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Evaluation of Permeability Characteristics of Terrasil Stabilized Lateritic Soil

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Abstract:
This paper evaluated the permeability characteristics of lateritic soil samples chemically stabilized with Terrasil. In this study, two samples labeled A and B were collected from two different borehole locations from a site. The effects of Terrasil on the engineering properties of the samples were investigated by conducting a number of laboratory tests before and after mixing with 2%, 4%, 6%, 8% and 10 % of Terrasil. The Samples were classified as A-6(4) and A-7-6(7) soils, sample A and B respectively. For Sample A, there is decrease in permeability from 0.000517cm/sec to 0.000416cm/sec, at 10% of the additive. Sample B also improved by decreasing in permeability, from 0.000412 cm/sec to 0.000348 cm/sec at 10% of the additive. From the results, the Terrasil stabilizer can be used for stabilization of some unsuitable materials that are widely available for major road construction works to check capillary rise from soil and prevent dampness and to check failure of pavement due to ingress of water.

Keywords: *Lateritic soil, permeability, stabilization, Terrasil*

1. Introduction

Numerous researchers have worked on improving the engineering properties of soils, especially for road construction purposes using Nano-chemicals. The following literature review describes the important research results regarding the feasibility for the use of such Nano-chemical as Terrasil. Priya and Rajha (2018) in a study titled "Effect of Nanochemicals on WBM Subbase of Flexible Pavements" found that, the permeability test results for WBM (Water –Bound Macadam) mix showed improved coefficient of permeability values by 26% .The coefficient of permeability (k) was found to be 6.74 x 10-4 cm/sec and 4.98 x 10-4 cm/sec for Basic and Treated mixes which is the average value of three trials conducted.

Also, Pavankumar *et al (2016)* in their work titled " Application of Geo-Textile and Terrasil Chemical to Reduce Permeability of Soil ", analysed permeability characteristics of poor lateritic soil by the chemical stabilization using Terrasil ; and stabilization using geo-textiles. Models were prepared and various tests with geo-textiles, terrasil chemical were carried out for permeability of soil. With Terrasil, permeability reduced from 1.6 x 10-4 cm/sec to 0.24 x 10-4 cm/sec. Whereas, geo-textiles reduced the permeability from 1.6 x 10^{-4} cm/sec to 0.39 x 10^{-4}cm/sec. These results led them to conclude that Terrasil method reduces 47.1% of cost with lower permeability as compared to geo-textile three-layer test.

2. Material and Methods

2.1. The Study Area

The study area lies in latitudes $7^{\circ}\ 18'\ 03''$ N to $7^{\circ}\ 18'\ 06''$ N and Longitudes $5^{\circ}\ 08'\ 02''$ E to $5^{\circ}\ 08'\ 05''$ E. Two samples, A and B of lateritic soils were collected within this location from a site proposed for the construction of an indoor sports hall at the Obanla campus of the Federal University of Technology, Akure, Nigeria. Figure 1 shows the study area.

Figure 1: A Street Map of the Federal University of Technology, Akure, Showing Sample Locations
Source: Google Maps

2.2. Material

Terrasil is a commercially available chemical stabilizer in concentrated liquid form. It is mixed with water in maximum of 1ml of Terrasil to 200ml of water proportions so as not to weaken the potency of the additive before adding it to the soil specimen. Figure 2 shows Terrasil in bottles.

Figure 2: Commercially Available Terrasil Nano-Chemical in Bottles

lateritic soil sample were collected at depths of 0.7m-1.0m from 2 different pits: A and B. Preliminary tests; classification and strength tests were conducted on each sample so as to assess their geotechnical index and engineering properties. These tests served as the control tests whose results were used to compare the subsequent tests on the Terrasil-treated soil specimen. In preparing the soil for treatment with Terrasil, Terrasil was first mixed with water to form a Terrasil: water solution in a 1:100 ratio before adding to the soil The solution was added in varied amounts to each of the two lateritic soil samples : A and B weighing 3000g each. The percentage of the additive by dry mass of the lateritic soil samples used were 2%, 4%, 6%, 8%, and 10% at 2% intervals. The mixture was then air-dried for 3 days so as to allow a complete reaction of Terassil with the soil, after which tests strength tests were conducted.

2.3. Permeability Test

2.3.1. Theory

Due to the existence of the inter-connected voids, soils are permeable. The permeable soils will allow water flow from points of high energy to points of low energy. Permeability is the measure of the soil's ability to permit water to flow through its pores or voids. The coefficient of permeability *k,* is a measure of soil permeability. It is determined in the lab using two methods: Constant-Head Test and Falling-Head Test.
The falling head test was used in this study and k was determined using the equation:
Coefficient of permeability, $k = \frac{2.303aL}{At} \text{Log}_{10}\left(\frac{h_1}{h_2}\right)$
Where,
A= cross sectional area of the soil specimen
a= cross sectional area of the stand pipe
L= Length of specimen
h_1= initial head at t=t_0

*h*2= initial head at t=t_1

2.3.2. Apparatus

Stop watch, Filter paper, Weighing balance, Permeameter mold, Drainage base with porous disk, Drainage cap with porous disk, Compaction equipment, graduated glass stand pipe, supporting frame for stand pipe and clamp,

2.3.3. Procedure

2500g of air-dried lateritic soil samples was compacted at OMC(Optimum Moisture content) in 3 layers in a permeameter mould by dropping a 2.6kg rammer through a height of 310mm 25 times(blows). The mold was then attached with drainage base and cap with porous disks, connected to the stand pipe. The stop cocks were opened to allow water flow into the specimen until it got saturated after which head difference was determined and time elapsed as flow progressed from h_1 to h_2, was measured using stop watch.

