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EFFECT OF PRELOADING ON POST-CONSTRUCTION CONSOLIDATION SETTLEMENT OF SOFT CLAY SUBJECTED TO REPEATED LOADING

HARUO FUJIWARA[i)] and SHUNJI UE[ii)]

ABSTRACT

The behavior of the soft clay grounds subjected to repeated loading is different from that subjected to sustained loading. The difference in settlement between these two loading patterns should be due to secondary compression over a long period of time. Consequently, soft clay grounds subjected to repeated loading tend to be more compressible than those subjected to sustained loading. Therefore, it is necessary for engineers to predict post-construction settlements under repeated loading. In this respect, the preloading is considered to be promising as a countermeasure to reduce the settlement of clay under repeated loading as well as under sustained loading.

The effect of preloading on post-construction consolidation settlement of soft clay subjected to repeated loading after removal of a part of preload is investigated in the present paper. It has become clear that the settlement of a clay sample after preconsolidation is mainly affected by the amount of preload, the degree of consolidation due to the preload, the amount of permanent load and the amount of repeated load after removal of preload.

The calculated settlement versus time relations using a method to estimate the amount of consolidation settlement of soft clay grounds subjected to repeated loading after removal of preloading were compared with the observed degree of consolidation as parameters of the intensities of preload and repeated load.

Key words : consolidation, preloading, repeated load, secondary compression, settlement (**IGC** : D 5/D 7/E 8)

INTRODUCTION

When the thick compressible soil deposit with high plasticity and organic matters is subjected to sustained and repeated loading the eminent settlements due to primary consolidation and secondary compression will be prevailed. It has been made clear from the previous study (Fujiwara et al., 1987) that the secondary compression of soft clay deposits subjected to repeated loading is more pre-

i) Professor, Department of Civil Engineering and Architecture, Tokuyama College of Technology, Kume 3538, Tokuyama 745.
ii) Associate Professor, ditto.
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dominant than that subjected to sustained loading. Therefore, some countermeasure methods should be adopted to improve the soft clay deposits undergoing the repeated loading. In this study, the soil mechanics features of preloading were investigated to reduce the post-construction settlement of soft clay under repeated loading.

Muromachi and Watanabe (1963) discussed the relations between the recoverable strain after removal of preload and the intensity of preload. They also proposed the calculation method during preloading. Johnson (1970) discussed the problem in his state-of-the-art report on preconsolidation techniques, and proposed a design method for this technique. Based on model experiments, he took into account the effects of surcharge loading on secondary compression settlements after removal of the preload. Pilot (1980) summarized the calculated method of primary consolidation, secondary compression and undrained strength gain caused by preloading.

Yasuhara et al. (1981) discussed that swelling and recompression characteristics of a saturated marine clay was examined by oedometer and direct shear tests. It was proved that the behavior of a clay after rebound was governed by the degree of consolidation by preload and overconsolidation ratio. The peak shear stress observed in direct shear tests increased with the degree of the consolidation at the removal of preload.

Aboshi et al. (1981) discussed several experimental data concerning the effect of surcharge loading on post-construction settlements, using a separate-type consolidometer. From the precise measurement of strain and pore pressure inside a consolidating specimen, several interesting experimental facts have been made clear. Settlement characteristics of a practical construction site under surcharge loading are also referred. Akaishi et al. (1981) proposed a method for prediction of settlement after surcharge loading using calculation of effective stress and dilatancy of specimens under one dimensional consolidation.

Samson and Rochelle (1972) described a case study of the design and performance of an expressway constructed over peat by preloading. They have made clear that preloading was simulated in the laboratory by mean of oedometer tests on peat samples : both the laboratory results and field observations revealed a remarkable agreement between the duration of the surcharge stage and the time for rebound to be complete after removal of the surcharge. Stamatopoulos and Katzias (1982) discussed time forecast should be based on field permeability tests or test field. The settlement versus log time curve of preloading can assume a variety of shape, depending on the geometry and permeability of sand-silt contained within the consolidating clay.

The present paper investigates the effect of the preloading on the soft clay subjected to repeated loading. From the measurement of strain of clay subjected to repeated loading after removal of preload, several interesting experimental facts have been made clear. Settlement characteristics of a clay subjected to repeated loading are mainly affected by several factors, and in these conditions a method to predict the settlements of a clay is proposed. This method of settlement analysis is described in the form of which the effect of secondary compression is combined with a modified version of Terzaghi's theory for repeated consolidation of clay.

