Improvement effect of high water content dredged clay using bamboo chip and cement

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ABSTRACT

In the west part of Japan, damage to the forest is reported by the propagation of a bamboo. Therefore, periodical felling and effective inflection of the bamboo is required. Currently, the bamboo is crushed into chip, and these materials have been promoted in various fields. The bamboo those that are crushed into chip contain fiber. Also, it has high water absorption ability. This study is focused on these abilities. On the other hand, the improvements of high water content dredged clay is required preliminarily such as stabilization and dehydration process due to the difficulty of earthwork and conveyance. In general, a cement solidification is usually used an improvement method. However, dredged clay containing a large amount of organic matter has a problem of raising the pH of the site due to the use of a large amount of solidified material. Therefore, the purpose of this research is to improve the high water content dredged clay by using water absorbing material of bamboo chip which is low cost and environmentally friendly. As the result of this study, it was revealed that the bamboo chip can reduce the water content irrespective of the physical characteristics and particle size distribution of clay samples. In this report, it was reduced water content of high water content dredged clay using a bamboo chip and examined materials characteristic of “Bamboo chip mixed cement-treated soil” which used solidification materials (cement) together. As a result, bamboo chip mixed cement-treated soil had decreased water cement by the absorbing water effect of the bamboo chip regardless of a kind of the clay. The strength of bamboo chip mixed cement-treated soil depends on the liquid limit and the initial water content of the improvement target soil.

Keywords: bamboo chip; absorption potential; water content; liquid limit; improvement effect

1 INTRODUCTION

High water content dredged clay is difficult to transport from construction sites and adjustment of the water content is required for effective utilization (Kato et al. 2005; Nabeshima et al. 2009; Hayashi et al. 2010). Also, in the west part of Japan, the abandoned a bamboo grove has been a social problem (Nishi Nippon Shimbun, News Paper Co., Ltd. 2013). Also, a bamboo which has strong fecundity. Cutting down the bamboo is taken place regularly to eliminate this problem. But as a consequence, it produces a large amount of cut-bamboo waste. So, the utilization of bamboo waste is also necessary. In this study, it is intended to purpose at the establishment of the soft ground improvement technology by using the bamboo. Also, this study reports the result of material properties of bamboo chip mixed cement-treated soil.

2 MATERIALS AND METHODS

2.1 Materials

Table 1 shows the properties of the bamboo chip. The initial water content of the bamboo chip was set at 0% by drying the chip at 60℃ with a furnace dryer for two days (Nishida et al. 2012). Kaolin clay, Kibushi clay, and Ariake clay were used as high water content dredged clay samples. Table 2 shows the physical characteristics of clay samples.

Table 1. Properties of the bamboo chip

Appearance	
Cutting filter	Circle 20mm
Fiber long width	2-35mm
Water content (%)	125.3
Bamboo chip dencity ρ_s(g/cm^3)	1.587

Table 2. Physical characteristics of clay samples

		Kaolin clay	Kibushi clay	Ariake clay
ρ_s	(g/cm^3)	2.731	2.690	2.614
w_n	(%)	-	3.9	87.2
Ig-loss	(%)	3.1	8.5	8.4
Fc	(%)	100.0	96.4	67.2
w_L	(%)	51.7	44.0	93.5
w_P	(%)	34.3	16.1	34.8
I_P	(%)	17.4	27.9	58.7

2.2 Absorption potential of the bamboo chip

Target strength of high water content dredged clay is unconfined compressive strength that can transport by a truck (q_u=50kN/m^2). Cone index q_c is 4 times of unconfined compressive strength q_u (q_c=4q_u), and Cone index assumed 200kN/m^2 the targeted value (Japan Cement Association 2012: Soil Improvement Manual Fourth Edition). Table 3 shows the cone index test (JIS A 1228) condition.

