Entrapped air influencing slope failures

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A large-scale sprinkling experiment was conducted to examine the effects on entrapped air for the landslide in the National Research Institute for Earth Science and Disaster Prevention in Tsukuba, Japan. Recent study about runoff generation in hillslopes predicts that grand water in bedrock fracture is important for runoff generation (Terajima 1993), and entrapped air can influence the pressure head and runoff generation (Marui 1991). On the other hand, when heavily inflow into drain increase water level at sewer system, water makes entrapped air and compresses the air. Because of that, sometimes compressed air blew off the manhole (Haman and McCorquodale 1982). When soil layer is saturated in the field, air can be entrapped in bedrock fracture. When the rainfall increase water level in bedrock, it can compress the entrapped air. Therefore entrapped air in bedrock fracture can cause of the large force to move the soil mass or water, and it can be result of landslides.

The experimental slope was 6.25 m long, 1.5 m wide, 60 cm depth and 30 degrees. Air pocket, which had 1 m long, 1 m wide and 10 cm height, was built in middle part of slope (position of 80 cm ˜180 cm from end of slope). By drilling through the bottom of the air pocket, we made a 13 mm hole to inject air by using air compressor. The soil which was 0.3 mm average of particle size, 2.0 $*$10-2 cm/s permeability, 15 cm capillary zone, 33 % porosity was compacted in 50 cm layers. We monitored pressure head by 28 tensiometers, runoff by triangular notch, and entrapped air pressure by barograph. Rainfall was constant while experiment was held. Air injection was started after outflow of water became steady state. Experiments were done four times (Run6: 30 mm/h rainfall, 50, 100 L/min air injection. Run7: 20 mm/h rainfall, 50, 100, 150, 200 L/min air injection. Run8: 30 mm/h rainfall, 100, 200 L/min air injection. Run9: 50 mm/h rainfall, 250 L/min air injection). Each air was injected for 3 minutes.

In all experiments, entrapped air pressure and pressure head reacted to air injection. The increased pressure in the air pocket was a linear function of injected air volume. Deep tensiometer measured significantly increase of pressure head, hydraulic gradient was correlated with entrapped air pressure. A landslide, having size 1.2 m long and 20 cm depth began at about 5 seconds after starting air injection in run9, although the increased air pressure was only 3.5 kPa. Previous work shows about 1000 kPa air injection caused the V shaped soil failure or the soil cavity production (Araya et al. 2003). The maximum hydraulic gradient was about 0.7, observed above the center of the air pocket. Suppose hydraulic gradient is neglected, safety factor is calculated at above 1. However, the safety factor is calculated at below 1, due to the increased upward vertically hydraulic gradient. Therefore, the landslide by entrapped air is found to be likely to occur through the increasing the upward hydraulic gradient in the saturated soil.

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