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Research article

REINFORCEMENT OF A LATERITIC SOIL USING OIL PALM FRUIT FIBRE.

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ABSTRACT.

Soil reinforcement is used to improve most of the soil mechanical properties. Oil palm fruit fibre is one of the widely used natural fibres for soil reinforcement. This study presents the effect of oil palm fruit fibres on the behaviour of a lateritic soil. Results show that the characteristics of the reinforced soil may not necessarily be improved by the randomly distributed reinforcement, but would significantly affect and alter the characteristics of the soil.

Keywords: Soil reinforcement, Oil palm fruit fibres, Mechanical properties, Lateritic soil, Swell, Cracks.

INTRODUCTION.

Laterites are generally used as fills for embankments in Nigeria taking into consideration its various geotechnical characteristics. However, clayey laterites may swell in the presence of water when saturated and shrink when dry. The shrinkage may lead to extensive cracks which may decrease the mechanical properties of the soil (Selah 1995). Compaction, chemical soil stabilization, soil replacement and soil reinforcement are some of the ways to tackle these problems, but in some special cases, the undesired disadvantages would be accompanied by awful disasters (Tabatabaee 1985).

Hudyma and Burcin (2006) have shown that mixing soil with sand can reduce or completely remove swelling potential of clayey soils; while the optimization of cement-lime chemical additives can stabilize soils as given by El Ravi and Al-Sanadi (1995). Stabilization of clayey soils with high calcium fly ash and cement is given by Kolias et al 2005, while mechanism of stabilization of Na-Montmorillonite clay with cement Kiln dust is given by Peethamparan et al (2009).

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Recent studies have shown the effect of reinforcement on swelling behaviour of clays (Puppala and Musenda 2000); reduction of soil swell potential with fibre reinforcement (Loher et al 2000); and effect of fibres on swelling characteristics of bentonite (Banu et al 2009).

Natural fibres have been used to reduce shrinkage cracks in clayey soils without the least environmental nuisances and at almost low performance costs (Sivakumar et al 2008). They are obtained from the waste of palm fruits and have acceptable mechanical properties and durability in natural conditions (Marandi et al 2008; Zare 2006).

This paper therefore presents the effects of palm fruit fibres in randomly distributed reinforcement of clayey soils. Swelling values of uniaxial reinforced and unreinforced cylindrical samples (fig 1.) were measured and cracking characteristics studied, together with unconfined compressive tests.

Figure 1a: Applied palm fibres

Figure 1b: cylindrical samples showing inscribed percentage fibre contents.

MATERIALS USED.

The soils properties and the particle size distribution of the lateritic soil are given in table 1 and fig 2 respectively.

Reinforcing fibres of about 30mm length and specific gravity of 0.91 were obtained from palm fruits; with ultimate density strength of 63Mpa, elastic modulus of 600Mpa and average diameter of about 30mm (fig 2). Laterite samples were tested for compaction, swelling, shrinkage and uniaxial tests with fibre contents of 0%, 0.25%, 0.5%, 0.75% and 1%.

Table 1: Soil Properties of the Lateritic Soil.

S/No	Description	Values
1	Moisture content	23.9
2	Liquid limit	37.6
3	Plastic limit	20.4
4	Plasticity index	17.2
5	Liquidity index	0.20
6	Specific gravity	2.65
7	Unified soil classification	CI