Table 3. Cone index test condition

Sample	Initial water content of clay w_0(%)	Bamboo chip content B(%)
Kaolin clay Kibushi clay Ariake clay	50 100 150	0, 10, 20, 30, 40, 50, 60, 70, 80

The bamboo chip content was set according to the ratio of dry weight of clay sample. The bamboo chip content was changed as B=10-80%. The initial water content of clay sample was adjusted to 50, 100, and 150%. For the specimen for the cone test, a sample mixed with bamboo chips and clay was tamped into a cone test mold having a diameter of 10 cm and a height of 12 cm by a tamping method in three layers, eight times in each layer, and each layer was compacted with the same energy.

Figure 1 shows the relations of the bamboo chip content and the cone index. The corn index increase under the influence of an absorbing water effect the bamboo chip and fiber of the bamboo with the increase in the bamboo chip content in both conditions and the test result satisfies target strength. Figure 2 shows the relations of the initial water content of clay and the bamboo chip content at q_u=200kN/m^2. The bamboo chip content at q_u=200kN/m^2 of all clay sample indicate a tendency to increase with increasing in the initial water content of clay. Then, Figure 3 shows the relations of the liquid limit and the bamboo chip content at q_u=200kN/m^2. With the increase of the liquid limit of the clay sample, the bamboo chip content at q_u=200kN/m^2 decreases. In addition, the differences between the initial water content and the liquid limit are small and, as a sample having high liquid limit, shift to a plasticity state when the initial water content is w=100% and indicate that the bamboo chip content at q_u=200kN/m^2 decreases.

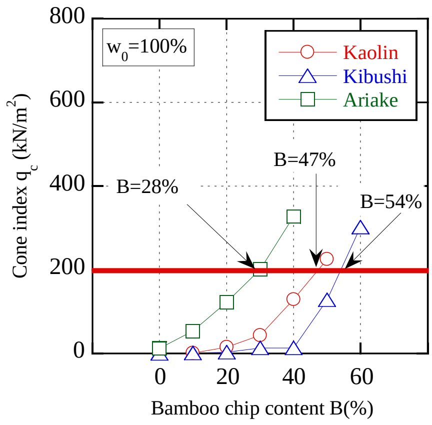

Fig. 1. The relations of Bamboo chip content and Cone index

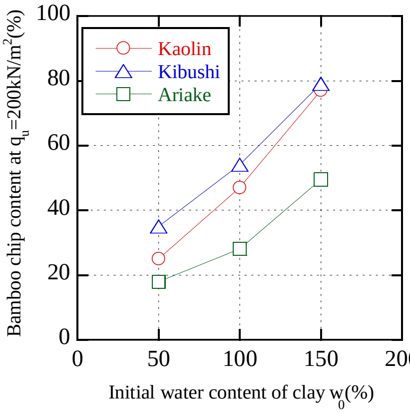

Fig. 2. The relations of Initial water content of clay and Bamboo chip content at q_u=200kN/m^2

