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EFFECT OF CLAY PARTICLES ON LIQUEFACTION OF SILT

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ABSTRACT

Presented in this paper are the results of experimental research of liquefacton characteristics of silt by varying the content of clay particles or by varying the dry density. The laboratory tests were run on remolded silt samples by using cyclic dynamic triaxial device and mini-penetrometer. The effect of clay particles on liquefaction of silt were studied. The conclusions were drawn that the lowest dynamic shear strength of silt is at 9% of content of clay particles. It is found that there are various regulations of cyclic stress ratio and mini-penetration test (MPT) blowcounts with content of clay particles and dry density.

KEYWORDS

Liquefaction resistant behaviour; clay particle contents; effect of dry density; mini-penetration test blowcount; dynamic shear strength.

INTRODUCTION

Up to now, the phenomenon, mechanism and assessment of the liquefaction of sands have been studied deeply and extensively by researchers, for example, Seed (Seed et al., 1966), Wang (Wang, 1979), Finn (Finn et al., 1971) etc. Hence most of the published subjects were concerning liquefaction of sands and its theory has become perfecter, used to practice for assessing the liquefaction of sands. The study of liquefaction of silt, however, has been started after Tang Shan Earthquake, China 1976. The results of cyclic load testing of silts carried out by Shi (Shi et al., 1984), Zhong (Zhong 1980) and Qiu (Qiu et al., 1988) et al. were examined. Although they studied relationship of vibrating pressure and number of cycle which make saturated silt liquefied, and proposed assessing some formulas of silt liquefied similar to that of saturated sand liquefied in Chinese code, by using of standard penetration test (SPT) blowcounts, yet this is just a beginning. Generally speaking, though the phenomenon and consequence of liquefaction of silt and sand are the same, silt contains large amount of clayey materials, small void and film water which make the properties of physics, mechanics and strength of silt from sands. Consequently affecting factors and mechanism of liquefaction are not completed identically. In order to further study liquefaction resistant characteristics of silt, the authors run on remolded silt samples of varying the dry density (γ_d) and varying the content of clay particles (P_c) by using cyclic dynamic triaxial device and mini-penetrometer. The laboratory test took us as more as a year to finish, finally drawn out the general regulation of liquefaction behaviour of silt.

TEST METHOD

Experimental Device

Cyclic Triaxial Device The instrument used is DSD——200 model cyclic triaxial device, stress controlled, designed by China. Its index properties are as follows:

Frequency 0.01HZ——50HZ

Maximum vertical pressure	25KN
Maximum confining pressure	1.0MPa
Height of sample	10cm
Diameter of sample	5.0cm

Mini-penetrometer This instrument was designed and made by the authors based on dynamic penetration resistance 0.86MPa(equal to that of in situ SPT). Its index properties are as follows:

Diameter of penetrating rods	1cm
Angle of penetrating cone	60°
Weight of penetrating hammer	400g
Free fall distance of hammer	15cm
Penetrating depth	25cm

Soil Characteristics

Silt and clayey particles used in this study were taken from the site which is located near Yi Fen bridge, on the west bank of Fen river in northern Tai Yuan. The physical properties of soil are summarized in Table 1. Clayey mineral is kaolinite analyzed by X—ray diffraction.

Table 1. Silt properties

Soil	Specific gravity	Plasticity index	Medium diameter(mm)	Coefficient of uniformity	Content of clay particles(%)
Silt	2.69	7.9	0.043	2.8	0
Clayey particles		20.99			40

Sample Preparation

All the samples were made in laboratory. The content of clay particles were 3%, 6%, 9%, 12%, 16%, and they were put in soil box size 900×400×300mm to deposit. These samples were divided into three groups according to their dry densities 14.4, 15.6, 16.4 KN/M^3 respectively. At the time of 2 months after the end of saturation and deposit, samples were made for test.

Samples for X-ray diffraction were air dried firstly and then rubbed with a glass bar until they can be cut into thin slices. The X-ray diffraction device is of Y—4QX type made in China.

Failure Criterion

The failure criterion adopted in this study is that the strain of double amplitude is equal to 5%.

ANALYSIS OF TEST RESULTS

The Effect of Fine Content to the Behaviour of Liquefaction Resistant

It is well known that the fine content is an important factor to affect the Liquefaction of silt. In ordet to evaluate the effect of clay particle contents to cyclic stress ratio quantitatively, the authors performed laboratory dynamic triaxial tests on remolded samples with different clay particle contents and different dry densities. The test results were shown in Figures 1 and 2(γ_d=14.4KN/M^3).

