Effectiveness of coconut coir utilization in peat soil stabilization

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INTRODUCTION

Peat soils can be found in many countries around the world; 2,000km^2 through Hokkaido, whereas in Sri Lanka 5% to 10% of land area is covered by peat soil. The process of urbanization has created the need to utilize those areas in construction. However, construction over peaty soils always create special problems due to their poor engineering properties. Low shear strength is a major problem often causing stability problems in peat soils. In order to prevent such failures, peat ground should be improved using appropriate techniques.

Soil reinforcements with natural fibers are commonly used as a successful ground improvement method. Among all-natural fibers used in industry, coconut coir (CC) has the highest tensile strength and it is highly recommended as a ground improvement material. Its high content of lignin (40%) enhances the strength of treated soil. Moreover, this natural fiber is widely available in Sri Lanka. In this study, CC which is made of coconut husks is used as an additive material for soil stabilization.

The main objective of this study is to utilize CC as an environmentally friendly material that can partially replace cement for peat ground improvement. Unconfined compressive strength (UCS) of specimens under various CC and OPC contents are compared.

METHODOLOGY

Test Material and Sample Preparation

Peat soil collected from Hokkaido, ordinary Portland cement (OPC) and Sri Lankan Coconut Coir provided by a Japanese company were used in this study. Properties of the materials are presented in Tables 1 and 2.

A total of 110 samples of peat and stabilized peat were prepared by hand mixing at corresponding percentage of OPC and CC (Table 3) at the average natural water content of peat soil until reaching uniform mixture. Each sample was compacted in 4 layers with 25 blows. Air curing technique was used for the specimens for 7, 14, 21 and 28 days.

Experimental Program

Water absorbability test was conducted for CC to evaluate absorbability tendency in short term. Absorbed water index is ratio between the decreasing water in biuret and volume of bamboo material. UCS tests were conducted after different curing period. In order to keep results consistent and reliable, a minimum of two samples were tested and average results were taken as UCS values. Basic physical and chemical properties of soil were tested.

Table 1 Hokkaido Peat Physical Properties

Hokkaido Peat Physical Properties	
Natural water content (%)	580
Ash content (%)	16.8
Organic content (%)	83.2
Bulk unit weight (kN/m^3)	10.6
Specific gravity, G_s	1.01
Liquid Limit LL (%)	375
Compression Index, C_c	2.60
Undrained shear strength (kPa)	6.80

Table 2 Chemical composition of Peat and CC

	C	Ca	Si	Al	Fe
Untreated Peat (%)	58.39	1.10	4.64	3.09	2.07
Natural CC (%)	49.98	3.17	4.92	1.33	1.70

Table 3 Added OPC and CC amounts

Case	OPC	CC Condition	CC (%)
1	5%	Natural	0%~10%
2	10%	Natural	0%~1.5%
3	None	Natural	0%~1.5%
4	5%	Dried	0%~10%
5	100%	-------	0%

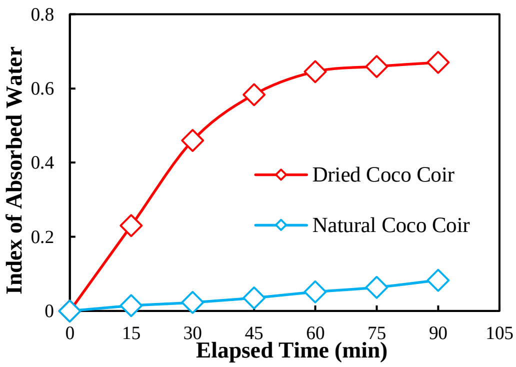

Fig. 1. Water Absorption of CC

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RESULTS AND DISCUSSIONS

Water absorption of coconut coir

Figure 1 shows the water absorbability of natural CC and Dried Coconut Coir (DCC). The natural CC demonstrates a low absorption rate with an index of absorbed water reaching at 0.1 after 90 min. However, DCC displays a fast water absorption rate initially. After 60 min absorbed water index converged to around 0.7.