TEST PROGRAM

Sample and specimen : The sample used in this study is the reconstituted Kanda clay. The specific gravity G_s is 2.67, the liquid limit w_L is 90.0%, plasticity index PI is 60.0, and organic matter content is 8.4%. These

Table 1. Index properties of Kanda clay used

Specific gravity G_s	2.67
Liquid limit LL (%)	90.0
Plasticity index PI	60.0
Organic matter content (%)	8.4
Compression index C_c	0.65
Swelling index C_s	0.09

Table 2. Experimental condition

Preconsolidation		Preloading		Load reducing		Sustained or repeated loading		
load (kPa)	period (min)	load (kPa)	period (min)	load (kPa)	period (min)	load (kPa)	period (min)	frequency (Hz)
88.2	1440	264	7 23 100	176	1440	39 78 118 176	10080	0.016

index properties are listed in Table 1. The specimens were prepared as follows ; the remoulded clay was mixed with the de-aired water to make a slurry with the water content of about 90%, and then they were isotropically consolidated in a large-triaxial consolidation chamber to produce the specimen with 20 cm in height and 40 cm in diameter (Fujiwara et al., 1987) under the confining pressure of 58.4 kPa for a month, which seems to be enough for ensuring the end of primary consolidation. The specimens were then cut into a section suitable for sizes of ordinary consolidation tests.

Apparatus : The apparatus used in the repeated consolidation tests was described in the previous paper (Fujiwara et al., 1985). This apparatus is a modification of the conventional consolidation apparatus which both sustained and repeated load can be applied either separately or simultaneously.

Test procedure : The following consolidation tests were carried out ; in the first step loading, the specimens were consolidated under a sustained load 88.2 kPa for 24 hours ; in the second step loading, the specimens were consolidated under the sustained load 353 kPa for 7, 23 and 100 min which approximately correspond to the degree of consolidation with 55, 85 and 100%, respectively ; in the third step loading, the consolidation pressure was reduced to 176 kPa from 353 kPa and then was kept under that load for 24 hours ; in the final step loading, the specimens were consolidated under the additional sustained or repeated load of 39, 78, 118, and 176 kPa respectively for a week. The loading sequences in every test are shown in Table 2. In the repeated consolidation tests, the loading period was 1 min. (i.e. 0.016 Hz) and a wave form of cyclic

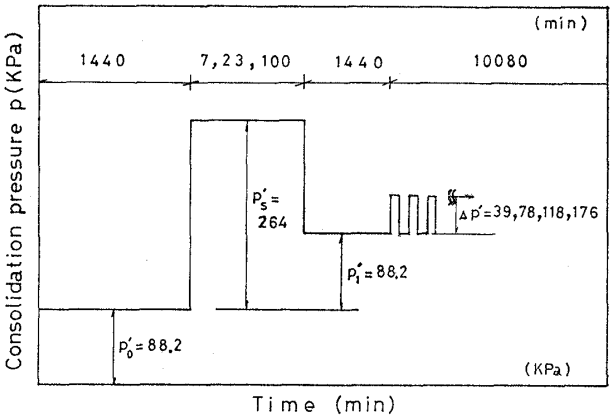

Fig. 1. Key sketch for loading sequence in oedometer test

load is square. The ratio of loading time to unloading time during one cycle was 1 to 1. Therefore, elapsed time was the sum of loading and unloading time. Fig. 1 illustrates the above-mentioned test procedure.

PRECONSOLIDATION EFFECT

Preloading involves the placement of a surface load prior to construction in order to precompress the foundation soil. On some occasions a preload greater than the structure load is used. This situation is termed surcharging. The excess of the preload over the actual load of structures is termed surcharge. It is important to determine at what time the surcharge should be removed, because if surcharge is removed after a short period of time, preconsolidation does not have an adequate effect on improvement of soft clay.

Watanabe et al. (1969) showed that the preloading method has an effect on reducing the settlement of soft clay deposit subjected to traffic-induced repeated loading. As shown in Fig. 2, when a soft clay deposit is subjected

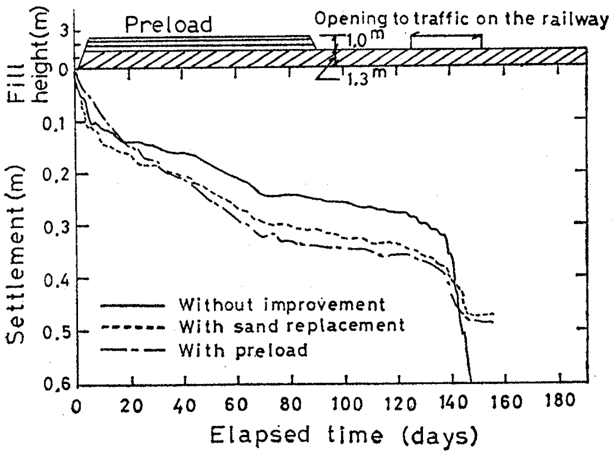

Fig. 2. Effect of preloading on settlement versus time relations of a railway on soft clay ground during preloading and after opening to traffic (Watanabe et al., 1969)

