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EFFECT OF SOIL PLASTICITY ON DAMPING OF SILTY SOILS UNDER RANDOM EXCITATION CONDITIONS

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SUMMARY

In this study, damping of various silty soils at different plasticities under random vibration conditions, evaluated by the conventional estimator of the transfer function are compared with those properties evaluated by the improved estimators. To accomplish this objective, silty soils with varying soil plasticities were tested in a resonant column apparatus under random torsional excitation conditions. The liquid limit ranged from 40 to 53. Confining pressures in the range of 60 KPa to 150 KPa were used. To obtain compacted specimens, the relationship between the moisture content and dry density for the silty soil was first established using the modified compaction test.

In this research, improved estimators of the transfer function (H2, H3, H4), in addition to the conventional estimator (H1), were used to evaluate the dynamic soil properties and to study the effect of soil plasticity on damping of soils. The results have shown that the different transfer function estimators resulted in variable damping values at low strain levels. As the liquid limit increased, the difference between the damping values also increased. The results also indicate that damping values of silty soils at low strain levels and with high liquid limits from routine soil dynamics testing may have to be corrected to obtain values that are more representative of actual field conditions.

INTRODUCTION

In soil dynamics problems, modal parameters are obtained in the vicinity of the resonance. In this vicinity, the improved estimators of the transfer function (H2, H3, and H4) provide more valuable information than the conventional estimator of the transfer function (H1) for the purpose of estimating the modal parameters or dynamic soil properties, namely, shear modulus and damping values [1-3]. This study focuses on the damping values. Although some studies of the behavior of various soils have been reported [4-14], the effect of soil plasticity with varying liquid limits on damping of silty soils under random excitation conditions and using various transfer function estimators is lacking. This study is directed towards understanding the behavior of silty soils at varying soil plasticities and under random

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excitation conditions. It is known that soil plasticity plays a significant role in dynamic behavior of cohesive soils. The objective of this study is to investigate the effect of liquid limit on damping values of these soils using improved transfer function estimators. As a result, a guide to the appropriateness of the use of laboratory testing data for design during actual earthquakes can be obtained.

EXPERIMENTAL PROCEDURES AND ANALYSIS

In this study, the soil samples were obtained from a construction site, and were constructed from different silty soils with various plasticities. Special care was taken during soil handling and testing to ensure that the soil samples are uniform. The soil liquid limit ranged from 40 to 53, and the plasticity index varied from 15 to 25. Confining pressures ranged from 60 KPa to 150 KPa. Table 1 summarizes the properties of soils tested. In this research, the relationship between the moisture content and dry density for the specimen was first established using the modified compaction test. This was done to obtain high degree of saturation. Then the optimum moisture content and curves of degree of the degree of saturation were determined. Once the moisture-density-saturation relationship was established, the required specimens were prepared with a degree of saturation of 98%.

Table 1. Soils Tested

Series	Soil Type	Liquid Limit	Plasticity Index	Percent Passing No. 200 Sieve	Specific Gravity
A	clayey silt, some sand	40	15	72	2.65
B	clayey silt, some sand	42	16	82	2.65
C	clayey silt, some sand	45	19	83	2.65
D	clayey silt, some sand	53	25	84	2.66

The soil samples were obtained from the compacted specimens using a tube. To eliminate the friction between the tube and the soil, the tube was first lubricated inside and outside. The tube was pushed vertically in the compacted soil in the mold, so that all the obtained specimens would have the same structural configuration. During this research, random torsional vibration was provided using a modified Drnevich type resonant column device. During the test, both input random excitation and output random response were sent to a Fast Fourier Transform (FFT) analyzer. The conventional estimator (H1) was provided using an FFT analyzer. A microcomputer was used for the purpose of obtaining improved estimators (H2, H3, and H4) of the transfer function. A frequency resolution of 0.3 Hz and a number of averages of 350 were used for sampling signals. For the continuous random signals, the Hanning function, which is a cosine-squared function, was utilized in this study. Details of experimental procedures are presented in Amini et al [5] and Aggour et al [6,14].

RESULTS AND CONCLUSIONS

Based on the data from the FFT analysis, the damping values of silty soils at various soil liquid limits and under random vibration conditions were evaluated by both the conventional and improved estimators of the transfer function. An example of the data obtained (confining pressure = 60 KPa; rms strain = 0.01%) is shown in Table 2.

Table 2. Damping values at various transfer function estimators and soil plasticities (confining pressure = 60 KPa; rms strain = 0.01%)

Soil	Damping (%) Sinusoidal	Damping (%) Random H1	Damping (%) Random H2 or H4	Damping (%) Random H3	Ratio of Damping (H1)/ Damping (H2)
A	1.4	4.7	4.0	4.4	1.18
B	1.3	4.5	3.7	4.0	1.22
C	1.2	4.2	3.3	3.9	1.27
D	1.1	4.1	2.8	3.6	1.47

As shown in this table, as the liquid limit increased, the damping of silty soils decreased. At higher liquid limit contents, H1 underestimated the true transfer function and therefore its damping values were the highest. Application of H2 and H4 resulted in higher transfer functions and hence lower damping values than H1. H3 gave a transfer function, and hence damping values between H1 and H2.

As the liquid limits increased, the effect of input noise was more pronounced in the vicinity of resonance, and the improved transfer function estimators behaved more differently from the conventional estimator. As the liquid limit increased, the ratio of damping values obtained from H1 to the ones obtained at H2 (or H1/H4) increased (shown in Table 2). It may be concluded that soil damping values of silty soils, particularly at higher liquid limits, may have to be corrected to obtain values that are more representative of actual field conditions during earthquakes.

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