Proceedings of Ninth World Conference on Earthquake Engineering
August 2-9, 1988, Tokyo-Kyoto, JAPAN (Vol.III)

4-1-8

CYCLIC LOADING TEST ON SANDY SOIL BY TRUE TRIAXIAL TESTING APPARATUS

Ryosuke KITAMURA[1] and Masato HIDAKA[2]

[1]Department of Ocean Civil Engineering, Kagoshima University, 1-21-40 Kourimoto Kagoshima, JAPAN
[2]Graduate Student of Kagoshima University, 1-21-40 Kourimoto Kagoshima, JAPAN

SUMMARY

The true triaxial soil testing apparatus, which can generate three different principal stress condition in the specimen and apply cyclic loading to the specimen, was used to make the liquefaction characteristics of sandy soil clear. The used materials were Toyoura standard sand and Shirasu. Shirasu is a non-welded part of pumice-tuff which is widely spread in the southern part of Kyushu Island, Japan. Two kinds of stress paths were adopted to investigate the influence of anisotropic fabric on the mechanical behavior under cyclic loading. It was found out from the test results that the differences in the fabric and the mean diameter of soil particles have influence on the liquefaction characteristics.

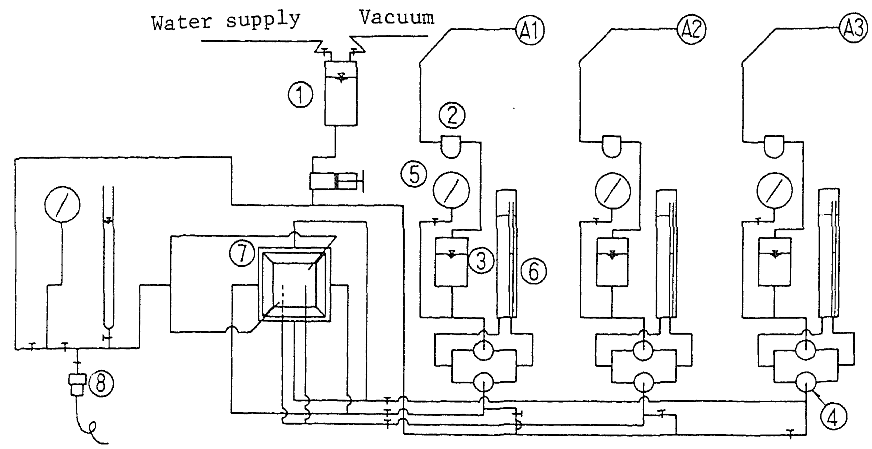
INTRODUCTION

Recently the reclaimed ground on the seabed are often made in Japan, for example the man made island for Kansai International Airport. In Kagoshima, which is located in the southern part of Kyushu Island, reclaimed grounds are also being made, where the main material is Shirasu. Shirasu is a non-welded part of pumice-tuff derived from the Pleistocene pyroclastic flow deposit and classified into special soil in Japan. The mechanical and physico-chemical characteristics of Shirasu are different from usual sandy soil in some aspects and they remain to be made clearer, especially the dynamic characteristics.

In this paper the cyclic loading test on Toyoura standard sand and Shirasu was carried out by using the true triaxial testing apparatus. Then the liquefaction characteristics were made clear for these materials.

APPARATUS

Figure 1 shows the main part of the box type's true triaxial testing apparatus. Figure 2 shows the detail of the box type's cell (⑦ in Fig.1), whose dimension is 10x10x10 cm. The static and/or cyclic loading is applied to cubical specimen through the rubber bags as shown in Fig.2. Three orthogonal principal strains are calculated by the change of water level in the double tube type's burette (⑥ in Fig.1). The change of water level in the burette is measured by the capacitance type's wave height meter. Figure 3 shows the data acquisition system for strain which is aided by the microcomputer. The cyclic pressure is generated by the function generator, transducer and ratio relay by which the electric signal is converted to the air pressure as shown in Fig.4.



