SETTLEMENT OF SOFT GROUND WITH LIME COLUMN UNDER SURFACE LOADING

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1 INTRODUCTION

A small scale laboratory test was conducted to examine the settlement response of soft ground stabilized with lime column. The columns are installed in group and subjected to surface loading applied over the entire improved area. Both the end bearing and the floating columns having various degrees of penetration are considered. The test results are compared with those of predicted, and a reasonable agreement is found between them.

2 EXPERIMENTAL WORK

The experiments were conducted in a circular plastic mold of 30cm diameter and 30cm high. The base clay was obtained from 3.0~4.0m depth from a site in Kawasoe town of Saga prefecture. The physical properties of the clay are shown in Table 1. The clay was thoroughly remoulded at a water content of about 120%. The clay slurry was poured taking care not to trap air bubbles. Clay slurry was placed in three layers and the preliminary consolidation was conducted for each layer under a uniform vertical pressure of about 2.5kPa for a certain time. After the completion of pouring slurry and preliminary consolidation, the final consolidation pressure 10kPa was applied for about one week until the end of primary consolidation. After that pressure was removed and the columns were installed. A casing of diameter 5cm, was driven in clay media till the desired depth and the equivalent clay cylinder as well as the casing were removed gradually. The lime columns were then placed. For a particular test, seven columns having the same diameter and length, were installed giving equal spacing. A typical arrangement of columns during test is shown in Fig.1. The cylindrical lime columns were made by using 10% of lime by the weight of clay. The columns were kept under water around one month for curing. Some specimens also were made for testing the compressive strength of columns. The columns have the diameter (=d_c) of 5cm and lengths (L_c) of 25, 20, 15 and 10cm, while the depth of clay layer (H_s) is 25cm for all the tests. After the installation of columns, the same pressure as used for the consolidation of clay slurry i.e. 10kPa, was applied again and kept it for 2~3 days. The incremental pressure was then applied and each load increment was kept till the end of primary consolidation. The applied pressure (p_o) was increased from 10 to 120kPa at an increment of 10kPa. The pressure was applied from a compressor through the rubber balloons. For each increment of pressure settlement were measured on the top of column and on soil, in between two columns. The settlements of the stabilized ground measured on the top of column and soil are shown in Table 2. The test results indicate that the settlement of the stabilized ground decreases with the increasing value of degree of penetration (L_c/H_s), which is, of course, as expected. The settlement measured on the top of column (S_c) and soil (S_s) varies from each other with L_c/H_s and p_o. At an applied pressure, p_o=50kPa, S_c/H_s and S_s/H_s decrease from 0.072 to 0.004 and 0.077 to 0.016, respectively, for increasing L_c/H_s from 0.40 to 1.0. At a degree of penetration of column, L_c/H_s=0.60, S_c/H_s and S_s/H_s increase from 0.005 to 0.096 and 0.005 to 0.118, respectively, for increasing p_o from 10 to 120kPa.

Table 1 Physical properties of used clay.

Natural water content, w_n(%)	115~125
Specific gravity, G_s	2.62
Liquid limit, w_L(%)	99.2
Plastic limit, w_P(%)	39.6
Plasticity index, I_P	59.6

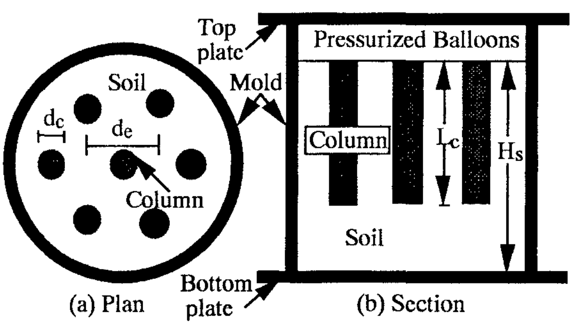

Figure 1 Typical arrangement of columns in test.

Table 2 Normalized settlement of improved ground measured on the top of column and soil.

