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# Renolith Appraisal on Lateritic Soils Along Oshogbo-Iwo Road in Southwest Nigeria

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**Abstract:** Soil stabilization using Renolith has proven to be an economical method of improving the properties of soil. Soil samples were collected from four different locations along Oshogbo-Iwo Road, Osun State in Nigeria. Portland cement and Renolith were used for stabilization. The Atterberg test carried out before stabilization shows that the Liquid Limit of the four (4) samples ranged between 29% and 47.5%, Plastic Limit between 18.81% and 35.98% while the Plasticity Index between 6.99% and 19.27%. Three varied mix proportions i.e., (Cement was kept constant at 5% while the Renolith was varied by 4%, 10% cement constant, Renolith varied by 6% and 15% cement constant, Renolith varied by 8%) of stabilizers were used to treat the samples. This was done by weight of the soil samples, to determine the effectiveness of using Renolith and also to determine the optimum concentration of cement-Renolith for stabilization. The tests carried out on the samples were Natural Moisture content, particle size analysis, hydrometer, Atterberg, California Bearing Ratio (CBR) and compressive strength. After stabilization, the properties of the soil were greatly improved as there was an increase in the CBR value of the samples up to 39.65% from 1.6%. the use of 5% cement and 4% Renolith by weight of soil sample has been recommended as effective to improve the soil to a sub-base material.

**Keywords:** Renolith, Stabilization, Atterberg Limits, Lateritic Soil, California Bearing Ratio

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## 1. Introduction

Engineering properties of soil are of great importance in the design of any civil engineering structure as all structures are founded on or in the soil. In a case where the soil properties are not satisfactory for supporting loads, suitable methods as alternative to enhancing its properties are employed [1]. Soil stabilization is one of such methods. Stabilizing the sub-grade and sub-base with an appropriate chemical stabilizer such as Quicklime, Portland Cement, Fly Ash, Bituminous materials or composites of chemical additives and polymers among others to increase the stiffness and reduces its expansion tendencies [2].

Several materials and methods have been employed to improved soil strength properties such as wood ash, lime, sawdust, waste materials, stone powder, cord reinforcement, waste beverage can among others. [3-10]. To stabilize soft

subgrades, the most rampant approach is by excavating the undesirable soil first. Materials that are stronger, such as crushed rock then will be used to replace it. The cost involved for replacing the materials is quite unaffordable, thus it leads to various researches to find another method in order to counter this problem [12-13]. In order to establish an improved soil material with desired engineering properties, it is important for the soil to go through alteration for one or more properties. Either by adapting the mechanical or chemical method. This process is called soil stabilization [14]. The purpose of soil stabilization not only limited to enhance the load-bearing of the soil capacity [15-16] but also improve the shear strength, filter, drainage system [16], permeability, enhance soil resistance to the weathering process and traffic usage (ASTM, 1992) to meet specific engineering projects requirement [17].

Soil stabilization through mechanical and physical

techniques can be done by decreasing the void rate through compacting [14, 18], the used of fibrous and geomaterials non-biodegradable reinforcement [18] or altering the grain size physically which also involves the particle size composition adjustment of the soil [14]. Through chemical technique, stabilization can be done by using chemical [13, 20], and emulsions since they work as compaction aids, binders, water repellants and as well as modifying the soil behaviour [20]. Reaction between chemical additives and particles of soil can bind the soil grains through strong network, thus produced soil with better quality compare to mechanical and physical techniques, since higher strength, durability and quality of soil can be achieved [14].

For the purpose of assessing the quality of the Renolith as a polymer additive and estimating its quality for stabilization, poor natural lateritic soil along Osogbo-Iwo road was examined. Renolith is an advanced cementitious polymer additive to cement that is soluble white milky viscous liquid. It is nontoxic and eco-friendly polymer which when combined with cement and in-situ soils, uniforms a concrete-like structure with the properties of flexibility, improved strength and enhance permeability properties of pavement. [1, 19]. Renolith appears to better control cracks and water penetration into those cracks to improve road base durability. All types of soils can be used exception organic soils. Granular soils are preferred in terms of easily pulverizing and mixing as a result it is more economically.

