Experimental research on appearance/disappearance process of anisotropy and its influence on monotonic shear behavior using reconstituted clay

Nagoya University, Student Member, ○Imran Khan, Kota Mizukami
Nagoya University, JSCE Member, Kentaro Nakai, Toshihiro Noda

1. Introduction

Anisotropy refers to the directional dependence of material properties. The anisotropy of clays intimately connected with their structure, which depends on the environmental conditions during which the soil is deposited as well as the stress changes subsequent to deposition. For example, Islam, M. S. et al (2011), investigated the strength anisotropy in both vertical and horizontal directions by trimmed the specimens at different angles so as to obtain the test samples of different orientations, compared to the depositional direction and then subjected to UC and DS tests for both the horizontal and vertical planes from undisturbed clay masses. He concluded that the clay samples collected from different places and different depths showed different coefficients of anisotropy in different laboratory tests. Numerous experimental studies on the effects of anisotropy, including the above examples, have been conducted. However, there is not much to explain how to determine the shear strength and young modulus of soil samples with anisotropic development, and how to explain how the anisotropy develops or disappears. In this paper, triaxial tests are carried out using the vertical and the horizontal extraction specimen of the reconstituted clay sample, for accumulating experimental facts of development of anisotropy during the preliminary consolidation process and the influence of the anisotropy on the shear behavior.

2. Experimental work

Physical properties and grain size distribution of the clay used in the experiment are shown in Table 1 and Figure 1 respectively. It is considered to be high plasticity clay with high fine particle content and large liquid limit. After thorough stirring and degassing at a water content of 1.5 times the liquid limit, we had applied pre-consolidation pressure of 200kpa for one week. After that extract the sample in horizontal and verticals samples (see, Figure 2). By extracting the reconstituted sample from different directions, Samples with different initial anisotropy were prepared. Five (5) types of isotropic stresses of 50, 100, 300, 600, 1800 kPa were applied, isotopically consolidated for 24 hours and shear for two days. The B values of each sample were confirmed to be 0.96 or higher. After isotropic consolidation, undrained shearing was carried out under constant axial strain rate of 0.0056(mm/min).

Table 1 Physical properties of Soil.

Liquid Limit w_L (%)	91.2
Plastic Limit w_p (%)	39.0
Plasticity index I_p	52.2
G_s(g/cm^3)	2.65

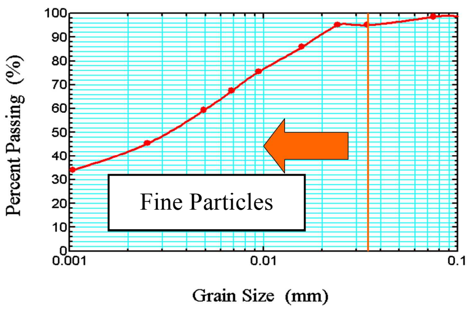

Fig.1 Grain size distribution

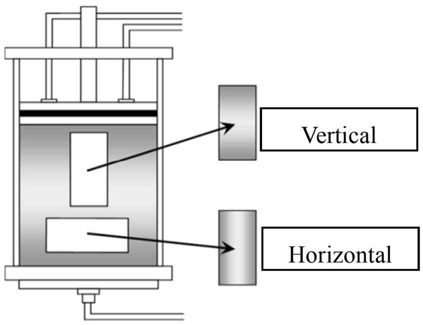

Fig.2 Sample preparation

Figures 3 to 7 shows the stress-strain relationship and effective stress path of vertical and horizontal specimen with different confining pressures. Figure 8 summarizes the difference in vertical and horizontal shear strength. By comparing the shear/peak strength of samples it is observed that vertical sample shows larger peak strength as compared to horizontal because of the development of anisotropy on the compression side. As the confining pressure increases, the difference becomes smaller and smaller which indicate that the anisotropy disappears/diminished and intensity ratio decreases. One more thing observed that Critical state index (slope of critical state line) is decreasing as confining pressure increases. However, even at 300, 600, and 1800kPa, the same degree of strength difference remains, so it was found that even if we have applied high isotropic consolidation pressure, anisotropy was not completely diminished. Moreover, since there was not much change in the intensity difference from around 200kPa which is the preliminary consolidation pressure, the development of anisotropy may be affected by over consolidation ratio.

