Geophysical Research Abstracts,
Vol. 11, EGU2009-13719, 2009
EGU General Assembly 2009

Ring shear test on creep in soils in help to the early warning on rainfall induced landslides

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Using prefailure creep for time prediction has become popular with the works of Saito and Uezawa (1961), Voight (1983), Fukuzono (1985) and others. The term of creep has been adopted from the mechanics of solids and defined as "time dependent deformation". Creep in different materials was found to show three distinctive phases – primary, when the rate of deformation decreases, secondary with constant rate of deformation and tertiary when acceleration in the rate is observed and eventually leads to rupture. Those phases have been also observed clearly in many natural slope slides. The characteristics of the tertiary creep gave opportunity for developing few time prediction models.

In recent years the ring shear tests have proved to be reliable for simulating close to natural conditions rainfall induced landslides. We worked out our calculations based on the well-known and vastly used Fukuzono's method (1985). He provided the description of the tertiary creep phase with the equation d2x/dt2=A(dx/dt) where x is the surface displacement, t is time and A and are constants. Our aim was to simulate creep in soils by raising the pore water pressure and investigate the mechanism of shear zone development during the creep. We examined the characteristics of the pre-failure deformations – displacement and rate of displacement as to provide new details on prediction of time of failure based on them.

DPRI-5 is an intelligent ring shear apparatus initially aimed on testing the residual strength of sheared soils and simulation of earthquake induced landslides (detailed description on DPRI-5 and its application can be found in Sassa et al., 2004). We chose the ring shear apparatus for its biggest advantage to the direct shear test and the triaxial test of providing predetermined shear zone, which does not change during the test and possibility of monitoring of the pore water pressure in vicinity to the exact shear zone is possible.

We have conducted 15 ring shear tests and analyzed in details the prefailure creep movement in soils triggered by gradually increasing positive pore water pressure. The soil samples were placed in the shear box of the apparatus and brought to a state of full saturation. Then normal stress and shear stress were applied. Backpressure was applied in the shear box from its upper outlets in "naturally drained" conditions until failure occurred.

Based on the shear displacement we calculated the velocity and the acceleration as to determine the beginning of the tertiary creep and to obtain the parameters A and for each test. We found that tends to become bigger with the higher Bentonite or Illite content and with the higher total normal stress and smaller over-consolidation ratio. As the parameter determines the inclination of the velocity-acceleration line in the double-logarithmic relation between them it means that the higher the bigger the inclination. The inclination corresponds to the rate the velocity is increasing and thereafter the speed of which soil is losing its strength. A higher will mean the soil is collapsing faster. That can be an alarm criterion when we have initial data for accelerated movement.

From the above paragraphs the following conclusion could be made. A soil with higher content of Bentonite clay or Illite mineral is going to fail quicker when the tertiary creep is initiated. The same will happen for deeper seated shear zones. As for the effect of OCR – a soil with higher OCR and density respectively has a smaller therefore its tertiary creep will last longer and the acceleration will be smaller than it is for a normally consolidated specimen