



Geotechnical Properties of Lateritic Soil Treated with Rice Husk Ash from Owo Community Area, Southwestern Nigeria

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Abstract

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Roads in Nigeria do not attain designed life-span due to poor quality of sub - base soils used during road construction. These roads formed death traps after developing potholes. This research was to determine the effects of rice husk ash (RHA) on stabilization of lateritic soil used for road construction. Three soil samples were collected in the study area at 1.5m depth. Soil samples were taken to FUTA for tests after they have been air dried for two weeks. The tests carried out include Atterberg limits, linear shrinkage, specific gravity, compaction, CBR and UCS. Soil samples were stabilized at 2, 4, 6 and 8% RHA by the weight of the soil. Results showed that the: specific gravity of the soil samples ranged between 2.64 and 2.68. The MDD was 1927Kg/m³ at OMC of 13.1% for the stabilized soil. The LS ranged between 5 and 15%, LL between 17.4 and 27.1%, PL between 30.3 and 53.0% and CBR between 3 and 34%. Soil samples tested have poor geotechnical properties and needed to be stabilized. The RHA stabilizer improves the engineering properties of the soil at 4% by weight of the soil. Therefore, RHA is suitable and effective stabilizer of lateritic soils.

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INTRODUCTION

Soils are naturally occurring materials that are used for construction purposes and they are subject to classification tests to provide a general concept of their engineering characteristics. The life span of any engineering structure depends on the bearing capacity of the sub base or sub grade soil. For that reason, soil is a critical element influencing the success of a construction process. Road pavement failure can be trace to geotechnical factors Gidigas, 1976, Meshida, 1985. Stabilization is the process of binding and mixing materials with a soil to improve its properties.

The necessity for improving the engineering properties of a soil has been recognized since the inception of

engineering construction. More recently soil stabilization has become a popular trend for global demand which raw materials are industrial wastes. Soil stabilization helps to improve the strength and durability of the soil. There are many techniques for soil stabilization which includes: compaction, dewatering and addition of materials to the soil. These processes enhance the physical properties thereby increasing the shear strengths as well as reducing the shrinkage properties of the soil, thus increasing the load bearing capacity of the sub-grade. Stabilizing lateritic soil with rice husk ash really help in the improvement of the properties of a subgrade to reduce the thickness requirement for overlying material by improving substantially the tensile strength and also layer stiffness to reduce wearing at the surface. Due to the significant

settlement cause by loading on poor soils, specific techniques have been used to improve the soil properties by stabilizing it by the use of pozolan. So far, different element such as fiber glass, zinc coating steels, polymers such as geo-textiles and fiber cut from polyethylene like plastic strips have been used to reinforce the soil to improve the soil geotechnical properties onsite to enable it to carry load and to increase the shear strength and decrease the compressibility of the soil (Ogunribido, 2012a, 2012b, Alhassan, 2008, Pam et al., 2011, Amu et al., 2011)

LOCATION AND THE GEOLOGY OF THE STUDY AREA

The study area is located in Owo area of Ondo State and it lies between Latitudes 7° 10' and 7° 15' North of Equator and Longitudes 5° 33' and 5° 37' East of Greenwich Meridian (Figure 1). The topography of the study area is gently undulating with isolated hills with peak of about 200 meters. The drainage pattern of the study area is dendritic and major rivers in the study area are: Lala, and Ose and most of the streams are seasonal. The climate of the study area is hot, humid and tropical. The wet season starts in April and ends in October while the dry season starts in November and end in March. The area is covered by thick evergreen forest with the exception of some places, where settlement and farming have resulted into deforestation.

