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A Study on the Effect of Basalt Fiber in Organic Soil

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Abstract: *Basalt fiber is an inorganic fiber which uses natural basalt ore as raw material. The basalt fiber has natural compatibility, excellent mechanical properties, high temperature, and acid and alkali resistance. The objective of this paper is to explore the potential use of natural basalt fiber in improving the geotechnical properties of organic soil. Both the content and length of basalt fiber were considered in this paper. The study has been conducted with three different fiber contents of 0.05%,0.10% & 0.15% by weight of raw soil. For each fiber content 10mm, 20mm, 30mm lengths of fiber were used. The fiber reinforced soil is then cured for 7,14 & 28days.The fiber reinforced soil were then subjected to Compaction test and Unconfined Compression test. The experimental results indicate that basalt fiber can effectively increase the strength of organic soil.*
Keywords: *Basalt fiber, compaction test, curing, organic soil,stabilization,unconfined compressive strength*

I. Introduction

Organic soil is a non-homogeneous soil that has been generated as an outcome of decomposition of organic matter such as plant remains, leaves, and trunks. Construction on the organic soil is generally avoided due to the instability and settlement problems. Organic soils are generally considered as problematic soil in any construction projects, because of its high compressibility and very low shear strength. With the rapid industrialization and population growth, construction is scheduled almost everywhere including the area of peat-land. The common construction practice is the replacement of peat soil by suitable fill material, but if the depth is more, it may not be economical. Out of several alternatives, one of the promising methods of construction on the organic soil is to stabilize the soil itself by suitable stabilizer.

The alteration of soil properties to meet specific engineering requirements is known as soil stabilization. Properties of soil may be altered in many ways, among which are included chemical, thermal, mechanical and other means.The chief properties of a soil with which the construction engineer is concerned are volume stability, strength, permeability and durability.

In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost effective method for soil improvement. Here, in this project, soil stabilization has been done with the help of randomly distributed basalt fiber obtained from crushed basaltic rocks.

Basalt fiber is a relative newcomer to fiber reinforced polymers (FRPs) and structural composites. The continuous basalt fiber (CBF) is a kind of high performance non-metal inorganic fiber, which is made from the natural volcanic rock. It has a similar chemical composition as glass fiber but has better strength characteristics, and unlike most glass fibers is highly resistant to alkaline, acidic and salt attack making it a good candidate for concrete, bridge and shoreline structures.

II. Literature Review

Several studies were conducted to determine the effect of fiber on geotechnical properties of soil. The results have shown that on fiber inclusion unconfined compressive strength increases with increase in fiber content.Unconfined compressive strength depends on both fiber content, fiber length and prolonged curing time. According to **Rekha Devi et al.(2016)** improvement in MDD and UCS with increase in fiber content is due to interfacial friction between fiber and soil. According to **Lei Geo et al.(2015)** increase in UCC strength is influenced by the interfacial force in the form of fiber soil column and fiber soil net. **Suchit Kumar Patel(2014)** has shown that specimens with higher fiber content, the fibers can confine the soil particles and increase the global stability of the soil mass. He also showed that fiber reinforcement has changed the brittle nature of soil to ductile, and the ductility is found to improve with fiber content. **M Jamei et al.(2013)** has shown that micro-reinforcement reduces surface settlement, increases the stiffness of soil and risk of cracking as a result of an increase in tensile strength.According to **Erdem O Tastan et al.(2011)** the UCS of organic soils can be increased using fly ash, but the amount of increase depends on type of soil and characteristics of fly ash. The reactivity effect appears to diminish as the water content decreases.The study conducted by **Tamas Deak et al.(2009)** showed that the basalt fibers were competitive with glass fiber.

III. Materials Used

A Soil

The organic soil sample for the present study is collected from Mangalam Dam, Palakkad district.The soil sample is collected within 1.5m of the ground surface. Index properties of the soil is determined and is shown in Table 1 .The classification of soil is done as per Indian standards and the soil sample comes under the category of organic soil of high plasticity (OH) . Fig. 1 shows the collected soil sample.

B Basalt Fiber

The fiber required for the study is collected from Indiamart suppliers, Mumbai. The collected fiber is shown in figure 2. Before being dispersed into the soil specimen, the strip basalt fiber is torn and then evenly incorporated into the soil. The basalt fiber is filamentous and its basic physical and mechanical parameters are shown in Table 2.

