III－213 EFFECT OF BEDDING ERROR ON STIFFNESS AND DAMPING RATIO OF GRAVELS IN CYCLIC TRIAXIAL TESTS

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INTRODUCTION

Stiffness and damping ratio of soils is essential for accurate analyses of ground response and soil-structure interaction problems. Many experimental studies on this subject mostly for sandy soils have been carried out by using several different testing methods. With recent advances in accuracy of laboratory testing measurements, static cyclic loading methods (e.g. cyclic triaxial tests) have become most popular in Japan. Recently, it has been shown that, even in cyclic loading triaxial tests (CTX tests) on dense specimens of coarse-grain soils using regular ends, the bedding error (BE) can have a significant effect on stress-strain relation. Since available experimental data as to BE effect for gravels is very limited to date, this research was conducted to investigate the BE effect on the cyclic stress-strain relation of gravels, combined with the effect of grain size gradation.

MATERIAL AND SPECIMEN PREPARATION

Since the magnitude of bedding error depends on several factors, including grain size, gradation of material and formation of specimen ends, two different gravels were used in this study. Hime gravel is uniform with round–shaped grains, while Nagoya gravel is well-graded with sub-angular shape (Fig.1). Dry gravel specimens 300 mm in diameter and 600 mm high were prepared directly on a triaxial cell base by pouring a preweighed amount of gravel into a 2 mm thick membrane lined mold in six equal layers with zero height of drop. Each layer was compacted by applying a vertical vibration using a vibrator for five minutes to achieve the maximum density. The top surface of the final layer was carefully flattened. For Nagoya gravel, the top of specimen was gently finished by using the fine grains and then compacted. Specimens were isotropically consolidated and tested at a constant lateral pressure using a large triaxial apparatus, which is capable of testing the same specimen for a wide range of strains from 10^{-6} to 10^{-1}. The details of the apparatus and testing procedure were described in Dong et al., 1993.

TEST RESULTS AND DISCUSSIONS

The relationship between the equivalent Young's modulus, E_{eq} and the single amplitude axial strain, $(\varepsilon_a)_{SA}$ in the CTX tests at a confining pressure of 78.5kPa are shown in Figs.2(a) and (b) for dense Hime and Nagoya gravels, respectively. In these and the following figures, LDT and Proximeter mean the axial strains, ε_a, measured locally on the lateral surface of specimen by means of a pair of

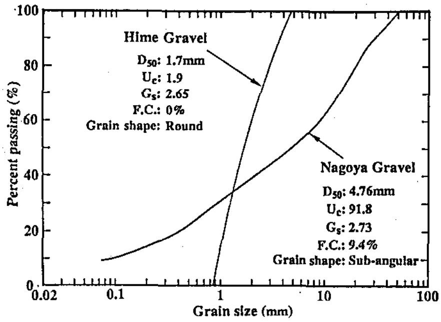

Fig.1 Grain size distribution of tested gravel

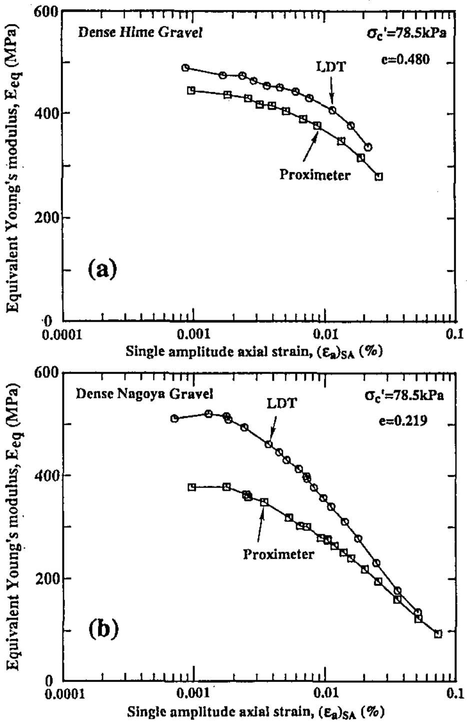

Fig.2 E_{eq}~log$(\varepsilon_a)_{SA}$ relation in 10th loading cycle for; a) Hime gravel and b) Nagoya gravel

LDTs and externally from the movement of the cap of the specimen using a pair of proximeters, respectively. It can be seen that the values of E_{eq} by proximeters are noticeably smaller than those by LDTs due to the effect of BE, while it is more significant for Nagoya gravel. This may be because the density of well-graded Nagoya gravel is much larger than that of Hime gravel and it is very difficult to achieve a very high density in the zone near the top of specimen, since this zone would have been inevitably disturbed during the trimming and levelling. Moreover, since the grain sizes of Hime gravel are relatively small and grain shape is round, the magnitude of the loose zone near the top of specimen formed during the end finishing could be smaller. Further, regardless of the large difference in grain size distribution, the initial modulus values by LDTs for the two gravels are surprisingly similar. It may also be seen that the strain level–dependency of stiffness for Hime gravel is smaller than that for Nagoya gravel.

