B09

Experimental studies of wash out and cavity formation in granular backfill behind a seawall

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1. Introduction

Unsaturated soils extend above groundwater level and have characteristic profiles of suction, depending on the degree of saturation and intensity of capillary actions. The lower the water content, the higher the suction is in general. Factors such as fluid waves, groundwater level fluctuation, infiltration and vibration can trigger wash out of fine particles and cause internal erosion. If the loss of material continues over a prolonged period of time, possible consequences involve cavity formation or surface settlement in the backfill soil behind seawalls. Until now, however, few experimental studies have been devoted to investigate factors that affect cavity formation in unsaturated soils. In order to clarify effects of suction on the formation of cavities and their standing time, we carried out a series of model tests on soil-retaining vertical walls that had apertures below the mean water level.

2. Test apparatus and experimental program

A representative cross section of the soil-retaining vertical wall is shown in Fig. 1. Soil and water chambers were provisioned in a transparent glass flume 60 cm long, 28 cm wide and 33 cm high. The water and sand chambers were separated with a vertical partition of Perspex, which had a circular aperture of a specified size. The provision of the aperture was to simulate leakage that would occur through detects in vertical seawalls under environmental loading such as wave actions. Video camera was used to observe the movement of sand in the course of wash out and flowage. A set of three tensiometers, model No. SK-5500-M6, were used to measure suction changes throughout the test. The locations of the tensiometers were in the capillary fringe above groundwater level.

Silica sand no. 7 (S7, D_{50} = 0.14 mm, h_c = 42 cm) and no. 6 (S6, D_{50} = 0.28 mm, h_c = 28 cm) were used in the tests. During the test, a volume of dry sand was spread by layers in the sand chamber, and then water was gradually introduced to the water chamber such that water seeped into the sand chamber. After the water level became stable (approximately 1 cm above the aperture), the seal of the aperture was removed, and wash out of sand was recorded by a video camera, and suction changes were measured.

3. Test results and discussion

Two tests on S7 and one test on S6 were performed. In all the tests, it was observed that the sand flew out through the aperture, once the seal was removed. As sand washed out by a certain amount, crack occurred first and then it developed into a cavity that stood in the unsaturated layer (Fig. 2). Suction at location C gradually increased and underwent marked decrease following the crack formation (Fig. 3). It is noted that water level was increased at time T1 and T2 to examine the response of tensiometers to specified changes of water level.

The observations from tests on S7 and S6 showed that a larger cavity was formed in the test on coarser sand (S6), indicating that capillary heights h_c as well as the distributions of suction in the sand layers were important factors to be examined regarding cavity formation.

It is interesting to note that after the full development of a cavity, a very little sprinkling of water over the soil surface (an attempt to simulate the infiltration of rainwater) triggered further wash out and enlarged the cavity. Studies of the influence of grain size, water fluctuation and infiltration on cavity formation are on-going, and will be reported in the near future.

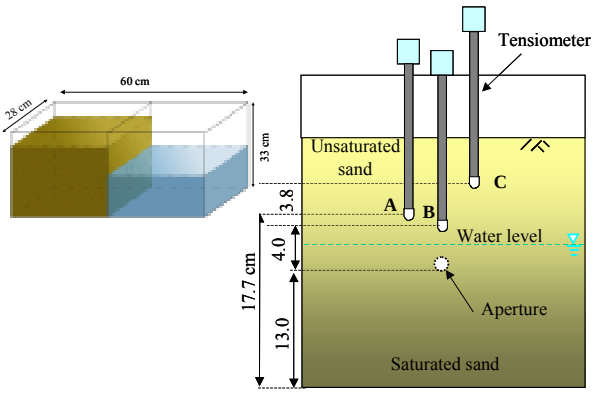

Fig. 1 Apparatus used in experiment

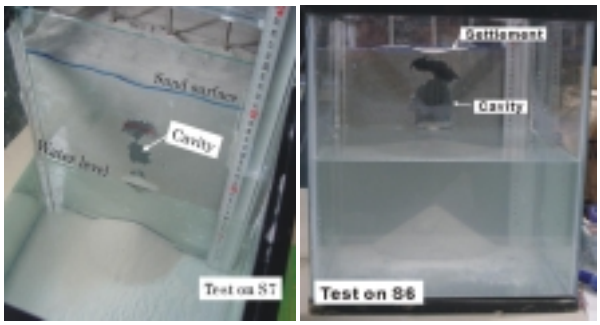

Fig.2 Wash out through aperture leading to cavity formation in unsaturated sandy backfill

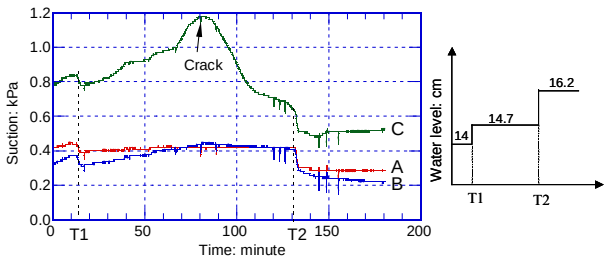

Fig. 3 Variations of suction with elapsed time