The Effect of Salt Concentration on Microstructure of Ariake Clays

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I Introduction

Lime and cement stabilizations are usually applied for ground improvement in soft clay. This study focuses on the effect of salt concentration that is one of the predominant factors on strength of lime and cement stabilized clays. The tests including unconfined compression test, consistency limits and consolidation test in addition with scanning electron microscope (SEM) and pore size distribution were performed on the samples with various salt contents. The details of test methods and results are described in following sections.

II Experimental Investigation

The samples were taken from Okawa area, Ashikari area, Isahaya Bay and Fukudomi area designated as Clay 1, Clay 2, Clay 3 and Clay 4, respectively. Properties of the samples are shown in Table 1. Liquid limit tests with various salt contents were performed on natural samples and "treated" samples in which extracted the organic matter. The organic matter shows the retarding effect on cementing in lime and cement stabilized clays. Unconfined compression test with various salt contents was conducted on treated samples mixed with 20% cement or lime at water content of 150% at 7 day curing time. Consequently, scanning electron microscope investigates on microstructure of natural Clay 3 samples with salt content of 28 and 0.7 g/l at water content of 150% and 100%, respectively. The natural Clay 4 samples in forms of undisturbed (UD), reconstituted (R) and reconstituted mixed with NaCl 30 g/l (RS) were used in the consolidation tests. Pore size distribution test was also conducted on natural Clay 4 by using R and RS samples.

Table 1 Properties of soil samples

Samples	Location	Depth, m	Water Content, %	Liquid Limit, %	Plastic index	pH	Salt Content, g/l	Particle size distribution, %		
								Sand	Silt	Clay
Clay 1	Okawa	1	185	143	90	6.0	0.7	3	52	45
Clay 2	Ashikari	3	150	133	71	7.6	15.4	1	44	55
Clay 3	Isahaya	3	170	150	88	8.0	23.1	0	19	81
Clay 4	Fukudomi	3	165	124	71	-	1.6	1	28	71

III Results and Discussions

Figure 1 shows the liquid limit of natural clays and treated clays at various salt concentrations. The liquid limits of all treated clays decrease with decreasing in salt concentration. It agrees well with previous researches (Ohtsubo et al.), indicating that lower liquid limit with a decrease in ion concentration is a typical behavior of non-swelling Ariake clays. Figure 2 indicates that the strength of the stabilized clay increases with the salt concentration.

Figures 3 and 4 illustrate the micrograph of Clay 3 at water content of about 150% with salt content 28 g/l, and 100% with salt content 0.7 g/l, respectively. Although Figure 3 has higher water content than Figure 4, the pore spaces in clay fabric are smaller. The liquid limit increases and pore space decreases with salt concentration. Figure 5 indicates the compression curve of Clay 4 by using UD, R and RS samples. The result presents that the yield stress increases with increasing salt concentration. Figure 6 shows the pore size distribution curves of R and RS samples at the same void ratio and water content. It shows that the higher the salt concentration is, the smaller the spacing between aggregates are obtained and induces the liquid limit to increase that agree well with the micrographs in Figures 3 and 4.

The schematic diagrams of salt concentration on Ariake clay are proposed in Figures 7 (a) and 7 (b). From the diagrams, the pore spaces between aggregates can be divided into 2 levels as: Comparatively large pore neighboring Macro-pore and Mezzo-pore (Matsuo and Kamon, 1976) which is enclosed by linkage. The schematic diagrams show that higher salt concentration yields the smaller size of inter-aggregate pore according to the rearrangement of the clay fabric, resulting in higher liquid limit, lower liquidity index and higher strength. Comparison of properties between Figures 7 (a) and 7 (b) are as followings; (1) Salt concentration, (a) < (b); (2) Liquid Limit, (a) < (b); (3) Liquidity Index, (a) > (b); (4) Inter aggregate pore size, (a) > (b) and (5) Shear Strength, (a) < (b).