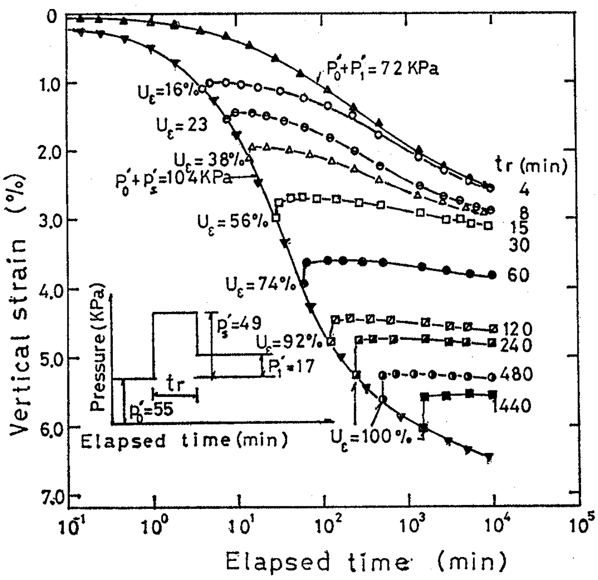

Fig. 3. Swelling-recompression curves due to release of preload (Yasuhara et al., 1981)

to repeated loads, the strain of deposit without any improvement is larger than that being preloaded. In this case, the repeated loads were the railway train loads.

Yasuhara et al. (1981) showed that the larger the degree of consolidation before unloading becomes, the smaller the post-construction settlement becomes, especially at a region beyound 90% of degree of consolida-tion by surcharge, as illustrated in Fig. 3.

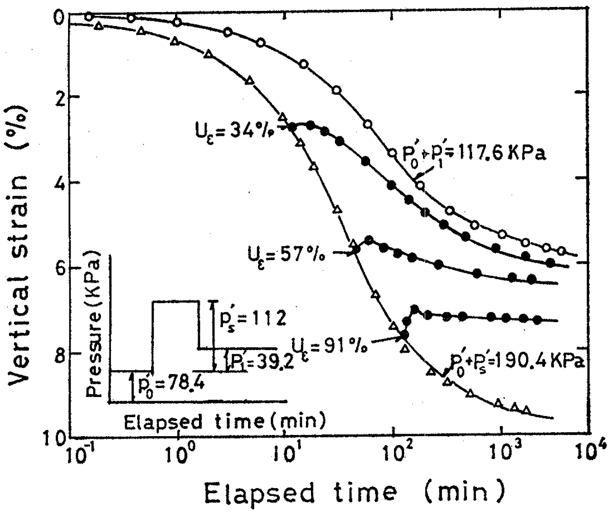

Fig. 4. Consolidation, swelling and reconsolidation curves in preloading method on Hiroshima clay using separate-type consolidometer (Aboshi et al., 1981)

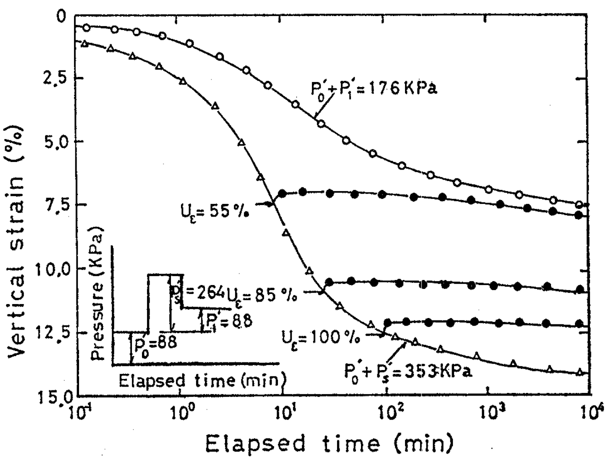

Fig. 5. Consolidation curves in preloading method on Kanda clay

Regarding the variations of undrained shear strength due to release of the preload, the peak shear stress observed in direct shear tests increases with the degree of consolida-tion at the release of preload.

Aboshi et al. (1981) showed that the higher the degree of consolidation at the rebound stage is, the smaller post-construction settle-ment takes place by the recompression, as shown in Fig. 4 The experiments have been performed as a model test of the preloading method, using a separate-type consolidome-

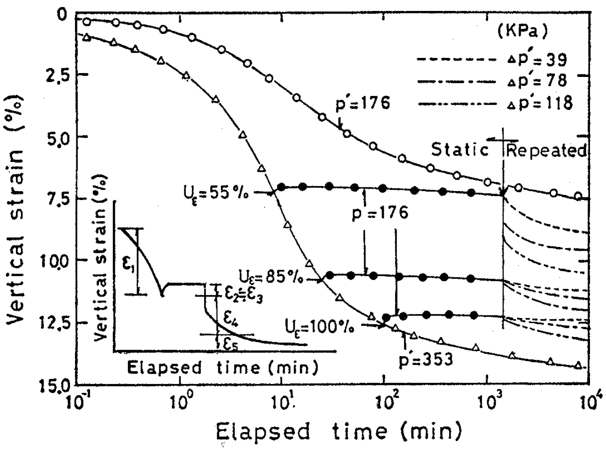

Fig. 6. Consolidation, swelling and reconsolidation curves in preloading method on Kanda clay under repeated loading

ter. In Fig. 4 the white circles and triangles show the settlement versus elapsed time curves under the constant loads with different magnitude. The specimens have been consolidated under $p=190.4$ kPa shown by the white triangles, then the surcharge is once reduced to zero at a certain percentage of consolidation and again surcharged to the same stress. Thus, they have had the settlement versus time curves given by the white circles in Fig. 4.

