EFFECTS OF EROSION ON THE MECHANICAL PROPERTIES OF WELL-GRADED VOLCANIC SOIL

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1. INTRODUCTION

Internal erosion can be divided into four types: concentrated leak erosion, contact erosion, backward erosion and suffusion. Out of them, suffusion is characterized as seepage induced loss of fine particles with no change in volume and an increase of hydraulic conductivity. The degree of migration of fine particles can affect both micro and macro structural behaviour of soil. Many researchers have conducted experimental investigations on different aspects of internal erosion such as the susceptibility of soil and progression of internal erosion using gap graded soils. A few studies have used well graded volcanic soil to explore the effect of suffusion. This paper analyses the impacts of suffusion on the mechanical properties of well graded soil in triaxial compression.

2. MATERIAL PROPERTY

Satozuka soil (volcanic ash soil) (G_s = 2.391 g/cm^3, ρ_{dmax} = 1.051 g/cm^3, ρ_{dmin} = 0.749 g/cm^3, w_{opt} = 42.6%) was used in tests; it contains about 45% finer fractions. The grading curve is shown in Fig. 1. According to Kenney and Lau (1985), Fig.2 shows that soil is regarded as an unstable material whose coarser soil particles do not prevent the transport of its finer soil particles.

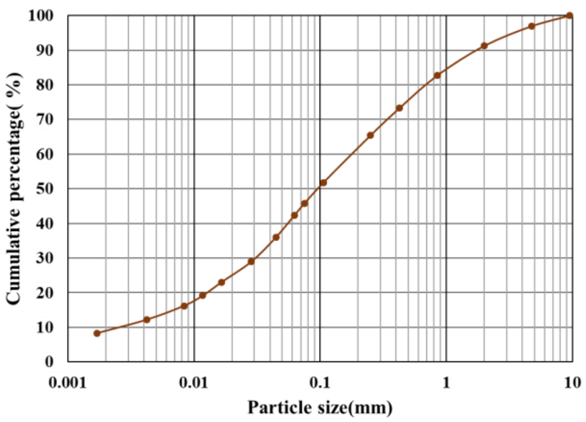

Fig. 1 Particle size distribution of Satozuka soil

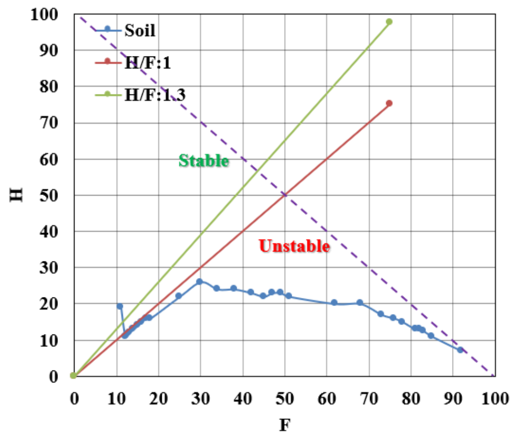

Fig. 2 Variation of H to F

3. TEST METHOD

The erosion triaxial apparatus developed by Sato and Kuwano (2018) was used in this test series. The specimen is 75 mm in diameter and 160 mm in height. A LVDT (external displacement transducer) was placed on the outside of the cell to measure the vertical strain ε_a of the specimen. HCDPT (high-capacity differential pressure transducer) was used to measure the effective stress in the soil specimen during the tests. The average axial strain ε_a, and horizontal strain ε_h were calculated from the LDTs (Linear displacement transducers) and CGs (Clip gauges), respectively during the consolidation and erosion. The test was conducted as follows. First, the specimen was prepared using the moist tamping method (Ladd 1978) into eight layers of equal thickness. Following the specimen preparation, 20 kPa of isotropic confining pressure was imposed on the specimen and maintained until the end of the test. Then double vacuum and saturation were applied to reach B>0.95. The backpressure is then incrementally increased to 200 kPa, with an increment of 5 kPa. At every 25 kPa, the pore water pressure was allowed to equalize, and the system was checked for leaks by closing the tank valves and ensuring that the effective cell pressure remains constant. After reaching 200 kPa backpressure (220 kPa cell pressure) the tank valves were closed, and the corresponding B value was checked. Subsequently, the tank valves are opened, and the specimen was consolidated to an effective stress of 80 kPa. After that soil specimen was eroded using back pressure (50 kPa-150 kPa) applied through the water tank. Then, a turbidity meter was used to measure the turbidity of the collected water every $\approx$ 60 minutes. Finally, monotonic loading was applied to specimen until axial strain reached to 15%. EC and CE are defined as Erosion before the Consolidation and Erosion after the Consolidation. Undrained tests were conducted on samples with relative densities of 80%, 50% and 30%, subjected to seepage with increasing hydraulic gradient, along with a sample which had not been subjected to erosion.