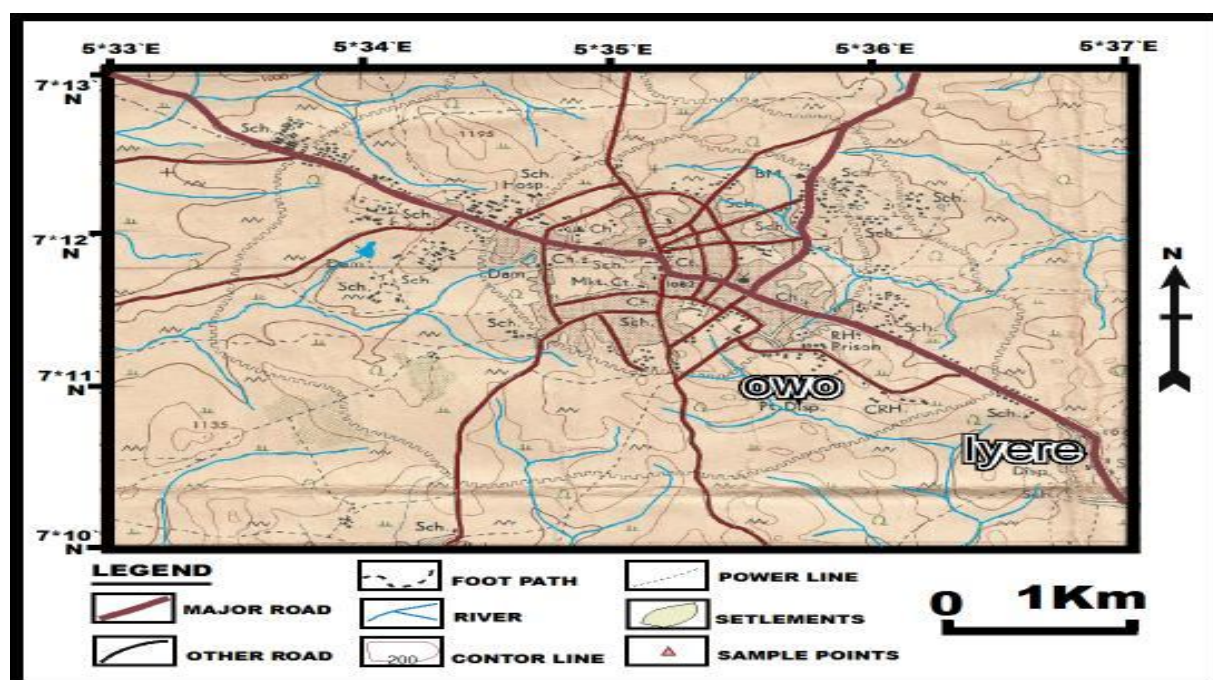


Figure 1: Topographical map of the study Area, Owo area of Ondo State, Nigeria

The study area is located in the Pre Cambrian-Basement Complex of Southwestern Nigeria (Oyawoye, 1964, Rahaman, 1976, 1988). The three major types of rocks found in the study area are migmatites, granite gneiss and grey gneiss. Migmatites: is made up of granite gneisses, quartzo-feldspathic gneisses, granites and basic rocks with quartzitic or pegmatitic intrusion cutting across and along the rock in different directions.

Granite gneiss: widely distributed and occurred mostly as hills. The granite gneiss has two components, namely felsic and mafic. The felsic is granitic in composition with aplite, granitic and pegmatitic portions often intruded by quartz veins with varying grain sizes. On the

other hand, the mafic component is the gneissic banding and textural part which is made up dark or grey coloured minerals. Grey gneiss: This is a grey foliated biotite-rich rock consisting of quartz with albite and /or hornblende gneiss of granodioritic to tonalitic composition. The texture of the rock is medium to coarse grained. It has both planar and linear fabric.

MATERIALS AND METHOD

Three soil samples were collected from three different locations in the study area. Sampling was done at depth of 1.5m. Samples collected were placed in a polythene bag to reduce moisture loss and to ensure good

preservation. The soil samples were air dried for two weeks at Engineering Geology Laboratory of Federal University of Technology, Akure before tests were carried out on them in accordance with British Standard Institute (BSI 1990a), American Society for Testing and Material (ASTM, 1979) and stabilization in accordance with British Standard Institute (BSI 1990b). The laboratory test carried out on the soil samples collected include; Natural moisture content, specific gravity, grain

size analysis, Atterberg limits, compaction, California Bearing Ratio (CBR), and unconfined compressive strength.

RESULTS AND DISCUSSION

The result of the tests on index properties and stabilization with rice husk ash carried out on the soil samples A, B and C are shown in Tables 1, 2, 3 and 4 respectively.

