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Comparison of Dynamic Behavior of Reconstituted and Core Barrel Sandy Soil Sample by Resonant Column Test in Flexural Mode

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ABSTRACT: Determining the dynamic properties of soils is an important issue in solving seismic geotechnical engineering problems. In this respect, several types of field and laboratory methods are available with different advantages and limitations regarding solving different problems. The difference between the results of in-site and laboratory tests is one of the engineers' difficulties. Some reasons for the difference between the values of dynamic parameters which achieved from field and laboratory tests, are the remolding effect of samples, difference in stress conditions and loss of cementation; negligence of these facts in soil dynamic properties may lead to serious damage due to unrealistic soil analysis. Among the laboratory methods, the resonant column test is one of the methods which determines the dynamic properties of soils at small strains. In this research, Young's modulus and damping ratio of core barrel and reconstituted earth materials have been studied by performing resonant column test in flexural mode. The effects of confining pressure and anisotropic confining pressure was studied by using the Young's modulus and damping ratio versus flexural strain diagrams. The results of the study indicate that reconstituting reduces the Young's modulus, but the variation of damping ratio versus shear strain for core barrel and reconstituted samples is negligible. Increase in the confining pressure and anisotropic confining pressure result in the increase of Young's modulus. Comparing the damping ratio results with the two methods of free vibration decay and half-power bandwidth indicates that the damping ratio values obtained from the half-power bandwidth method are higher.

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1- Introduction

Soil Characteristics that affect the phenomenon of wave propagation and other small strain phenomena are called soil dynamic characteristics. Two of the most important soil dynamic characteristics are shear modulus and Young's modulus [1]. Most of the laboratory research has focused on determining and exploring the effects of various features such as laboratory methods, particle size, particle shape, material type, etc. on small strain dynamic characteristics [2-5].

One of the important issues in evaluating dynamic parameters is the difference between the results of in-situ and laboratory experiments, which can be due to the remolding effect of samples and the difference in stress conditions. Negligence to these facts may lead to serious damage due to unrealistic soil analysis. Studies in this field have shown that remolding reduces the shear modulus and increases the damping ratio slightly [6-8]. Experimental studies on the effect of stress anisotropy indicate that anisotropy increases the shear modulus but has an insignificant effect on the damping ratio. [6, 9, 10]

Despite the few studies which have been done on remolding and anisotropic effects on shear modulus, it is also essential to study these factors on Young's modulus. In this Research, Young's modulus and damping ratio of core barrel and reconstituted earth materials have been studied by performing flexural resonant column tests. The tests have been done in the form of isotropic and anisotropic with different levels of confining pressures. Furthermore, comparison of damping ratios calculated by free vibration decay and half-power bandwidth methods has been studied.

2- Methodology

In this study, flexural resonant column tests were performed on two core barrels and reconstituted samples of high-plasticity sandy soil (SC). The confining pressures of 150, 300 and 500 kPa in isotropic and anisotropic stress conditions have been studied on the samples. For anisotropic stress conditions, anisotropic ratios of 1.43, 1.21 and 1.13 have been chosen. Reconstruction of the sample was performed by the wet tamping method at optimum moisture content. All tests are performed in accordance with the ASTM-D4015 standard.

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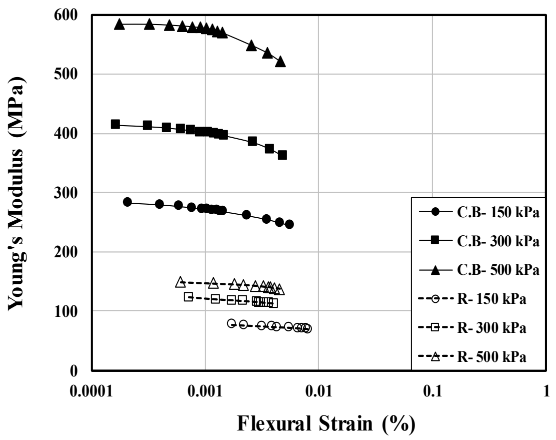