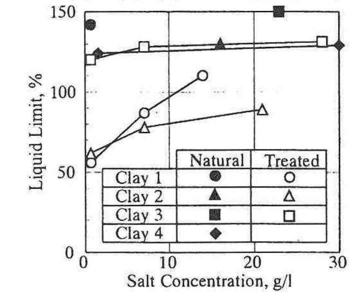

Fig. 1 Effect of salt concentration on liquid limit of Ariake clay

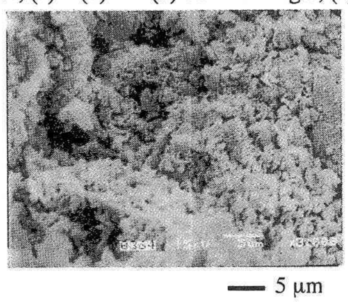

Fig. 3 Micrograph of Clay 3 at salt concentration 28 g/l and water content 150%

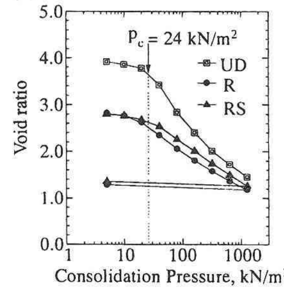

Fig. 5 Compression curves of natural Clay 4

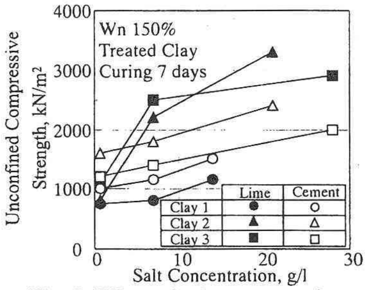

Fig. 2 Effect of salt concentration on strength of stabilized clay

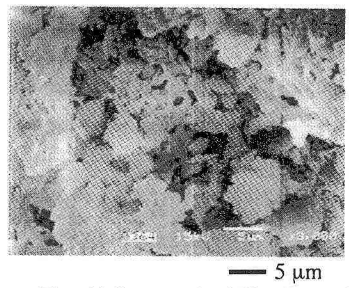

Fig. 4 Micrograph of Clay 3 at salt concentration 0.7 g/l and water content 100%

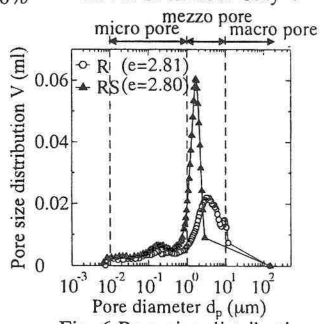

Fig. 6 Pore size distribution curves of natural Clay 4

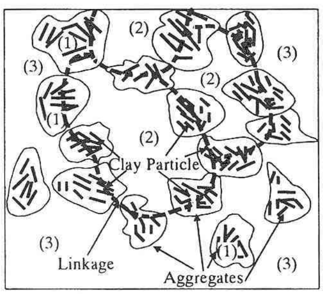

Fig. 7 (a) Schematic diagram of reconstituted Ariake clay

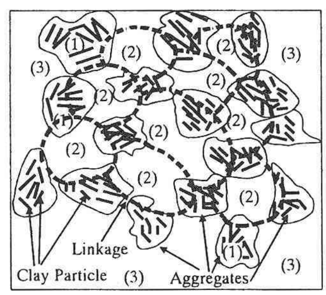

Fig. 7 (b) Schematic diagram of reconstituted Ariake clay mixed with NaCl 30 g/l

Notes:

1. Both figures are at the same void ratios.
2. (1) denotes Intra-aggregate Pore.
3. (2) denotes Mezzo-pore enclosed by linkage (Inter-aggregate pore).
4. (3) denotes Mezzo-pore –Macro-pore.
5. (— —) denotes linkage.

IV Conclusion

The salt concentration is the dominant factors affecting the level of the cementing bond and fabric. The increasing of salt concentration will increase the strength of stabilized clay. Micrographs and pore size distribution are obviously indicated that at the same void ratio and water content, the higher salt concentration yields the smaller spacing between aggregates that induces the increasing in liquid limit resulting in the lower liquidity index.

V References

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