# The effect of entrapped air on water flow in the slope during a pipe clogging event

*山崎 琢平[1]、井本 博美[1]、濱本 昌一郎[1]、西村 拓[1]
*Takuhei Yamasaki[1], Hiromi Imoto[1], Shoichiro Hamamoto[1], Taku Nishimura[1]

1. 東京大学大学院農学生命科学研究科
1. University of Tokyo

Introduction

Soil pipes, continuous macropores parallel to the slope, are often observed at hillslope. Recent field studies revealed that in hillslope, soil pipes usually enhance the drainage from the hillslope during a rainfall event and may keep the slope stable. However, once the pipe outlet is suddenly, clogged soil pipe loses the drainage function, which is considered as one of the causes of the slope failure. Laboratory experiments reproducing the pipe clogging during rainfall have been conducted. These studies showed different types of water pressure rise in the slope during the pipe clogging event; one showed sudden pressure jump, but the other showed gradual increase in water pressure. However, the mechanisms are still unclear.
This study examined the water dynamics in the slope during the sudden pipe clogging. We focused on the effect of the air in the soil pipe on water pressure rise around the soil pipe.

Materials and Methods

An acrylic plastic pipe, 7 mm inner diameter, 10 mm outer diameter, and 50 cm long, was used as an artificial soil pipe. Drain hole with 3 mm diameter were evenly opened on the pipe wall at a density of 1.3 holes cm$^{-2}$. Soil pipe was covered by nylon mesh to prevent sediment inflow. Soil pipe was connected to a pressure transducer through flexible PVC tube to measure air pressure in the soil pipe. Two-needles electrodes were set inside the soil pipe to detect liquid water in the soil pipe.
Acrylic plastic rectangle box, 60 cm long, 4 cm wide and 35 cm high, was used. Downslope boundary of this box was set to the seepage face. Toyoura sand with 3% mass water content was packed to the box with a dry bulk density of 1.43 g cm$^{-3}$ to a thickness of 30 cm. Artificial soil pipe was buried at 2.5 cm above the base of the soil box, and protruded by 1 cm from the downslope boundary. After packing the soil, soil box was tilted up to 20 degrees. Rainfall simulator was used for water supply and rainfall intensity was kept at a rate of 200 mm h$^{-1}$. After steady-state flow was attained, we fitted the ball valve at the pipe outlet. The valve closed suddenly to simulate the sudden pipe clogging. During the experiments, soil water pressure around the soil pipe and outflow rate were measured at every 10 seconds.
Two soil pipe conditions were set. One is the OpenPipe condition, where soil pipe was connected to atmosphere only at the pipe outlet. The other is the OpenMacropore condition, where pipe was connected to the atmosphere through the flexible PVC tube, which represents the vertical macropores open to the soil surface, as well as at the pipe outlet.

Results and Discussion

At steady-state water flow, open soil pipe showed lower groundwater table compared to that without the soil pipe. Soil pipe drained much water from the soil slope.
After the pipe clogging, OpenPipe and OpenMacropore condition showed quite different water and air dynamics in the slope. In OpenPipe experiment, air pressure in the soil pipe showed sudden jump at the pipe clogging, and all the tensiometers around the soil pipe also showed sudden water pressure jump. After steady-state flow, groundwater table became similar to that without the soil pipe. Air in the soil pipe

 

was entrapped suddenly due to the pipe clogging, and the entrapped air prevented water intrusion from the surrounding soil though it had positive water pressure. In OpenMacropore condition, water pressure only at the lower part of the slope rose gradually after the pipe clogging, and electrode sensors showed an increase in water level in the lower part of the soil pipe. At steady-state flow, nearly horizontal groundwater table was formed at the lower part of the slope. This suggested that high permeability of the soil pipe made smaller hydraulic gradient in the lower part of the slope.

キーワード：土壌パイプ、パイプ閉塞、空気封入、斜面崩壊
Keywords: Soil pipes, pipe clogging, entrapped air, slope failure

 