Fig. 1. Effects of Reconstitution and confining pressure on Young's Modulus

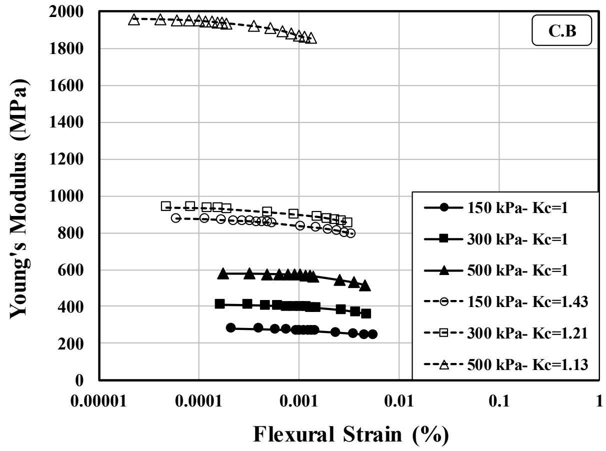

Fig. 2. Effect of stress anisotropy on Young's modulus in core barrel sample

3- Results and Discussion

Figure 1 shows the effects of confining pressure and reconstituting. Based on the results, Young's modulus values for the core barrel sample are greater than the reconstituted sample at all levels of the confining pressure and Young's modulus for the reconstituted sample is reduced by about 70% compared to the core barrel sample. Furthermore, increasing the confining pressure has caused an increase in the stiffness of the sample, because soil particles become more compressed. By increasing confining pressure, more friction occurs between the sample and the top cap of the sample as well, which leads to a reduction in the possibility of the cap slipping on the sample. This fact may cause measurement of the shear wave velocity and stiffness at smaller strains. Accordingly, by the increase in confining pressure level, smaller strains are measured. Furthermore, by increasing flexural strain, Young's modulus will decrease, because of the nonlinear behavior of the soil and stress transfer from the elastic to the elastoplastic range.

According to the results, by increasing flexural strain, the damping ratio increases because the amount of energy loss will surge. The damping ratio of the core barrel sample is less than the reconstituted one, and the variations of the damping ratio for both samples are in the range of 1 to 3%. These show the negligible influences of reconstitution and confining pressure on the damping ratio.

According to Figures 8 and 9, anisotropic stress condition in both samples increased the Young's modulus. In the core barrel sample, stress anisotropy increased the Young's modulus by an average of 65%. This significant increase can be attributed to the cementation of the sample or the overhead pressure of the upper soil layers over the years, while there was no opportunity for cementation in the reconstituted sample. Despite the significant differences between the results of the core barrel sample in the case of isotropic and anisotropic stress conditions, it is observed that the Young's modulus ratio diagrams for the isotropic and anisotropic stress

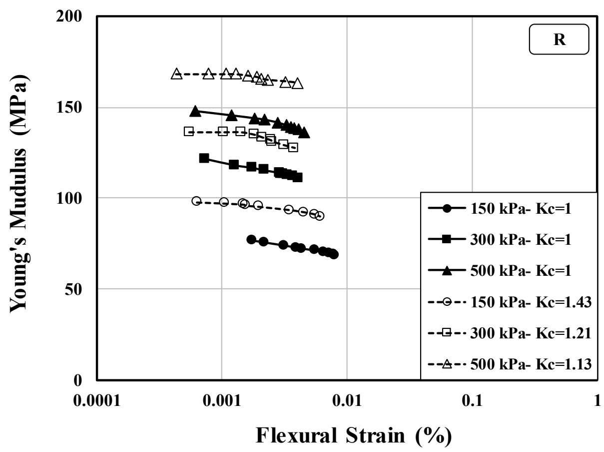

Fig. 3. Effect of stress anisotropy on Young's modulus in reconstituted sample

conditions are almost identical. In addition, stress anisotropy will result in minor changes to the damping ratio at small strain level.

Also, by comparing the results of the two methods for calculation of the damping ratio, it is observed that for all samples, the damping ratio values obtained from the half-power bandwidth method are higher than the free vibration decay method.

4- Conclusions

In this research, by studying the dynamic characteristics of core barrel and reconstituted samples, the effects of reconstitution due to sample reconstitution in the laboratory, confining pressure and stress anisotropy have been explored. The results of the experiments show that with increasing flexural strain, the Young's modulus and damping ratio decrease and increase, respectively. Furthermore, the Young's modulus of the reconstituted sample is about 70% less than the core barrel sample. While the effect of reconstitution on the damping ratio is negligible. Increasing in confining pressure for both samples led to surge in the Young's modulus. The elastoplastic strain threshold in the Young's modulus ratio diagrams for the reconstituted sample is higher than that of the core barrel sample in some extent.

Applying anisotropy stress conditions increases the Young's modulus for both samples. Increase in stress anisotropy will have a more effect on increasing the Young's modulus, while it has slight influence on the damping ratio. The damping ratio values obtained from the half-power bandwidth method for both samples in all stress conditions are higher than the free vibration decay method.

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