Keywords: Well-graded, Suffusion, Erosion-triaxial, Undrained, Monotonic loading
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4. RESULTS AND DISCUSSIONS

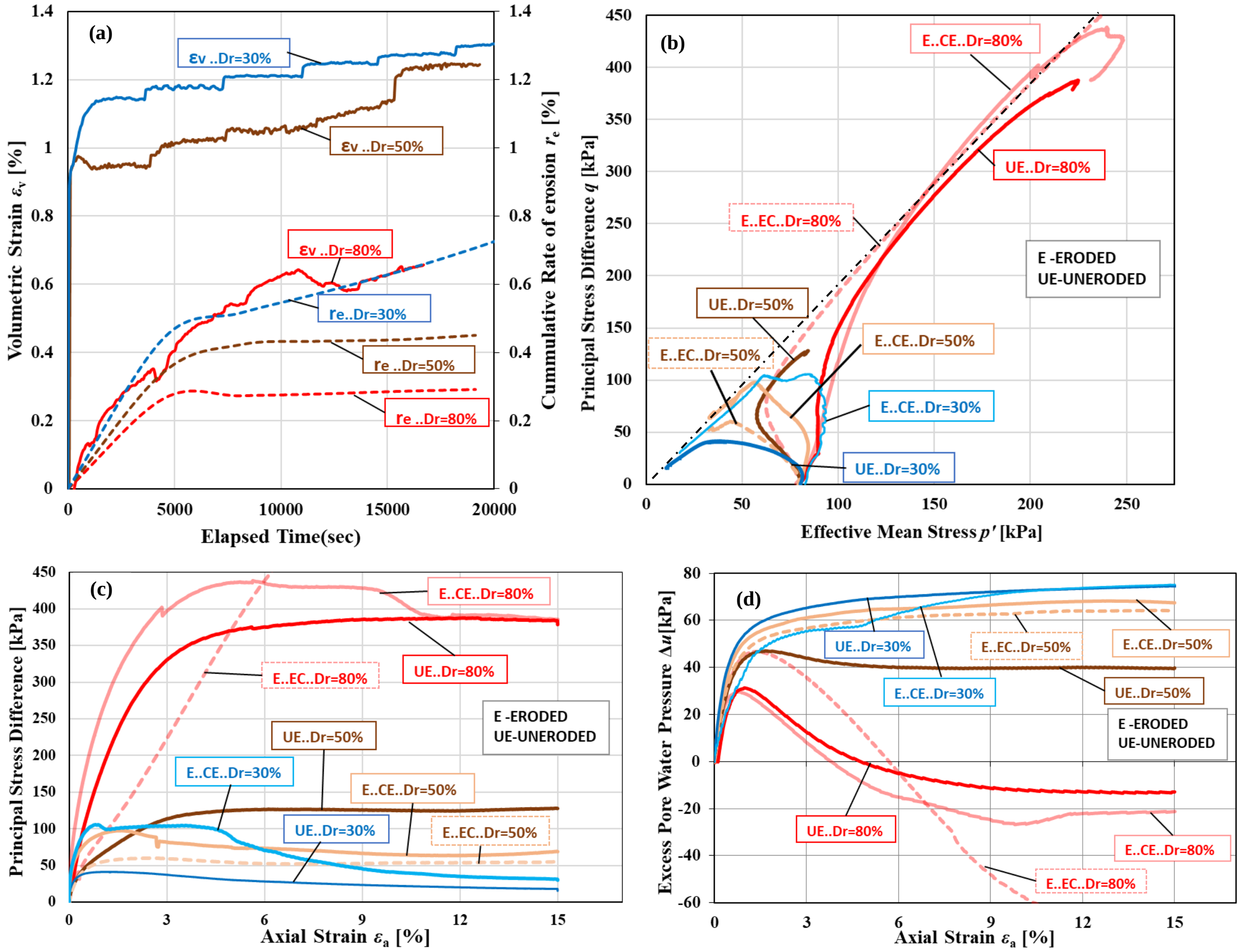

Fig. 3 (a). Volumetric strain of CE, (b). Stress path, (c). Stress-strain, (d). Excess pore water pressure curves

Fig 3.(a) illustrates, at the beginning of erosion, the rate of erosion is high for all specimens, as the fines confined to the pores of the coarse soil skeleton, and not participating in the transfer of stress under isotropic conditions, are eroded easily. The erosion rate then reaches to an asymptotic state as the fines participating in the force transfer become more difficult to erode. The degree of erosion is evidently affected by the density of the specimen. Further, based on results, hydraulic gradient (i=35-100) does not impact the flow rate (0.25ml/s) or rate of erosion significantly. Fig 3(c) and 3(d) depict that beneath undrained conditions, suffusion causes an increase in peak strength in the small strain region (0-4%) , possibly because the force chains are benefitting from an increase in interparticle contacts caused by the rearrangement of the soil skeleton including fabric orientation during erosion. Subsequently, the force chains begin to buckle under the increasing stress and the loss of cushioning fines leads to a collapse behaviour, most clearly seen in the loose soil specimen. These observed effects are also density dependent, as the densest specimen shows dilative behaviour and steady stage in medium strain while others show a sudden drop in the stability. Further, a small degree of erosion does not evidently affect the peak or residual strength during shearing. Fig 3(b) and 3(d) confirmed that the looser samples become less dilative with increasing amounts of erosion, which could encourage the liquefaction of soil. Further comparison of CE and EC confirmed that stress history impacts the rate of erosion and stress path of soil.

5. CONCLUSION

An experimental investigation was conducted to study the erosion progression and the post-erosion stress-strain behavior of a well-graded volcanic ash. Looser eroded soil become stiffer while medium dense and denser soils become less stiff or unchanged. In the undrained triaxial compression tests it was observed that eroded soil shows higher peak strength at small strain and becomes more collapsible than uneroded soil at higher strains due to removal of fines and particle rearrangement during the erosion.

REFERENCES

Sato, M. and Kuwano, R.: Laboratory Testing for Evaluation of the Influence of a Small Degree of Internal Erosion on Deformation and Stiffness, Soils and Foundations, 58-3, 2018, pp.547-562.
Kenney, T.C. and Lau, D.: Internal Stability of Granular Filters, Canadian Geotechnical Journal, 22-2, 1985, pp.215-225.
Ladd, R.S.: Preparing Test Specimens Using Under-Compaction, Geotechnical Testing Journal, 1-1, 1978, pp.16-23.