1.Water reservior 2.Air filter 3.Air-fluid interface
4.3-way ball valve 5.Pressure gauge 6.Volume change gauge
7.Cubical triaxial cell 8.Pressure transducer

Fig.1 Main Part of True Triaxial Testing Apparatus

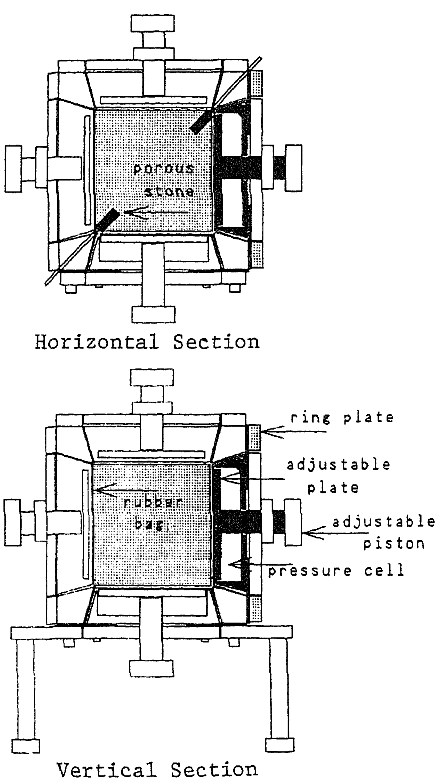


Fig.2 Detail of Cubical Triaxial Cell

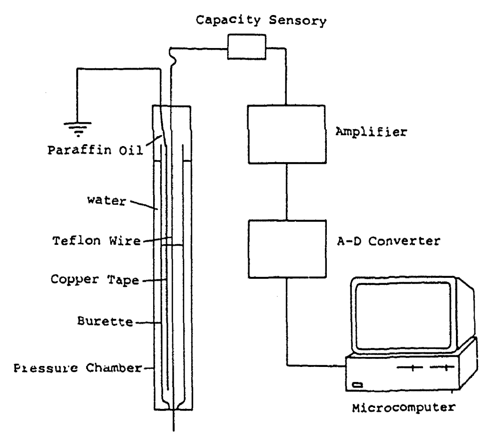


Fig.3 Data Acquisiton System of Strain

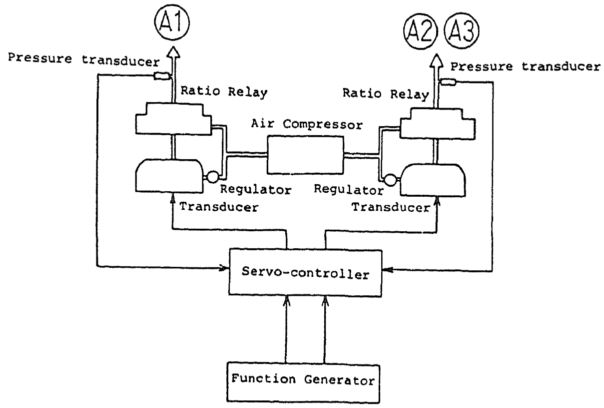


Fig.4 Generation System of Cyclic Loading

Table 1 Physical properties of material

	mean diameter (mm)	Specific gravity	e_{max}	e_{min}
Toyoura standard sand	0.22	2.64	0.938	0.582
Shirasu A (0-2000μm)	0.15	2.60	1.308	0.758
Shirasu B (74-420μm)	0.22	2.50	1.813	1.085
Shirasu C (420-2000μm)	0.83	2.63	1.476	1.037