Fig. 1 Collected organic soil sample

Table 1. Geotechnical properties of soil

Sl. No.	Geotechnical Properties of Soil	
	Soil Property	***Values***
1	Initial water content (%)	56
2	Specific gravity	1.9
3	Percentage of gravel (%)	4
4	Percentage of sand (%)	16
5	Percentage of silt (%)	61
6	Percentage of clay (%)	19
7	Liquid Limit (%)	65
8	Plastic Limit (%)	50
9	Shrinkage Limit (%)	41
10	Maximum dry density (kN/m^3)	10
11	Optimum moisture content (%)	52
12	IS classification	OH
13	Unconfined Compressive strength (kN/m^2)	28
14	Organic content (%)	24

Table 2 Properties of basalt fiber

Sl . No.	***Properties***	***Values***
1	Density (g/cm^3)	2.65
2	Elastic Modulus (GPa)	85.9
3	Tensile strength (MPa)	2611
4	Length (mm)	30
5	Filament diameter(μm)	0.16

Fig. 2 Basalt fiber

IV. Methodology

The soil properties (specific gravity, liquid limit, plastic limit, IS classification, swell index and organic content) of the particular soil selected for this study were determined in the laboratory according to the relevant I.S. code (IS 2720). Soil reinforced with basalt fiber had been taken as the prime sample material, in order to predict the effect of fiber inclusion into the soil. Compaction test and Unconfined Compression test were carried out on the prepared soil specimen.

The varying lengths of the fiber used were 10mm,20mm,30mm.Fiber of three different percentages, i.e. 0.05%,0.1% & 0.15% by weight of raw soil, were added to the soil and mixed randomly to obtain uniform mixture of reinforced soil. All the samples for UCS test were prepared at corresponding maximum dry density and optimum moisture content obtained from compaction test.

V. Results And Discussions

A Compaction characteristics

The optimum moisture content and maximum dry density have an important role in changing the strength properties of soil. The variation in optimum moisture content and maximum dry density for 0.05%, 0.10% and 0.15% are shown in fig. 3 & fig. 4. The result obtained for optimum moisture content and maximum dry density for 0.05%, 0.10% and 0.15% are shown in Table 3. The optimum moisture content and maximum dry density of the soil was found to be 52% and $10.0kN/m^2$ respectively. With the addition of basalt fiber in different aspect ratios, the optimum moisture content decreases and maximum dry density is found to increase. The increase in MDD is because of the high specific gravity of the fiber. The reduction in OMC with increase in fiber content suggests that the water absorption capacity of the fiber is low. The maximum MDD value 14.6 kN/m^3 is shown by the specimen with 0.15% fiber content of 30mm length at an OMC of 26%.

Table 3 Variation in compaction characteristics

Length of fiber(mm)	Fiber content(%)	Organic soil	
		OMC (%)	MDD (kN/m^3)
10	0.05	42	13
	0.1	31	13.6
	0.15	29	13.6
20	0.05	31	13.5
	0.1	29	13.7
	0.15	27	14.3
30	0.05	29	13.7
	0.1	27	13.9
	0.15	26	14.6