3. Results and Discussion

3.1. Permeability of the Untreated Lateritic Soil Samples

The Falling Head Permeability test was carried out on the untreated lateritic soil specimen and the coefficient of permeability(*k*), determined from the experimental data, reveals that, sample A has a permeability of 0.000517cm/sec. It is therefore more permeable than sample B, which has a coefficient of permeability of 0.000412cm/sec. These results are tabulated in Table 1

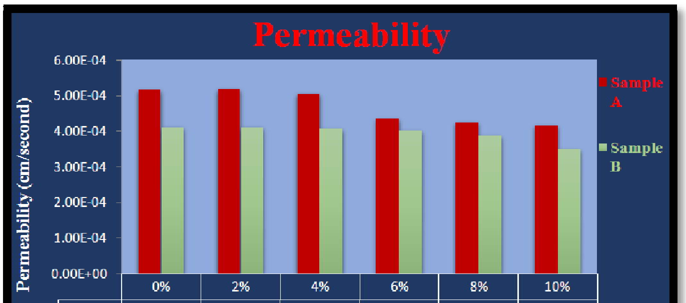
Parameters		*Sample A*				*Sample B*		
Determination No.	1	2	3	4	1	2	3	4
Initial head at t=t_0 ,h_1(cm)	80	80	80	80	80	80	80	80
Final head at t=t_n, h_2 (cm)	70	70	70	70	70	70	70	70
Head Difference,h1-h2 (cm)	10	10	10	10	10	10	10	10
Cross-sectional area of Stand pipe, a(cm2)	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Cross-sectional Area of Soil Specimen(cm2)	81.72	81.72	81.72	81.72	81.72	81.72	81.72	81.72
Length of Soil specimen in mould (cm)	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2
Time, t (seconds)	24.15	29.09	35.44	41.61	32.82	37.96	42.08	45.94
Coefficient of Permeability (cm/seconds)	6.67E-04	5.54E-04	4.55E-04	3.87E-04	4.91E-04	4.24E-04	3.83E-04	3.51E-04
Average Coefficient of Permeability, k		5.16E-04				4.20E-04		

Table 1: Permeability Characteristics of Untreated Soil Samples

Permeability test conducted on treated sample 'A' showed a decrease in the coefficient of permeability from 0.000517cm/sec to 0.000416cm/sec. at 10% of the additive. Treated soil sample B also improved by decreasing in permeability, from 0.000412 cm/sec to 0.000348 cm/sec. Table 2 summarizes the results of permeability test on the treated soil samples. These permeability results agree with those of earlier research on soil stabilization with Terrasil, that the nano-chemical additive (Terrasil) reduces the permeability of soil. Permeability of the treated soils decreased steadily with increase in the percentage of Terrasil in them, reaching the minimum values at the maximum percentage of the additive-10% .This variation of coefficient of permeability with percentage of Terrasil in the soil samples is shown in Figure 3

Soil Treated with Terrasil		**Permeability(cm/second)**	
Lateritic Soil (%)	Terrasil (%)	Sample A	Sample B
100	0	0.000516	0.000412
98	2	0.000518	0.000410
96	4	0.000505	0.000405
94	6	0.000435	0.000401
92	8	0.000425	0.000386
90	10	0.000416	0.000348

Table 2: Permeability Characteristics of Lateritic Soil Treated with Terrasil



	0%	2%	4%	6%	8%	10%
Sample A	5.16E-04	5.18E-04	5.05E-04	4.35E-04	4.25E-04	4.16E-04
Sample B	4.12E-04	4.10E-04	4.05E-04	4.01E-04	3.86E-04	3.48E-04

Figure 3: Variation of Permeability with Percentage of Terrasil in Samples a and b

4. Conclusion

On stabilization, the Plasticity Indices of both samples decreased with increase in amounts of Terrasil. Sample 'A' decreased in Plasticity Index (PI) from its natural 16.18% to 12.17% at 6% of the additive and decreased in permeability from 0.000517cm/sec to 0.000416cm/sec., at 10% of the additive, Sample B also improved by decreasing in permeability, from 0.000412 cm/sec to 0.000348 cm/sec at 10% of the additive. The additive can be used with other traditional soil stabilizers for highway pavement construction to check failure of pavement due to ingress of water.

5. References

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