Effects of Oxidation on Ariake Clays

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I Introduction

Prior to the field construction series of tests are conducted to predict the behavior of in situ soil. There is a question that the soil samples after stored for months represented the in situ characteristics of soil or not. The clay samples usually are changed in color after storage. The process responsible for changes of properties during storage is referred to as “oxidation process”. Many cases have been reported where significant changes in sensitivity, Atterberg limits, and pore water chemistry occurred during storage. Lessard and Mitchell (1984) investigated the changes during storage of soft Champlain clay in 1 year period to evaluate the effect of various storages. Regardless of storage procedure, the remolded strength, plastic index, and liquid limit increased with time, whereas the sensitivity, the liquidity index and the pH decreased. The water content, plastic index and undisturbed strength are still unchanged. The pore water concentrations of calcium, magnesium, and sulfate were increased by several folds. In order to understand the geotechnical and chemical changes occurring in Ariake clay during storage, the testing program was carried out on Ariake clays. The results of the testing program are presented in this paper.

II Experiment Investigation

The soft Ariake clay samples used in the testing program consisted of undisturbed piston sample from Ashikari and disturbed samples from Rokkaku Kawa and Kashima tideland, Saga prefecture, Japan. The properties of Ariake clay samples are shown in Table 1. Ashikari sample was kept in the stainless steel tube for 2 years before testing. Color of samples was changed from gray to reddish brown due to oxidation at the surface. The sample was cut into two portions by two different colors. Testing including physical properties, scanning electron microscope and pore size distribution were performed on the sample. For disturbed samples, Rokkaku and Kashima clays stored in the buckets were periodically conducted Atterberg’s limit, pH on natural samples, cation concentrations in pore water of natural samples and unconfined compression test on lime stabilized sample until reaching 3 months.

Table 1 Properties of soil samples

Location	Depth, m	Water Content, %	Liquid Limit, %	Plastic index	pH	Salt Content, g/l	Particle size distribution, %			Ignition Loss, %
							Sand	Silt	Clay	
Rokkaku	1	123	142	88	7.6	4.4	2	31	67	12.8
Kashima	1	300	177	108	7.6	20.0	1	69	30	13.8
Ashikari	2	146	122	65	7.6	3.0	2	28	70	8.9

III Result and Discussions

The oxidation process of soil, for the most part, is attributed to the oxidation process of pyrite, which results in the formation of iron hydroxide and sulfuric acid. The production of acid causes the dissolution of calcium carbonate, which increases the concentration of divalent cationic in the clay, then reducing interparticle repulsion and increasing the remolded strength. The oxidation of organic matter, resulting in the formation of carbonic acid, also contributes on the solubility of calcium carbonate (Lessard and Mitchell, 1984).

In Figs. 1a) and 1b) illustrate the micrographs of red and gray portions of undisturbed samples. In the gray portion, as typical Ariake clay, diatoms and pyrite (i.e. the small sphere in the middle of Figure 1a) can be observed in microstructure. The existing of diatoms and pyrite is shown that soil environment is rather reductive condition (Hino et al., 2001). While in the red portion, pyrite was not present due to oxidization as shown in Figure 1b). Observed void size