The vertical strain versus elapsed time curves obtained by the sustained consolidation tests on the Kanda clay are shown in Fig. 5. The white circles and triangles show the relations between vertical strain and elapsed time subjected to sustained loading of 176 and 353 kPa. When the elapsed time became 7, 23 and 100 min corresponding to the degree of primary consolidation by surcharge $U_\varepsilon=55$, 95 and 100%, respectively, under sustained load of 353 kPa, the surcharge was reduced to 176 kPa. It is clear from Fig. 5 that the smaller the degree of consolidation by surcharge is, the smaller the preconsolidation effect on reducing the settlement of clay after removal of surcharge is revealed.

For the purpose of investigating the influence of repeated loading on vertical strain versus elapsed time relations after removal of surcharge, the specimens were consolidated under repeated loadings which were 39, 78, 118, and 176 kPa, respectively.

Fig. 6 shows the results from repeated consolidation tests. In the condition that the specimen is subjected to the repeated load, the strain of the specimen due to the high degree of consolidation by surcharge before application of repeated load is smaller than that due to the low degree of consolidation by surcharge before application of repeated load. In other words, it becomes clear that the strain of specimen due to repeated load application after preconsolidation is mainly affected by the degree of preconsolidation by surcharge. In the condition of the same degree of consolidation, on the other hand, the larger the repeated load is, the larger the strain of specimen subjected to repeated loading after removal of the surcharge becomes, as shown in Fig. 6. The strain of the specimen subjected to repeated loading is caused by summing the primary consolidation strain due to surcharge and the secondary compression strain due to repeated loading. From the results mentioned above, the strain of specimens subjected to repeated loading after removal of the surcharge is influenced by combination of several factors, such as the amount of surcharge p_s', the degree of consolidation U_ε by surcharge, the amount of the permanent load p_1' and the amount of the repeated load $\Delta p'$, when frequency of cyclic load or way of repeated loading (one-way or two-way) are maintained constant.

PREDICTION METHOD OF STRAIN OF CLAY SUBJECTED TO REPEATED LOADING

Some researchers (Aboshi et al., 1984 ; Johnson, 1970 ; Shibata et al., 1984 ; Kawakami et al., 1977) proposed the methods for calculation of settlement after removal of surcharge, but they have not established the design of surcharge method yet. Neither the design method of surcharge for a soft clay subjected to repeated loading has been established at the present.

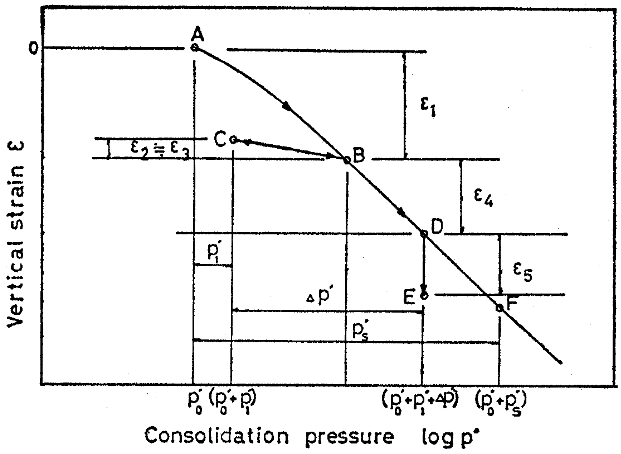

Fig. 7. Key sketch for ε-log p' relation under surcharge, permanent and repeated loads

The following assumption has been made in carrying out the calculation of design of surcharge method under sustained loading conditions. The proposed method of settlement analysis is a method in which the effect of secondary compression is considered into a modified version of Terzaghi's theory for repeated consolidation of clay (Fujiwara et al., 1987). The total vertical strain ε_t of a clay undergoing repeated loading after removal of surcharge is composed of the strains at the following five stages. Fig. 7 illustrates a key sketch for ε-log p' relation under surcharge, permanent load and repeated load. The strain of first stage is the primary consolidation strain ε_1 for a given period of time in which the degree of consolidation is given by U_ε by surcharge. The location of vertical strain and consolidation pressure is shifted from point A to point B, (A→B), in Fig. 7. If degree of consolidation by surcharge is 100%, this location is shifted from point A to point F, (A→F). The strain of second stage is the swelling strain ε_2 by the removal of the surcharge, (B→C). The strain of third stage is the recoverable strain ε_3 by repeated load, (C→B). The strain of fourth stage is the primary consolidation strain ε_4 by repeated load for the part of unconsolidation due to surcharge, (B→D). The strain of final stage is the secondary compression strain ε_5 by repeated load after primary consolidation, (D→E).