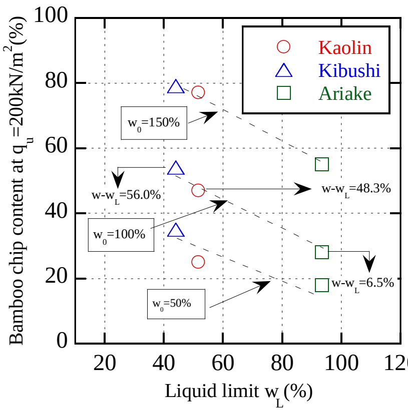

Fig. 3. The relations of Liquid limit and Bamboo chip content at q_u=200kN/m^2

2.3 Testing Method

It is examined the strength and deformation properties of bamboo chip mixed cement-treated soil using unconfined compression test (JIS A 1216). Table 4 shows the unconfined compression test condition. In consideration of the liquid limit, the initial water content of clay sample was adjusted to 50, 100, and 150%. In advance the cone index test, the additive rate of the bamboo chip was changed as B=0-50%. The test specimen of unconfined compression test prepared mixing clay which is adjusted to the initial water content and the bamboo chip and cement content C=20% by the tapping method. In this study, blast furnace cement was used as solidification material.It is not examine it in the condition that had difficulty in test specimen method by the water absorptivity of the bamboo chip in this time here. After curing the test specimen for 7 days, unconfined compression test carried out. Unconfined compressive strength assumed q_u=300kN/m^2 the targeted value (Japan Cement Association 2012: Soil Improvement Manual Fourth Edition) as laying earth on the ground materials by this experiment.

Table 4. Testing condition

Sample	Initial water content of clay w_0(%)	Bamboo chip content B(%)	Cement content C(%)	Curing
Kaolin clay Kibushi clay Ariake clay	50 100 150	0 10 20 30 40 50	20	7 days

3 RESULTS AND DISCUSSIONS

3.1 Physical properties of the bamboo chip mixed cement-treated soil

Figure 4 shows the bamboo chip content and the water content of clay after the bamboo chips mixing. In this figure, the initial water content w_0=100% of each sample, and only kaolin clay shows the initial water content $w_{0=}$50 and 150%. The water content of the clay in the test specimen decreases by the absorbing water effect of the bamboo chip with the increase in the bamboo chip content. Also in the kaolin clay having different the initial water content, the water content decreases as the bamboo chip content increases. The bamboo chip have equivalent water absorption characteristics regardless of the initial water content ratio of clay. Figure 5 shows the bamboo chip content and the wet density of test specimen. The wet density of the specimen greatly decreased with the increase of the bamboo chip content. The specimen of the bamboo chip mixed cement-treated soil has a skeleton structure changed from clay to bamboo as the bamboo chip content increases. Therefore, many voids are generated in the specimen due to mixing of bamboo chips.

3.2 Mechanical properties of the bamboo chip mixed cement-treated soil

The results of the unconfined compression test of bamboo chip mixed cement-treated soil using the kaolin clay on the bamboo content B=0, 20% are shown in Figure 6. In both the bamboo chip content, the strength increases with decreasing of the initial water content. In addition, it is showed a toughness destruction form more by adding a bamboo chip. As for this, the toughness effect of the bamboo chip has an influence on the deformation characteristic of the test specimen.

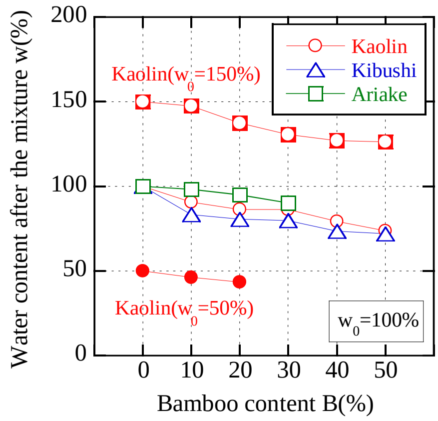

Fig. 4. The relations of Bamboo chip content and Water content of clay.

