors past experiment on the similar masa samples in June 1999 Hiroshima debris flow case. Authors have embedded pore pressure control system for the undrained ring shear apparatus.

Strongly weathered sandy soils were sampled just on the smooth and flat granitic sliding surface of one of the upstream small-scale landslides. Those contained finer grains and lower permeability rather than the one sampled in the Hiroshima case. Sample was consolidated by smaller stress corresponding to the site condition, and saturated by overnight circulating de-aired water. Normal stress and shear stress corresponding the slope condition was given, then, pore pressure (back pressure) was raised artificially at constant rate. When the effective stress reached the failure line, suddenly measured pore pressure monitored at about 2 mm above the shear plane, quickly increased. This sudden change abruptly accelerate the shear displacement. Stress condition soon reached the steady state and remained there thereafter. The reason of the excess pore pressure generation was the negative dilatancy, following a slight positive dilatancy. Most of the negative dilatancy could be explained by collapse of loose soil skelton as well as grain crushing during deformation and shearing.