It can be clearly seen from these figures that with the increase of clay particle contents, the cyclic shear ratio is not monotonously increased and achieves a minimum value at P_c=9%. They follow the parabola relation, and the regression equation is as following:

$$\sigma_d/2\sigma_0 = 0.850 - 0.097(P_c) + 0.0061(P_c)^2$$

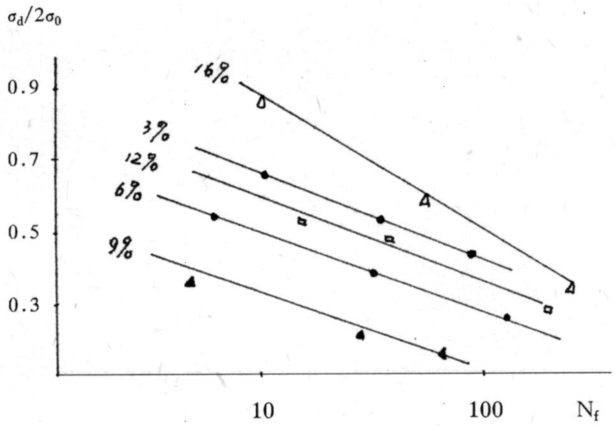

Fig. 1 Cyclic stress ratio vs. number of cycles for samples of different clay particle contents.

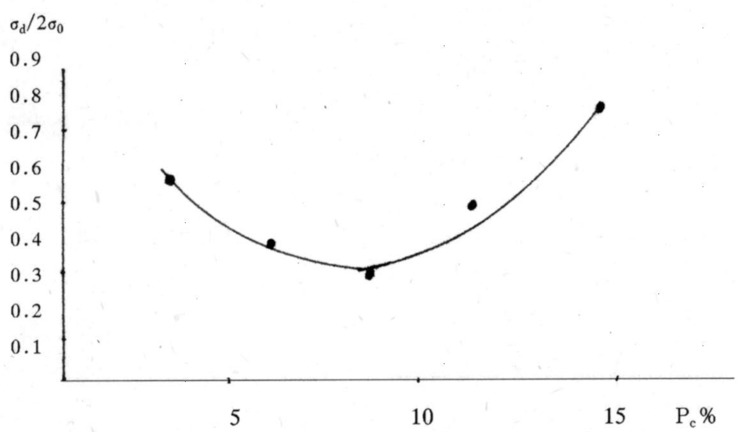

Fig. 2 Relationship between cyclic stress ratio and clay particle contents.

Relationship of MPT Blowcounts and Cyclic Stress Ratio

Figure 3 shows the results of the cyclic triaxial test and mini – penetration test (MPT). Their dry densities are 14.4, 15.6, 16.4KN/M^3 respectively. Relationship of MPT blowcounts and cyclic stress ratio behaves curves of parabola with mouth opening upward. It is also shown that parabola curves shift towords to right with increasing dry densities.

According to various content of clay particles, relative curves of cyclic stress ratio versus MPT blowcounts are shown in Fig. 4. It can be seen that the dynamic shear strength increases linearly with MPT blowcounts at a given clay particle contents.

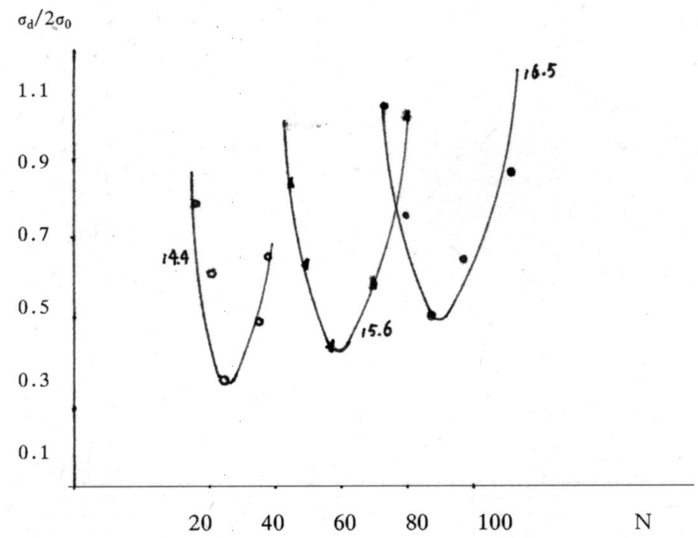

Fig. 3 Relationship between cyclic stress ratio and MPT blowcounts.

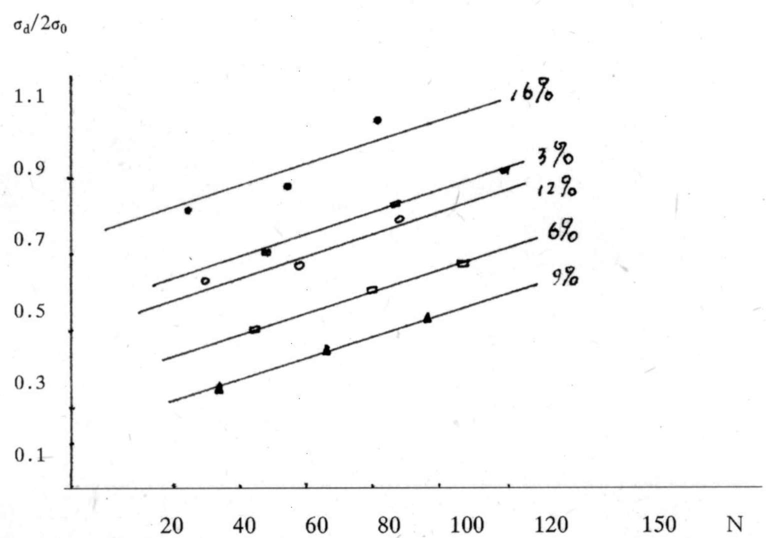

Fig. 4 Correlation between cyclic stress ratio and MPT blowcounts.

