Time Effects on the Stress Strain Behavior of Geomaterials under Cyclic Simple Shear

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1.INTRODUCTION

Many researchers have studied time and aging effects on the stress strain behavior of soils. These effects can briefly summarized as:

Effects of constant strain rate, effects of step changes in strain rate, efects of aging (drained creep), effects of recent stress or strain history on the rates of creep, viscous effects under unloaded conditions during cyclic loading and effects of strain acceleration and deceleration.

In this paper using the results of one directional simple shear tests, the effects of time and aging on the cyclic stress strain behavior of unsaturated relatively dense soil, are discussed.

2.TEST METHOD

2.1.Material

Two types of soils were used. The first soil was sampled from a natural deposit from the foundation of a building in the central part of Tokyo, and belongs to Yurakucho silty sand stratum. The other one was sampled from a natural deposit of loam in Chiba prefecture. The grain size distributions of these soils are shown in Fig. 1.

2.2.Apparatus

The conventional direct shear apparatus was modified to provide the simple shear mode during cyclic shearing. Ten circular teflon rings substituted the two rigid boxes, each with the thickness of 2 mm and inner diameter of 60 mm. The height of specimens was 20 mm. The horizontal loading motor was also modified to provide automated loading - unloading, with different rates and for long time creeping. This horizontal load was applied to the top cap. A two-componet load cell was designed and placed inside the lower base, to measure the applied vertical and horizontal loads. Two other load cells were also used to measure horizontal and vertical loads on top of the specimen. A membrane supported the specimen inside the teflon rings.

2.3.Test Procedure

Silty sand samples were compacted with optimum water content to about 75% of the maximum dry density. These specimens were consolidated under 98 KPa vertical stress for 150 min. For monotonic tests, the horizontal load was applied to the top cap with a constant rate of loading, until the shear strain reached to about five percent. For cyclic tests, the horizontal load was applied to the top cap with a constant rate of loading to provide initial static shear stress. The static shear stress was kept constant for half an hour for all the specimens, exept for test No. 110, which was creeped for four days. Then loading was resumed with the initail rate, and 50 cycles of harmonic cyclic loading was applied. The vertical pressure was kept constant during the drained shearing.

Test procedure for Loam samples were similar to silty sand ones, except for the consolidation time, degree of compaction and number of cycles, which were 30 min., 85% and 20, respectively.

3.RESULTS

Test results confirm the former research on time and aging effect of geomaterials under monotonic loading.

As shown in Figs. 2, 3 and 4, a very stiff stress strain behavior, which is close to elastic deformation characteristics, is observed immediately after the process of loading is resumed after intermission of creep stage. Fig. 3 shows that this behavior is more significant after four days of creeping.

The creep rate increases with the increase in the initial strain rate at the start of the creep stage; that is, when the stress state of a given creep stage is reached by loading at a constant strain rate, as the time that has elapsed until the creep stage is reached becomes shorter, the creep strain rate at subsequent creep stages become higher.

These figures also indicate that, similar to post creep behavior, there is an overshooting in the stress strain curve after the cyclic loading. These results imply that there are at least three types of post cyclic stress and strain relationships:

Type1: The one, which rejoins the original primary loading relationship without exhibiting an overshooting

Type2: The one, which rejoins the original primary loading relationship after having exhibited a temporary overshooting; and

Type3: The one, which does not rejoin the original primary loading relationship, exhibits a persistent overshooting, with noticeably larger peak strength than obtained by the original primary loading.

Fig. 5 shows that, regardless of creep time and rate of loading, the shear stress- strain curves of the samples tend to show very similar behavior, immediately after cyclic loading. Fig. 6 shows a similar behavior in shear stress-volumetric strain curves. This may indicate that enough number of cyclic loading, can gradually change the aged structure of soil.

Fig. 7 presents that different samples have different residual strains at the end of creep stage. Due to the stiff stress strain behavior after intermission of creep stage, samples which experienced longer creeps, show smaller residual strain for the first cycle of loading; but as the number of cycles increases, the residual strain due to the cyclic loading tends to converge.

4.CONCLUSION

Based on the results of the tests it can be concluded that:

1. After enough number of cyclic loads and regardless of creep time and rate of loading, the shear stress- shear strain and shear stress- volumetric strain curves of the samples, tend to show a very similar post cyclic behavior.
2. As the number of cycles increases, the residual strain due to the cylclic loading tends to converge to a single value.

5.REFERENCES

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2)Mohajeri,M., Towhata,I. (1999): Stress strain behavior of silty sands, Proceedings of 35th Japan Conference on Geotechnical Engineering, Vol.2, pp. 1657, 58.