$$\varepsilon_t=\varepsilon_1+\varepsilon_2+\varepsilon_3+\varepsilon_4+\varepsilon_5 \quad (1)$$

$$\varepsilon_1=\frac{c_c}{(1+e_0)}U_\varepsilon\log\left(\frac{p_0'+p_s'}{p_0'}\right) \quad (2)$$

$$\varepsilon_2=\frac{-c_s}{(1+e_1)}\left[U_\varepsilon\log\left(\frac{p_0'+p_s'}{p_0'}\right)-\log\left(\frac{p_0'+p_1'}{p_0'}\right)\right] \quad (3)$$

$$\varepsilon_3=\frac{c_r}{(1+e_1)}\left[U_\varepsilon\log\left(\frac{p_0'+p_s'}{p_0'}\right)-\log\left(\frac{p_0'+p_1'}{p_0'}\right)\right] \quad (4)$$

$$\varepsilon_4=\frac{c_c}{(1+e_1)}\left[\log\left(\frac{p_0'+p_1'+\Delta p'}{p_0'}\right)-U_\varepsilon\log\left(\frac{p_0'+p_s'}{p_0'}\right)\right] \quad (5)$$

$$\varepsilon_5=\frac{c_c}{(1+e_2)}\log\left(\frac{t_s}{t_0}\right)^{R/(1-\lambda)} \quad (6)$$

where c_c, c_s, c_r and c_α are compression index, swelling index, recompression index and coefficient of secondary compression, respectively, p_0', p_s', p_1' and $\Delta p'$ are overburden load, surcharge, permanent load and repeated load respectively, e_0, e_1, e_2 are initial void ratio and void ratios at the time of removal of surcharge and at the time of repeated load, respectively, t_0, t_s are time at the end of primary consolidation and time during secondary compression, U_ε is degree of consolidation by surcharge (degree of consolidation is determined by strain), R and λ are c_α/c_c and c_s/c_c, respectively.

Therefore, the strain of clay subjected to repeated loading after removal of surcharge results in $(\varepsilon_3+\varepsilon_4+\varepsilon_5)$. In the case that the strain due to consolidation by surcharge is equal to the strain due to 100% primary consolidation under a permanent load and a repeated load, after removal of surcharge strain of clay subjected to the repeated load becomes $(\varepsilon_3+\varepsilon_5)$.

Fig. 8 shows the relation between the experimental results and the results calculated by the proposed method using Eq. (1). The strain versus time relation for the clay subjected to repeated loading over a long period of time may be fairly accurately predicted

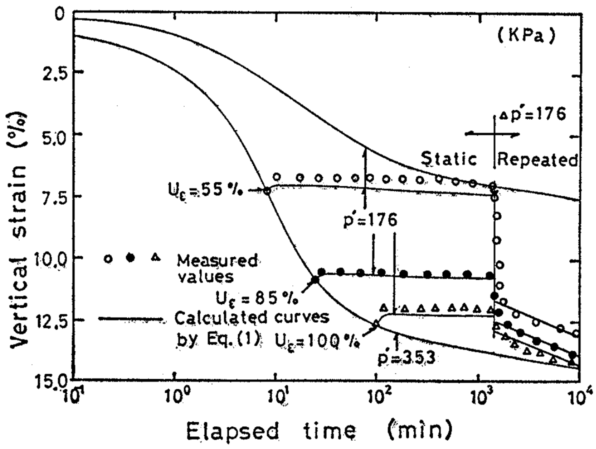

Fig. 8. Relation between experimental results and calculated ones on Kanda clay under repeated loading after removal of surcharge

by the proposed method. In this calculation, we have adopted the assumption that the swelling index c_s should be equal to the recompression index c_r.

When the soft clay deposit is thick, it may sometimes become necessary to calculate the interval distance of the sand drain piles installed for the purpose of accelerating the degree of consolidation by surcharge. Generally speaking, in the preloading method for improvement of soft soil, it is important to determine at what time the surcharge should be removed. For, if surcharge were removed for a short period of time which is not enough to ensure the adequate primary consolidation for the thickness of soil layer, surcharge would not be effective as improvement of soft clay. However, if the soft clay is subjected to surcharge for a long period of time which is enough to avoid the recompression after removal of surcharge, the effect of surcharge would not be effective as improvement of soft clay in proportion to a long period of time. When using a surcharging method, it is customary that we attempt to eliminate primary consolidation strain. In other words, it is required from the stand point for reducing the post-construction settlement that the end of primary consolidation should be attained before removal of a surcharge. If primary consolidation strain was eliminated, the strain developed during construction and post-construction would consist of the strain of recompression and secondary compression under permanent and repeated load, respectively. When using the degree of consolidation of the soft clay for surcharge removal and neglecting the primary consolidation under repeated loading, it is necessary that the strain by surcharge for the required degree of consolidation corresponding to the time of surcharge removal must be equal to the strain the 100% degree of consolidation under permanent and repeated loading. In this case, primary consolidation strain by repeated loading ε_4 is equal to zero, i.e. point B is equal to point D. Therefore, the required degree of consolidation $U_{\varepsilon s}$ by surcharge to eliminate the primary consolidation under repeated loading can be expressed by means of Eq. (7).

