# Influence of the cement clay mixing on the undrained shear strength for large strain range

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## 1. INTRODUCTION

Structures like embankment may be affected by settlement as a result of adverse static and dynamic conditions. Ground improvement method been used to reduce the settlement, improve the shear strength. And prevent the working stresses being exceeded. Various indexes to represent the strength of cement-treated was observed by several researcher (Kasama et al, 2006 and Miura et al, 2001). One example is the characterization failure with optimum design which the cement ratio from the weight ratio of cement to dried soil and cement weight per wet soil volume of 1 m$^3$. Figure 1 Shows the typical stiffness variation and strain ranges for laboratory tests and structures. Accordingly, threshold separating the small and large strain levels is 0.1%. Structures like embankments and foundations fall within this narrow strain levels. In order to Study the deformation at the large strain the shearing rate relatively on 1 mm/minutes was used. To fulfill the criterion of small strain, the local displacement transducer as the strain gauges is needed to optimize.

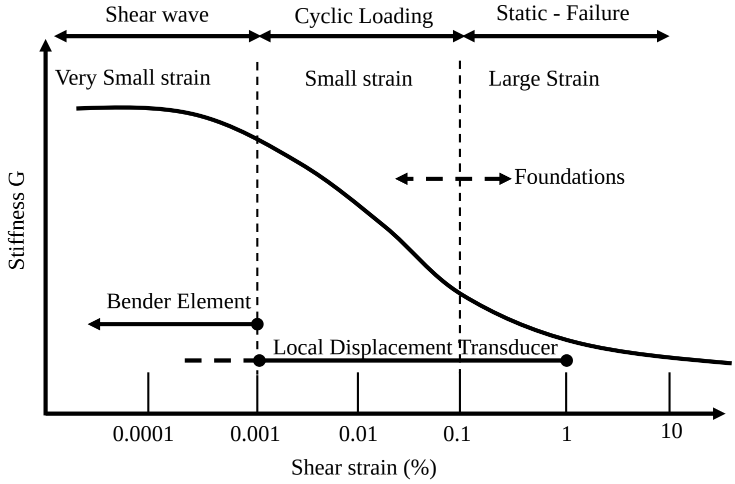


Fig. 1. Typical stiffness variation and strain ranges for laboratory tests and structures (Modified from Atkinson, 2000)

## 2. METHOD

The material on this study is Ariake clay from Saga prefecture and the properties are shown in Table 1. It was mixed with cement contents of 10%, 25% and 50% and the mixing method is dry condition due to the high initial water content. On a natural soil, the preparation is from the slurry condition and created the pre-consolidation test using one dimensional pressure. Soil binder ratio is calculated from the mass of dry binder divided by the mass of dry soil. The soil specimens were 5 cm in diameter and 10 cm in height and were tested according to JGS-0821 (Japanese Geotechnical Society, 200) under consolidated undrained conditions. After the mixing process, the material is poured into the mold carefully. A compaction process is needed for the dry binder to create a flat surface 30 times in each layer according to JGS-0821 (Japanese Geotechnical Society, 2000). Application of the local displacement transducer (LDT) into triaxial or unconfined compression test was developed by Goto et al. (1991). LDT are prepared with the calibration procedure to get the exact same number on displacement and strain analysis.

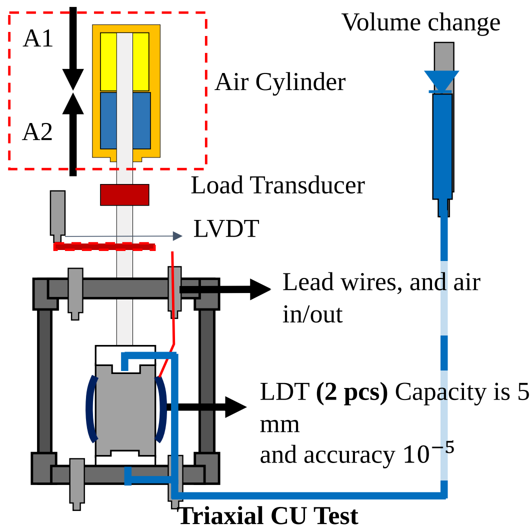


Fig. 2. Schematic diagram of Triaxial Consolidated Undrained with Local Displacement Transducer

## 3. RESULT AND DISCUSSION

Static Triaxial with consolidated undrained was performed on the Ariake clay and soil cement mixture. During the static loading, the apparatus was combined with Local displacement Transducer to collect the data of axial strain. Initially, the analyses of LDT need to be optimized, in order to know the large strain condition on the clay with cement mixture with varying cement proportion. During the shearing process, the LDT was performed and interpreted based on terms of deviator stress ($q = \sigma_a' - \sigma_r'$) and the axial strain ($\varepsilon_a$) The axial and radial effective stress are also representing the shear stress and shear strain condition.

Table 1. Soil Properties

| Soils | Natural Water Content (%) | Specific Grafity | 425 $\mu$m size (%) | $D_{50}$ (mm) | Plasticity Index (Ip) |
|---|---|---|---|---|---|
| Ariake Clay | 240 | 2.547 | 100 | $8.59 \times 10^{-4}$ | 79.58 |

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The axial strain has found the gap between the Linear Variable Displacement Transducer (LVDT) and LDT. The LDT has a greater deviatoric stress within the small axial strain compared to the LVDT. Focus on the boundary between small strain to large strain, Figure 3 shows the relationship between the shear modulus and shear strain from LDT performance. The variation of soil cement mixture shows on the cement 10% it shown the shear modulus within 0.1% has a small gap from natural soil, meanwhile the higher cement content more than 25% has a huge different with 10% cement content. Based on shear modulus, it has a feature to interpret the optimum cement proportion.