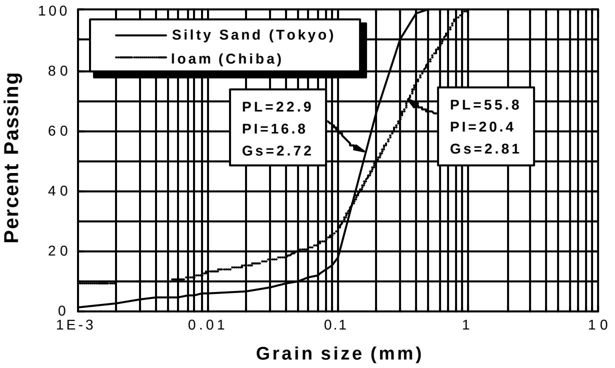

Fig.1. Grain Size Distribution of Silty Sand and Loam

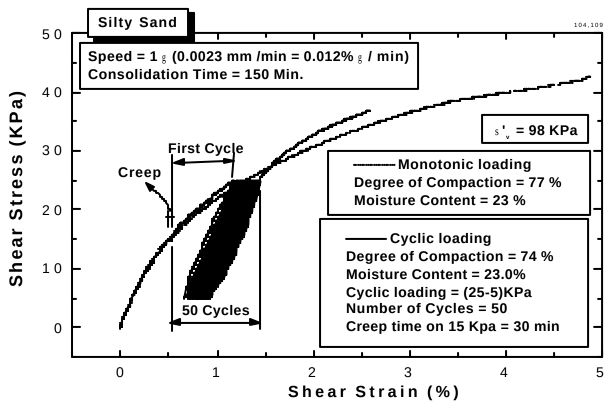

Fig. 2. Effect of creep and cyclic loading on the stress strain behavior of silty sand

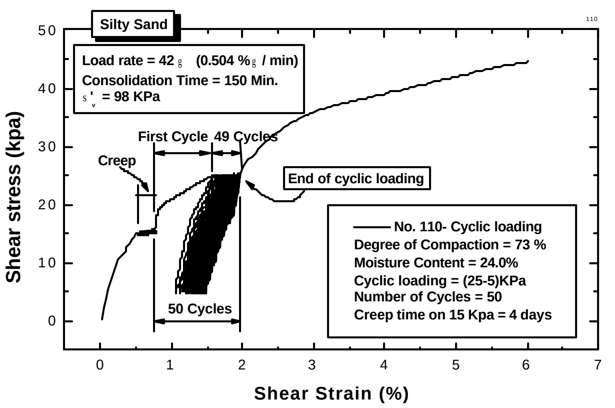

Fig. 3. Long creep and cyclic loading effect, on the stress strain behavior of silty sand

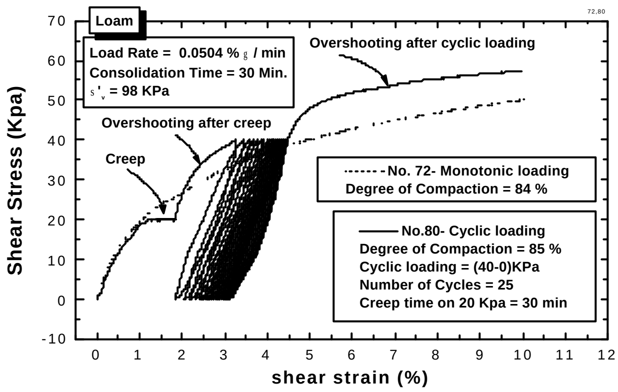

Fig. 4. Effect of creep and cyclic loading on the stress strain behavior of loam

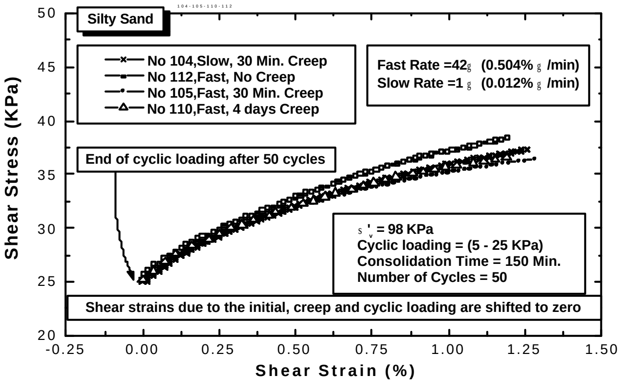

Fig. 5. Shear stress strain curves, after cyclic loading

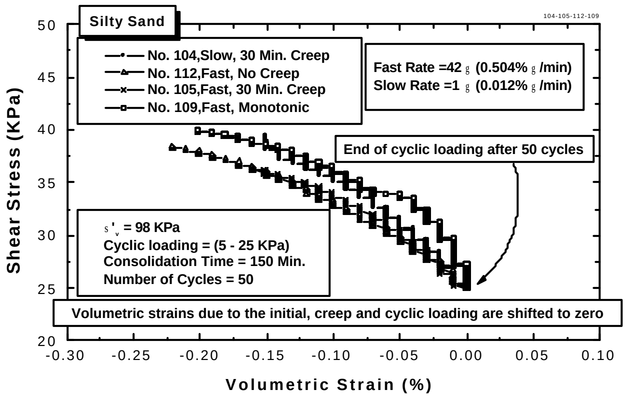

Fig. 6. Shear stress -volumetric strain after cyclic loading

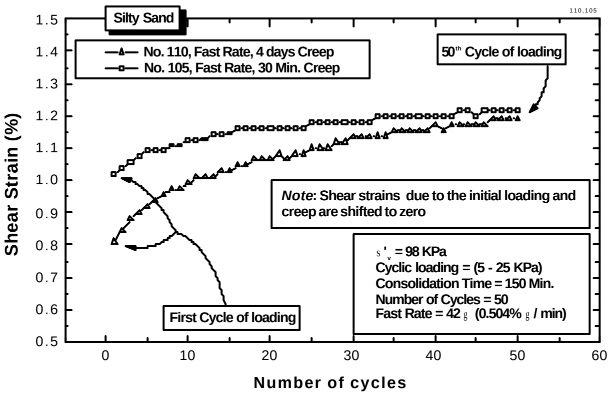

Fig. 7. Effect of number of cyclic loading on the residual strain of silty sand