III-147 Isotropic Compression Tests on Toyoura sand

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1 Introduction

Granular materials usually show a pattern of packing depending on the manner in which they are deposited. This may make the material to behave anisotropically even in isotropic compression tests [1]. So for the realistic modeling of granular materials, especially for the development of volumetric plastic strain, many isotropic compression tests have been performed; however, they tend to over-estimate the volumetric deformation due to effect of bedding error and membrane penetration at the specimen boundaries. The present study attempted to obtain very accurate deformation characteristics of Toyoura sand during loading and unloading of isotropic compression and the inclination of a yield cap at the point of crossing the I_1 axis in the $I_1 \sim \sqrt{J_2}$ space.

2 Testing Procedure

Two isotropic compression tests were performed using two triaxial specimens (height~63cm and diameter~30cm). Specimens were prepared by pluviating Toyoura sand in air. The density was controlled by changing the size of the hole through which sand was flowed out into a set of criss-crossed sieves. One specimen was loose (e=0.785) and the other was dense(e=0.673). In both cases, lubricated ends were used to reduce the effect of end-friction. The thickness of grease layer was 0.06μm. The thickness of the end rubber disks was 0.3mm and the lateral rubber membrane was 0.8mm. A pair of Local Deformation Transducers (LDT) were used to measure the deformations excluding bedding error. Three sets of Radial Deformation Transducers(RDT) were used to measure the change of the specimen diameter (Fig.1). Since the diameter change as measured involved the effect of membrane penetration(MP), it was corrected by assuming: (1) the effect of MP is a function of σ_c, but the same during loading and unloading of σ_c, and (2) the behaviour during unloading is isotropic. Loading was controlled by vaccuum (up to 0.8 kgf/cm^2) and subsequently by air pressure (upto 7 kgf/cm^2), while the axial load was applied by using a set of Belloframe cylinders so as to maintain the isotropic stress condition at the top of specimen. Loading was controlled manually, all data was monitored and stored in a computer.

3 Results

Figs.2 and 3 show the relationships between the effective confining pressure σ'_c and the axial and radial strain, ε_a and ε_r, respectively. Significant differences in ε_a between the values measured with LDTs and gap sensor may be seen. This means that the uncorrected axial strain obtained from the axial displacement of cap is totally unreliable for conventional specimens having lubricated ends with a height of about 10~15cm. Fig.4 shows clearly the anisotropy during loading for both loose and dense specimens. The degree of anisotropy increased with the increase in void ratio [1]. Fig.2, 3 and 4 show that the plastic/irrecoverable change is very small in case of dense sand. Figs.5, 6 show that isotropic compression curve ($e - logp$) is nonlinear. Fig.7 shows the relationships between the volumetric strain (using corrected ε_r) and p' during loading for the range of $p' = 0.5 \sim 5.5kgf/cm^2$. From these apparently linear curves, the accurate bulk modulii for loose ($K = 222kgf/cm^2$) and dense sand($K = 361kgf/cm^2$) can be obtained.

4 Conclusions

From the results shown above, it can be concluded that–

1) With lubricated ends, the axial strain from the axial displacement of specimen cap is totally unreliable.

2) Toyoura sand exhibits very little volumetric plastic strain in isotropic compression tests.

3) Toyoura sand is anisotropic during loading in isotropic compression tests.

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References

[1] M. A. El-Sohby and K. J. Andrawes. "Deformation characteristics of granular materials under hydrostatic compression". *Canadian Geotechnical Journal*, November 1972b.

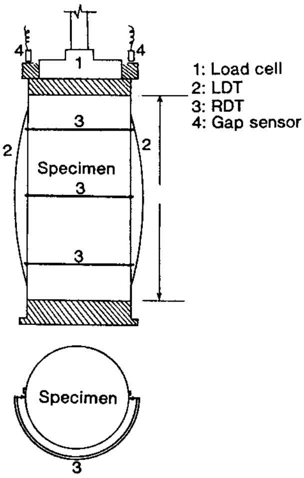

Figure 1: Specimen settings

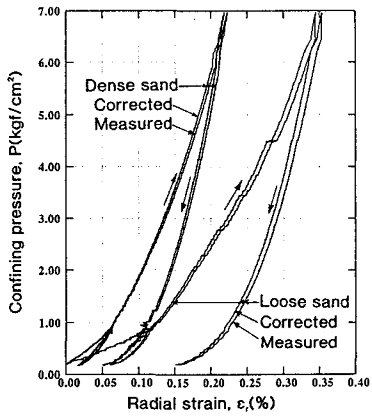

Figure 2: Confining pressure-axial strain curves

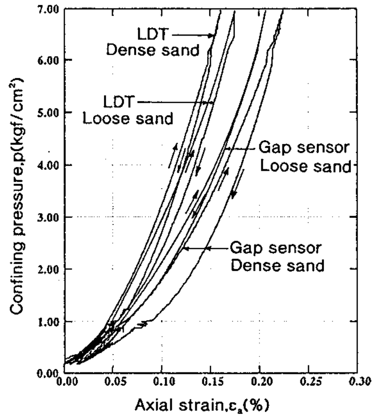

Figure 3: Confining pressure-radial strain curves

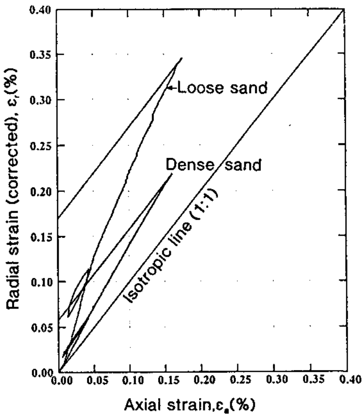

Figure 4: Anisotropy of loose and dense Toyoura sand

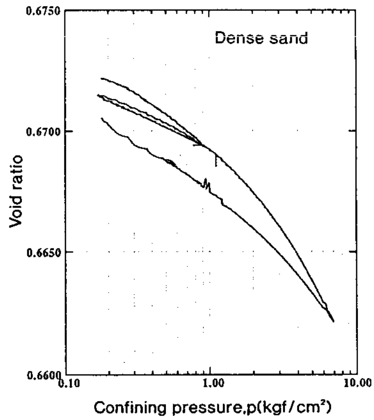

Figure 5: e-Logp' curve of Toyoura sand

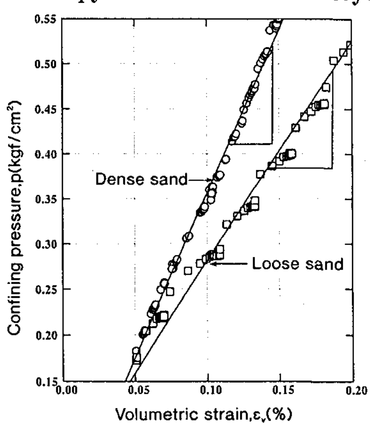

Figure 7: Bulk modulus of Toyoura sand

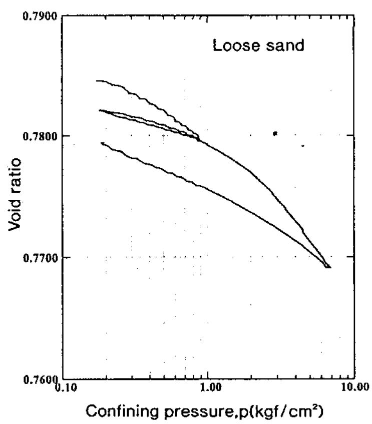

Figure 6: e-Logp' curve of Toyoura sand