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IMAGING FINE SOIL PARTICLES TRANSPORTATION THROUGH SOIL SKELETON CAUSED BY SEEPAGE FLOW

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Summary: Internal erosion, which is a phenomenon of fine soil particles detaching and transporting due to seepage flow, is the main mechanism responsible for disorders or failures of civil engineering structures. In this study, a series of permeability tests were conducted using x-ray tomography in order to visualize the process of occurrence of internal erosion.

1. INTRODUCTION

Internal erosion is a phenomenon of fine soil particles detaching and transporting due to seepage flow. Internal erosion is one of the main causes triggering various problems such as collapse of dams or dikes, land subsidence, or even clogging in the process during producing methane gas from its hydrate state. There is no end to the issues related to internal erosion. In this paper, we focus on failure of engineering structures. These failures usually take place as soon as the soil, which constitutes either the entire engineering structure or only its foundation, comes into contact with water flows [1].
Indeed, numerous soil structure failures have been reported in the literatures. It can be classified into four types according to their boundary conditions. In this paper, we focus on suffusion out of four types. Studies on internal erosion have been carried out However, the mechanisms responsible for the detachment and transportation of fine particles triggering internal erosion are not yet fully comprehended. Accordingly, in this study, we aim at visualization of internal erosion using x-ray tomography and investigation on the process of internal erosion and water pathway in soils based on the CT images analysis.

2. EXPERIMENTAL METHOD

Test sample used in this study is silica No.3 sand and silica No.8 sand, whose mean diameter are about 1.2mm and 0.065mm, respectively, and both the sands are uniform. Measuring weight of silica No.3 and silica No.8: 74.77g of silica No.3 and 32.04g of silica No.8 are mixed to be 7 : 3 as weighted ratio. This mixing ratio is determined based on the test results obtained by Ke and Takahashi (2012) [2]. The specimen is prepared by moist-tamping method. The size of the specimen is 35mm in diameter and 70mm in height. A series of permeability tests was conducted for 3 hours at each hydraulic gradient varying i = 1, 2, 4, 8, and 12 under a confining pressure of 10 kN/m^2. X-ray CT images were taken at each hydraulic gradient level using KYOTO-GEOμXCT [3].

3. IMAGE ANALYSIS

The obtained CT images were segmented by a region growing method [4] into four phases: silica No.3, silica No.8 with water, water, and air phase. Here, we treat silica No.8 mixed with water as a single phase since it is impossible to distinguish silica No.8 itself from a mixture with water due to the limit of the capacity in spatial resolution. Then morphology analysis was performed to extract only the water phase out of four phases and to create 3D images of water phase which exists in the specimen. This morphology analysis enables us to view the change in distribution

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of pure water phase, and thus the process of water passageway advancing during permeability test caused by internal erosion of fine soil particles, silica No.8 through the soils skeleton of silica No.3.

4. RESULTS

Figure 1 shows the results of morphology analysis during permeability tests in which blue portions indicate pure water phase. It revealed that fines were transported and resettled in the specimens and clogging occurred when hydraulic gradient was less than 2. When hydraulic gradient became larger than 4, fines were detached and fully transported without clogging into the outside. Morphology analysis proved that the pore water took the place of fines, after fines which existed in voids were lost due to suffusion. In addition, we observed that the initiation of loss of fine particles began at the bottom of the specimen, the boundary of soil and water, and as a result, water pathway expanded upwardly. Morphology analysis enabled us to observe the formation of large water pathway.

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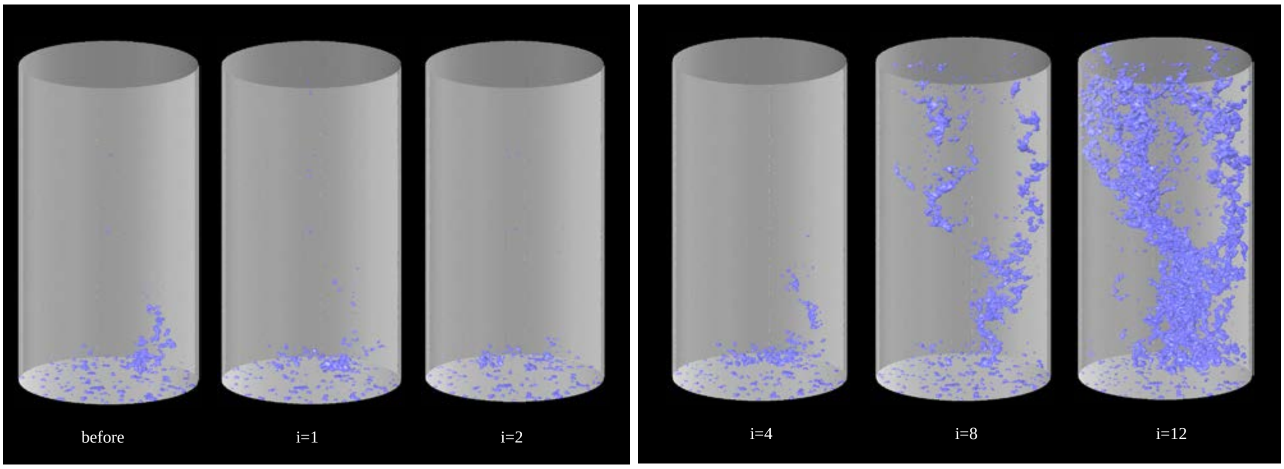

Figure 1: Results of morphology analysis during permeability tests (blue: pure water phase)