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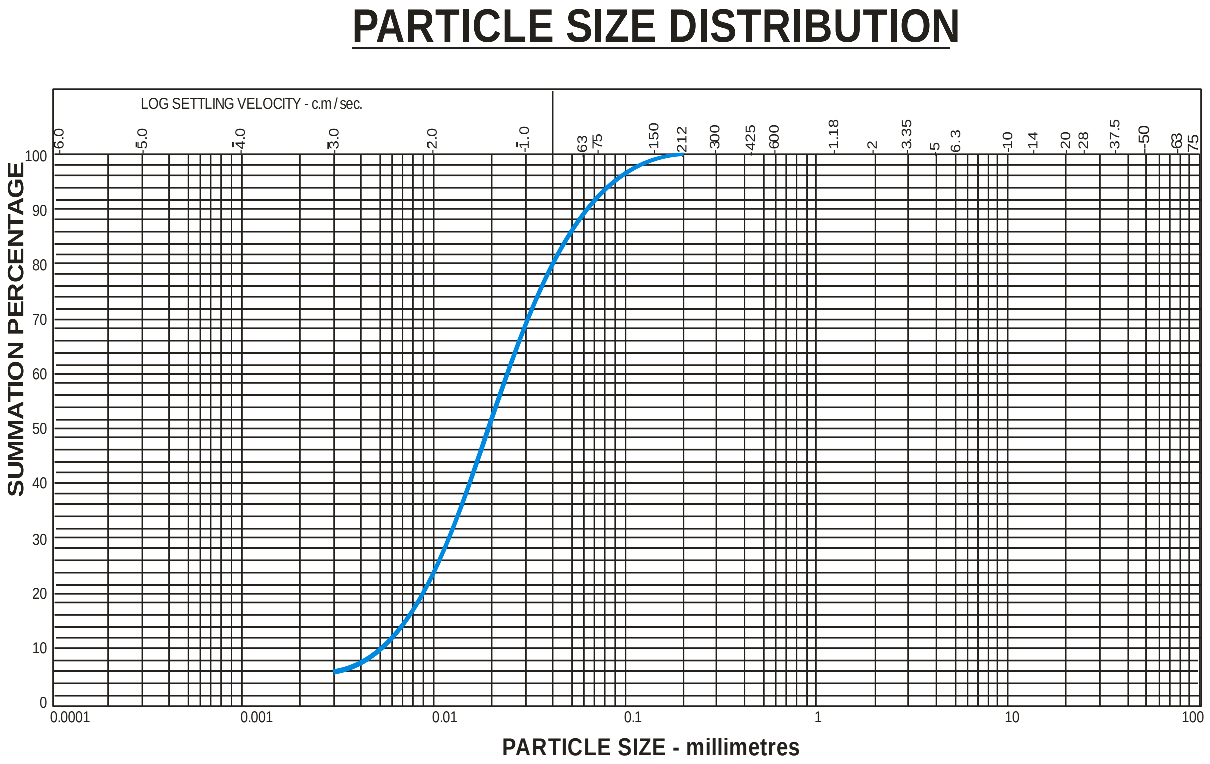

Figure 2: Particle Size Distribution of the Laterite.

TESTING PROCEDURE.

Laterite samples with respective fibre contents were allowed to swell in water for a period of 72hours; and then the volume changes were measured and tabulated in table 2.

Table 2: Swelling Tests Results.

S/No	**Fibre content %**	**Initial height of samples (mm)**	**Final height of samples (after swelling) (mm)**	**Volume change (%)**
1	0	50.5	55.4	9.7
2	0.25	50.0	55.5	11.0
3	0.50	50.5	56.5	11.9
4	0.75	50.3	58.0	15.3
5	1.0	50.0	59.3	18.6

Thereafter, the samples were air dried in the laboratory for a week, then the type and number of cracks were recorded together with their dimensions. Characteristics of the shrinkage cracks are presented in table 3.

Table 3: Characteristics of Shrinkage Cracks.

S/No	**Fibre content (%)**	**Crack type**	**Number of Cracks**	**Length of Cracks (min)**	**Width of Cracks (min)**
1	0	Randomly distributed	2	22-25	0.3-10.5
2	0.25	Randomly distributed	4	15-27	0.3-0.8
3	0.5	Unidirectional	6	19-23	0.5-1.0
4	0.75	Unidirectional	10	12-28	0.5-1.5
5	1.0	Unidirectional	25	10-26	1.0-2.0

After studying the characteristics of the shrinkage cracks, unconfined compressive tests were performed on the cracked samples in order to find out the differences in the strength behaviour of the reinforced and unreinforced samples. Table 4 shows the values of unconfined compressive strengths, ultimate strains and modulus of elasticity obtained from the tests.

Table 4: Unconfined Compressive Test Results.

