SWELLING AND CONSOLIDATION BEHAVIOR OF PALM LEAVES FIBER-REINFORCED EXPANSIVE SOIL

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INTRODUCTION

Mainly 'expansive soils', in geotechnics, refers to soils sensitive to changes in moisture content as they swell with increase in moisture content and shrink with its decrease. A number of damages, namely caused to lightly-loaded structures, have been reported resulting from the differential heaving of the expansive soils they are founded over. Jones et al. (1975) have reported that those damages per year, in the US alone, are estimated twice more than the earthquakes, floods, tornados and hurricanes damages combined [1]. Moreover, the losses are increasing at an alarming rate as reported in Fig.1. Those soils are found in many regions around the world and their behavior is more troublesome in regions where the water content of the soil is subjected to wide fluctuations, such in arid and semi-arid regions [2].

Among the remedial measures present today to reduce the change in volume of the expansive soils, attention is increasing to natural fibers incorporation in the soil. In fact, with the increase in concerns about the environmental impact of the different reinforcing materials, the natural fibers are rising as alternative materials in the light of sustainable Geotechnics [3]. In difference to the synthetic fibers, the behavior of fiber-reinforced soils with natural fibers is not dependent only on the physical and mechanical properties but it is also a function of the biochemical properties. Palm trees are one of the potential sources of natural fibers and are getting more attention to better understand their uses as reinforcing materials [4].

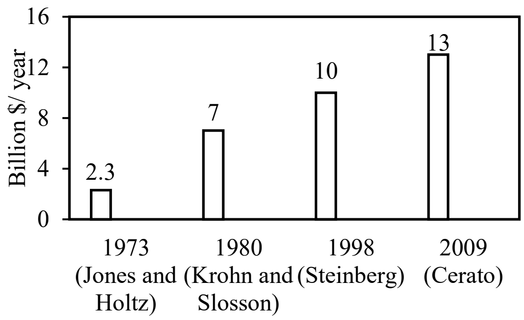

Fig.1: Damages in US associated with swelling and shrinkage of expansive soil

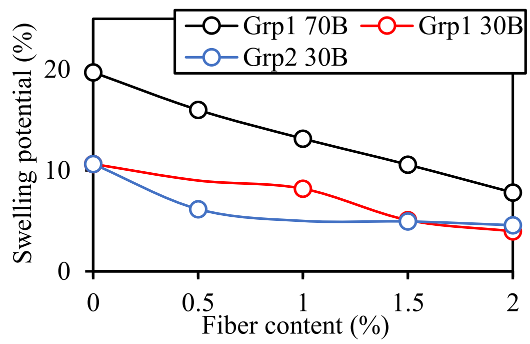

Fig.2: Swelling potential from free swell test at different fiber content

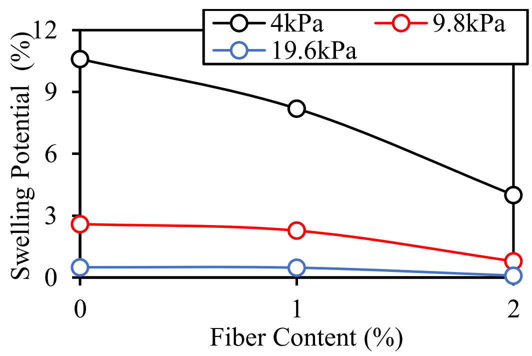

Fig.3: Swelling potential of loaded swell for 30B with different fiber content of Grp1

OBJECTIVE

This research intends to study the mechanism of natural fibers reinforcement of expansive soils and also to study the behavior of palm fibers reinforced expansive soils under wetting and consolidation to evaluate the potential of this type of fibers in limiting the expansion of the soil.

REASEARCH MATERIAL

Palm leaves fibers

Palm trees cultivation is very popular in different regions around the world and is a premier source of income in many locations, especially in the rural areas. Fibers extracted from the wastes of those trees are used in different industries [5]. In this study, the fibers were extracted by crushing dried leaves of palm tree. After sieving, two types of fibers were used; grp1 was composed of fibers retained at sieve n 40 and grp.2 was composed of fibers retained at sieve n 100, present in abundance.

Soil

Artificial soil was prepared by combination of expansive kaolinite and bentonite of montmorillonite with high plasticity. Soil1 was made of 30% Bentonite with 70% Kaolinite and Soil2 of 70% Bentonite and 30% Kaolinite respectively noted as 30B and 70B.

EXPERIMENTAL PROGRAM

Specimen preparation

1-D swelling-compression tests were conducted for prepared specimens of unreinforced and reinforced samples with a random distribution of fibers at different contents by dry weight of the soil. Samples were prepared by compaction of three layers of the specimen with the maximum dry density in an oedometer ring of 6 cm diameter and 2 cm height.