Table 1: Summary of index properties of soil in the study Area

Index	Sample A	Sample B	Sample C
Liquid limit %	37.2	53.0	37.7
Plastic limit %	17.9	25.0	17.4
Plastic index %	19.3	28.0	20.3
Specific gravity	2.66	2.64	2.68
UCS Kpa	47.4	44.5	77.6
Natural Moisture content	14.3	15.3	14.7

Table 2: Summary of the stabilization of soil A with Rice Husk ash

Soil Properties	Rice husk ash content % by weight				
	0	2	4	6	8
Linear Shrinkage %	10.7	10.7	8.6	10.0	11.4
Liquid limit %	37.2	36.8	35.6	31.7	30.3
Plastic limit %	17.9	18.1	18.3	18.2	18.8
Plasticity index %	19.3	18.7	17.4	13.5	11.5
Optimum moisture content %	12.3	13.2	12.0	12.7	13.1
Maximum dry density Kg/m ³	1956	1923	1968	1939	1927
Unsoaked CBR %	32	30	34	33	32
Soaked CBR %	20	19	21	21	20

Table 3: Summary of the stabilization of soil B with Rice Husk ash

Soil Properties	Rice husk ash content % by weight				
	0	2	4	6	8
Linear Shrinkage %	12.1	14.3	9.3	10.7	15.0
Liquid limit %	52.0	52.9	53.0	51.8	49.8
Plastic limit %	25.6	25.1	27.5	26.2	27.1
Plasticity index %	26.4	27.8	25.5	25.7	22.7
Optimum moisture content %	13.4	13.6	12.1	13.1	12.2
Maximum dry density Kg/m ³	1915	1906	1964	1927	1960
Unsoaked CBR %	10	7	12	11	10
Soaked CBR %	3	3	5	5	3

Table 4: Summary of the stabilization of soil C with Rice Husk ash

Soil Properties	Rice husk ash content % by weight				
	0	2	4	6	8
Linear Shrinkage %	11.4	12.1	5.0	10.0	12.1
Liquid limit %	36.7	37.4	37.7	35.9	35.1
Plastic limit %	18.7	17.5	17.4	19.2	21.1
Plasticity index %	18.0	20.0	20.3	16.7	14.1
Optimum moisture content %	18.6	18.8	16.8	18.2	17.8
Maximum dry density Kg/m ³	1701	1693	1775	1717	1734
Unsoaked CBR %	28	27	29	26	25
Soaked CBR %	13	13	15	12	11

Natural Moisture Content

From Table 1, the result of the natural moisture content test of the soil samples ranged from 14.3 to 15.3. Moisture variation is governed by season and depth of collection, natural moisture content of soil increases due to wet season and rapid infiltration during this season at depth due to high precipitation. Soil moisture is one of the major determinants of failure in any engineering structures. Excessive moisture in soil has been found to be responsible for collapsing and swelling of soil. It helps to evaluate the usefulness of the subsoil material and influence the design of the pavement (Jegade, 1999)

Specific Gravity

The result of the specific gravity showed that the lowest specific gravity was 2.64 and the highest was 2.68 (Table 1). This may be attributed to heavy minerals from the original parent rock which are granites and gneisses from which the soil was derived as a result of weathering. The mineral composition of the crystalline rock might have contributed to the relatively high specific gravity values (Jegade, 1999). A good lateritic soil should have specific gravity ranging from 2.5 to 2.75. This shows that the soil samples in the study area are good for construction after being stabilized.

Particle Size (Sieve and Hydrometer Method)

The grain size distribution of a soil is good for determining the importance of the soil in engineering construction. The fines range from 10.5% to 16.1%. The presence of sand in a soil fabric may impact strength in the soil particularly when used in construction projects. According to Clause 6201 of Federal Ministry of Works and Housing (Federal Ministry of Works and Housing, 1975) specification requirement for a sample to be used as both subgrade fill and base, the percentage by weight passing the no. 200 sieve (75 μ m) shall be less than but not greater than 35%. However, if the percentage passing sieve No. 200 for lateritic base course is greater than 35%, there will be no need for further tests so such a material should be rejected. The results show that stabilized lateritic soil sample is good for construction.

