EVALUATION OF LIQUEFACTION STRENGTH OF SANDY SOILS

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SUMMARY

To grasp liquefaction strength of sandy soil is exceedingly important from the viewpoint of earthquake engineering. Soil dynamic testing apparatuses centering on dynamic triaxial test equipment have been generally used for this purpose. In recent years the author et al conducted liquefaction test by dynamic triaxial test equipment with use of undisturbed sandy soil samples. In this paper the author tried to interpret the test results by means of multiple regression analysis and to express the strength value as function of N value, effective overburden pressure $\sigma v'$, fine content F.C, etc.

DEFINITION OF LIQUEFACTION STRENGTH

The dynamic triaxial test equipment used for the test and definition of liquefaction strength are shown in Fig. 1 and Fig. 2 respectively.

SAMPLE USED FOR MULTIPLE REGRESSION ANALYSIS

Samples used for the analysis are listed in Table 1. Those samples were recovered by Twist Smpler (Imai et al, 1978) in undisturbed condition.

METHOD OF MULTIPLE REGRESSION ANALYSIS

Equation used for the analysis is as follows.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n \qquad \text{Eq. 1}$$

Where, Y: dependent variable
$X_1 \sim X_2$: independent variables
β_0: intercept
$\beta_1 \sim \beta_n$: partial regression coefficents

In this paper Y is $R\ell_{20}$ or $\log R\ell_{20}$, and $X_1 \sim X_n$ are various geotechnical constants.

RESULTS OF ANALYSIS

Correlation coefficients the author considered this time between all variables are shown in Fig. 3. According to the figure it is apparent that $\sigma v'$ and F.C have high correlation with $R\ell_{20}$ and that N value, e_c and D_{50} are rather small correlation coefficient with $R\ell_{20}$. Further, correlations among e_c, D_{50} and F C are high. Therefore, in the subsequent analysis the author deleted of e_c of which practical value is minor from the variables and supposed the functional expression of $R\ell_{20}$ as follows.

$$R\ell_{20} \text{ or } \log R\ell_{20} = f(\sigma v' N, \text{F C or } D_{50}) \qquad \text{Eq. 2}$$

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Fig. 4 is the list of results of multiple regression analysis made by the author concerning the aforementioned functional values. F values is shown in this figure in addition to multiple correlation coefficients. From the figure the author selected the combinations of ① - ③ in which multiple correlation coefficient is high and partial regression coefficient is significant to every variable. Then, replaced $R\ell_{20}$ with $LogR\ell_{20}$ and conducted multiple regression analysis. The results are shown in Fig. 5. According to the Fig. 4 and Fig. 5 best regression formulas are:

$$R\ell_{20} = 0.164\ (1.012)^{N}\ (F.C)^{0.0868}\ \sigma v'^{-0.441} \quad (F.C \leqq 60\%) \quad \text{Eq.3}$$

$$R\ell_{20} = 0.159\ (1.012)^{N}\ (F.C)^{0.0967}\ \sigma v'^{-0.468} \quad (F.C \leqq 30\%) \quad \text{Eq.4}$$

Fig. 6 compares the actual measured value $R\ell_{20}$(measured) with theoretical value $R\ell_{20}$(estimated) obtained from equations 3 and 4. Considerably fine agreement is seen between the two.

Fig. 7 is the result of study to check similar relation by means of existing equation (Tatsuoka et al, 1978) recently being used in Japan.

$$R\ell_{20} = 0.0882\sqrt{\frac{N}{\sigma v'+0.7}} - 0.255\ \log\left(\frac{D_{50}}{0.35}\right) \quad (0.04 \leqq 0.6\text{mm})$$

$$R\ell_{20} = 0.0882\sqrt{\frac{N}{\sigma v'+0.7}} - 0.05 \quad (0.6 \leqq D_{50} \leqq 1.5\text{mm}) \quad \text{Eq.5}$$

Because of large dispersion in this data fine relation could not be obtained. The author presumes that the proposed equation 3 and 4 may contain some influences by characteristics of test equipment, sampling method, etc. and plans to conduct further detail research in the future.

