DEVELOPMENT OF LATERAL DISPLACEMENT METER AND ITS APPLICATION IN TRIAXIAL TEST

三軸試験における横変位測定装置の開発とその応用

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Abstract:

The soil deformation characteristic in small strain region (less than 1%) has become important especially in soil deformation prediction during the tunnel construction and dynamic analysis. There is much research, which has been done regarding the measurement of small strain by using proximeter on triaxial test (Atkinson, 1993). The research on axial displacement in small strain had been worked out well but there are a few studies about displacement in lateral direction.

Therefore, in this study, three types of lateral displacement meters (LDM) were developed to measure the radial displacement during triaxial test. The CU and CD tests on Yoneyama sandy silt were conducted employing the proximeter to detect the soil deformation during the tests and the comparison on accuracy of each type of LDM was done to determine the most accurate LDM. As the result, LDM type 3 showed the most reliable result. Besides, it was also shown that the influence of consolidation hours on Poisson's ratio needed to be considered as the result showed different value at different consolidation hours.

1.Types of LDMs and the new triaxial test apparatus

Three types of LDMs have been suggested in this study. The shape of each type is shown in Figs. 1.1, 1.2 and 1.3. In LDM type 1, two proximeters were employed and two standing rod were needed to set these proximeters for measuring lateral displacement. In type 2 and type 3, only one proximeter was needed but the glue used to attach the LDM considerably strong enough to keep the position of LDM. The proximeter, which was used in the test, is AEC-5505 with sensor PU-05. It can measure soil deformation less than 2mm by using the current eddy loss principle.

In the previous triaxial apparatus, the de-aired water was supplied up to the top cap and air pressure was applied to the top of the cell water. The degree of saturation decreases during long-term test because the air dissolved in the cell water and the dissolved air went into the specimen via rubber membrane.