## 2. Research Methodology

Soil samples were collected from four different locations along Osogbo-Iwo Road. the additives used for stabilization and modification were Renolith and Portland cement which were purchased from the market and stored properly in the laboratory to prevent early hardening. Parts of the samples were subjected to tests without being treated with stabilizers to serve as control specimens.

The top soil was dug up and the samples were taken from a depth of 1.5 m below the natural ground level. The samples were subjected to laboratory tests such as natural moisture content, particle size analysis, hydrometer analysis, Atterberg limit,

compaction, California Bearing Ratio and Unconfined Compressive Strength. The samples were treated with the stabilizers by varying the percentage by mass of the soil. The variation was done in order to determine the optimum percentage that gives the most effective result. Atterberg limits, compaction, California Bearing Ratio and Unconfined Compressive Strength tests were repeated to determine the effect of the stabilizers (cement and Renolith) on the samples. All these tests were carried out according to [21], methods of tests for soils for Civil Engineering Purposes.

The wet method of grain size distribution test was adopted for this study because the samples contained a significant amount of fines. The portions of each sample passing sieve

No 200 (75  $\mu\text{m}$ ) were subjected to hydrometer analysis. Liquid limit and plastic limit tests were carried out on the portions of each sample passing 425  $\mu\text{m}$  sized sieve. Standard compaction (Proctor) test was carried out to determine the optimum moisture content and maximum dry density of each of the samples. The strength of the soil samples to be used as base material for road is determined using the California Bearing Ratio test.

## 3. Results and Discussions

Presented in Tables 1 to 3 are the results of the tests carried out on the soil samples. Table 1 presents the test results for fine grained samples for natural moisture content, Atterberg, particle size distribution and compaction tests while Tables 2 and 3 present the classification of the soils based on American Association of State Highway and Transport Officials (AASHTO) and Unified Soil Classification System (USCS) classification systems.

It is seen in Table 1 that the average percentage of fine materials that passed through the 75  $\mu\text{m}$  was 36% which is not reliable. Hence, hydrometer test was carried out to further determine the amount of fine materials present. The results of the sieve and hydrometer analyses are as presented in Figures 1 to 4 these show the gradation of the soil particles from fine gravel to fine silt/clay materials. Furthermore, the results show that the soils are generally poor as sub-grade materials as there are presence of too much silt/clay contents as shown by the classification systems adopted. The Atterberg limits consisting of the liquid limit, the plastic limit and the plasticity index is generally high which implies that the four soil samples are inconsistent. Consequently, the moisture contents of the soils gave moderately high values except in sample 3. The maximum dry density of the control soil sample could not be adjudged see table 1. Hence, soil stabilization was done to improve the strength and constituency of the soils

### 3.1. Compaction Test

The compaction tests carried out on the control samples yielded the results of maximum dry density and optimum moisture content values presented in figures 5 to 8. The maximum dry densities for the control samples 1 to 4 are 1800  $\text{Kg/m}^3$ , 1658  $\text{Kg/m}^3$ , 2200  $\text{Kg/m}^3$ , and 1550  $\text{Kg/m}^3$  while the percentage moisture contents are 16.4%, 13.2%, 9.5% and 16% respectively. The comparisons of the compaction test results of the treated samples and the control samples are presented in Figures 9 to 12 for the corresponding percentages of stabilizers used i.e., cement kept constant at 5%, 10% and 15% while Renolith was varied at 4%, 6% and 8%. There were more improvements in the dry densities of the samples when the Renolith was varied at 4% and cement kept constant at 5%, also the moisture contents were drastically reduced compare to the untreated samples. Although the various variations used gave viable results, the 5% cement constant and 4% varied Renolith was considered the best fit.

Table 1. Test Results for fine grained samples.