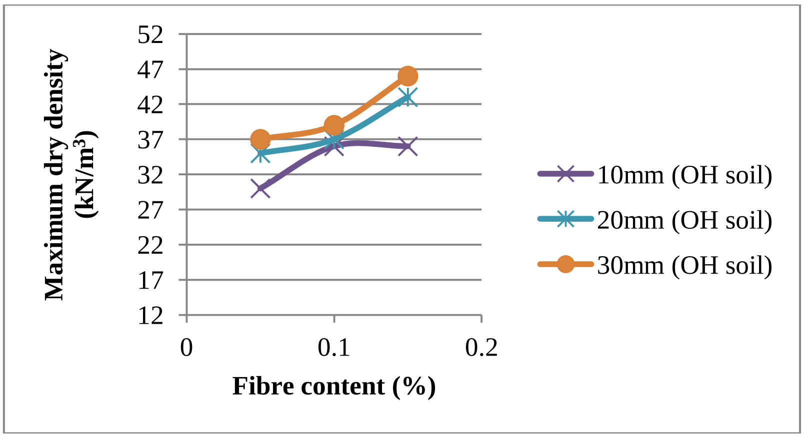

Fig. 3: Variation in MDD characteristics

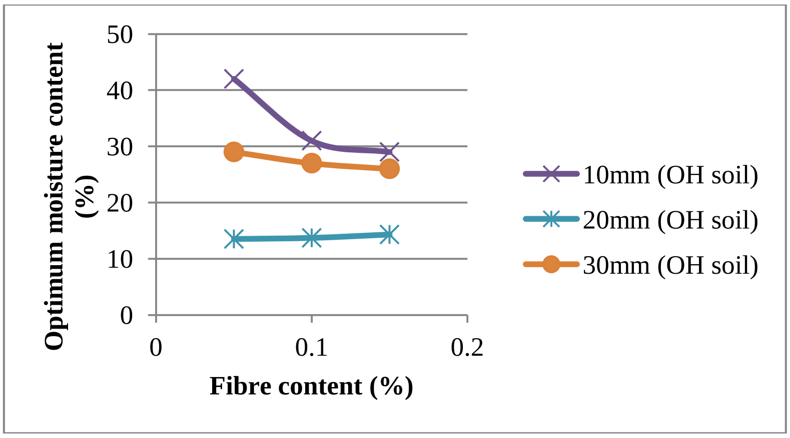

Fig. 4: Variation in OMC characteristics

B Unconfined compressive strength characteristics

The Unconfined compression (UCS) test is one of the most commonly used methods for the evaluation of shear strength of soils. The results obtained are shown in Table 4. The variations in UCS is shown in fig. 5 .The UCS strength of the soil seems to increase with the addition of basalt fiber. About the mechanism of basalt fiber reinforced clay soil, the strength of clay soil is influenced through the interfacial force in the form of fiber-soil column. The content of fiber will decide whether to form an effective fiber-soil net inside the soil. The electrostatic interaction between the fiber filaments cannot be ignored when the content of fiber is large. The length of fiber will affect the total stress and distribution pattern of fiber-soil net and thus affect the overall strength of soil samples. The maximum percentage increase in strength was attained by specimen with 0.05% fibre content of length 10mm after 28 days of curing. The strength increased by 650% with respect to unreinforced inorganic soil with a strength of 210 kN/m^2.

Table 4 Unconfined compressive strength characteristics based on curing

FIBER LENGTH (mm)	FIBER CONTENT (%)	ORGANIC SOIL			
		q_u(kN/m^2) with 0day curing	q_u(kN/m^2) after 7day curing	q_u(kN/m^2) after 14days curing	q_u(kN/m^2) after 28 days curing
10	0.05%	31	65	112	204
	0.10%	71	85	94	147
	0.15%	100	117	131	139
20	0.05%	45	76	113	117
	0.10%	112	122	146	149
	0.15%	147	153	164	167
30	0.05%	57	123	127	131
	0.10%	136	142	156	172
	0.15%	168	172	178	185

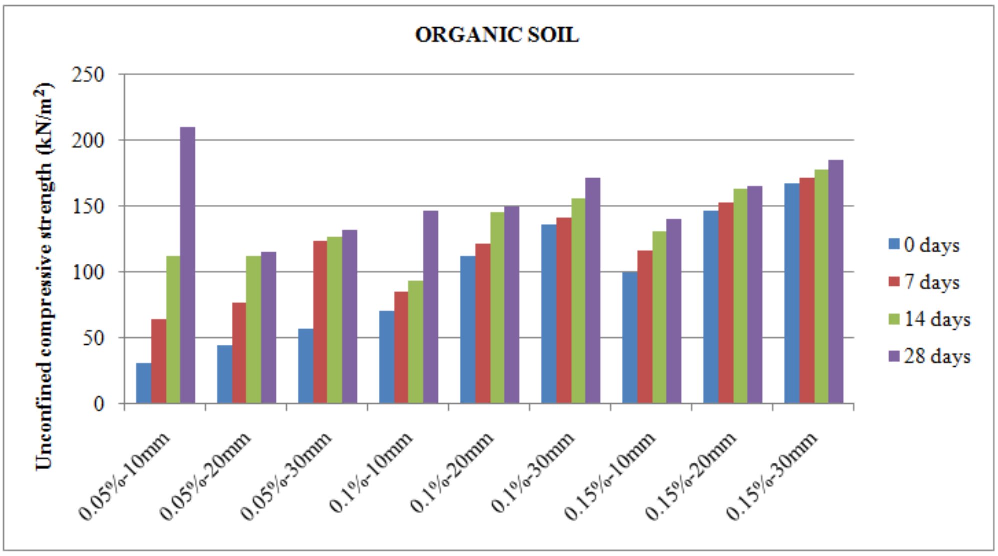

Fig. 5 Unconfined compressive strength characteristics based on curing

VI. Conclusion

Fiber reinforced soil behaves as a composite material in which fibers of relatively high tensile strength are embedded in a matrix of soil. Shear stresses in the soil mobilize tensile resistance in the fibers, which in turn imparts greater strength to the soil. In this way, laboratory test results have led to encouraging conclusions proving the potential use of fibers for the reinforcement of soil mass. The following conclusions were made based on the test results:

- The maximum MDD value 14.6 kN/m^3 is shown by the specimen with 0.15% fiber content of 30mm length at an OMC of 26%.
- The maximum percentage increase in strength was attained by specimen with 0.05% fibre content of length 10mm after 28 days of curing. The strength increased by 650% with respect to unreinforced inorganic soil with a strength of 210 kN/m^2.

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