Figs.3(a) and (b) show the values of damping ratio, h, versus $(\varepsilon_a)_{SA}$ for the two gravels, respectively. It may be seen that the values of h are also influenced by the effect of BE. This point can be more clearly seen from Fig.4, which compares the damping values, h_{LDT}, by LDTs and $h_{Proximeter}$, by proximeters at the same loading stage. The values of $h_{Proximeter}$ are larger than those of h_{LDT}. Particularly for Nagoya gravel, the increase in h due to the BE effect is even up to more than 100% for small h values. The results are consistent with those of tests on dense Toyoura sand by Teachavorasinskun and Tatsuoka (1991). Further, the damping values of Nagoya gravel are generally larger than those of Hime gravel (Fig. 3).

CONCLUSIONS

The following conclusions were obtained:

1)The effects of BE on both modulus and damping are significant. Local measurements of axial strain are imperative for accurate evaluation of stiffness and damping ratio of gravels in cyclic triaxial tests.

2)For the maximum density condition, the initial stiffness seems to be least influenced by the grain size distribution, however, it can affect the trend of strain level–dependency of stiffness and damping.

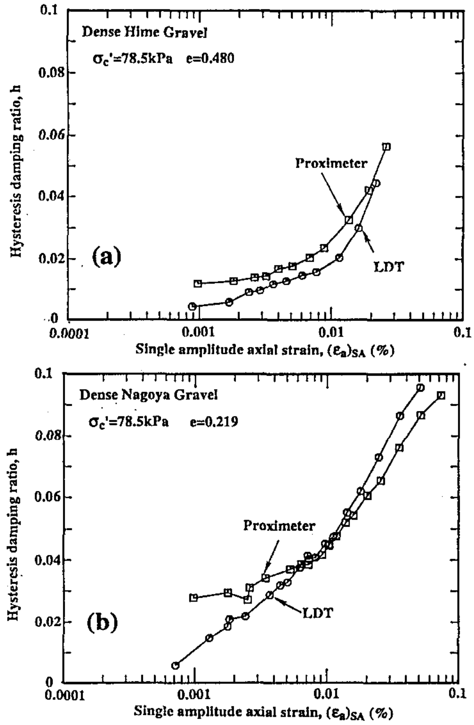

Fig.3 h~log$(\varepsilon_a)_{SA}$ relation in 10th loading cycle for; a) Hime gravel and b) Nagoya gravel

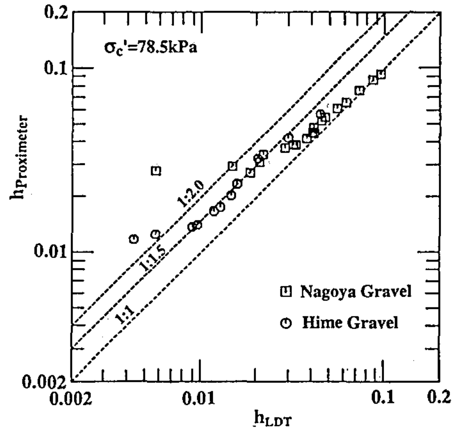

Fig.4 Comparison of damping ratio between LDT and proximeter measurements

REFERENCES

1)Dong, J., Tatsuoka, F., Sato, T. and Nakamura, K. (1993): Stress-strain behavior of gravels for a wide strain range in triaxial tests, Proc. 28th Japan National Conf. on SMFE, JSSMFE, Kobe. 2)Dong, J., Tatsuoka, F., Kohata, Y. and Endo, O. (1993): Deformation properties of gravels during monotonic and cyclic loading, Proc. 28th Japan National Conf. on SMFE, JSSMFE, Kobe. 3)Tatsuoka, F. and Shibuya, S. (1992): Deformation properties of soils and rocks from field and laboratory tests, Keynote Lecture, Session I, Proc. 9Asian Regional Conf. on SMFE, Bangkok, 1991, Vol.II, pp.101–170. 4)Teachavorasinskun,S. and Tatsuoka,F. (1991): Effect of bedding error on the measured damping of sand, Proc. 46th Annual Conf. of JSCE, Vol.III.