Samples	Natural Moisture Content	Particle Size Distribution			Atterberg Limits			Compaction	
		Passing No 200 (%)	Silt Content (%)	Clay Content (%)	LL (%)	PL (%)	PI (%)	MDD (kN/m <sup>3</sup> )	OMC (%)
1	8.5	36.00	28.23	20.25	35.0	28.01	6.99	1800	16.4
2	4.0	36.26	32.32	25.63	44.0	24.73	19.27	1658	13.2
3	1.1	36.25	27.44	28.22	29.0	18.81	10.19	2200	9.5
4	4.4	36.00	33.08	19.33	47.5	35.98	11.52	1550	16.5

Table 2. Summary of Atterberg limit and Soil Classification Analysis (AASHTO).

sample	(%) passing sieve 200	LL (%)	PL (%)	PI (%)	Soil Group	Group Index	Rating as Sub-Grade Material
1	36	35	28.01	6.99	A-4	A-4 (0)	Fair
2	36.26	44	24.73	19.27	A-7-6	A-7-6 (2)	Poor
3	36.25	29	18.81	10.19	A-4	A4 (1)	Fair
4	36	47.5	35.98	11.52	A-7-5	A-7-5 (1)	Poor

Table 3. Summary of Atterberg limit and Soil Classification Analysis (USCS).

Samples	% passing NO 200 sieves	% passing No 4 sieves	Coarse fraction	Fraction of gravel	Fraction of sand	Atterberg plot on plasticity chart	Group symbol	Group names
1	36	88.18	64	11.82	52.18	below	ML	Sandy silt
2	36.26	84.3	63.74	15.7	48.04	above	CL	Sandy clay with gravel
3	36.25	92.52	63.75	7.48	56.27	above	CL	Sandy clay
4	36	77.02	64	22.98	1.02	below	ML	Sandy silt with gravel

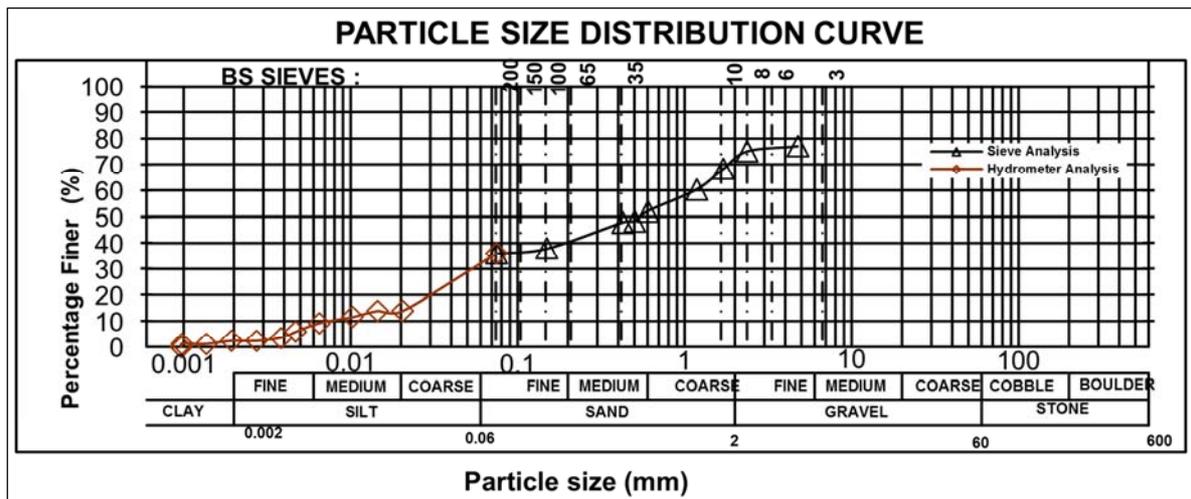


Figure 1. The Combined Sieve and Hydrometer Analysis chart for sample 1.