$$U_{\varepsilon s}=\log\left(\frac{p_0'+p_1'+\Delta p'}{p_0'}\right)\Big/\log\left(\frac{p_0'+p_s'}{p_0'}\right) \quad (7)$$

The calculated relations between $U_{\varepsilon s}$ and p_s'/p_1' are summarized in Fig. 9 through a parameter of $\Delta p'/p_0'$. The required degree of consolidation of the soft clay before surcharge can be obtained from Fig. 9 in case of normally consolidated soils. When the required degree of consolidation of the soft clay $U_{\varepsilon s}$ is known for an assumed value of surcharge loading ratio p_s'/p_1' and a known value of permanent loading ratio p_1'/p_0' through an assumed value of repeated loading ratio $\Delta p'/p_0'$, the time at surcharge removal can be calculated in the usual manner from $t=T_vH^2/c_v$. In many cases the time at surcharge removal is pre-determined, because of necessity of the time for opening to traffic. If a repeated load intensity and a time at surcharge removal are determined, we can calculate the required surcharge loading ratio p_s'/p_1'. It is also suggested that this procedure should be commonly available with the situations under sustained and repeated loading. Therefore, adaptation of Fig. 9 is convenient for the design of preloading method at the field to determine the

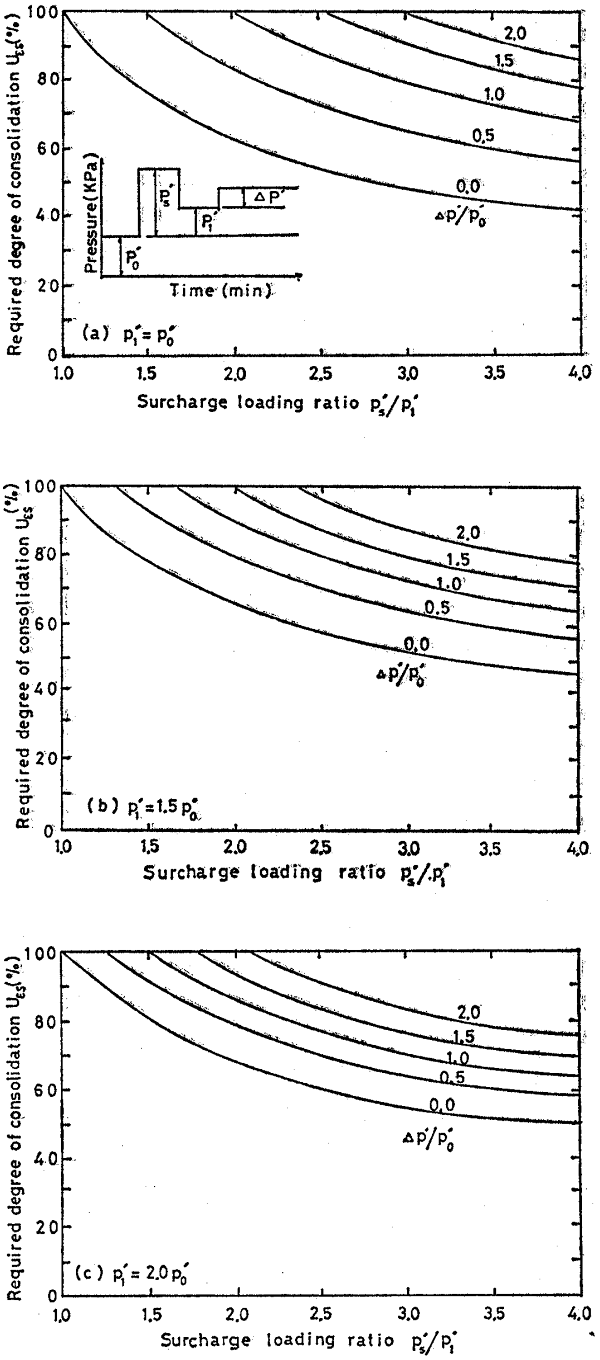

Fig. 9. Degree of consolidation by surcharge load required to eliminate primary consolidation

effective surcharging time. The strain can be estimated in a conventional manner, but subsequent settlement may be produced by resulting from secondary compression.