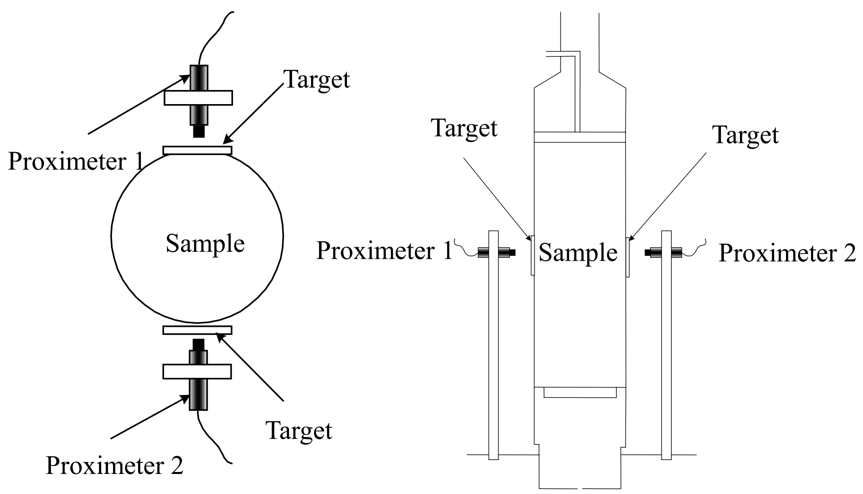

Fig 1.1 LDM type 1

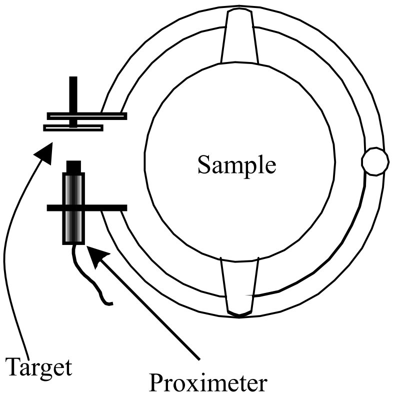

Fig 1.2 LDM type 2

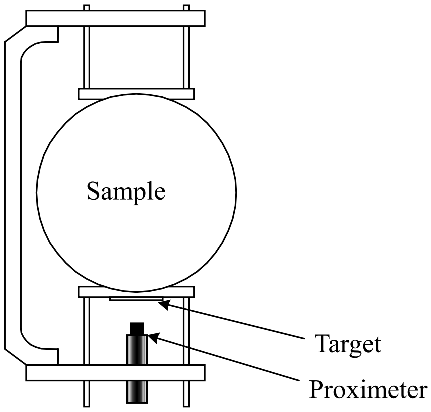

Fig 1.3 LDM type 3

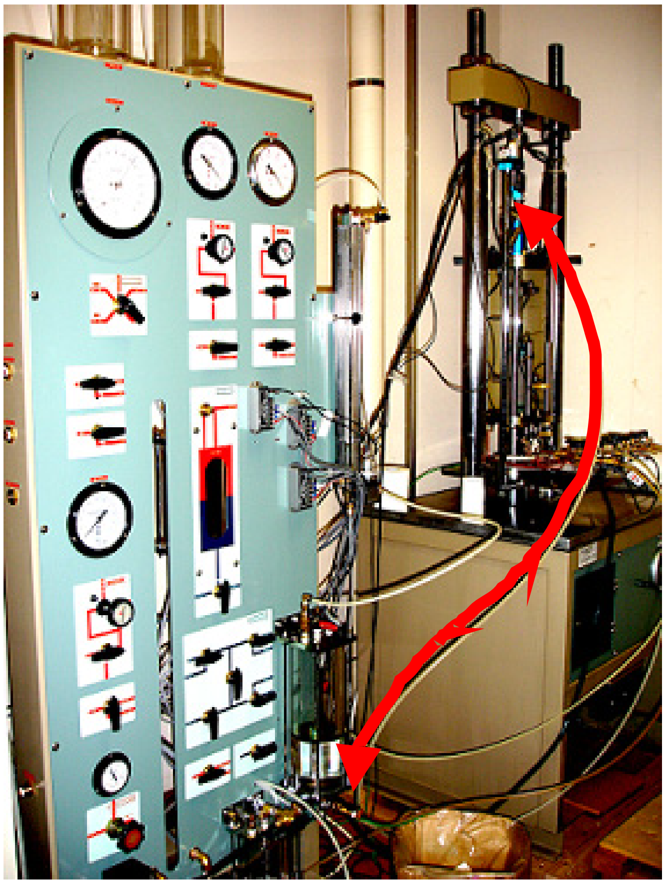

Fig 1.4 The new triaxial apparatus

While, in the latest apparatus, the triaxial cell was filled with de-aired water, then the cell pressure was applied through a water tank filled with some de-aired water and olive oil at the top layer, where the olive oil played the role in guarding the air dissolved in the water. The description of the latest triaxial apparatus is shown in fig 1.4.

2. Test material and outline (Toyota et al., 2003):

a) Material

The material used in this experiment was Yoneyama sandy silt. The soil grain size was controlled to be smaller than 840 μ m and the soil consisted of 23.6%, sand 19.4% and silt 57%. The properties of this soil are liquid limit(ω_L)=52.4%, plastic index (Ip)=22.5% and specific gravity 2.746 g/cm3, which was defined by the Japanese Standard Association.

The soil (550g) was mixed with distilled water (1000 g) and kept for one night so that it would be mixed well. Then, the air was removed from this slurry to get good saturation during vacuuming process and the soil was consolidated under vertical pressure 80kPa for about two days until it turned into soil block. This soil block was trimmed into 5 cm diameter and 12.5 cm height cylindrical specimen.

b) Experiment

The experiment started with saturating process where the soil specimen was fully saturated and the saturation ratio was confirmed by the B-value which is more than 0.95. After the B-value check process, the targets and proximeters were attached to the specimen and the data will be recorded from this stage. Then the backpressure was applied to achieve a good saturation, and then the specimen was isotropically consolidated.

Finally, the specimen was compressed until the shear failure occurs. During the compression process, the test was conducted with two different condition; Consolidated-Drained (CD) and Consolidated- Undrained (CU). The data was recorded and calculated by computer program. Comparison on each LDM result was done to determine the most accurate LDM. The effect of consolidation time on soil stiffness also was examined.

3. Experimental results

<u>3.1 Comparison during isotropic consolidation process</u>

Figure 3.1 shows the axial strain and radial strain during isotropic consolidation of saturated soil specimen. The results of each LDM types were assembled in one graph and then compared to the isotropic line, which was considered as ideal behaviour during this process. All the lines show that the radial displacement occurred during the consolidation and it increased with an increase of axial strain. When the uniformity of the specimen is assumed during the process, the soil specimen is uniformly deformed in both vertical and horizontal directions. In this case, the LDM type 3 came out with the result approximately to the isotropic line. It can be considered that the most accurate LDM is type 3 in this condition.

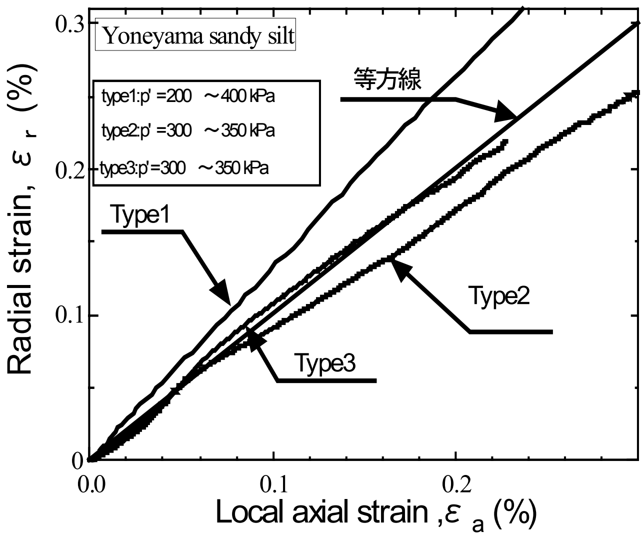

Fig 3.1 Relationships between axial strain and radial strain during saturated isotropic consolidation