L_c/H_s \ p_o (kPa)		10	20	30	40	50	60	70	80	90	100	110	120
0.40	S_c/H_s	0.017	0.028	0.045	0.065	0.072	0.091	0.10	0.105	0.114	0.119	0.124	0.129
	S_s/H_s	0.014	0.027	0.046	0.069	0.077	0.10	0.11	0.116	0.126	0.132	0.139	0.145
0.60	S_c/H_s	0.005	0.011	0.021	0.038	0.049	0.057	0.065	0.072	0.083	0.088	0.092	0.096
	S_s/H_s	0.005	0.015	0.030	0.049	0.061	0.070	0.080	0.088	0.102	0.102	0.113	0.118
0.80	S_c/H_s	0.006	0.013	0.017	0.022	0.028	0.030	0.033	0.036	0.038	0.040	-	-
	S_s/H_s	0.006	0.016	0.023	0.031	0.040	0.045	0.049	0.054	0.059	0.064	-	-
1.00	S_c/H_s	-	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.009	-
	S_s/H_s	-	0.005	0.009	0.014	0.016	0.018	0.021	0.024	0.027	0.028	0.029	-

3 PREDICTION OF THE TEST RESULTS

The theoretical model recently proposed by Alamgir (1996) is used to predict the measured settlement response of the stabilized ground. This method is already validated with the finite element analysis, using CRISP (Britto and Gunn 1987). The mechanical properties of the soil and the columns are estimated as E_s=500kPa, E_c/E_s=80 and ν_s=0.40 based on the routine laboratory test results, where E_s and E_c are the deformation moduli of soil and column, respectively and ν_s is the Poisson's ratio of soil. The diameter of the zone of influence (d_e) for each column is estimated as 1.13cm. The measured and the predicted values are presented in Figs.2 and 3 for the settlements on the top of column and on the soil, respectively. From these figures, it can be seen that the predictions are good in determining the settlement at the top of column and at the top of soil upto the stress level of 75kPa. But beyond this applied stress level, the proposed model overpredicts the settlements compared to those obtained from the tests. This may be due to the changing of column and soil stiffnesses at higher stress levels during the tests which is not considered in the prediction. However, the differences between the predicted and the measured values of settlements for stress levels over 75kPa, remain within tolerable limit.

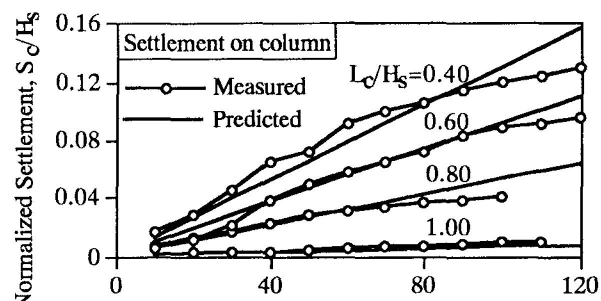

Figure 2 Settlement on the column with applied stress.

4 CONCLUSIONS

The test results and the predictions lead to the following conclusions: (i) The soft ground stabilized with lime column experiences differential settlement in case of surface loading; (ii) The overall settlement of the improved ground decreases with the increasing value of degree of penetration of column; and (iii) The model recently proposed by Alamgir (1996) can be used successfully to predict the settlement response of such improved ground.

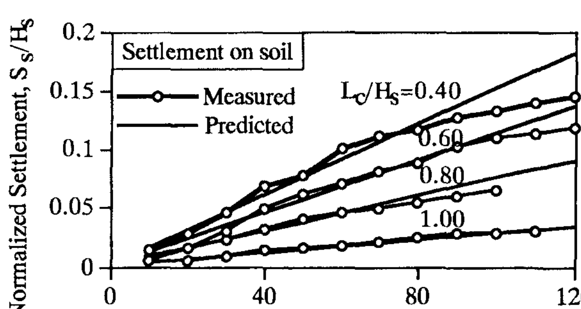

Figure 3 Settlement on soil with applied stress.

REFERENCES

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