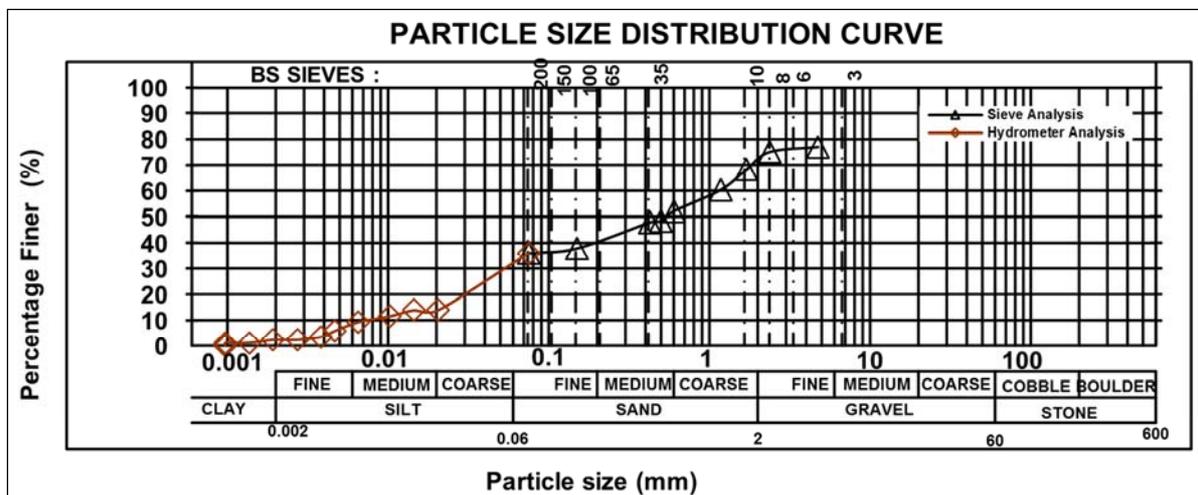


Figure 2. The Combined Sieve and Hydrometer Analysis chart for sample 2.



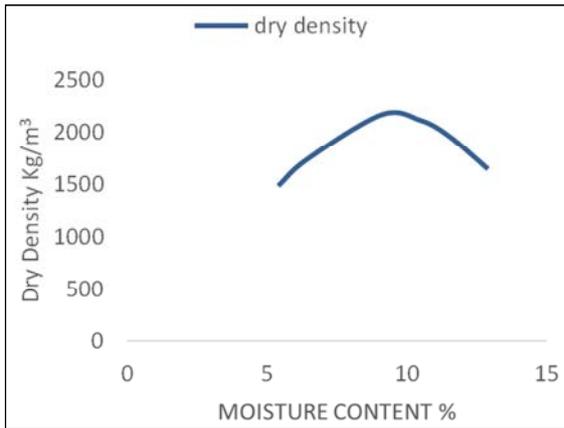


Figure 7. Standard Proctor Compaction for Control Sample 3.

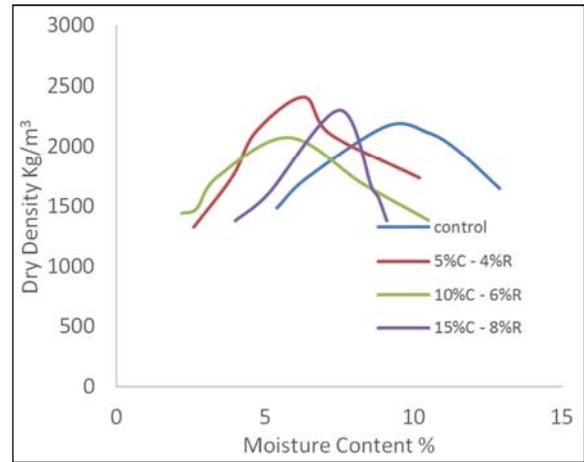


Figure 11. Comparison of MDD for sample 3.

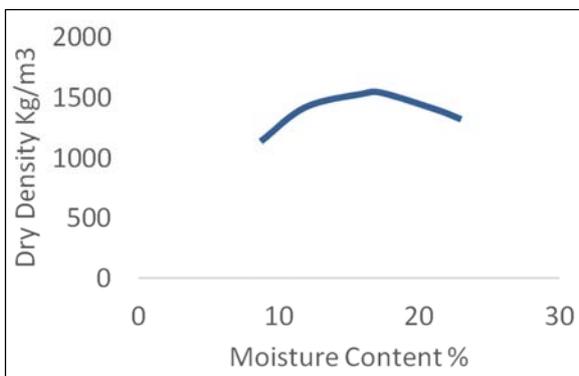


Figure 8. Standard Proctor Compaction for Control Sample 4.

