III-526 EFFECT OF LIME STABILIZATION ON THE STRENGTH OF SOFT CLAY

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1 INTRODUCTION

This paper is concerned with the effects of lime stabilization on the strength parameters of soft Bangkok clay. Fully drained and undrained triaxial compression tests were carried out to study the effects of lime stabilization on the angle of internal friction (Ø) and cohesion (c). Quicklime was used as stabilizing agent. Six series of consolidated undrained (CIU) triaxial tests were carried out on lime stabilized samples with lime contents of 2.5, 5, 7.5, 10, 12.5 and 15% at 1 month curing period. The pre-shear consolidation pressures were 5, 10, 15, 20, 40 and 60 t/m^2. Additionally, three series of tests were carried out on samples with 5, 7.5 and 10% lime contents only at 2 months curing period. The pre-shear consolidation pressures were the same as in the series of tests with one month curing period. Fully drained triaxial compression tests (CID) were carried out on samples with 5, 7.5 and 10% lime contents and with the same pre-shear consoli- dation pressures used in the undrained tests. These tests were carried out at curing periods of 1 and 2 months. The procedure suggested by Duncan et. al (1980) was adopted in the determination of the effective strength parameters, as shown in Fig. 1. The strength parameters for the base clay were found to be Ø = 24.4° and c = 0.

2 RESULTS AND DISCUSSIONS

The undrained effective strength parameters for lime stabilized samples are summarized in Table 1. A lime content of 2.5% caused marginal increases in c to 1 t/m^2 and Ø to 27.8°, and can be considered to be ineffective. After one month curing, lime contents of 5 to 15% resulted in relatively similar increases in strength parameters, with Ø = 33° to 36°, and c of about 2.2 t/m^2. Comparing the strength parameters for one and two months curing periods, it is seen that the angle of friction increased slightly to almost the same value (Ø = 36.2°) for lime contents of 5, 7.5 and 10%. On the other hand, a very large increase in the cohesion occurred from the first to the second month, from 2.3 to 8.2 t/m^2 and 2.3 to 9.0 t/m^2 for lime contents of 7.5 and 10%, respectively; for 5% lime content, a moderate increase in cohesion from 2.3 to 4.1 t/m^2 occurred.

Calculated strength parameters from CID tests are summarized in Table 2. After 1 month curing, the cohesion increased to about 3 to 4 t/m^2, while the angle of friction increased to between 30 to 32°; the increases are apparently independent of lime content. After 2 months, the values of Ø were not much higher that at 1 month, except for specimens with 10% lime content for which Ø increased from 32.1 to 35.3°. As in the CIU tests, the significant increase in Ø occurred within the first month of curing. On the other hand, very large increases in cohesion were found from the first to the second month: from 2.9 to 7.5 t/m^2, 3.9 to 8.4 t/m^2, and 4.3 to 13.8 t/m^2, for 5, 7.5 and 10% lime contents, respectively. A lime content of 10% brought about the largest increases in both the angle of internal friction and the cohesion.

It has been shown (Buensuceso et. al, 1991) that the strength development of lime stabilized soft Bangkok clays can be considered to consist of three phases. Phase I is a period of slow, gradual strength increase; this phase corresponds to an initial period when the cementation effects are not yet mechanically felt even if chemical reactions are taking place. The strength development significantly increases in phase II, mainly because the bridging between the soil particles is already efficient. Meanwhile, phase III is characterized by the slowdown of strength development. This conceptual model of strength development is useful in explaining the observed effects of lime stabilization on the strength parameters as follows. The results of both CIU and CID triaxial tests have shown that lime stabilization resulted in increases in both the angle of friction and the cohesion. However, the significant increase in Ø was observed to take place within the first month of curing, while the effects on the cohesion were more pronounced after the first month of curing. The gradual increase in strength in phase I may be considered to be the result of the changes in the frictional nature of the stabilized clay (shown by the increase in Ø). In phase II, the large increase in the strength after the formation of effective bridging of the cemented clay structure is manifested by the sharp increase in cohesion.

3 CONCLUSION

The strength development of lime treated clays may be considered to consist of an initial period of gradual increase in strength which is the result of the changes in the frictional nature of the stabilized clay. Thereafter, a large increase in the strength occurs after the formation of effective bridging of the cemented clay structure, which is manifested by the sharp increase in cohesion.

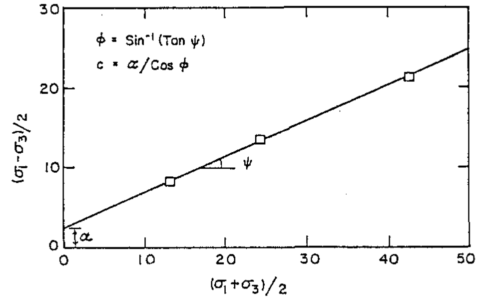

Fig. 1 Estimation of strength parameters

Table 1 Strength parameters from CIU tests

Curing Time	Lime Content (%)	Strength Parameters ψ (degrees)	Strength Parameters α (t/m²)	Mohr–Coulomb Parameters ø (degrees)	Mohr–Coulomb Parameters c (t/m²)
1 month	2.5	25.0	1.14	27.8	1.00
	5	28.7	1.90	33.2	2.27
	7.5	30.0	1.90	35.3	2.32
	10	30.0	1.88	35.3	2.30
	12.5	30.5	1.90	36.1	2.35
	15	30.0	1.86	35.3	2.27
2 months	5	30.6	3.33	36.3	4.13
	7.5	30.5	6.66	36.1	8.24
	10	30.5	7.27	36.1	9.00
(-)	untreated	(-)	(-)	24.4	0

Table 2 Strength parameters from CID tests

Curing Time	Lime Content (%)	Strength Parameters ψ (degrees)	Strength Parameters α (t/m²)	Mohr–Coulomb Parameters ø (degrees)	Mohr–Coulomb Parameters c (t/m²)
1 month	5	26.9	2.50	30.5	2.90
	7.5	27.0	3.33	30.6	3.87
	10	28.0	3.57	32.1	4.27
2 months	5	27.0	6.48	30.6	7.53
	7.5	26.9	7.24	30.5	8.40
	10	30.0	11.25	35.3	13.78
(-)	untreated	(-)	(-)	24.4	0

REFERENCES 1) Buensuceso, B.R., Balasubramaniam, A.S. and Miura, N. (1991). Strength development of lime treated soft clays. Annual meeting, JSCE (Seibu Branch), March, 1991. pp. 432-433; 2) Duncan, J. M., Byrne, P., Wong, K. and Mabry, P. (1980). Strength, stress-strain and bulk modulus parameters for finite element analyses of stresses and movements in soil masses. Report no. UCB/GT/80-01. Coll. of Eng., Office of Research Services, Univ. of Cal., Berkeley.