Atterberg Limits

The liquid limit values for un-stabilized soil samples ranged between 37.2% and 53.0% (Table 2, 3 and 4). From the result obtained it was observed that the sample collected at location B has the highest liquid limit value (53.0%) while the sample obtained at location A has the lowest liquid limit value (37.2%). The results for the stabilized soil samples with RHA show that sample A

has liquid limit which ranged from 37.2% - 30.3%, sample B from 53.0% - 49.8% and sample C from 37.7% - 35.1%. High liquid limit indicates weakness in soil strength (Jegade, 1999). The plastic limit values of the un-stabilized soil samples ranged from 17.4% - 25.0%. Increased amount of rice husk ash from 2 to 8% by weight of soil as stabilizer reduces the LL from 37.2% to 30.3% for sample A and 53.0% to 49.8% for sample B and 37.7% to 35.1% for sample C. However, increase in the plastic limit was consistently large enough to reduce the plasticity index. Hence the resulting PI decreased steadily with higher rice husk ash content from 19.3% to 11.5% for sample A and 27.8% to 22.7% for sample B and 20.3% to 14.1% for sample C. A soil with liquid limit greater than 50% with addition of stabilizer shows high moisture content. The samples contain low moisture due to liquid limit less than 50%, except for sample B

Linear Shrinkage

The results of linear shrinkage limit for stabilized soil samples by RHA ranges from 5.0% - 15%. The linear shrinkage for soils to be used as sub grade should not be greater than 8% (Madebor, 1983, Jegede and Ogunsanwo, 2000, Brink et al., 1982). Since the linear shrinkage were higher than 8% in samples A and B, the soil samples A and B in the study area are likely to swell at high moisture content. Stabilization with rice husk ash indicates the improvement in the linear shrinkage with optimum at 4% of rice husk ash by the weight of the soil

Compaction

The maximum dry density for sample A ranged between 1927 Kg/m³ and 1968 Kg/m³, 1906 Kg/m³ and 1964 Kg/m³ for sample B and between 1693 Kg/m³ and 1775 Kg/m³ for sample C while the optimum moisture content values for sample A was between 12.0% and 13.1%, between 12.1% and 13.6% for sample B and between 16.8% and 18.8% for sample C. Following the soil specification for construction works as stated by the Federal Ministry of Works (Madebor, 1983) and particularly for sub-grade material, the nature and magnitude of compaction on a fine-grained soil has a significant influence on the engineering behaviors of the compacted soil. It was recommended that the sub-grade should be compacted during construction to a relative density of at least 95% of maximum dry density at optimum moisture content. Since the compaction values are all above the recommended value, it follows that the soil will not be suitable for construction. The best are those with high dry density at relatively low moisture content (Gidagasu, 1976).

The results have shown that the stabilizer reduce the maximum dry density and increase the optimum

moisture content. The Federal government of Nigeria specification for road construction must not be greater than 1800kg/m³ and optimum moisture content must not be greater than 50%. Therefore sample C is fairly good for construction.

California Bearing Ratio (CBR)

From Tables 2, 3 and 4, soaked and unsoaked CBR values of soil samples decreased from 34% to 19%, 11% to 3% and 28% to 13% for sample A, B and C. These results show that the values of CBR increases with the addition of rice husk ash as stabilizer (Table 2, 3 and 4). The CBR values increases with the addition of rice husk ash which means that rice husk ash is suitable for stabilizing CBR of soil. The Federal Government of Nigeria's Standard specification for pavement design stipulates that unsoaked CBR value greater than 80% is the acceptable value for road pavement materials. Therefore, none of the samples tested were suitable.

Unconfined Compressive Strength

The unconfined compression strength (Table 2, 3 and 4) for soil samples A, B and C are: 47.4 Kpa, 44.5 Kpa and 77.6 Kpa . The shear strength was obtained from the curve by comparing the result of the shear strength of this soil (DAS 2000). The addition of rice husk ash to the soil, improved the soil properties.

CONCLUSIONS

Soil samples in the study area are of poor quality and cannot be used as sub base or sub grade except they are stabilized. Addition of 2% to 8% by weight of rice husk ash was observed to cause reduction in the maximum dry density and the strengths of the soil samples in the study area. However geotechnical properties of the tested soil samples indicate poor quality but when stabilized with rice husk ash; their properties improve at 4% rice husk ash by the weight of the soil. That indicated that rice husk ash is a good stabilizing agent for lateritic soils.

The major factors responsible for the poor quality of the soils in the study area include low CBR, high plasticity index, high liquid limit, high linear shrinkage, which can give rise to settlement and road failure. Other factor is poor drainage system on the road in the study area

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