Test program

Two types of swelling tests were conducted, free and loaded swell. In the 'free swell', the specimens were inundated with water only under the loading plate pressure and were subjected to the consolidation test according to the standard JGS-0412 after the swelling. In the 'loaded swell', the specimens were first loaded up to a defined consolidation pressure then they were allowed to swell under this pressure by wetting, the consolidation test was afterwards completed.

Keywords: Natural Fibers, Palm leaf, Expansive soil, Swelling and Consolidation.
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For the evaluation of the specimens swelling, the swelling potential, defined as the ratio of increase in height of the specimen to the initial height was determined. Moreover, the consolidation parameters were compared between unreinforced and reinforced soils.

RESULTS AND DISCUSSION

Fig.2 represents the swelling potential of the two soils with respect to the fiber content in the case of free swell. In all cases, the increase of fiber content was accompanied by a decrease of the swelling potential. Moreover, fibers addition up to 2% has demonstrated a reduction of 62% of the heave.
For the loaded test, only soil with 30B was tested. The results of the swelling potential with respect to the fiber content is given by Fig.3. At all cases, fiber-reinforced soils exhibited lower heave. However, the decrease of the swelling potential is more significant for fiber-reinforced soils at low initial pressures.
From the compression curves of 8 tests of reinforced specimen and an unreinforced sample under the free swell and with soil combination of 30B70K, Fig.4 summarizes the influence of fiber content and type on the compression index. There was little influence shown from the type of fiber and more significant was the fiber content for the compression index which demonstrated a relatively linear decrease with increase in the fiber content. The results are going in accordance with other researchers' findings [4] where natural coir fiber were used for reinforcement of black cotton soil; the swelling reduction reached 40% with increase of the fiber content up to 1.5% and also a decrease of the compression index with fiber content increase was noticed.
As far as the permeability is concerned, Fig.5 plots the variation of the coefficient of permeability at different fiber content. This figure reveals the presence of an optimal value at 1% content for the coefficient for both types. However, a different behavior is noticed from the two types.

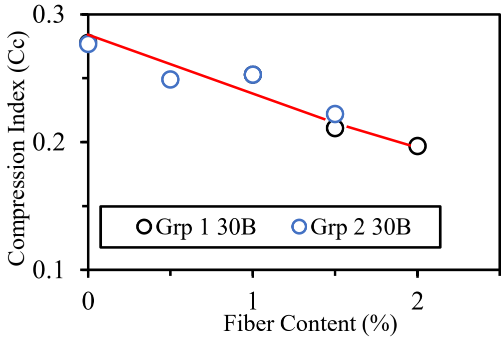

Fig.4: Compression Index after free swell of Samples of 30B with different fiber content

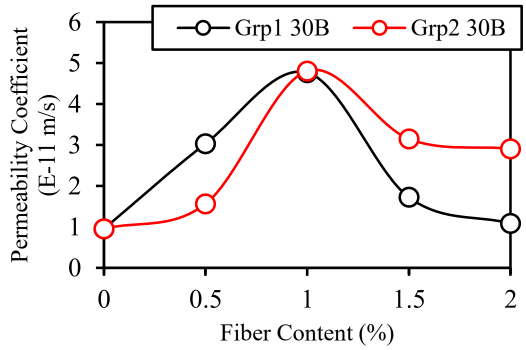

Fig.5: Permeability coefficient after free swell of Samples of 30B with different fiber content

CONCLUSIONS

The palm trees waste represents a potential material for reuse in geotechnics especially in arid and semi-arid areas where it is presence in abundance. In the current study, a series of 1-D swell-compression tests were conducted to evaluate the effectiveness of randomly distributed palm leaves fibers in addressing the swelling behavior of expansive soils.
Based on the results of this study, the swelling potential of expansive soils has been reported as a decreasing function of fibers content reaching 61% of reduction at 2% of fibers content. The effect of the fibers on heave was noticed more significant for samples subjected to low initial consolidation pressure before samples wetting.
Moreover, from the consolidation test, the compression index in fiber-reinforced soils decreased linearly with increase of fiber content. And it is to be noted that the coefficient of permeability has shown an optimal value around 1% of fiber content which may suggest an optimal value for fiber content around 1%.
The results obtained from the tests go in accordance with findings of other researches by use of other natural fibers. It is suggested that the effectiveness of natural fibers in limiting the swelling of expansive soil goes through the interfacial resistance developed in the soil-fiber contact zone, by the fibers stretching throughout the soil matrix during swelling. Those suggestions may be confirmed through shear strength evaluation of unreinforced and palm leaves fibers reinforced expansive soils.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Mr. M. Nakashima, technical staff at Kyushu University, for providing support to this study. Also, funding support of JICA via ABE Initiative Program to this research is gratefully acknowledged.

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