SEM observation for compacted clay

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Introduction

Compaction of soil, an ancient construction technique, has been widely adopted all over the world. To investigate relationships between mechanical properties and microstructures of compacted soils, which were compacted several thousands years ago such as the compacted burial mound soils in Yoshinogari, and time effects on the relationships, as the first step, it is necessary to investigate homogeneous compacted soils, because the Yoshinogari soils consisting of soils with extensive size range. This paper represents partial results of investigations on microstructure and unconfined compressive strength of compacted homogeneous clay, 'Kaolin'.

Materials and methods

In this research one commercial clay, 'Kaolin', was used (furnished by the Wako Pure Chemical Industries, Ltd). Table1 shows some geotechnical properties of Kaolin, and Figure1 shows the cumulative grain sizes distribution of the Kaolin which covers a narrow range. The gross result of a compaction experiment named Harvard compaction method, in which soil samples were compacted in a mold 3.5 cm in diameter, 8 cm in height, with average compaction force about 20 KN, and 10 blows for each of three layers, is given in Figure2.

Table 1. Indices for Kaolin

Specific Gravity		2.82
Atterberg Limits	w_L(%)	63.1
	w_P(%)	36.3
	I_P	26.8
Grain size Distribution	Silt(%)	20.5
	Clay(%)	79.5
Maximum ρ_d (g/cm³)		1.26
$w_{opt.}$ (%)		39.5

Based on the attained compaction curve, specimens were prepared by impact-compaction method for unconfined compression tests and two methods, impact-compaction and static-compaction, for SEM observation with three water contents, dry side (34.5%), optimum side (39.5%) and wet side (45.0%). Specimens for unconfined compression tests were prepared at curing periods of 0, 1 and 7day(s), and the specimens for SEM tests were prepared by freezing-dry method in order to avoid large pores shrinkage.