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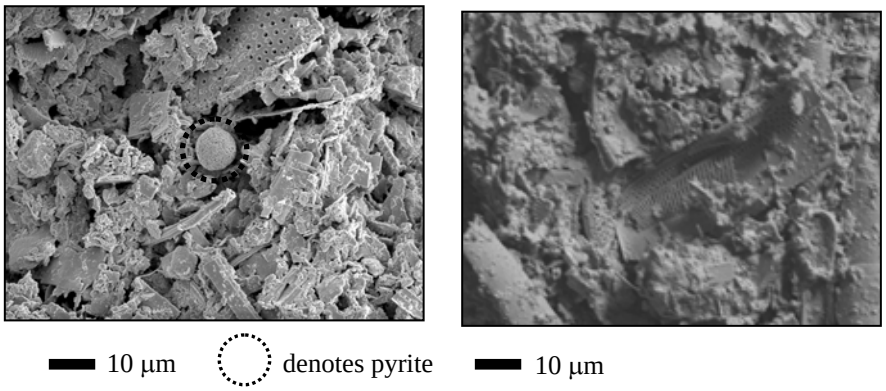
in the red portion sample was also smaller than that in gray portion sample. Figure 2 shows the pore size distribution of red and gray portions of undisturbed samples. The both curves have 2 peaks at 3 and 7 μm. Red portion curve shows that volume at 7 μm was reduced due to oxidation. This result is consistent with micrograph that shows slightly smaller size of void in red portion than gray portion. Liquid limit of disturbed samples is slightly increased while plastic limit is seemed to be constant as showed in Fig. 3. The pH values for disturbed samples as presented in Fig. 4 are decreased with time due to acid formation produced by oxidation. The strength of clay stabilized with 10% lime is also invariable with time during 3 months storage. The divalent cations as tabulated in Table 2 were increase with time which agreed well with previous researches.



a) Gray portion b) Red portion

Fig. 1 Micrographs of undisturbed samples

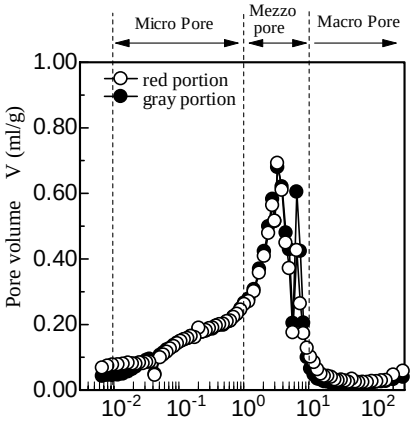


Fig. 2 Pore size distribution of UD

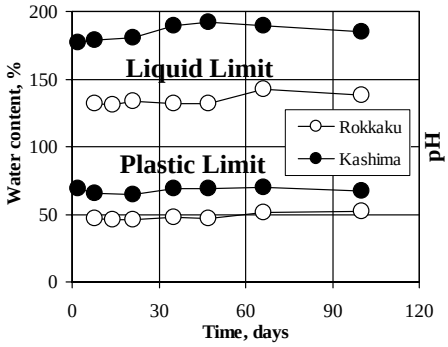


Fig. 3 Atterberg's limits of disturbed samples

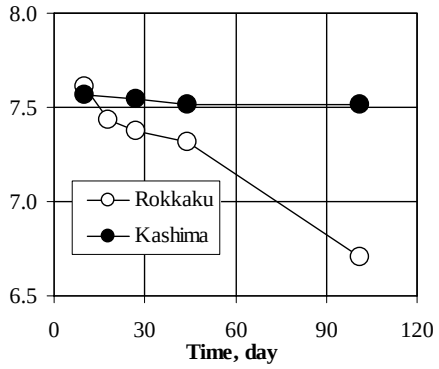


Fig. 4 pH of disturbed samples

Table 2 Ion concentrations at 81 and 95days storage periods

Ion Type	Ion Concentration (mg/l)			
	Rokkaku		Kashima	
	81 d	95 d	81 d	95 d
Ca^{2+}	159	308	351	533
Mg^{2+}	325	944	700	2319
Na^{+}	1,779	1,630	5,686	5,529
K^{+}	144	163	391	420

IV Conclusions

The oxidation process plays an important role on soil properties during storage. The process begins from the oxidation of pyrite, which results in producing of sulfuric acid. The acid causes the dissolution of calcium carbonate, which increases the concentration of divalent cation in clay, thus altering in soil properties. The soil properties changed during storage due to oxidation process are as follows. The colors of samples change from gray to reddish brown. pH decreases due to increasing of acid. In addition, the micrographs show that after storage, pyrites are disappeared because of oxidation. Soil stabilization with lime has no significant effect by oxidation during 3 month storage.

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