# EXPERIMENTAL RESEARCH ON DEVELOPMENT/DIMINISHING OF ANISOTROPY USING RECONSTITUTED CLAY AND SILT CLAY

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## 1. INTRODUCTION

Anisotropy refers to the directional dependence of material properties. The anisotropy of clays and silty clay 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 have been conducted focusing on the shear strength, however, there is not much to explain how the anisotropy develops or disappears with ongoing plastic deformation. In this paper, triaxial tests were carried out using the vertical and the horizontal extraction specimen of the reconstituted clay and silty 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. Also the comparison of clayey and silty clay and how the grain size affects of on development/diminishing of anisotropy are discussed.

## 2. EXPERIMENTAL WORK

Physical properties and grain size distribution of the clay and silty 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 for clay and two days for silty clay. After that extract the sample in the horizontal and vertical direction. 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 on clay and (2) two isotropic stressed of 50 and 300kPa were applied on silty clay. Both clay and silty clay were isotopically consolidated for 24hours and shear for two and one day respectively. 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.

| Description | Clay | Silty-Clay |
|---|---|---|
| Liquid Limit $w_L$ (%) | 91.2 | 45.82 |
| Plastic Limit $w_p$ (%) | 39.0 | 25.37 |
| Plasticity index $I_p$ | 52.2 | 20.44 |
| $G_s$(g/cm$^3$) | 2.65 | 2.65 |

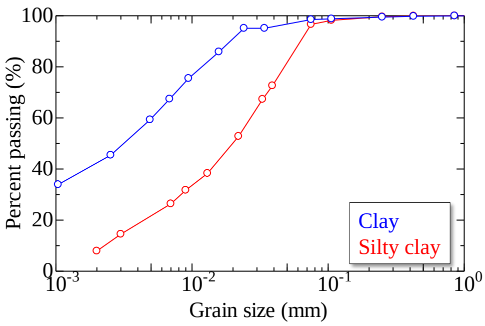


Fig.1 Grain size distributions

Figures 3 to 6 showing the stress-strain relationship and effective stress path of vertical and horizontal specimen with different confining pressures of clay and silty clay. By comparing the shear/peak strength of samples of clay in figure 3 and 5 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. 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 specially in case of clayey soil but in case of silty clay it almost disappeared soon as compared to clay, at confining pressure of 300kpa. Figure 7 and Figure 8 summarizes the clay and silty clay samples difference in vertical and horizontal shear strength and changing of critical state index with increasing confining pressure. One more thing observed that critical state index (slope of critical state line) is decreasing as confining pressure increases. 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.

Keywords: Clay, Silty Clay, Anisotropy, Isotropic Consolidation pressure, Critical State index and Grain size

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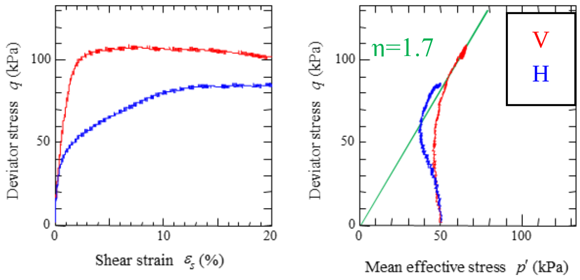


