EFFECT OF A WATER FLOW IN INTERNAL EROSION OF SOILS

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1. INTRODUCTION

The phenomenon of internal erosion refers to the detachment of soil particles from the main structure due to the action of a fluid flow; both suffusion and piping are result of internal erosion in the ground, and can cause disasters in hydraulic structures due to heavy rainfalls. In order to know the influence of water penetration into the ground, a series of permeability tests had been performed in a highly erodible soil, applying water with various hydraulic gradients from the top part of specimens with different densities, and letting fine particles drain out, leaving the coarse skeleton behind.

2. TEST

2.1 Test material

In this study, colored red silica sand number 5 was used; this variety of sand is produced from the degradations of quartz, and has a mean diameter D_{50} of 0.5mm. Also, non-plastic silt called DL-Clay was used; it is a fine material without plasticity that looks yellowish brown and has a mean diameter D_{50} of 23μm.

Both soils (Silica sand and DL-clay) were mixed using various percentages combinations based on the study made by Kenney (1985), in which, the author suggested the maximum content of detached particles a granular soil can contain, and therefore the maximum loss possible. According to this, the percentages of Silica sand (primary fabric) and DL-clay (detached particles) were estimated taking into consideration the void ratio and average porosity.

Three soil conditions were studied: (1) loose soil (Dr= 4~10%) with 65% of primary fabric (silica sand) and 35% of detached particles (DL-clay); (2) loose soil (Dr= 4~10%) with 80% of primary fabric and 20% of detached particles; and (3) dense soil (Dr= 88~90%) with 80% of primary fabric and 20% of detached particles (Fig. 1).

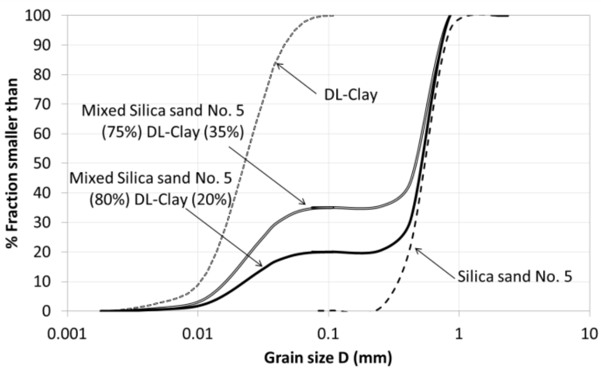

Fig. 1 Grading curves of the soils studied

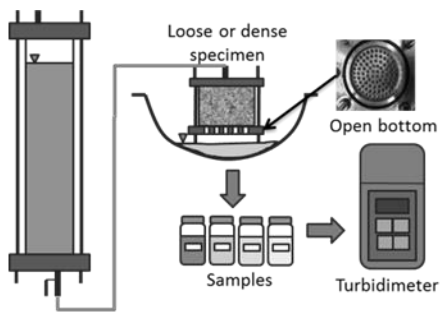

Fig. 2 Apparatus

2.2 Apparatus

Pressurized water flowed from top to bottom in a chamber containing the soil in study, in order to investigate the effect of water and how it can drain out detached particles from a main structure. The acrylic chamber has an internal diameter of 81mm and height of 67mm; it has a bottom part with 88 holes of 5mm diameter, covered by gauze with opening of 1mm (Fig. 2).

2.3 Test procedure

The water pressure is applied to the top part of the specimen and the water with detached particles is recollected from the bottom. The pressure applied was varied in every test. The water with fines was weighted, then, the weight of particles drained out was measured by drying the water in the oven. Additionally, the turbidity of the water expelled was measured during the experiments.

3. RESULTS

Internal erosion induced by a water flow has been evaluated. A highly erodible soil was used in loose and dense state; moreover, different percentage combinations of primary fabric and detached particles were used, examining the effect of the hydraulic gradient in the movement of detached particles. The percentage of soil expelled varies significantly between the loose and dense state. In the loose specimens the percentage drained out was around 10 to 13% of the initial mass, while the dense specimen reached around 3% in the more eroded case.