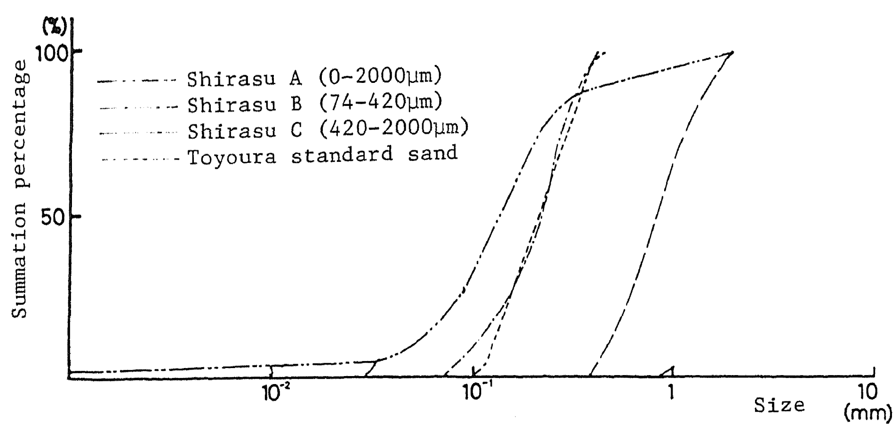


Fig.5 Grain size distribution curve

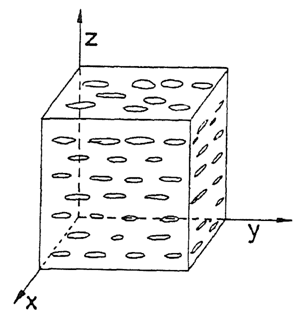


Fig.6 Anisotropic fabric

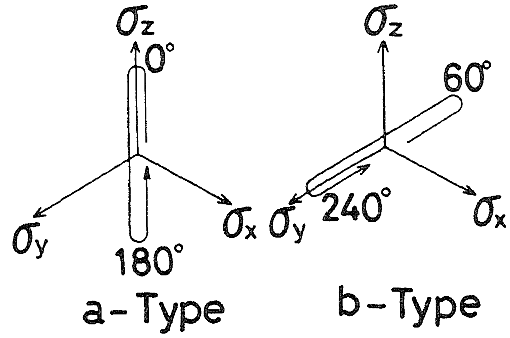


Fig.7 Stress Path on Π-plane

MATERIAL AND TEST PROCEDURE

The used material is Toyoura standard sand and Shirasu. Shirasu is divided into three kinds of material by sieving, i.e., the grain size of Shirasu A, Shirasu B and Shirasu C ranges between 0-2000μm, 74-420μm and 420-2000μm respectively. The mean diameter, the specific gravity, and the maximum and the minimum void ratios of each material are list in Table 1. Figure 5 shows the grain size distribution curve of these materials.

After the saturated material is set in the cubical triaxial cell, the isotropic pressure, 1 kgf/cm^2, is applied. Completing the isotropic compression, the back pressure, 1.5 kgf/cm^2, is applied and the isotropic pressure is increased to 2.5 kgf/cm^2 at the same time. Under this condition the pore water coefficient is measured, which is more than 0.93 for all the test. Then, the undrained cyclic loading test is carried out, where the frequency of cyclic loading is 0.1 Hz.

Figure 6 schematically shows the anisotropic fabric. This figure means that the particles tend to be sedimented so that the longest axis of particles is in the horizontal direction. The principal stress σ_z is always in the vertical direction. Figure 7 shows the stress path on Π-plane, i.e., under the constant mean principal stress condition the radial stress path on Π-plane is adopted in this test series.

RESULTS

Figures 8(a) and (b) show the liquefaction resistance for Toyoura standard sand and Shirasu with the stress paths as shown in Fig.7, where the liquefaction is defined as the stress state in which the mean effective stress is initially zero. The followings are found out from Figs.8(a) and (b);

1) Shirasu B, whose grain size distribution is almost same as Toyoura standard sand, has the same liquefaction characteristics as Toyoura standard sand.
2) Shirasu C, which has larger mean diameter than Shirasu B, has larger liquefaction resistance than Shirasu B.
3) Shirasu A has larger liquefaction resistance than Shirasu B at larger shear stress amplitude, while Shirasu A has smaller liquefaction resistance than