<u>3.2 Comparison during Consolidated -Undrained shearing process</u>

The data during CU shearing test was also compared for each type of LDM. During the shearing process, the volumetric strain which is defined as $\varepsilon_v=\varepsilon_a+2\varepsilon_r$ are supposed to be zero because of undrained condition. According to the relationship between axial strain and radial strain, the measured data was plotted to confirm the accuracy of LDMs in which the line plotted should be inclined of –0.5 with the negative value of radial strain since the specimen was expanding to the lateral directions during the compression process (refer fig 3.2). As the result, it also confirmed that the LDM type 3 showed the most reliable result.

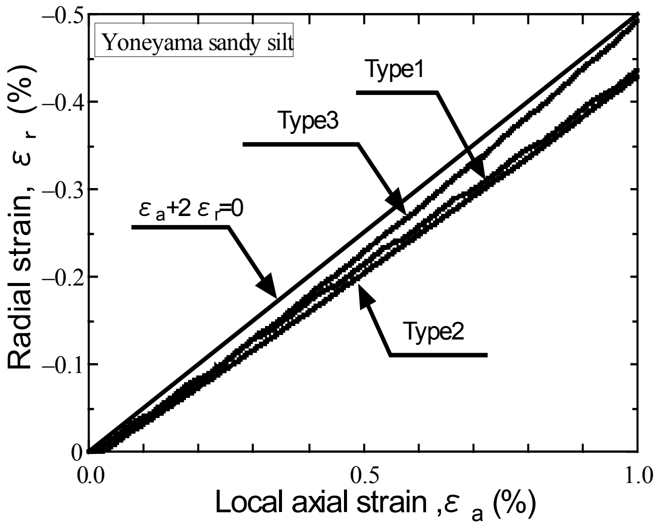

Fig 3.2 Relationships between axial strain and radial strain during consolidated-undrained shearing test

3.3 Effects of consolidation time on Poisson's ratio

The tests were also conducted with different hours (3 hrs, 6 hrs, 12 hrs and 48 hrs) of consolidation process under the same mean effective stress p'=300 kPa. The consolidation time of this specimen is 3 hrs based on 3t method. The result shows that the Poisson's ratio ν increases with the extension of the time during consolidation process. From this result, it is affirmed that the stiffness of cohesive soil easily changes by the consolidation time.

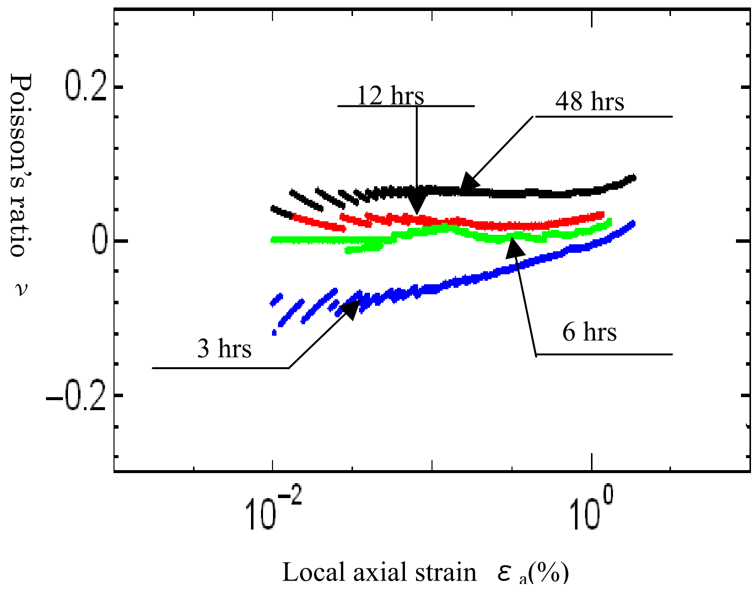

Fig 3.3 Relationships between axial strain ε_a and Poisson's ratio ν

4. Conclusion

From the test results, the final observation can be concluded as follows:

① LDM type 3 was found to be the most accurate lateral displacement meter for measuring small strain.

② Triaxial test apparatus was improved not to decrease the saturation degree of saturated specimens during long-period experiment.

③ The consolidation time affects the stiffness of cohesive soil where the stiffness increase as the period of consolidation process increase.

References:

1) John Atkinson (1993): An Introduction to the Mechanics of Soils and Foundations Through Critical State Soils Mechanics, McGraw-Hill International Series in Civil Engineering.

2) Toyota, H., Nakamura, K., Sakai, N. and Sramoon, W. (2003): Mechanical Properties of Unsaturated Cohesive Soil in Consideration of Tensile Stress, Soils and Foundations, Vol. 43, No. 2, pp. 115-122.