Relationship of Dry Density, Content of Clay Particles, MPT Blowcounts and Cyclic Stress Ratio

In order to investigate the relation of dry density, clay particle contents and liquefaction strength of silt, a series of cyclic dynamic triaxial tests and mini-penetration tests have been performed on 45 remolded silt samples, clay particle contents of which are 3%, 6%, 9%, 12%, 16% respectively and dry densities of which are 14.4, 15.6, 16.4KN/M^3respectively. The test results are shown in Figs. 5 (A, B)

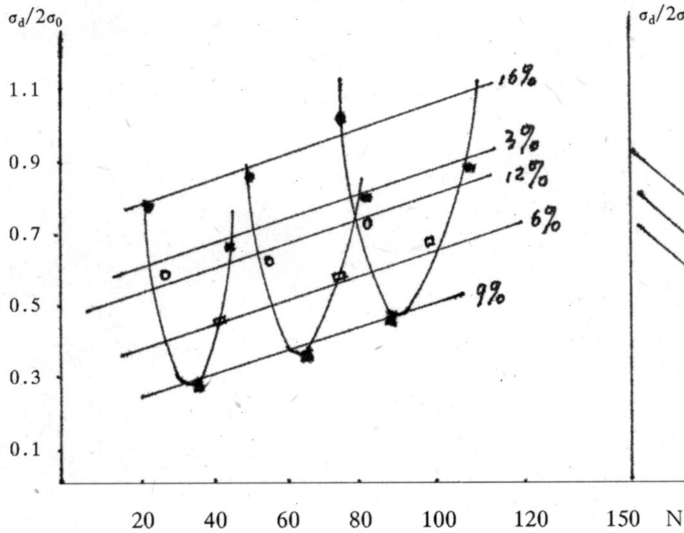

Fig. 5(A) Cydic stress ratio vs. MPT blowcounts.

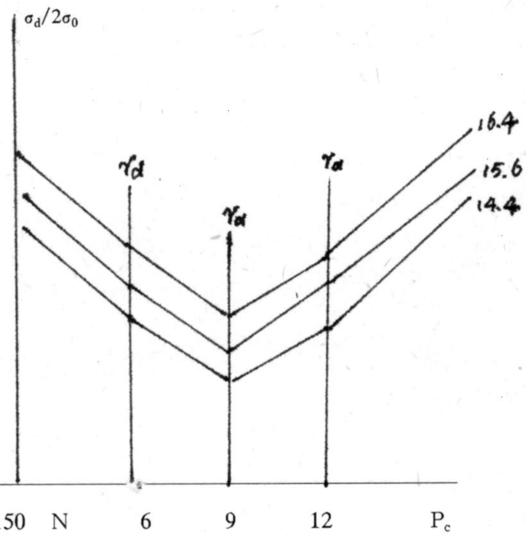

Fig. 5(B) Nomogram of cyclic stress ratio, clay particle contents and dry densities.

Figure 5(A) shows the closer relations of cyclic stress ratio, dry density, clay particle contents and MPT blowcounts. Figure 5(B) gives the relations between clay particle contents and cyclic stress ratio at different dry densities. It can be judged that not only indexs are able to convert but also the cyclic stress ratio of the other clay particle contents and dry densities are able to make out Fig. 5(B). Then, to determine content of clay particles and dry density of silt sample, cyclic stress ratio are found from the nomogram. Consequently liquefaction poteneial of silt can be obtained by seed's method.

CONCLUSION

Based on the results of the study described above, the following general conclusions can be drawn out:

(1) The cyclic stress ratio of remolded silt changes with the content of clay particles and MPT blowcounts in a relation of parabola. The lowest shear strength is at 9% of content of clay particles.

(2) The cyclic stress ratio and MPT blowcounts of silt linearly increased with content of clay particles and dry density.

(3) Dry density, content of clay particles, cyclic stress ratio and MPT blowcounts have very close relations. According to the typical nomogram of γ_d—P_c—$\sigma_d/2\sigma_0$ for local silt, designer can obtain the cyclic stress ratio from the nomogram by measuring the content of clay particles and dry density in laboratory for a given silt. Therefore Fig. 5 is very useful in practice.

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