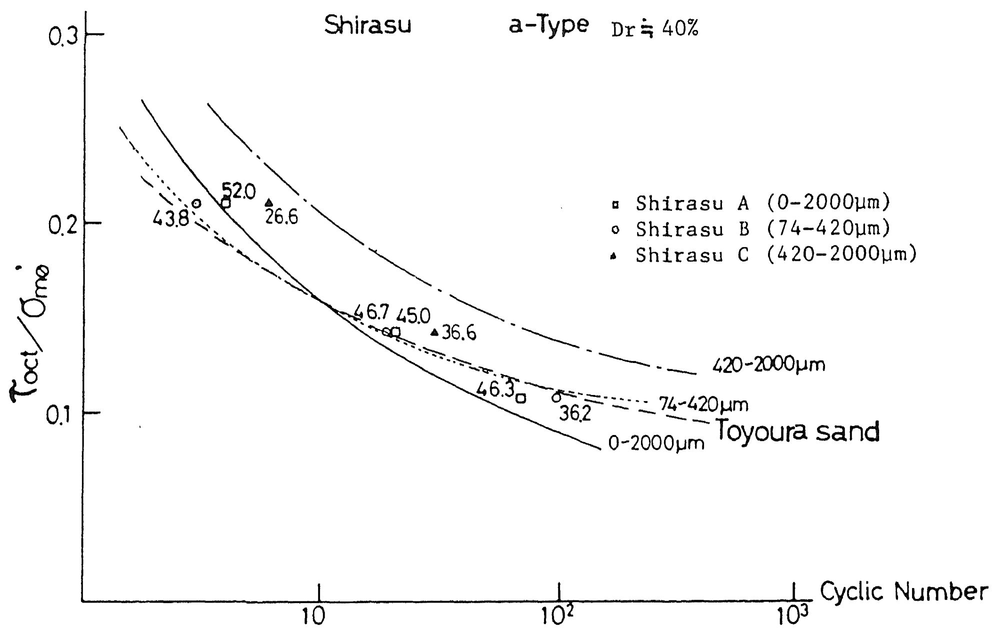


Fig.8(a) Liquefaction resistance of a-type

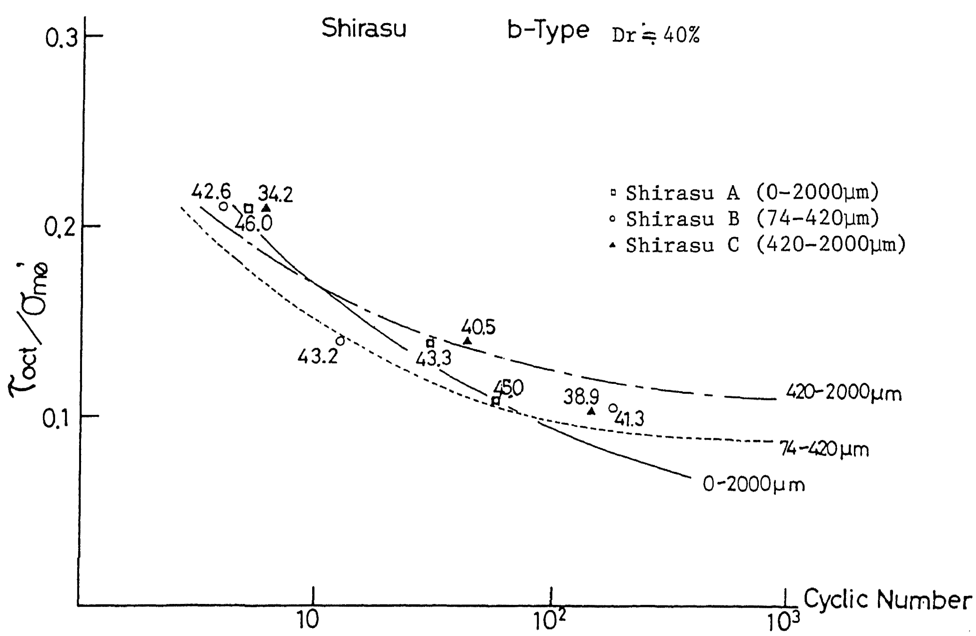


Fig.8(b) Liquefaction resistance of b-type

Shirasu B at lower shear stress amplitude.

4) The liquefaction resistance with the stress path of a-type is larger than the one with the stress path of b-type. This means that the anisotropic fabric influences the liquefaction characteristics.

CONCLUSIONS

The box type's true triaxial testing apparatus is explained for the liquefaction test. This apparatus can generate three different principal stress condition and simulate the stress state of the actual ground more accurately. The liquefaction characteristics for Toyoura standard sand and Shirasu are made clear by using this apparatus, i.e., the anisotropic fabric and the grain size distribution influence the liquefaction characteristics. We have done the liquefaction test under the limit condition, i.e., Dr≒40% and only two kinds of stress paths. So, it is necessary to have more data for liquefaction in order to obtain the comprehensive characteristics of sandy soil and to compare them with other data which were obtained by different apparatus, different stress condition, different material and so on.

This research was supported by the Ministry of Education, Science and Culture of Japan under Grant-in-Aid for Developmental Scientific Research, No.60850098.