S/No	Fibre content (%)	Compressive strength kN/m^2	Ultimate Strain	Modulus of Elasticity MN/m^2
1	0	68.5	0.080	0.819
2	0.25	82.9	0.085	0.975
3	0.50	89.6	0.087	1.030
4	0.75	99.8	0.089	1.121
5	1.00	135.7	0.108	1.256

DISCUSSION OF RESULTS.

The aim of reinforcing clayey soils is to improve its mechanical properties; which is achievable depending on the type of reinforcement.

In this study, palm fruit fibres have been used to reinforce a lateritic soil. As shown in table 2, the volume change is directly proportional to the fibre content. This may be attributed to the fact that the fibres can absorb water and drain it vertically downwards like a conducting pipe as demonstrated in fig 3. Thus, the fibre would increase the soil permeability significantly.

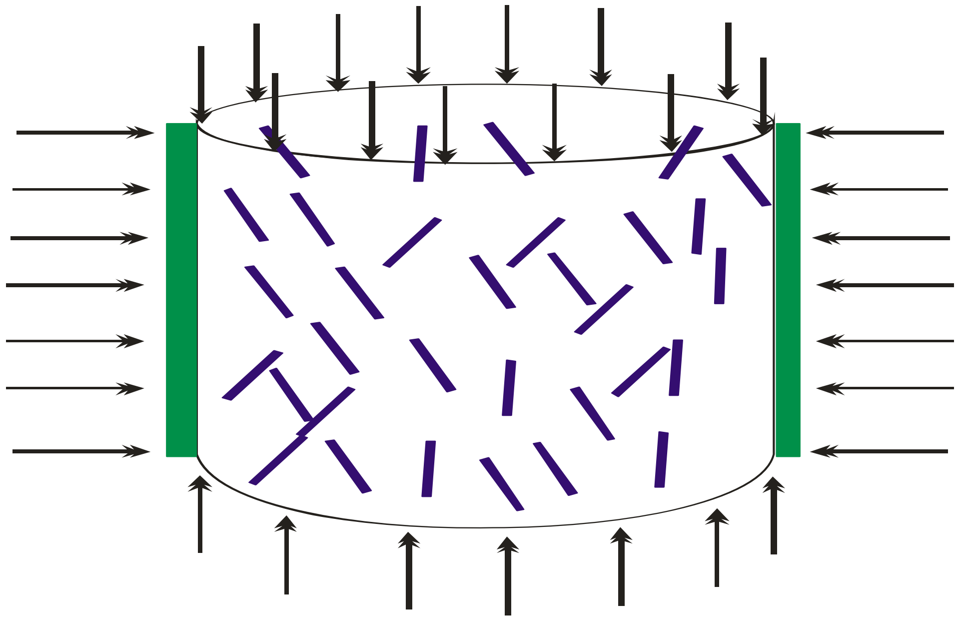

Figure 3: Sketch demonstrating fibres working as conducting pipes inside a reinforced soil sample.

There is no doubt that absorption of water by soil and fibre caused the volume change to be higher with increase in fibre content. However, subsequent drying of the reinforced soil would cause the fibres and soil particles to get dry together to form a bond to withstand production of severe structural cracking (table 3).

Table 4 and fig 3 show that the unconfined compressive strength, modulus of elasticity and ultimate strain are directly proportional to the fibre content, even after shrinkage cracking. This means that the palm fruit fibre has surely improved the mechanical characteristics of the reinforced soils.

CONCLUSION.

The fibre reinforced lateritic soils were soaked in water and allowed to swell; and thereafter, air dried in the laboratory. Cracking was observed and unconfined compressive strength measured.

The study shows that the palm fibre reinforcement worsens the swelling characteristics of the lateritic soil as the volume change is seen to be directly proportional to the fibre content, because of the alteration in soil permeability.

However, on drying, the benefits of the palm fruit fibre is clearly seen in the result of the unconfined compressive tests; as the increase in compressive strength, the elasticity modulus and the ultimate strain are all seen to be directly proportional to the increase in fibre content.

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