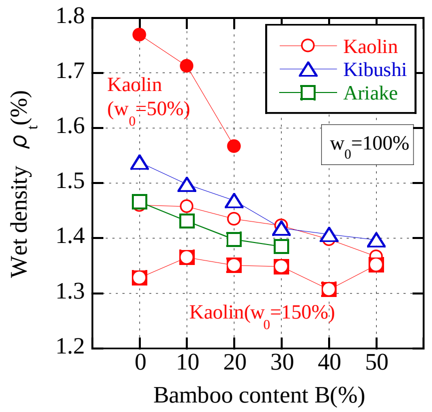

Fig. 5. The relations of Bamboo chip content and Wet density of test specimen

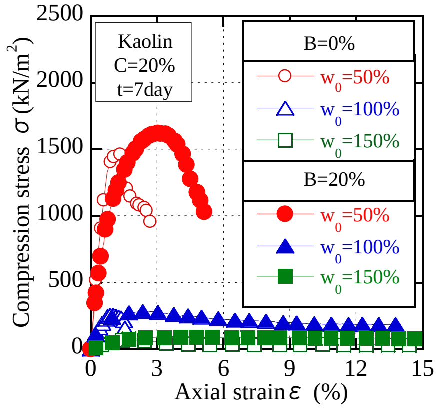

Fig. 6. The results of the unconfined compression test

Figure 7 shows the bamboo chip content and unconfined compressive strength, the initial water content w_0=100% of each sample. After having shown a peak, in Kaolin clay and Ariake clay, unconfined compressive strength decrease with increasing the bamboo chip content. On the other hand, in Kibushi clay, unconfined compressive strength only increases with increasing the bamboo chip content. It is thought that these are caused by the water absorption and rigidity of the bamboo chip. In addition, from Figure 4, it is thought that water content indicates a tendency to decrease with a factor with the increase in the bamboo chip content in both conditions. It is suggested that the strength of bamboo chip mixed cement-treated soil is influenced by the liquid limit of each clay and the initial water content ratio. Therefore, Figure 8 shows the relationship between the uniaxial compressive strength at the bamboo chip content B=0 to 30% and the liquid limit value of each clay. Here, the initial water content is w_0=100%, which is indicated by a black line in the figure. With the Ariake clay having lowest differences between the liquid limit and the initial water content, unconfined compressive strength decreases by the increase of the bamboo chip content.

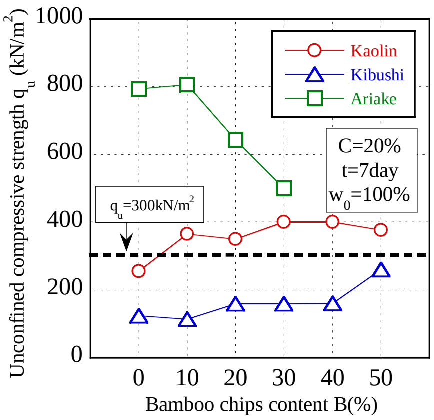

Fig. 7. The relations of Bamboo chip content and Unconfined compressive strength.

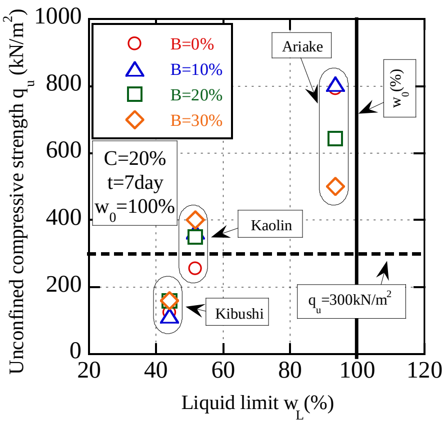

Fig. 8. The relations of Unconfined compressive strength in bamboo chip content B=0-30% and relations with liquid limit and the initial water content

On the other hand, in the Kibushi clay which is the highest in differences between the liquid limit and the initial water content, increase of unconfined compressive strength by the increase of the bamboo chip content, but the improvement effect is low. In this way, it is suggested that an improved effect by the addition is high for the bamboo chip so that differences between the liquid limit and the initial water content are small. However, it is necessary to warn a change of skeleton structure when it decreases in what the bamboo chip adds than the liquid limit.

4 CONCLUSION

1) Bamboo chip mixed cement-treated soil had decreased by the absorbing water effect of the bamboo chip regardless of a kind of the viscous clay. However, the viscous clay having high water content has low absorbing water effect of the bamboo, it is necessary to consider the cement content.

2) Improvement effect of bamboo chip mixed cement-treated soil is highly dependent on the liquid limit and the initial water content of the clay. With differences between the liquid limit and the initial water content, improved effects by the addition are different for the bamboo chip.

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