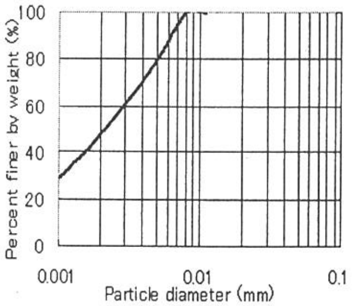


Fig.1. Grain sizes distribution curve

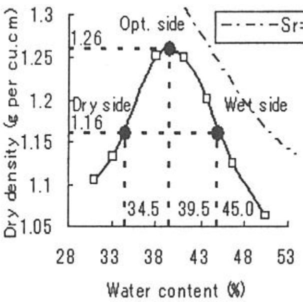


Fig.2. Impact-compacted curve

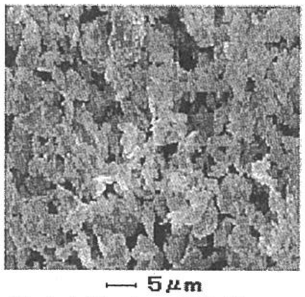


Photo 1. Powders of Kaolin

Results and discussion

1. Unconfined compression tests

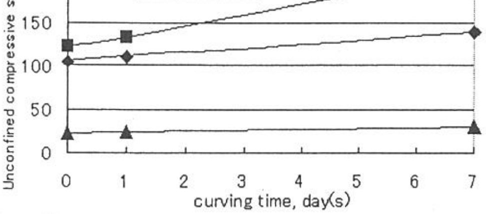


Fig.3. Unconfined compressive strength versus curing days

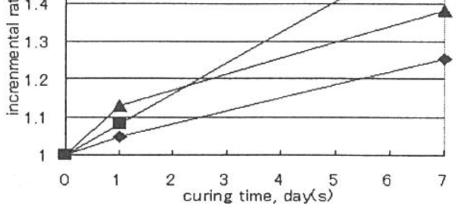


Fig.4. Strength increments against curing days

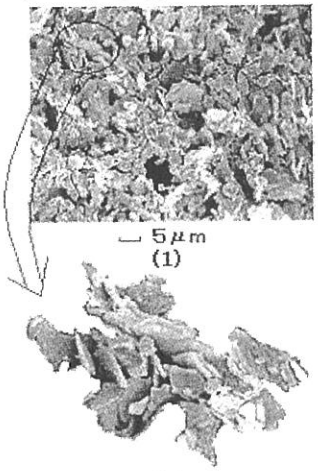
Figure3 shows strength development of compacted clays at curing days, and Figure4 shows the strength incremental ratios of compacted clays against curing time. In the period of curing time, varieties of soil structure took place. Having been applied with some constant compaction energy, clays with different water contents possessed different clay structures. It is should be pointed out that there was no peak value in the compressive process of wet side on curing 0 and 1day, but on curing 7days there was a peak value.

2. SEM observation

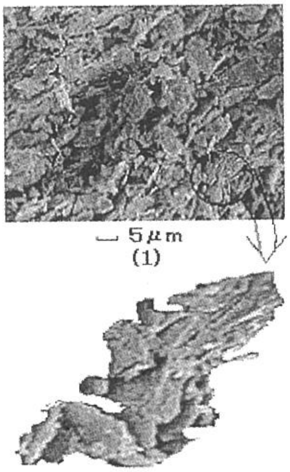
Since Lamb(1958) proposed his hypotheses about the microstructures of compacted clays, researchers have carried out investigations on microstructures of compacted clays in the light of the hypotheses, such as Diamond(1974) etc. Photos of impact-compacted clays have been presented many times, so in this paper photos of static- compacted clay are presented.

Photo1 shows microstructures of Kaolin in the condition of powders with magnification (×3000), and in this paper a single platy 'Kaolin' particle is named element. Photo2, 3 and 4 shows vertical planes of microstructures of compacted Kaolin with water contents 34.5%, 39.5% and 45.0% respectively and magnification (×3000).

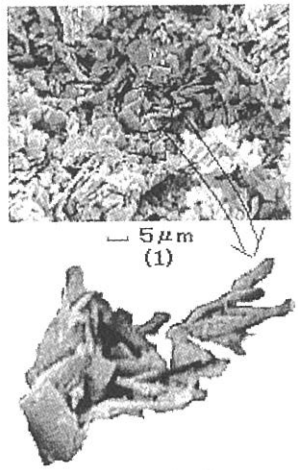
Comparing with Photo1, Photos, 2(1), 3(1) and 4(1), show that soil structures had been produced by the method of compaction, and particles constituted by elements and pores can not be distinguished clearly, yet the ways of elements connection are some different. Photo 2(1) indicates that there are large pores in the clay, and elements connect others as 'edge-face' and 'edge-edge' forms. Photo 3(1) indicates that elements connect others as 'face-face' form. Although Photo 4(1) also show that elements connect others as 'face- face' form, the angles and pores existing between main planes of two elements connecting with each other are larger than those in Photo 3(1). To make clear description of particles connection, enlarged photography, Photo 2(2), 3(2) and 4(2), are given.



(2)
Photo2. Dry side



(2)
Photo3. Opt. side



(2)
Photo4. Wet side

Conclusion

1. Unconfined compression tests results show that unconfined compressive strength of compacted clays increases with curing time, therefore the clay structures should vary with curing time.
2. Compacted by a constant energy, clays with different water contents possess different clay structures.
3. In this attempt, there are differences between microstructures of compacted clays with three water contents, dry side, optimum side and wet side.

Reference

1. Laing Barden and Deoferey sides (1971): Sample Disturbance in the Investigation of Clay Structure, Geotechnique 21 No.3,pp.211−222.
2. Syed Ahmed, Charles William Lovell and Sidney Diamond (1974): Pore Size and Strength of Compacted Clay, A.S.C.E Journal of the Ceotechnical Engineering Division, Vol.100,pp.407−425.
3. Sidney Diamond (1970): Microstructure and Pore Structure of Impact−Compacted Clays, Clays and Clays minerals Vol.19,pp.239−249.