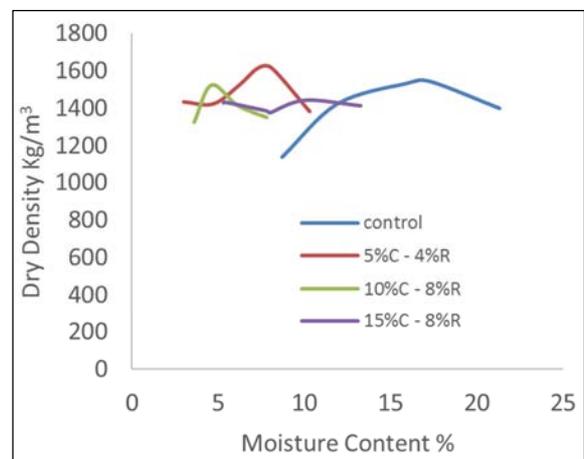


Figure 12. Comparison of MDD for sample 4.

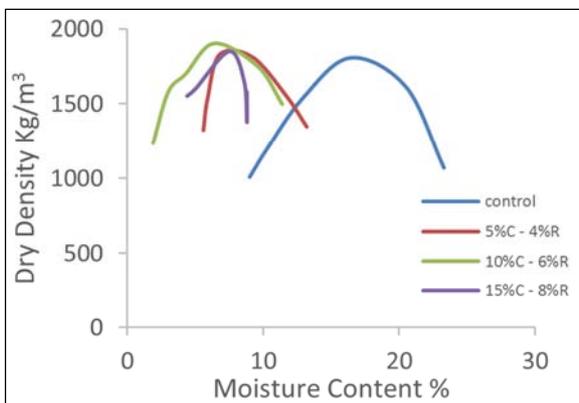


Figure 9. Comparison of MDD for sample 1.

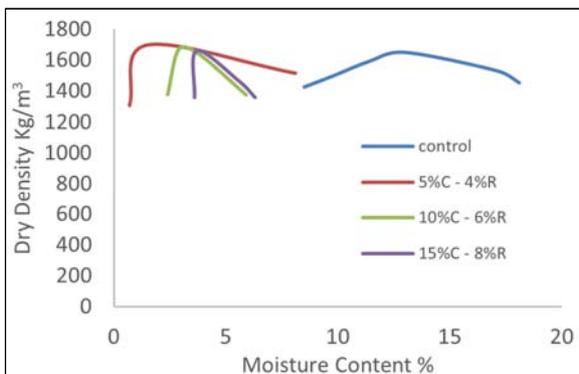


Figure 10. Comparison of MDD for sample 2.

### 3.2. Strength and Durability

Table 4 presents the results obtained from the California Bearing Ratio (CBR) for the control samples and also the treated samples. The results of the control samples are indication that none of them are suitable for sub-grade. When treated with cement-Renolith, dramatic improvement was seen as the results showed well improved percentage differences from the control samples.

Table 4. Percentage values of the CBR of control and treated samples with their percentage difference.

Sample	1	2	3	4
	(%)	(%)	(%)	(%)
<b>Control</b>	<b>1.8</b>	<b>1.6</b>	<b>8.1</b>	<b>8.7</b>
Cement constant at 5% varying Renolith by 4%	14.04	27.65	22	14
Cement constant at 10% varying Renolith by 6%	24	38.4	12	29.17
Cement constant at 15% varying Renolith by 8%	26.3	27.2	22.2	14.4

## 4. Conclusion and Recommendations

Based on CBR analysis, the amount of renolith that gave

the best stabilization for sample 1 was the combination of 10% cement and 6% Renolith with maximum dry density of 1850 kg/m<sup>3</sup> with an optimum moisture content of 6.4% with CBR value of 26.3%. For samples 2,3 and 4, the combination that gave the best results was 5% cement and 4% Renolith which gave maximum dry densities of 1800 kg/m<sup>3</sup>, 2400 kg/m<sup>3</sup> and 1620 kg/m<sup>3</sup> and optimum moisture content value of 8.5%, 6.2% and 6.9% respectively with CBR values of 39.65%, 22% and 30%.

The test results have shown the beneficial effects of Renolith as a modifier to cement stabilized mixtures, improvement to strength and ability to reduce moisture content and capillary rise of water in soil.

The use of 5% cement constant and varying Renolith at 4% by weight of soil is therefore recommended to improve and upgrade the soil to a sub-base material. Further research should be carried out on this work using percentages higher than the ones presented so as to determine the optimum amount of Renolith – cement that will give the best result.

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