Fig.3 Confining pressure (Clay) 50kPa

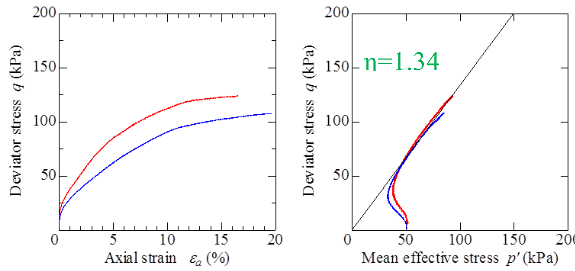


Fig.4 Confining pressure (Silty Clay) 50kP

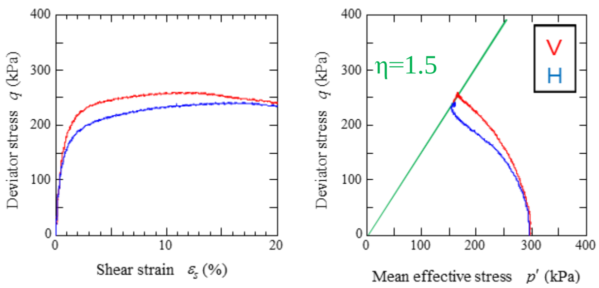


Fig.5 Confining pressure (Clay) 300kPa

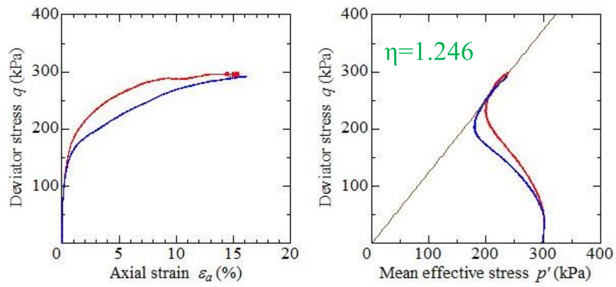


Fig.6 Confining pressure (Silty Clay) 30

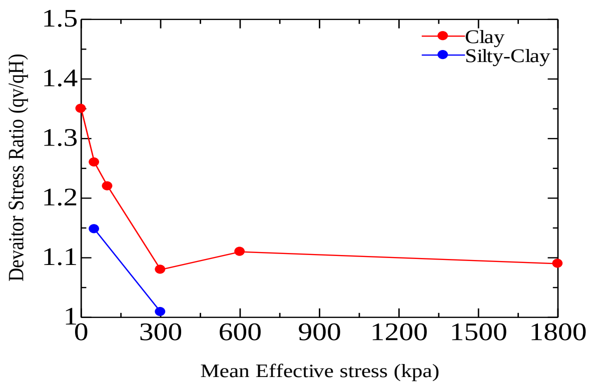


Fig.7 Difference in vertical and horizontal shear strength

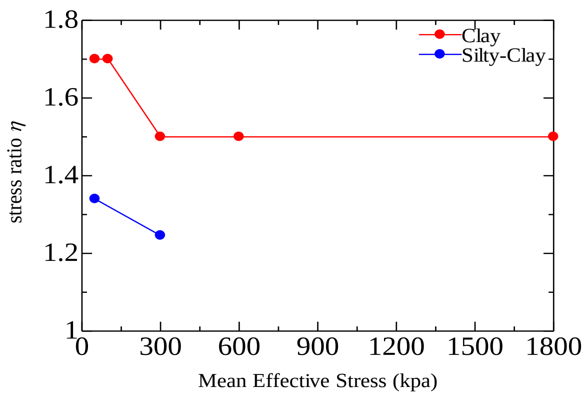


Fig.8 Difference in Critical state Index

## 3. CONCLUSIONS

From a series of experimental results, it is concluded that anisotropy developed in the preliminary consolidation process, and anisotropy disappears due to isotropic consolidation. Nevertheless, it does not completely disappear even under high confining pressure especially in case of clay. However, if we compare clay and silty clay soil, silty clay materials lose their anisotropy at lower confining pressure as compared to clay materials. Therefore, the grain sizes have significant effect on the developing and diminishing of anisotropy. Another important fact is observed that, critical state index (slope of critical state line) is decreasing and become constant as confining pressure increases. To describe the effect of anisotropy, rotational hardening concept is often used. However, when introducing the rotational hardening concept directly to the original Cam Clay Model, critical state index does not change even if the anisotropy develops and disappears. On the other hand, when introducing the rotational hardening concept to Modified Cam Clay model, critical state index changes according to the plastic deformation. From this viewpoint, Modified Cam Clay model is more suitable to use as compared to the original Cam Clay Model. Further experiment will be performed to observe the effect of cyclic shear test, to evaluate the development/diminishing of anisotropy. Moreover, based on experimental facts, we will validate the constitutive model and add some improvement if necessary. Also, an extension test will also perform to observe the effect of intermediate principal stress.

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