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Effects of Lime Stabilization on the pH Values of Lateritic Soils in Ado-Ekiti, Nigeria

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Abstract: In Nigeria, the use of stabilizing agents in road construction has been in practice for some thirty years. The city of Ado-Ekiti, the capital of Ekiti State, Nigeria is currently undergoing some road rehabilitation projects and therefore necessitated the investigation of a particular property of lime stabilized lateritic soil-the pH value. In this study, three selected burrow pit lateritic soil materials used for road rehabilitation in Ado-Ekiti and its environments were used and the effects of the lime stabilizer on the pH values were determined in the laboratory. The percentage of lime used on the samples varied from 0 to 10%. From the analysis carried out, it was found that the treatment of the samples with lime content changed the pH of the samples from acidic to alkaline and the value increased with increasing lime content for all the samples. For examples the pH value for sample A changed from 5.8 at 0% lime content to 11.30 at 10% lime content, sample B changed from natural pH value of 6.1 at 0% lime content to 11.4 at 10% and the same for sample C from 5.7 at 0% lime content to 11.4 at 10%. The changes were as a result of the changes in the chemical properties and the composition of the samples due to their chemical reactions with lime additive.

Key words: Lime, stabilization, pH value, lateritic, soil

INTRODUCTION

When a significant quantity of lime is added to a soil, the pH of the soil-lime mixture is elevated to approximately 12.4, the pH of saturated limewater. This is a substantial pH increase compared to the pH of natural soils. The solubilities of silica and alumina are greatly increased at elevated pH levels[1]. In an early study of soil-lime reaction, Eades[2] suggested that the high pH causes silica to be dissolved out of the structure of the clay mineral that makes it available to react with the Ca^{2+} to form calcium silicates. Eades[2] and Dimond *et al.*[3] generally suggest a solution mechanism in which clay lattice components are dissolved from the clay structure and re-precipitated as $CaO.SiO_2.H_2O$ and $CaO.Al_2O_3.H_2O$, direct reaction of the lime at the surface of clay mineral particles has not been ruled out. Another study in the adsorption of lime by kaolinite and montmorillonite, Diamond *et al.*[3] tends to support the idea that surface chemical reactions can occur and new phase may nucleate directly upon the surfaces of clay particles. The pH value of laterite is dependent on the exchangeable cation of the soil. The cation type that can exits in a particular soil depends on the mineralogy of the parent material and the organic proportion present in the soil. Kaolinite, the predominate mineral in Nigerian lateritic soils has low cat-ion exchangeable cation and the pH value does not deviate much from 7. Soils that have high cation exchangeable cations have pH values slightly acidic to neutral between 5-7.

The nature of the reaction was studied by Kezdi[4], who stated that lime addition will increase the pH value of water content in the soil and will give rise to increased solubility.

This study was carried out to determine the effects of lime stabilization on the pH values of lateritic soils taken from a number of road construction burrow pits in Ado-Ekiti town and environs in Nigeria. The results of this study will provide reliable technical information on the subject matter and will also provide useful guidelines for highway engineers in materials selection for road constructions especially in our own tropical environment.

MATERIALS AND METHODS

Three lateritic soil samples named A, B and C were used for this study. The samples are burrow pit materials used on:

(I) The Federal Polytechnic, Ado-Ekiti road rehabilitation project- Sample A

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(ii) Ado-Ekiti-Ilawe road rehabilitation project-Sample B
(iii) Ado-Ekiti-Ikere road rehabilitation project-Sample C

All the samples were chosen as representative samples after tests had been carried out on various samples around Ado-Ekiti environment.

After collection, samples were immediately stored in polythene bags to prevent loss of moisture prior to their use. A sizeable amount of quicklime was obtained which was slaked and used as the stabilizing agent. Deleterious materials such as roots were removed from the samples that were later air-dried, broken down with mortar and pestle and passed through a No. 10 sieve to remove large particles. To compare the relative effects of the additives on the performance of samples, varying proportions of the additives used expressed as percentages of the dry weight of the samples were 0, 2, 6 and 10%. Mixing of samples with additive was done manually at the optimum moisture content of natural samples as obtained from compaction tests.