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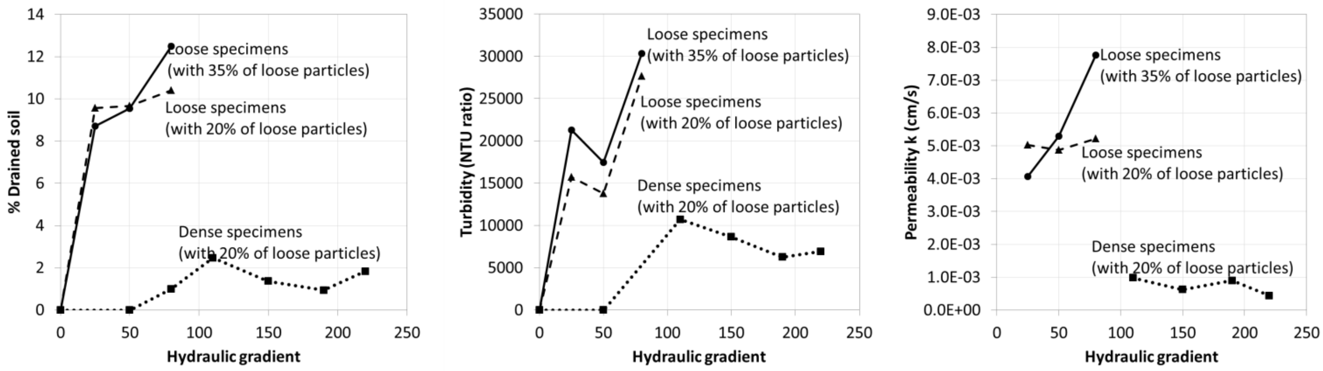
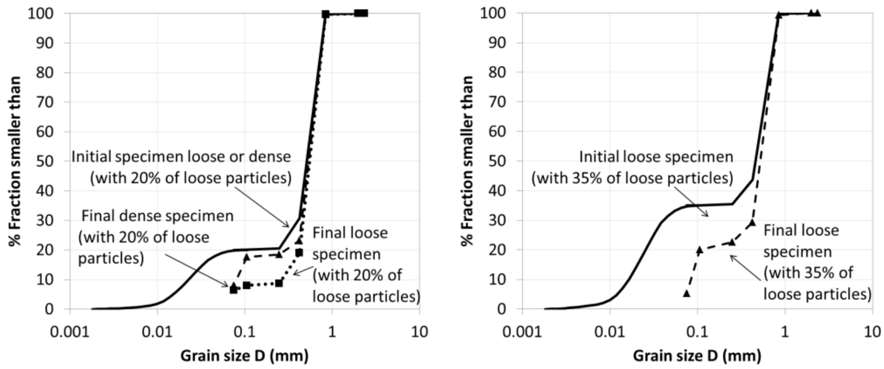
It should be noted that for the loose specimens the amount of soil expelled increased with the rising of hydraulic gradient, for the dense specimens the amount of soil washed out reached a maximum point around 110 of gradient value, and then decreased (Fig 3 (a)). Consequently, the turbidity measured in the water after passing through the specimen shows a similar trend; therefore, the value of turbidity can give an approach to the amount of soil expelled by the action of a water flow (Fig 3 (b)). The coefficient of permeability increased with the rise of hydraulic gradient in the loose cases, it is consistent with the behavior of the expulsion of detached particles, because to the voids left in the fabric allow a smoother pass of the water through and result in an increment in the permeability (Fig 3 (c)).



(a) (b) (c)

Fig. 3 Variation of percentage of drained soil, turbidity and permeability vs hydraulic gradient

A comparison between the grading curves of the soil before and after the test is shown in fig. 4, just the cases with extreme results are in the figure. For the soil with initially 20% of detached particles, the loss of grains is about 3% in the dense state and 17% in the loose (fig. 4 (a)). For the specimen with initially 35% of detached particles, the loss is around 13% (fig. 4 (b)).



(a) (b)

Fig. 4 Grain size distribution of initial and final specimens

4. CONCLUSIONS

Effects of a water flow in the internal erosion were studied in this research, by applying water pressure to soil considered as highly erodible. It was found that specimens with relative density around 4 to 10% exhibited a large amount of particles displaced (around 13% of the total), and for the specimens with relative density around 90% the particles drained out represented 3% of the total. The tests in loose specimens were performed for two combinations of soils (20% and 35% of detached particles), however the particles expelled are of the same proportion in both cases, meaning that the amount of detached particles is not as significant as the gradient of water. The turbidity of the water that passed through the soil and carried out the detached particles was also measured, it was found that the turbidity value can be related to the amount of particles removed, and therefore the measuring of the turbidity can be used in field in order to estimate the grade of internal erosion.

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