In the case that soft soil is subjected to surcharge for a long period of time, it is said that the soft soil behaves as though it were under overconsolidation. In addition, it is known that delayed compression causes soft soil to behave like the overconsolidated soil, since it brings about an increase in the effective stress. The authors have regarded the soft soil subjected to surcharge for a long period of time as a quasi-overconsolidated soil. In this type of soil, the behavior is assumed to be equivalent to that of overconsolidated soil due to release of overburden pressure. Fig. 10 shows the typical example of vertical strain ε versus elapsed time relation in which a soft soil is subjected to surcharges p_s' and $(p_s'+\delta p')$, respectively, for a long period of time. The strains of soil due to primary consolidation and secondary compression during the elapsed time t_s under surcharge p_s' are equivalent to a difference between the strain of soil due to primary consolidation subjected to p_s' and $(p_s+\delta p')$, respectively. The strain of soil due to secondary compression is calculated as

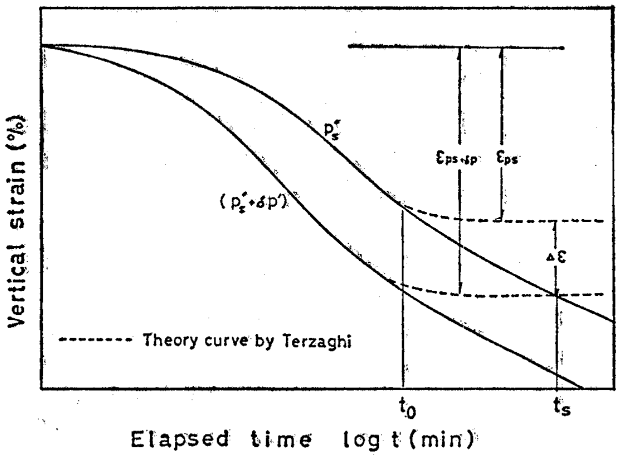

Fig. 10. Key sketch for strain-time relation under surcharge

$$\Delta\varepsilon=\frac{c_c}{(1+e)}\log\left(\frac{t_s}{t_0}\right)^{R/(1-\lambda)} \qquad (8)$$

On the other hand, $\Delta\varepsilon$ is considered to be a difference between the strain of soil due to primary consolidation subjected to p_s' and $(p_s'+\delta p')$, respectively.

$$\Delta\varepsilon=\frac{c_c}{(1+e)}\left[\log\left(\frac{p_s'+\delta p'}{p_0'}\right)-\log\left(\frac{p_s'}{p_0'}\right)\right] \qquad (9)$$

Therefore, by equalizing Eq. (8) to Eq. (9), we have

$$\log\left(\frac{p_s'+\delta p'}{p_s'}\right)=\log\left(\frac{t_s}{t_0}\right)^{R/(1-\lambda)} \quad (10)$$

$(p_s'+\delta p')/p_s'$ is, in fact, the overconsolidation ratio. From Eq. (10) the increase in the effective stress is given by,

$$\delta p'=p_s'\left[\left(\frac{t_s}{t_0}\right)^{R/(1-\lambda)}-1\right] \quad (11)$$

For example, Kanda clay has $c_c=0.65$, $c_\alpha=0.02$ and $c_s=0.09$. Let us consider the condition that surcharge is 353 kPa and primary consolidation time t_0 is 100 min (drain length of specimen is 1 cm). If secondary compression time t_s is 1 week or 1 month, quasi-overconsolidation ratio induced by secondary compression is 1.18 or 1.30, and the increase in effective stress $\delta p'$ is 64 or 86 kPa, respectively using Eq. (11). Therefore, quasi-overconsolidation ratio and the increase in effective stress of soft soil subjected to secondary compression can easily be calculated using the above-mentioned equation. When we have a enough time until construction of structures during placement of surcharge for a long period of time, the effective stress of soft clay will gradually increase.

SECONDARY COMPRESSION UNDER REPEATED LOADING AFTER SURCHARGE REMOVAL

It has been made clear from the previous study (Fujiwara et al., 1987) that the behavior of soft clay grounds subjected to repeated loading is different from the one subjected to sustained loading. Besides, it has been emphasized that the difference in settlement between these two loading patterns must be due to secondary compression over a long period of time. Then, the authors have made clear that soft clay grounds subjected to repeated loading tend to be more compressible than those subjected to sustained loading. It is expected from the above mentioned laboratory test results that the preloading is considered to be promising as a countermeasure to reduce the settlement of clay under repeated loading. Aboshi et al. (1981), Yasuhara et al. (1981) and Shirako et al. (1987) showed that the coefficient of secondary compression is plotted against the overconsolidation ratio. They concluded that the larger the degree of consolidation by surcharge became, the more eminently coefficient of secondary compression decreased. In the present paper, the authors attempted to make sure of this matter by carrying out the repeated consolidation tests on reconsolidated Kanda clay which was previously described.