The soil-lime mixtures were hand mixed after they were weighed prior to the mixing in of water at the required proportions. Moulding of test specimens were started as soon as possible after the completion of mixing and the tests were conducted according to BS 1377 standards. For each percentage of additives, a total of four specimens were used to obtain each point of the moisture-density relations.

Tests were carried out on each of the three samples to determine the mineralogical compositions, clay minerals, pH values and other chemical constituents of the soils. Lime was added in varying proportions of 0, 2, 6 and 10%. The procedures used in carrying out these tests were the BS 1377 standard methods.

RESULTS AND DISCUSSION

The chemical analysis result of the tests performed on the three samples are as presented in Table 1. This is to make all relevant factors available for establishing a correlation between the compositions of the soil being stabilized with lime.

For the three samples, the silica to Iron and Aluminum sesquioxide ratio are shown in Table 1. All the values so obtained are less than 2 indicating that they are mostly lateritic soils. The pH values of the samples indicate that they are acidic (Table 1). The results of the mineralogical composition of all the samples showed that they mainly contain Kaolinite minerals.

The treatment of the samples with lime content changed the pH values of the samples from acidic to alkaline and the value increased with increasing lime content for all the samples (Table 2).

Table 1: Chemical analysis of three different samples

Sample type	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	LOI (%)	U (%)	pH (%)	SiO_2/ (Al_2O_3+Fe_2O_3)
A	45.10	38.00	1.53	12.17	3.20	5.8	1.14
B	51.00	37.15	0.85	8.15	2.85	6.1	1.34
C	54.40	34.10	0.50	10.71	0.29	5.7	1.57

SiO_2-Silica content, Al_2O_3-Alumina content or Aluminum sesquioxide
Fe_2O_3-Iron content or Iron sesquioxide, LOI-Loss on ignition,
U-Undetermined

Table 2: The pH values of the lime stabilized soil samples

Sample type	Type A				Type B				Type C			
Lime content (%)	0	2	6	10	0	2	6	10	0	2	6	10
pH	5.8	10.4	11.1	11.3	6.1	10.8	11.0	11.4	5.7	10.1	11.1	11.4

The pH value for sample A changed from 5.8 at 0% lime content to 11.3 at 10% lime content, that of sample B changed from 6.1 at 0% lime content to 11.4 at 10% lime content and that of sample C changed from 5.7 at 0% lime content to 11.4 at 10% lime content.

These changes were as a result of the changes in the chemical properties and composition of the samples due to their chemical reactions with the lime additive.

The solubilities of Silica and Alumina are greatly increased in the stabilized clay soils to form calcium silicate gel which coats and binds lumps of clay together and occupies the pores in the soil. Reaction proceeds only while water is present and is able to carry calcium and hydroxyl ions to the surfaces of the clay minerals. That is the reason why the pH value of lime treated soil samples is high[5].

Results of the various tests carried out on the samples showed that the addition of lime to natural samples changed the pH values and the chemical compositions of the natural samples. The natural samples have their pH values of 5.8, 6.1 and 5.7 for samples A, B, C, respectively, changed to 11.3, 11.4 and 11.4.

The properties and characteristics of lime treated lateritic soils vary significantly depending on the types of soil, amount of additive, types of additive and curing conditions including time, temperature and moisture.

The results showed that stabilizing lateritic soil with lime improves the soil in the following ways:

(i) The treatment of the samples with lime content changes the pH of the samples from acidic to alkaline and the value increased with increasing lime content for all the samples.
(ii) The solubilities of silica and alumina are greatly increased in the stabilized clay soil with a resultant increase in the strength of the soils.

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