III-336

CORRELATION OF CYCLIC STIFFNESS DEGRADATION OF UNDISTURBED CLAYS WITH PLASTICITY INDEX

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INTRODUCTION For the purposes of preliminary analysis, simple judgment using empirical relations based on routine tests is preferable to correlate the mechanical behavior of clays. This paper points out a correlation study between the cyclic stiffness degradation and plasticity index of normally consolidated (NC) and slightly over-consolidated (OC) undisturbed clays.

TESTED CLAYS AND EXPERIMENTAL WORK

Two natural NC and one slightly OC undisturbed saturated marine clays taken from the alluvial and diluvial clay deposits in Osaka basin are selected for the present analysis. In the experimental work, specimens are trimmed and isotropically consolidated for about 24 hours, and then cyclically loaded in an instrumented and servo controlled electro-hydraulic triaxial apparatus[1,2&4]. The physical properties, test conditions and results are shown in Table (1).

ANALYSIS AND CORRELATIONS

Cyclic Degradation Parameters

Fig.1 illustrates a typical diagram of the cyclic degradation index ,δ, and the numbers of cycles applied[3]. δ versus N relationship can be expressed as follows:

$$\delta = N^{-t} \qquad \text{.......(1)}$$

in which t is the cyclic stiffness degradation parameter, which represents the negative slope of the relation as follows:

$$t = -\frac{\log \delta}{\log N} \qquad \text{.......(2)}$$

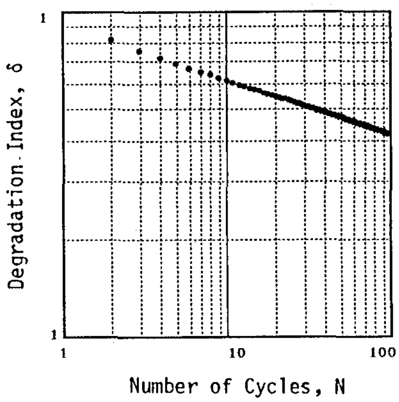

Fig.1 (δ) Versus (N) Relationship

Degradation Parameter Versus Cyclic Axial Strain Relationship

Fig.2 illustrates the relation between the degradation parameter ,t, and the cyclic axial strain ,ε_c, for the tested clays. From this figure it can be seen that the degradation parameter increases as increasing ε_c. Also for a given ε_c, the degradation parameter decreases as increasing the plasticity index, being

Table (1) Summary of Physical Properties, Test Conditions and Results

Tested Clays	Physical Properties				Consolidation Test			Cyclic Strain Controlled Test			
	Clay Fraction (<2μm) (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Over Consolidation Ratio	Consolidation Pressure (kgf/cm²)	Back Pressure (kgf/cm²)	Frequency (Hz)	Cyclic Axial StrainRanges (%)	Number of Cycles	Degradation Parameter,t
NC E. Osaka Clay	30.0	59.4	27.3	32.1	1.0	2.0	1.0	0.5	0.310-2.010	100	0.052-0.191
NC Ma13 Clay	57.9	72.5	27.9	44.6	1.0	2.0	1.0	0.5	0.486-1.922	100	0.064-0.159
OC Ma12 Clay	48.0	94.1	25.5	68.6	1.3	2.5	3.0	0.5	0.299-1.983	100	0.030-0.118

followed by that differences of clay mineral types may affect this conclusion.

Inspection of the results in Fig.2 shows that it may be possible to get reliable fitting results for the data points by the solid curves using the following equation.

$$t = a \ [\varepsilon_c]^b \quad \dots\dots\dots\dots\dots\dots\dots\dots (3)$$

in which a and b are parameters. The parameter a is dependent upon the degree of clay plasticity, while the parameter b is found to be within a certain narrow range. It is found that it may be possible to fix the parameter b as an average value equal to 0.7. A verification of the suggested equation after fixing the parameter b by 0.7 is extended to cover the present test results and the results obtained for some other NC and slightly OC clays[5]. The results are shown in Fig.3.

Cyclic Degradation Versus PI Correlation

Fig.3 illustrates the effect of clay plasticity on the cyclic degradation parameter of three sets of low, medium and high plastic clays. The average data points of each set are fitted using Eq.(3) with the parameter b equal to 0.7. From this figure it can be noticed that a reliable fitting result is obtained, especially for both medium and high plastic clays.

Fig.4 shows the variation of the obtained parameter a with plasticity index. It can be seen that the parameter a decreases as increasing the plasticity index, therefore the parameter a can be judged in term of plasticity index. Its decreasing rate is markedly observed within the range of plasticity index less than about 23, while at higher plasticity indices, it is located within a narrow range.

Thus, it can be possible to fit the data points by two straight lines. These two lines intersect togeather at about 23 of plasticity index. Finally, Eq.(1) can be expressed as a function of plasticity index as follows:

$$\delta = [\ N \ ]^{-\{a(\varepsilon_c)^{0.7}\}} \quad \dots\dots\dots\dots\dots\dots (4)$$

where for PI<23 $a = 0.52 - 0.0170\ PI$ ..(5)

for PI>23 $a = 0.16 - 0.0014\ PI$ ..(6)

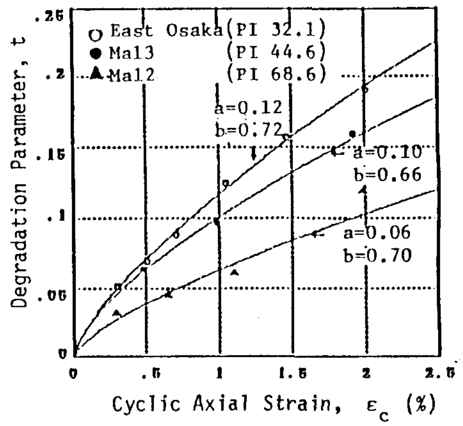

Fig.2 (t) Versus (ε_c) Relation

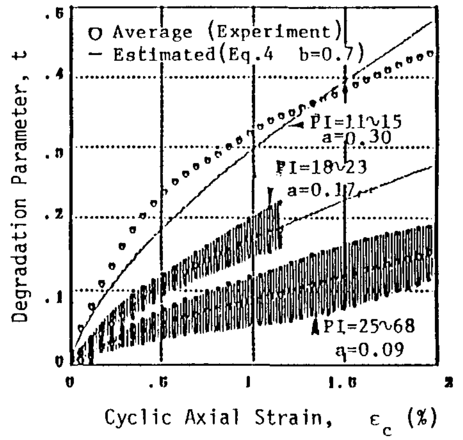

Fig.3 Effect of PI on The Cyclic Degradation of Undisturbed Clays

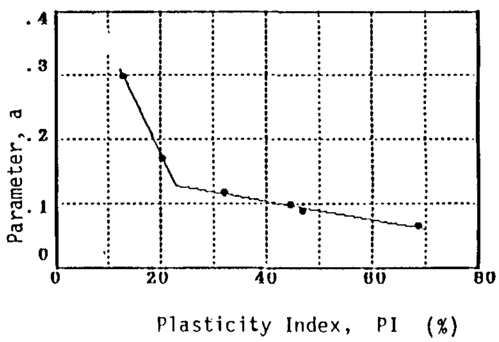

Fig.4 Correlation of (a) with (PI)

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