Fig. 11 shows the relation between void ratio and elapsed time during repeated loading consolidation of Kanda clay. In the case that the degree of consolidation is 55% by surcharge, the eminent primary consolidation by repeated load is apparently observed after repeated loading. On the other hand, after repeated loading the primary consolidation by repeated load is not observed for the case that the degree of primary consolidation by surcharge is 100%. With reference to loading pattern, it is clear that the coefficient of secondary compression c_α has become large under repeated loading in comparison with the one under sustained loading. The magnitude of secondary compression to start upon completion of primary consolidation can be computed as ε_5 mentioned above and illus-

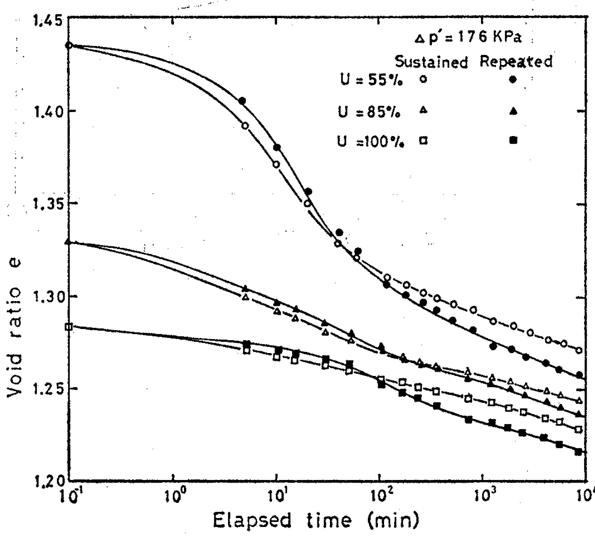

Fig. 11. Relation between void ratio and elapsed time under repeated loading after removal of surcharge

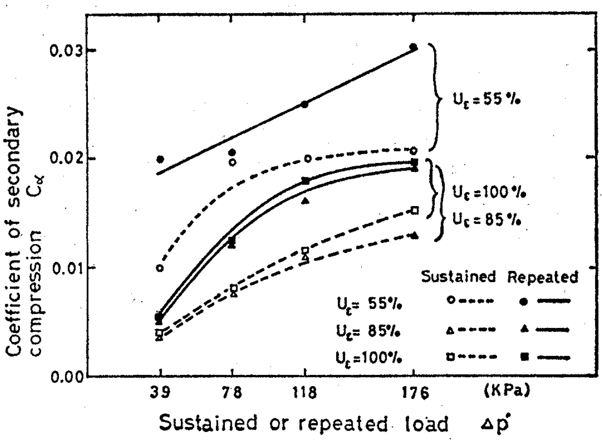

Fig. 12. Relation between the coefficient of secondary compression and the intensity of sustained and repeated loads

trated in Fig. 7.

In this study, the value of the coefficient of secondary compression by repeated load after the removal of surcharge is illustrated in Fig. 12. In the case which a surcharge was removed after a short period of time during preconsolidation, the coefficient of secondary compression is large because the degree of consolidation by surcharge is small. There is no significant difference about the coefficient of secondary compression at a region beyond 85% of degree of consolidation by surcharge as illustrated in Fig. 12. Therefore, when we want to reduce the residual secondary compression, the surcharging time required should be longer than the elapsed time corresponding to the degree of consolidation under surcharge to eliminate primary consolidation.

With reference to loading pattern the values of the coefficient of secondary compression under repeated loading are of about 50% increase in comparison with the ones of sustained loading. These results are similar to those described in the previous paper (Fujiwara et al., 1987). Therefore, the strain of soft soil subjected to repeated loading is larger than that subjected to sustained loading compared with the corresponding period of time. It is indicated from Fig. 12 that the magnitude of coefficient of secondary compression under repeated loading is affected by the amount of repeated load and the loading pattern (sustained or repeated loading).

The values of the coefficient of secondary compression are proportional to the intensity of the sustained or repeated load ; i. e. secondary compression strain corresponding to an increase in the amount of the sustained or repeated load over a long period of time.

CONCLUSIONS

The following conclusions were obtained from the present study ;

1) Settlement characteristics of a clay subjected to repeated loading are affected by the amount of surcharge, the degree of consolidation at the removal of surcharge, the amount of permanent load and the amount of repeated load.

2) When using the degree of consolidation at surcharge removal and eliminating the primary consolidation, the required degree of consolidation is determined from the relation between surcharge loading ratio and intensity of permanent loading ratio as a parameter of repeated loading ratio.

3) The coefficient of secondary compression under repeated loading is influenced by the amount of load increment ratio and the loading pattern, such as sustained or repeated loading pattern. In particular, the coefficient of secondary compression increased proportionally to the intensity of additional applied load after removal of surcharge.

4) The strain-time relation for the clay subjected to repeated loading over a long period of time after removal of surcharge may be fairly accurately predicted by the simplified method proposed in the present paper.

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NOTATIONS

c_r=recompression index
c_α=coefficient of secondary compression
p_0'=overburden load
p_s'=surcharge load
p_1'=permanent load
t_0=time at 100% degree of primary consolidation
t_s=time during secondary compression
U_ε=degree of primary consolidation by surcharge load
$U_{\varepsilon s}$=degree of consolidation required to eliminate primary consolidation under surcharge
$\Delta p'$=incremental repeated load
ε_t=total vertical strain
ε_1=strain due to surcharge load
ε_2=strain after surcharge load removal
ε_3=recoverable strain due to repeated load
ε_4=primary consolidation strain due to repeated load for the part of unconsolidation due to surcharge
ε_5=strain due to secondary compression

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