REFERENCES

Imai, T. and Yokota, K. 1978 "Sand sampling using Twist Sampler", Proceedings of Soil Sampling Symposium, Japan Society of Soil Mechanics & Foundation Engineering

Tatsuoka, F. et al, 1979 "A method for estimating undrained cyclic strength of sandy soils using standard penetration resistances", Proceedings of Soils and Foundations, Vol.18, No.3, J.S.S.M.F.E.

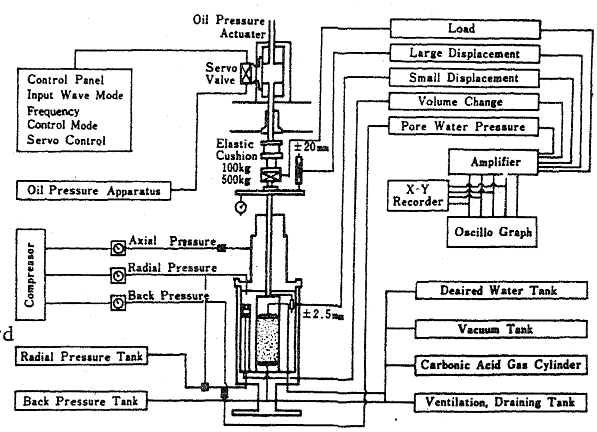

Fig. 1 Test apparatus

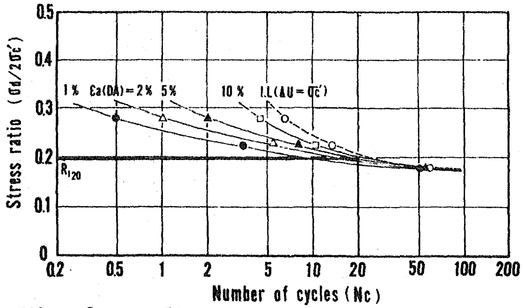

Fig. 2 Definition of liquefaction strength

Site	Major Soil Type	Remarks
A (Aichi Pref.)	fine to med sand	Reclaimed sand (Dep.<5m) Alluvium sand (Dep.≧5m) N Value 5～20
B (Chiba Pref.)	silty to fine sand	Reclaimed sand (Dep.<10m) Alluvium sand (Dep.≧10m) N Value 5～25
C (Kagawa Pref.)	med to coarse sand	Reclaimed sand (Dep.<5m) Alluvium sand (Dep.≧5m) N Value 5～15
D (Saitama Pref.)	silty to fine sand	Alluvium sand N Value 5～15
E (Chiba Pref.)	silty to fine sand	Reclaimed sand (Dep.<6m) Alluvium sand (Dep.≧6m) N Value 5～20
F (Miyagi Pref.)	med to gravelly sand	Alluvium sand N Value 10～40
G (Miyagi Pref.)	med to gravelly sand	Alluvium sand N Value 5～20