Water content variation of stabilized soil with curing period

Figure 2 shows the water content variation of 1.5%CC with different proportions of OPC with respect to the curing period. Without OPC, water content almost remained unchanged from the beginning to the end. However, with 5% and 10% OPC, water content shows a gradual decrease at initial state due to the primary hydration of cement and after that became almost stable until the end of curing period. Plainly, the water content declined when the OPC content larger.

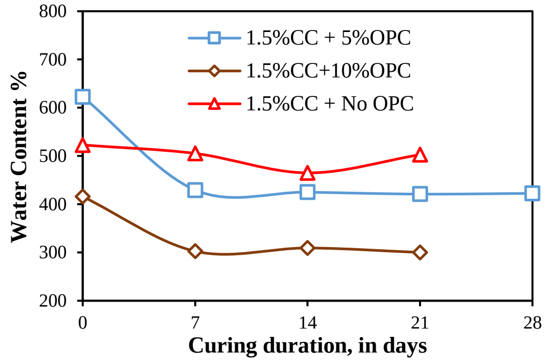

Fig. 2. Water content variation

Unconfined compressive strength with curing period

Figure 3 shows the relationships between UCS and curing period under different mixing condition.10% of CC+ 5% of OPC, shows the highest strength throughout the period. At 21 days, strength was recorded 31 kPa. With 8.5% lower CC and 2 times higher OPC, however, shows a 5 kPa less strength at the same curing period. This result indicates that high amount of CC can increase the strength as well as reduce the cement utilization. This also proves that the longer the curing period, the performance of treated peat became better.

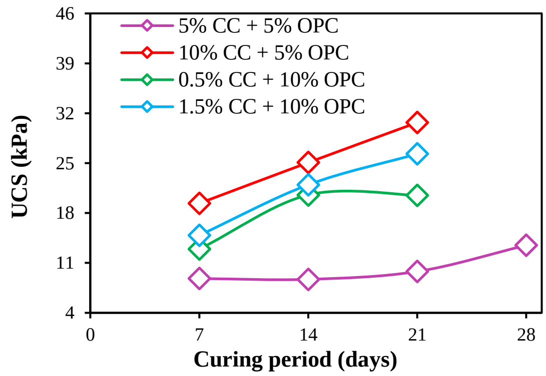

Fig. 3. UCS of Stabilized Peat

Effect of CC on cement stabilized peat

Figure 4 shows the normalized UCS variation of samples under a curing period of 7 days. Corresponded absolute values of UCS are shown in an arrowed box. It can be detected that 10% DCC+ 5% OPC has the highest UCS of 50kPa and was discovered to be about 15 times better than untreated peat and 1.5 times greater than UCS of peat cement specimen (100%OPC).

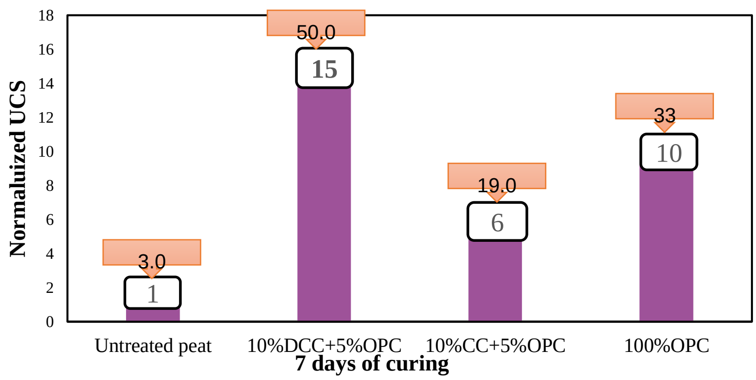

Fig. 4. Normalized UCS

CONCLUSIONS

1. Dried Coconut Coir (DCC) shows higher water absorption characteristics. During the absorption process, coir is able to penetrate into soil mixture and it enhances the interaction between soil particles.
2. Higher UCS can be attained using DCC.
3. Water content tends to depend on the rate of hydration with varying OPC composition.
4. UCS of the soil increases significantly with the increase of Coconut Coir content and curing period.
5. Coconut Coir can be used for replacing the utilization of cement amount partially for peat ground stabilization. Thus, the lower consumption of cement can contribute to greener earth by reducing the greenhouse gas emissions in construction.

REFERENCES

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