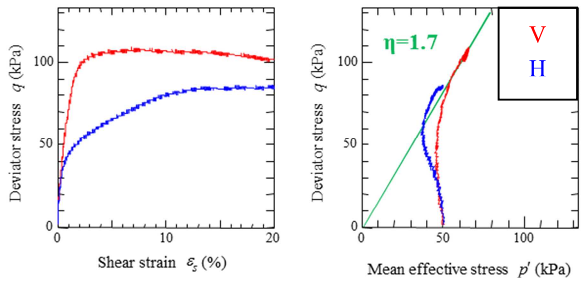

Fig.3 Confining pressure 50kPa

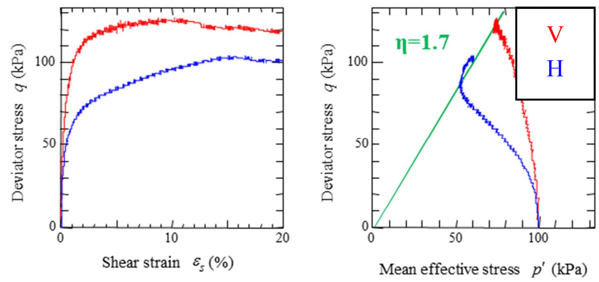

Fig.4 Confining pressure 100kPa

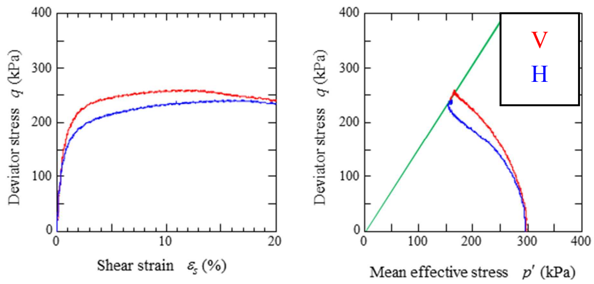

Fig.5 Confining pressure 300kPa

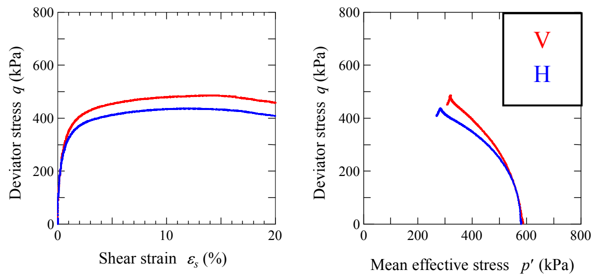

Fig.6 Confining pressure 600kPa

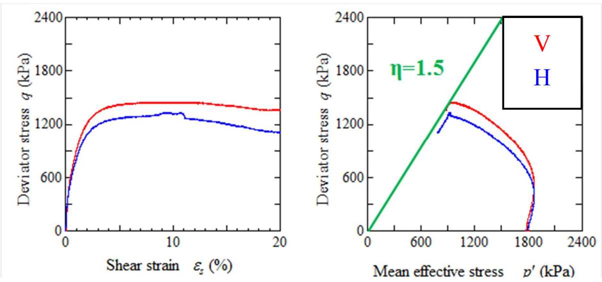

Fig.7 Confining pressure 1800kPa

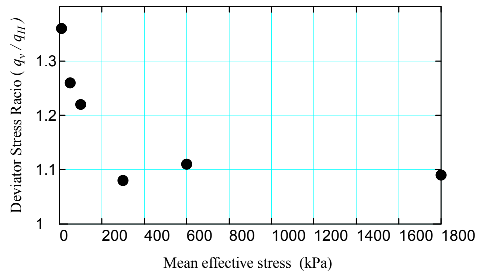

Fig.8 Difference in vertical and horizontal shear strength

3. Conclusions

From a series of experimental results, it is confirmed that anisotropy developed in the preliminary consolidation process, and anisotropy disappears due to isotropic consolidation, but it does not completely disappear even under high confining pressure. In the future, we will confirm the effect of differences in physical properties on the development of anisotropy, and also conduct cyclic shear tests. Moreover, based on experimental facts, we will validate the constitutive model and add some improvement if necessary.

4. References

Hoque, E., & Tatsuoka, F. (1998). Anisotropy in elastic deformation of granular materials. *S&F*, 38(1), 163-179.
Nishimura, S. et al. (2007). Shear strength anisotropy of natural London Clay. Geotechnique 57, No. 1, 49–62
Islam, M. S. et al. (2011). Strength anisotropy in undisturbed Dhaka Clay. J. of Geotechnical Engineering, 1(1), 7-15.