Table 1 Samples used for multiple regression analysis

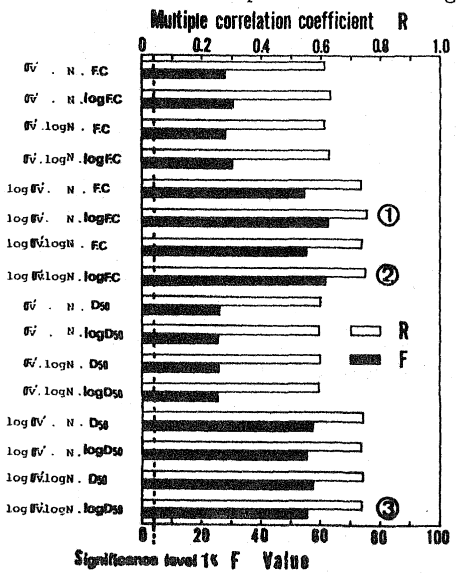

Fig. 4 Multiple correlation coefficients

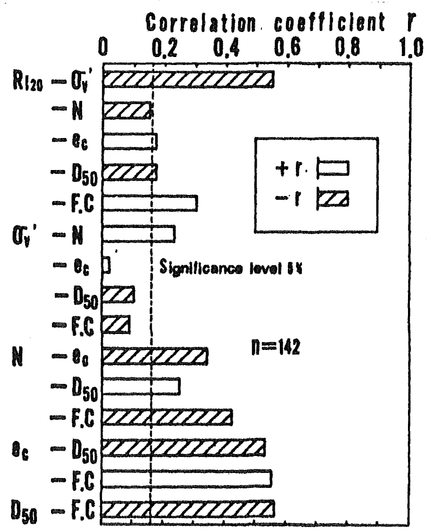

Fig. 3 Correlation coefficients

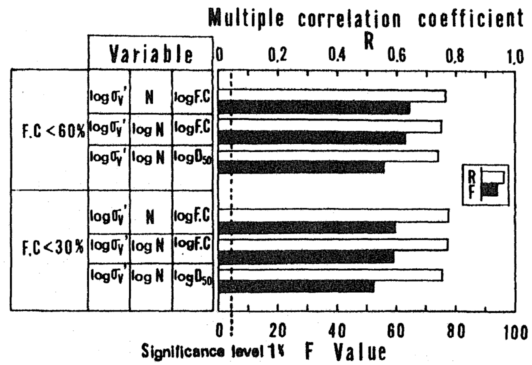

Fig. 5 Multiple correlation coefficients

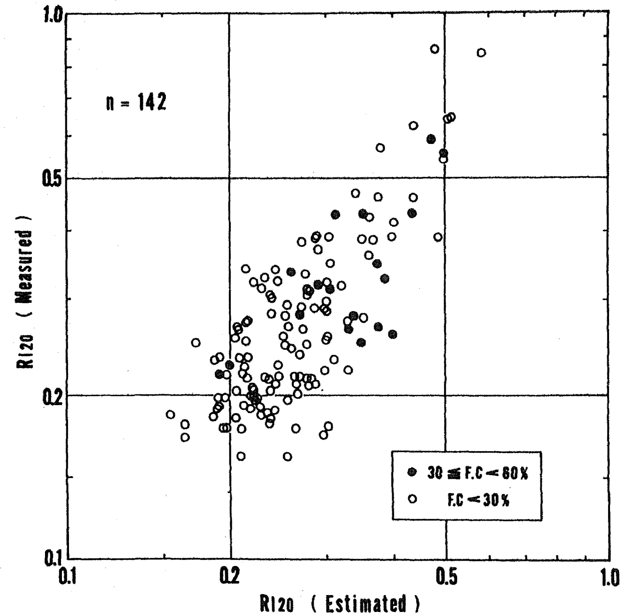

Fig. 6 Relationship between $R\ell_{20}$ (estimated) and $R\ell_{20}$(measured) of author's

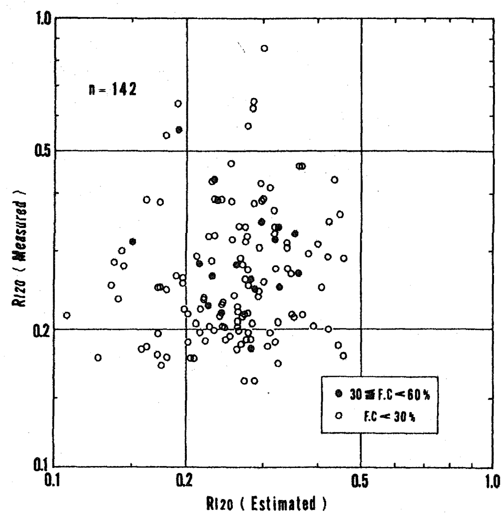

Fig. 7 Relationship between $R\ell_{20}$ (estimated) and $R\ell_{20}$(measured) of others