Furthermore, to estimate the stiffness of the material, not only the cement proportion, but the effectiveness of undrained shear strength also affects the modulus elasticity (E). The relationship of undrained shear strength ($su = (q_{max}/2)$ in terms of different confining pressure on soil cement mixture is used to determine the failure envelope by different consolidation pressures. The influence of the initial water content of the undrained shearing process are overconsolidation caused by the high stiffness from cement mixture (Kasama et al, 2006). In the meantime, the key parameter to control the shear modulus and also undrained shear strength is cement content.

Figure 4 shows the relationship of undrained shear strength with confining pressure with varied confining pressure from 50 kPa to 150 kPa on high soil cement mixture proportions. Meanwhile, the influence of different confining pressure can affect the estimation of Modulus Elasticity. Figure 5 depicts the effect of cement content to the modulus elasticity. It can be seen that the optimum cement content is approximately 10-20%. It is indicated by the change of the confining pressure. When the confining pressure is 150 kPa and the cement content is 50%, there is a sudden decrease to the modulus elasticity. The limitation of axial strain in this research is about 1 %, according to the range from small strain to large strain. However, within the small strain condition, it is difficult to determine the small strain during 1.0 mm/min of shear loading rate.

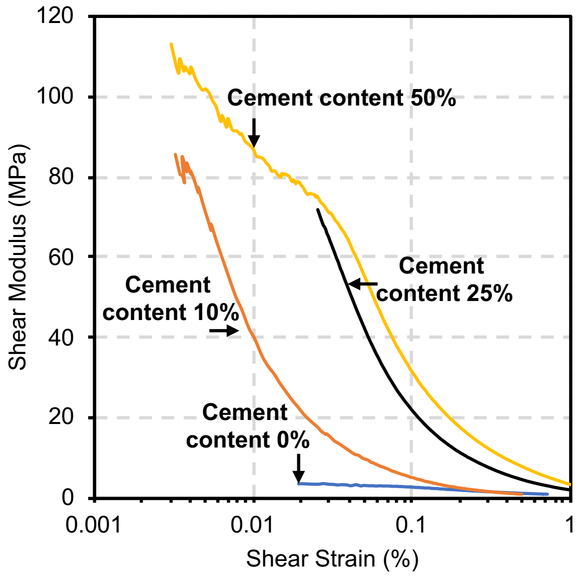

Fig. 3. LDT measurement on Shear Modulus and Shear strain with 150 kPa confining

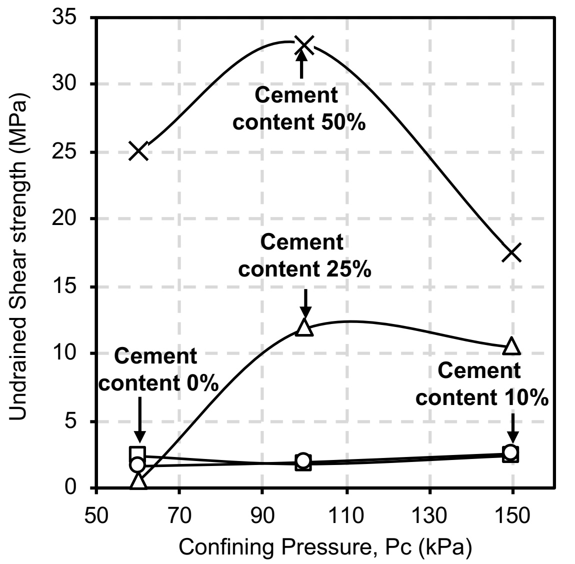

Fig. 4. Undrained shear strength and confining pressure with varied of soil cement mixture

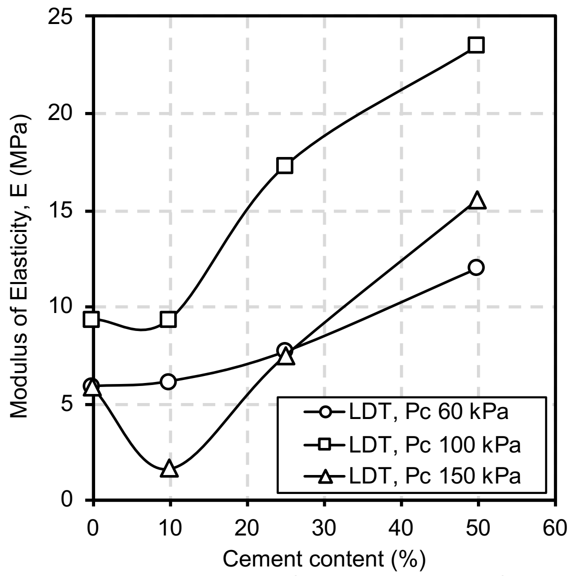

Fig. 5. Modulus of Elasticity and confining pressure with varied of soil cement mixture

## 3. CONCLUSION

1. The optimum cement proportion in the high initial water content with dry mixing method (7-day curing) was determined to be within the 10% to 25%, it could be observed that the modulus elasticity gradually increase with different confining pressure.
2. The higher displacement in shear loading rate did not cover the small axial strain condition. It could be seen within the steep line on axial strain less than 0.2%. Furthermore, the slower displacement in shear loading rate may influence the high stiffness on the soil cement mixture.

## 3. References


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