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SEEPAGE FAILURE ANALYSIS WITH AIR BUBBLES USING SPH

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ABSTRACT

Large flowage deformations and hydraulic collapse of ground are induced by permeation of water through ground. That plays important roles in the destabilization of ground during floods, liquefaction, injection, driving of pile and so on. It is necessary to model progressive seepage failure in the soil to analyze these phenomena more precisely. Some Reports have found important roles for interactions among all three phases in solids, liquids and gases. In particular, Kodaka and Asaoka's paper [1] might be the first article which revealed importance of dynamics of air bubbles in geo-engineering. Indeed, when the Tokai flood disaster attacked Nagoya region on 11th Sept. 2000, a man saw the process of dike failure. He mentioned in a newspaper that after a crack generated on the surface of the dike, white bubbles water blew out from the dike and then dike gradually failed for about three hours. This kind of phenomena has been seen many times since old time. This blowing air bubbles before seepage failure was called *frog blows bubbles* by elderly people. Figure 1 shows the simple demonstration.

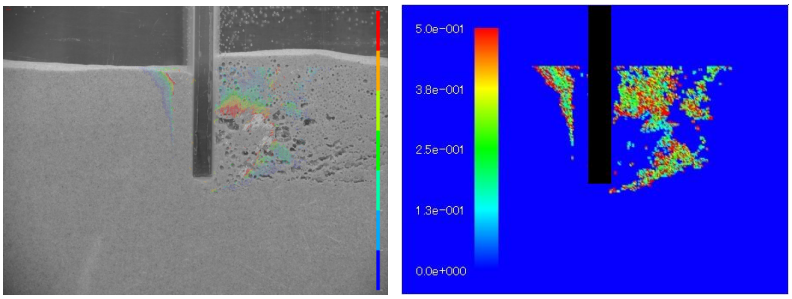

Fig.1. PIV image analysis results of velocity and shear strain rate distributions for a model test of seepage failure around sheet-pile with air bubbles in the case of lower seepage force and higher DO(demand oxygen); 'the target of simulation proposed'

In this study, we conducted model test and developed a new numerical simulation method for the seepage failure with air bubbles. Discrete analysis (e.g. DEM) is adapted to abruption, failure and flowage, but unsuitable procedure to analysis domain of large scale. Continuum analysis (e.g. FEM) has opposite properties to that. The smoothed particle hydrodynamics method (SPH) ([2], [3]), a completely mesh-free technique, was

used to obtain the combined benefits of both distinct and continuum methods. In this study ([4]-[6]), SPH with a new method for calculating density, surface tension and multi-phases coupling was proposed. In this paper, the simulation results, moreover, were verified by comparison with model test results including velocity of ground and pore water pressure at failure. Figure 2 show analysis results using proposed methods.

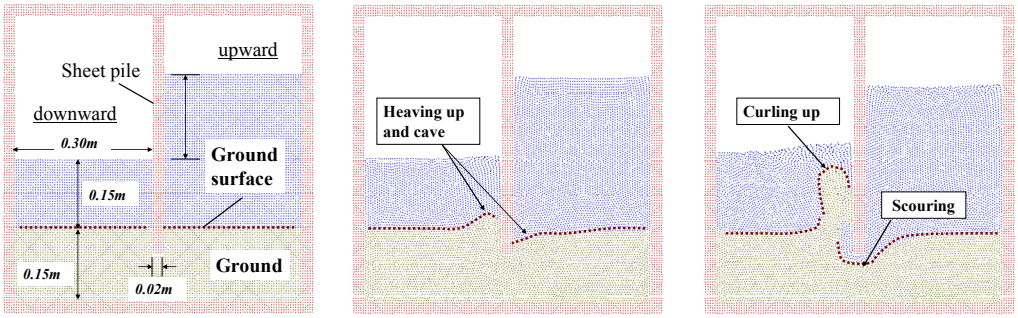

Fig.2. A seepage failure analysis result around sheet-pile using SPH modified.

A series of model tests using PIV image analysis revealed that the evolution of air bubbles in the ground caused the degradation of the ground. The local degradation brings the evolution of bubbles. This paper showed clearly the validation and usefulness of SPH to be applicable for problems three phase. The analysis performance is qualitatively high. Some analysis results were verified with model test results and we found the accuracy of this proposed analysis procedure although we conducted the verification in only some data. The procedure will be able to be developed to simulate seepage failure from the generation of the bubbles to the evolution.

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