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主 論 文 の 要 旨

論文題目 **UNDERSTANDING THE MECHANICAL BEHAVIOR OF CLAYEY MATERIAL FOCUSED ON DEVELOPING/DIMINISHING OF ANISOTROPY AND DISTURBANCE OF STRUCTURE**
(異方性の発達／消滅と構造の乱れに着目した粘性土の力学挙動の把握)

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論 文 内 容 の 要 旨

The earthquake damage prediction is mainly focused on the seismic instability of sandy foundations although the clayey foundation could also be vulnerable to earthquake damage. Previously for the dynamic problem the conventional clay is safe but recently investigated results showed that clay foundation showed loss of rigidity and cause damages due to earthquake. If the past earthquake damage is examined carefully, although there are not many cases like liquefaction damage of sandy foundation, earthquake damage of clayey foundation can be also observed.

Naturally deposited clays/sands are mostly found in structured, and usually also in overconsolidated states. Furthermore, they exhibit what is more or less a condition of anisotropy. In an artificial/remolded sample, the soil skeleton structure is disturbed but in naturally soil, the soil skeleton structure is developed. In order to deal with naturally deposited materials, it is very important to know about soil skeleton structure, especially structure and anisotropy.

The main purpose of this research is to understand the work of soil skeleton structure especially for anisotropy and structure and to know the mechanical properties of clay and the developing/diminishing of anisotropy. Natural deposited soil has a highly developed structure as compared to remolded soil, so during the deposition process, anisotropy is considered to be also highly developed. The knowledge of development/diminishing of anisotropy are very important, to understand the mechanical behavior of natural soil and the work of soil skeleton structure with ongoing plastic deformation is important.

Another important aim is to artificially produce the soil sample having similar characteristics to those of naturally deposited soft clay in the laboratory. Because it is very important to grasp both static and dynamic mechanical properties of naturally deposited clayey materials and it can be achieved by carrying out various systematic experiments using the undisturbed soil samples.

Since the cyclic shear strength varies depending on the loading rate, it is important to conduct experiments using a suitable loading rate. Therefore, it is important to obtain experimental results at the lowest possible loading rate so that the internal state of the specimen can be treated as homogeneous and uniform. Therefore, reconstituted clayey samples were subjected to undrained cyclic triaxial compression/extension tests with loading rate from 1.0Hz to 0.0042Hz by stress control, and 0.01%/min by strain control to determine the undrained cyclic shear behavior of clayey soil under a drastically changed loading rate. Finally, the final values of excess pore water pressure after the homogenization process was the same regardless of the loading rate. This means that if sufficient time is left after cyclic loading, the final mean effective stress value becomes equal regardless of the loading rate.

Triaxial tests were carried out using the vertical and the horizontal extraction specimen of the reconstituted clay and silty clay, for accumulating experimental facts of the development of anisotropy during the preliminary consolidation process and the influence of the anisotropy on the shear

behavior. The 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 between the peak strength of vertical and horizontal becomes smaller and smaller which indicates that the anisotropy diminished and intensity ratio decreases. By comparing clay and silty clay, silty clay materials lose their anisotropy at lower confining pressure (600kPa) as compared to clay materials (1800kPa). Therefore, the grain sizes have a significant effect on the developing and diminishing of anisotropy. Another important fact observed was critical state index is decreasing and becomes constant as confining pressure increases.

In the past, according to the results of laboratory experiments, it has been found that destabilization such as liquefaction phenomenon does not occur in clayey soil because clayey soil maintains relatively high rigidity and strength even after cyclic loading. It is common that the soil was in the state of "high water content", "high sensitivity", and "soft" where the earthquake damage occurred. The difference between a natural deposited sample and a reconstituted sample is considered to be the degree of development of "soil skeleton structure" that develops over a long period of deposition process over several tens of thousands of years. Therefore, the influence of the disturbance of soft clay due to cyclic loading is grasped from undrained triaxial compression tests and importance/implication of soil skeleton structure.it was observed that it can be understood that the degradation of structure and accumulation of over consolidation occur during the repetition.

It is difficult to prepare the number of homogeneous soft clay samples, due to the problem of variability of quantities during sedimentation, disturbance during sampling and high expense of the boring surveys. Therefore, the influence on mechanical properties when hydration reaction controlled cement is added to clayey soil and also we describe the results of examining the influence of calcium leaching on the mechanical properties of cemented cohesive soil. By using the remolded sample, focused on the cementation reaction, in order to artificially produce the soil sample having similar characteristics to those of naturally deposited soft clay. By doing so, while maintaining the reproducibility of the specimen, it might be possible to perform a large number of systematic experiments, and to conduct such

model experiments as impossible in the past, in order to artificially produce the sample having similar characteristics to those of naturally deposited soft clay. As a result, the solidification effect was so strong that localized failure occurred in the soil specimen due to cracking followed by a sudden decrease of shear stress with no increase in excess pore water pressure. So, in terms of the necessity to reduce the solidification effect, a newly attempted method was introduced "addition of hydration reaction controlled cement" and "calcium leaching" to represent similar characteristics of soft clay material. It was concluded that the addition of cement makes it possible to reproduce the characteristics of naturally deposited soft clay to some extent, such as high sensitivity ratio and high compressibility ratio and by using pre-curing cement and stirring the mixture for a while, the solidification action of the hydrated product was destroyed and by controlling the hydration reaction, it showed ductile behavior. Moreover, by using Calcium leaching Smooth stress in shearing behavior -Strain curve and softening behavior were achieved.