STRENGTH DEVELOPMENT WITH TIME OF LIME STABILIZED ARIAKE CLAY

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1 INTRODUCTION It is generally recognized that the development of strength of lime stabilized clays is time dependent (Fig. 1), as are the chemical reactions (cation exchange, flocculation and pozzolanic reactions) which take place when lime is mixed with clays. This study presents data on the long-term strength development of lime stabilized soft Ariake clays and describes the characteristics of the increase in strength with curing time.

2 EXPERIMENTAL DETAILS The base clay was obtained from 2 to 3m depth from a site in Kawasoe area, Saga City. Initial properties of the base clay are: ω_n=120-130%, ω_L=89%, I_P=42%, G_s=2.62, γ_d=0.6 kgf/cm^2, A=0.56 and q_u=0.2 kgf/cm^2. Three kinds of lime were used to stabilize the clay, namely: quicklime (97% CaO), hydrated lime (97% $Ca[OH]_2$) and a low-grade commercial (or LGC) lime (52% $Ca[OH]_2$ and 28% $CaCl_2$ xH_2O). Lime contents were varied from 5, 10 and 15% of the dry weight of clay. The water content of remolded clay was fixed at 150% during the mixing process, to preclude any effects of variation in the initial water content. Uniform mixing of the lime and clay was done with the use of a soil mixer. Specimens of 5 cm diameter and 10 cm height were prepared in PVC molds, making sure that large voids are not present. The specimens were sealed with plastic sheets and cured in a constant (20°) temperature humid room. Unconfined compression tests were carried out at curing times of 1, 3, 5, 7, 14, 21, 28, 42, 56, 70 and 84 days according to JSSMFE JIS A 1216/JSF T-511, with a strain rate of 1%/m. Three specimens were tested for each test condition.

3 RESULTS AND DISCUSSIONS The development of strength with curing time is illustrated in Fig. 2. It is clearly seen that the strength gain is affected by the type of lime and the lime content. The relative strength increase can be divided into three types: (1) ineffective, as for the case of 5% LGC; (2) moderately effective (about 10-20 times q_u), e.g. 5% CaO, 5% $Ca[OH]_2$ and 5 & 10% LGC; and (3) highly effective (more than 50 times q_u), e.g. 10% CaO and 10 & 15% $Ca[OH]_2$. For 5% LGC, insufficient amount of lime was added such that there was no strength gain even after 84 days.

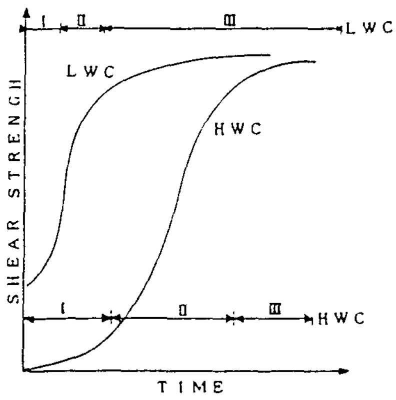

Fig.1 Increase of strength with time (After Locat et.al, 1990)

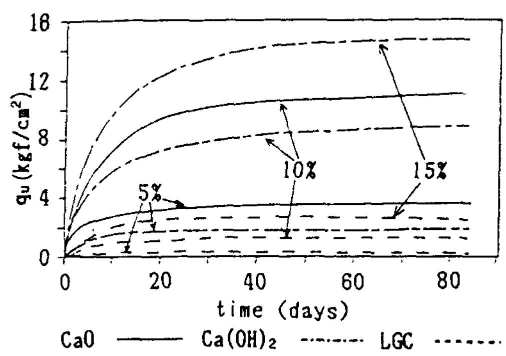

Fig.2 qu:time curves for lime stabilized clay

The development of strength for lime stabilized Kawasoe clay can be described as follows (see Fig. 3). With sufficient lime concentrations in the clay, the strength can be expected to increase considerably within 7 days, such that the 7-day strength is approximately 50-60% of the 28-day strength. Although subsequent increases after 28 days can be expected, the data revealed that the 28-day strength is approximately 90% of the 84-day strength. The present practice of using the 28-day unconfined strengths may therefore be justified, but it must be pointed out that the results of this study cover curing periods of only up to 84 days. In general, these findings may be taken as an advantageous characteristic of the strength development for lime stabilized Kawasoe clay, as compared with, for example, 60 days for lime stabilized soft Bangkok clay (Buensuceso et. al, 1991) and 50-100 days for sensitive Canadian clays (Locat et. al, 1990).

For the same percentage of dry weight (10%) but for different lime types, Fig. 4 shows that quicklime or CaO results in the highest strength gain. However, since the natural stabilization agent for clays is calcium hydroxide, it may be preferable to compare the strengths using samples with equivalent concentrations of $Ca[OH]_2$, e.g. 10% $Ca[OH]_2$ is equivalent to adding 7.5% CaO or 18.7% LGC. Unconfined tests were carried out on specimens with equivalent $Ca[OH]_2$ concentrations and the results are shown in Fig. 4. Considering the occurrence of an additional hydration reaction when quicklime is mixed with soft clay, CaO was expectedly found to result in slightly higher strengths compared with $Ca[OH]_2$. For the case of LGC lime, however, the strengths were only about 50% of those with $Ca[OH]_2$, which can be attributed to the presence of $CaCl_2$ and other impurities in the low-grade commercial lime.

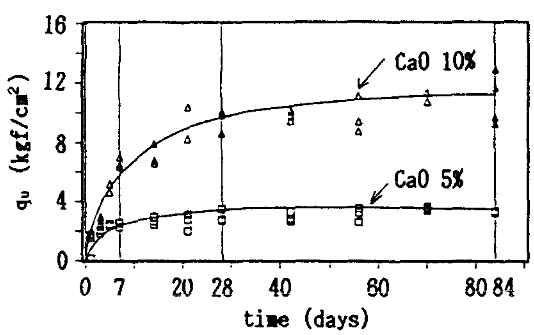

Fig.3 Strength development for specimens stabilized with CaO

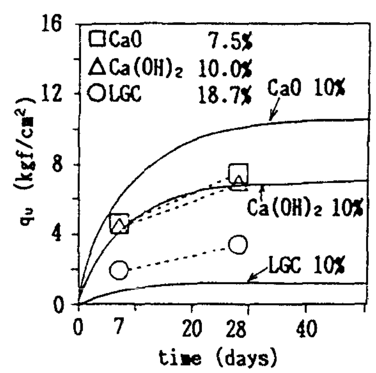

Fig.4 Influence of lime type and lime content on strength

4 CONCLUSIONS The following conclusions on the lime stabilization of Kawasoe clay are made based on the results presented in this paper: (1) the relative strength increase is influenced by the type of lime and the lime content; (2) about 90% of the long-term strength increase occurs within the first 28 days of curing; (3) the 7-day strength is approximately 50-60% of the 28-day strength; and (4) a significant amount of pozzolanic reactions that result to strength increase have taken place within 28 days after lime stabilization.

5 REFERENCES (1) Locat, J., Berube, M. and Choquette, M. (1990). Laboratory investigations on the lime stabilization of sensitive clays: shear strength development. Canadian Geot. J. 27, pp. 294-304. (2) Buensuceso, B.R., Balasubramaniam, A.S. and Miura, N. (1991). Strength development of lime treated clays. Proc. Annual Meeting of the JSCE. (Seibu branch). March 1991. pp. 432-433.