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Volume Change of Sand Under Drained Cyclic Simple Torsional Shear

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1.Introduction

Volume change of sand during drained shearing is one of the parameters which is being used in models of drained or undrained behavior of sand and estimation of deformation or settlement of soil structures. A number of drained cyclic simple shear test on Toyoura sand specimens with different densities were performed. Based on the results of these tests the volume change of sand and its correlation with shear energy, another key factor on behavior of sand, will be discussed.

2.Apparatus and test procedure

A hollow torsional shear test apparatus was used in this study. The soil specimen of Toyoura sand was a hollow cylinder with 19.5cm height, 10cm outer diameter and 6cm inner diameter. Density of specimens was in the range of loose to very dense(void ratio:0.694, 0.756, 0.832 and 0.895). The isotropic consolidation pressure for all of the specimens was same value of 98 KPa., specimens were sheared in cyclic drained simple shear mode under large number of constant strain amplitude(3%). In this mode of shearing the shape of the planes parallel to shear direction and vertical stress must be kept constant, which means that horizontal and tangentical strain increment must be kept zero. By independent computerized control of inner cell pressure, outer cell pressure and vertical stress in hollow torsional shear machine this mode can be achieved. For increasing the measurement precision of volume change of specimen a digital balance was used.

3.Results and conclusion

Fig. 1 shows stress-strain path and volume change of dense sand with initial void ratio of 0.756 or 58% Relative density. Due to large number of cyclic loading some volumetric change happened and its void ratio at the end of cycles changed to 0.658 (Dr=84%). Fig. 2 is the same graphs for a loose sand with initial void ratio of 0.895(Dr=21%). In this case large volume contraction happened due to shearing. Comparison between this two figures shows that after applying a number of cycles at points which the specimens have same void ratio the volume change per cycle is different for them. Initially denser sand which has experienced less number of strain cycles has more volume change in each cycle at the points which they have same void ratio.

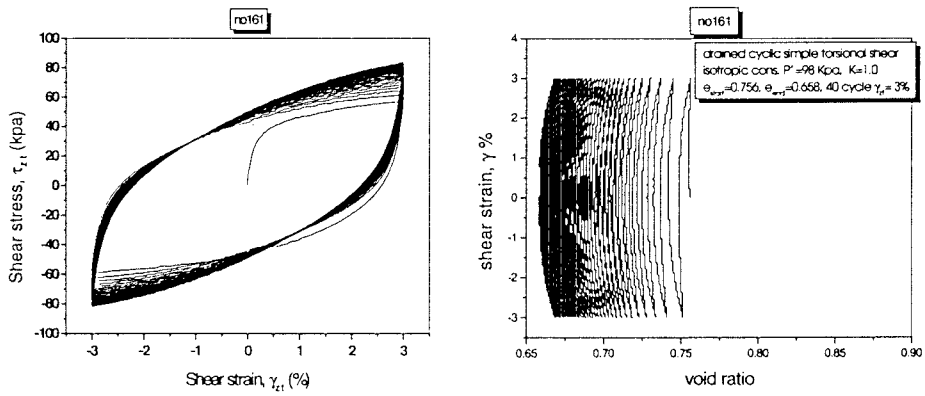

Fig. 1. a) stress –strain graph of dense sand b) change of void ratio of dense during shearing

Shear energy during the cyclic loading for the specimens was calculated at points which $\tau_{zt}=0$ and its relation with void ratio are summarized in Fig. 3. This figure shows that the energy - volume change

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correlation is different for the specimens with different initial density. But it seems that all graphs converge to a limit in large value of shear strain energy.

Fig. 4 compares the relationship between the volumetric strain end energy. This graph is plotted for all points and also only at points which τ_{zt} =0. According to this figure it can be concluded that the volume change of the sand during each cycle has a recoverable and irrecoverable component. Total volume change of sand after a large number of cycles can be considered as the second term. For the analysis of undrained stress-strain behavior of sand both component must be considered. The second term is particularly important in liquefaction problems.

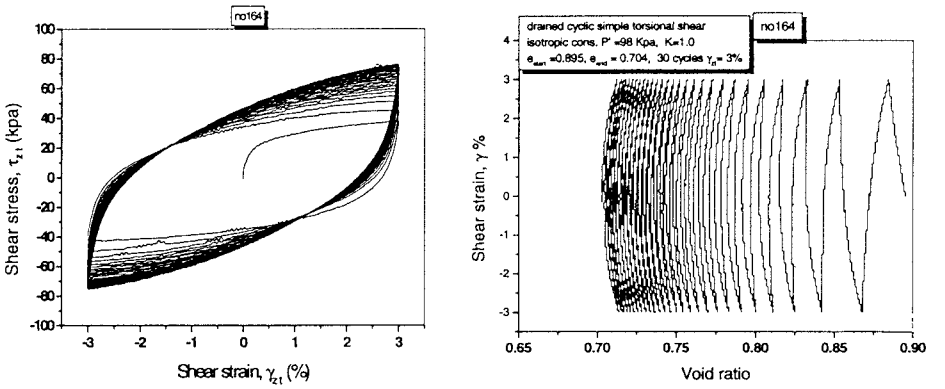

Fig. 2. a) stress-strain graph of loose sand b) change of void ratio of loose sand during shearing

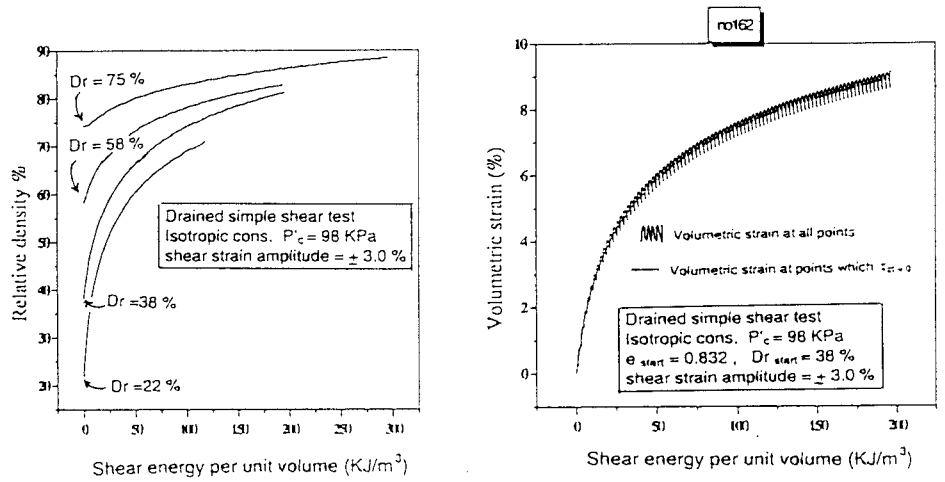

Fig. 3. Effect of density on correlation between relative density and shear strain energy

Fig. 4. Different component of volumetric strain versus shear strain energy

4.References

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