研 究 速 報
UDC 552.517 : 624.131.52 : 620.176.251

Effect of Cyclic Prestraining on Stiffness of Sands II
——Test Results——
砂のせん断剛性率に及ぼす繰返しせん断履歴の影響 II
——試験結果——

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INTRODUCTION

This report is the continuation of the first report[12], in which the testing method will be described, and in this second and last report, the effects of cyclic prestraining which were observed in the three tests listed in Table 2 will be reported.

Table 2 Summary of initial conditions

Test No.	Apparatus	Sand	$e_{0.05}$ [1]	σ'_c [2]
TC	Cyclic Triaxial	Toyoura	0.706	0.5
LTO	Cyclic Triaxial	Toyoura	0.819	0.5
TI	Cyclic Triaxial	Ticino	0.663	0.5

[1] $e_{0.05}$=void ratio measured at a confining pressure of 0.05 kgf/cm²
[2] the confining pressure in kgf/cm²

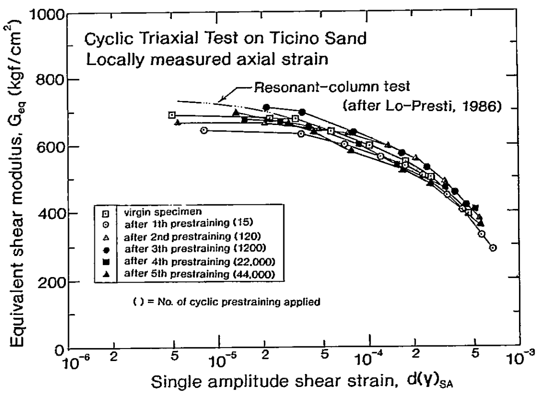

Fig. 7 Effect of cyclic prestraining on stiffness, dense Ticino sand (Test TI)

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TEST RESULTS

The equivalent shear moduli, G_{eq}, of Test TI, obtained at sequences of cyclic loading were plotted against the single amplitude shear strain $d(\gamma)_{SA}$ ($\gamma=\varepsilon_a-\varepsilon_r$).Figs. 7,8 and 9 show the results of Tests TI of dense Ticino sand, TO for dense Toyoura sand and LTO for loose Toyoura sand, respectively. In these figures, the values of stiffness have not been corrected for the decrease in the void ratio during cyclic prestraining. The lateral strain, ε_r, was obtained by averaging the values measured at the three levels along the specimen height. These three values were found not very different from one to the others. In the present study, the maximum number of cycles and $d(\gamma)_{SA}$ for cyclic prestraining were about 44,000 and 0.06 % in the eighth and last cycle in Test LTO. Note particularly that in Figs. 7 and 8, the data points of symbol □ are those measured during the first sequence of cyclic loading on the virgin specimen and

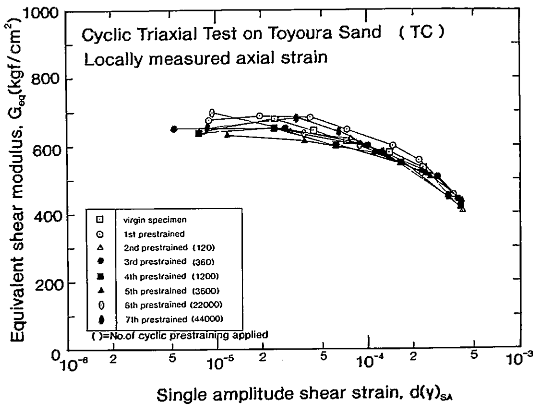

Fig. 8 Effect of cyclic prestraining on stiffness, dense Toyoura sand (Test TC)

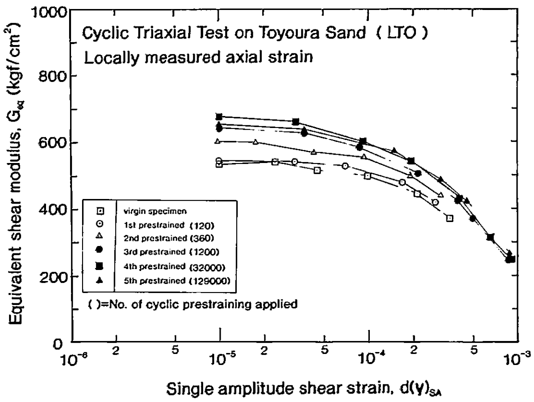

Fig. 9 Effect of cyclic prestraining on stiffness, loose Toyoura sand (Test LTO)

