Development of 3D self-potential tomography for visualization of groundwater condition

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In recent years, as the frequency of torrential rain increases, the number of landslides tends to increase. It is important to understand the process of slope failure triggered by rainfall, monitor the slope, and forecast the occurrence time of failure. We are trying to develop an early warning system for rainfall-induced landslide by the Self-potential (SP) method. The SP method is a passive method to measure the electric potential naturally generated by groundwater dynamics using electrodes buried near the ground surface. This method has an advantage that the cost can be reduced and the observation can be performed over a wide range easily, compared with the observation using a pore pressure gauge with a borehole. From the results of the laboratory experiments to date, it has been confirmed that there is a relationship between the movement of water and the displacement of the soil layer and the SP changes (the electro-kinetic effect is the source of SP). Furthermore, in the sandbox experiments, visualization of groundwater dynamics using the SP method (two-dimensional SP tomography) was verified to be effective. However, application to real slopes requires 3D tomography technology. In this paper, we tried to develop a self-potential tomography to realize three-dimensional visualization of groundwater dynamics using a sandbox experiment. Specifically, the consistency of the estimation of the SP generated by groundwater flow by numerical simulation (direct problem) and the inverse problem of estimating the groundwater dynamics (pressure head and water flow) from the natural potential generated by the simulation described above are examined. A computer experiment was performed, and an actual sandbox experiment was performed using the same parameters as the numerical experiments. Here, the computer and the actual experiment are injection experiments: water is poured into the sandbox in which sand is uniformly spread over and water is injected from the lower part of the side of the box. The parameters related to the sand in the soil layer, such as the permeability coefficient, etc., were measured in other experiments.

First, the reconstructed results of pore water pressure (pressure head) and water flow obtained by the forward problem and the inverse problem by computer experiments are harmonious, and the constructed tomography algorithm and its effectiveness have been demonstrated. Also, compared with the reconstruction results by 2D tomography in the previous study, the errors of the pressure head and the magnitude of the flow vector were smaller and the results of 3D tomography were good. Next, an actual experiment of the same scheme as the above computer experiment was performed, and the head and water flow were inversely analyzed from the observed self-potential data. As a result, in the actual experiment, it was found that the pressure head distribution was different from the ideal distribution by the simulation due to the effect of the unevenness of the soil layer. For the reconstructed water flow, it was found that the flow direction by the tracer in the actual experiment and the direction of the reconstructed vector were generally consistent. The self-potential generation model based on the electrokinetic effect, the developed tomography algorithm and its effectiveness were demonstrated. The application to multi-layer structures and practical slopes is an important issue for the future, but it is expected to be applied to the visualization of groundwater dynamics below the slope. Details will be given in the presentation.