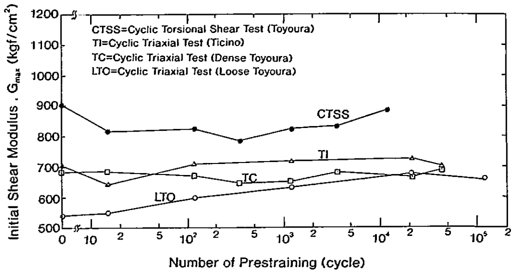

Fig. 10 Initial shear modulus, G_{max}, versus the number of cyclic prestraining immediately before the measurement of G_{max}. Note the number of cyclic prestraining shown here is not the accumulated value.

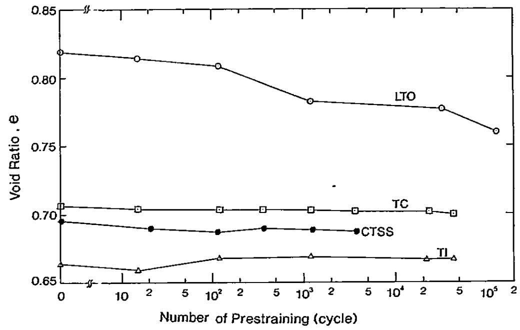

Fig. 11 Number of cyclic prestraining versus void ratio at the end of each cyclic prestraining

those of symbol ◇ in Fig. 7 and ● in Fig. 8 are those measured during the last sequence after the last cyclic prestraining. It is clear from Figs. 7 and 8 that the cyclic prestraining did not increase the initial shear moduli of these two types of sands, unlike the test results reported for Ottawa sand by Drnevich and Richart [1] and Shen et al.[6] and for Toyoura sand by Tokimatsu et al. [11]. In Fig. 9 for a loose Toyoura sand, it may be seen that the stiffness increased due to cyclic prestraining. It mey be noted, however, that this increase was due to the decrease in the void ratio during cyclic-prestraining, as explained below. The present authors cannot explain these different results.

Fig. 10 shows the values of the initial shear moduli, G_{max}, defined for $d(\gamma)_{SA}$ less than 0.001 %, plotted against the number of cyclic prestraining which was made immediately before each sequence at which the measurement of stiffness was made. Fig. 11 shows the void ratio at the end of the previous cyclic prestraining. Note that the number of prestraining shown in Figs. 10 and 11 are not accumulated ones. In addition, shown also is the result of one torsional shear test on saturated Toyoura sand (the details of the testing method is described in 9,10). It may be noted from Fig. 10 that the increase in G_{max} by cyclic prestraining cannot be noticed except in Test LTO. Test LTO was performed on a loose specimen of Toyoura sand, and therefore, a large amount of densification by cyclic prestraining was observed as shown in Fig. 11. The void ratio changed from the initial value of 0.802 to 0.759 at the end of the final cyclic restraining. When it ts assumed that G_{max} is a function of

$$f(e)=(2.17-e)^2/(1+e),$$

this change of void ratio yields an increase in G_{max} of about 13 %, which was well comparable with the measured value of 15 %.

It is also extremely important to note in Fig. 7 that the shear modulus of Ticino sand is very close between the present cyclic triaxial tests performed at Institute of Industrial Science and the torsional-type resonant-column test which has been performed independently in Italy (3).

CONCLUSIONS

In the test results shown in this paper, the initial stiffness, G_{max}, defined at strain levels of 0.001% (10^{-5}) or less and those at larger strain levels of the two kinds of sands did not increase noticeably by cyclic prestraining which involved many numbers of cycles (up to 120,000) at an axial strain of about 0.05

% when the void ratio did not decrease noticeably by cyclic prestraining. The initial stiffness G_{max} increased by cyclic prestraining only when the void ratio decreased correspondingly, and the increase in G_{max} could be explained by the decrease in void ratio during the cyclic prestraining. These teet results strongly suggest that such plastic deformation characteristics as the resistance of saturated sand against undrained cyclic stresses could not be uniquely correlated to the initial stiffness.

ACKNOWLEDGEMENTS

The experiments were performed at the Institute of Industrial Science while Dr. Lo Presti was staying at IIS, being financially supported by IIS. The authors acknowledge the contribution of Mr. Y. Ishii and Mr. T. Sato. (Manus cript received, FEBRUARY 25, 1991)

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