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EXPERIMENTAL AND FIELD EVALUATION OF A-6 LATERITIC SOIL STABILIZED WITH RECLAIMED ASPHALT PAVEMENT

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ABSTRACT
Stability and strength are major properties investigated for materials used in road construction. Hence it is important for tests to be conducted on these materials before use. This paper evaluates the compaction characteristics and strength properties of Reclaimed Asphalt pavement mixed with lateritic soil (RAP-soil mixture) obtained from tests conducted in the laboratory and on the field. The tests were carried out on samples prepared by adding 20, 40, 50, 60, 80, 100, 120 and 140% RAP by dry weight of soil to lateritic soil and a clean sample with 0% RAP was also used as the control. The compaction test was carried out in the laboratory using the British Standard Heavy (BSH) compaction type. OMC obtained from the laboratory compaction was found to decrease from 12.3% at 0% RAP content to 6.72% at 120% RAP content. Although it further increase to 7.97% at 140% RAP content. The MDD obtained was found to increase from 2.163g/cm^3 at 0% RAP to 2.252 g/cm^3 at 120% RAP content after which it decreases to 2.231 g/cm^3 at 140% RAP content. The optimum RAP content of 120% obtained was used for the field experimentation and in-situ density obtained was found to be 2.282 g/cm^3 28 days after compaction. The CBR determined from the laboratory is 18.3%, while the value obtained on the field 2 days after compaction was 19.28%. This result yielded a strong correlation of 0.95 to validate the study's findings.

Keywords: *California Bearing Ratio, Compaction, Lateritic Soil, Reclaimed Asphalt Pavement, Stabilization*

1.0 INTRODUCTION

The use of quality and cost-effective materials for road construction with the aim of achieving the required design is of paramount importance to engineers. Stability of soil by adding industrial waste have been investigated by several authors in order to establish to what degree it can be manipulated so as to determine the required strength design. Mechanical stabilization improves soil properties by mixing other soil materials with the target soil to change the gradation and therefore change the engineering properties. It is also done to improve the load bearing capacity of a subgrade to support pavements and foundations. According to Bessa *et al*. (2015), the use of recycling technique in the rehabilitation of old pavement have become an important tool for pavement engineering practice.

Reclaimed Asphalt Pavement (RAP) is defined as pavement materials containing asphalt and aggregates which have been removed and reprocessed. These materials are generated when asphalt pavements are removed for reconstruction, resurfacing, or to obtain access to buried utilities. When properly crushed and screened, RAP consists of high-quality, well-graded aggregates coated by asphalt cement (Jirayut *et al.*, 2014). Pradyumna *et al*., (2013) concluded from their research that Asphalt mixes with 20% RAP performs better than virgin Asphalt mixes as it improves the properties of bituminous mixes.

Several authors have used RAP in stabilization of soils and their properties were reported to improve. According to Jirayut *et al*., (2014) an increase in RAP content in laterite soil- RAP mixture decreases the OMC to an optimum soil/RAP ratio of 50/50. Results obtained from compaction tests carried out by some authors have also shown that increase in RAP content increases the MDD of RAP- soil mixtures while a decrease it decreases their OMC (Edeh *et al*., 2012; Mustapha *et al*; 2014; Ochepo, 2014)

Ochebo, (2014) reported from his research on Stabilization of laterite soil using reclaimed asphalt pavement and sugarcane bagasse ash for pavement construction that addition of RAP to laterite soil reduces the Optimum Moisture Content (OMC) and increases the Maximum Dry Density (MDD) as compared with the natural soil.

Laterite soils can be used as base course for roads, in some cases, without any improvement. These soils may contain substantial amount of silica in the form of clay silicate minerals and could affect its strength and stability. Sourcing for alternative suitable soil for road construction maybe too expensive in areas where deposits of these laterites exist. Therefore, stabilizing the available laterite to meet the desired strength and stability may be necessary (Mustapha *et al.*, 2014).

Numerous research works have also been carried out on stabilization of laterites with other industrial wastes such as Bagasse ash and sugar cane straw ash.

2.0 MATERIALS AND METHODS

2.1 MATERIALS

2.1.1 Lateritic Soil

The lateritic soil sample used for this study was collected from a borrow pit at Gidan kwanu main campus of Federal University of Technology Minna, Niger State, Nigeria, along Minna-Bida Road. Disturbed samples were collected from the borrow pit. The soil was air dried, and index properties test was conducted on the natural soil collected Plate I.

Plate I: Preparation of lateritic soil sample

2.1.2 **Reclaimed Asphalt Pavement** (RAP)

The reclaimed asphalt pavement material used in this study was obtained from a scarified discarded pavement surface along Suleja-Minna Road (47Km from Suleja) in Niger State, Nigeria on latitude 9˚23'30" N and longitude 6˚58'0" E. The RAP was milled using milling machine. Substantial amount of RAP was collected, pulverised and sieved through sieve 5.0mm, Plate II.

Plate II: Pulverized Reclaimed Asphalt Pavement

2.2 METHODOLOGY

2.2.1 Sample Preparation

The soil was air dried in the laboratory and the mix were prepared by adding 0, 20, 40, 50, 60, 80, 100, 120 and 140% RAP by dry weight of the lateritic soil to the laterite. The samples were thoroughly mixed and a total of nine samples were gotten with the sample containing 0% RAP as the control mix for the study.

2.2.2 Compaction Test

The optimum moisture content (OMC) and maximum dry densities (MDDs) of the mixtures were obtained by carrying out compaction tests in the laboratory in accordance with BS 1377 (1990). The control mix specimen containing only the lateritic soil material and the remaining seven specimens were compacted using British Standard Heavy (BSH) compactive efforts. The BSH or modified proctor compactive effort utilized 27 blows of the 4.5 kg rammer falling freely from a height of 450mm onto 5 layers of the soil in a 1000 cm^3 mould. The dry densities and moisture contents were plotted on a graph to obtain the OMC and MDD of the specimens.

Compaction is also carried out on field using a roller. The compaction is carried out at optimum RAP-laterite content which corresponds to the mixture with the highest OMC. The in-situ density of the mixture is obtained on the first day of compaction and at different intervals of 28, 60 and 90 days. Results obtained from field in-situ density are hereafter compared to the MDD of the optimum mixture obtained from the laboratory test conducted Plates III – VI.

Plate III: Field compaction of laterite-RAP mix

Plate IV: Field compaction of laterite-RAP mix

Plate V: In-situ density test of lateritic soil sample

Plate VI: In-situ density test of RAP

2.2.3 California Bearing Ratio

It involves penetration of the moulded soil sample (optimum mixture) with a cylindrical plunger at a constant rate of 1 mm/min. The force corresponding to penetration of 5.0mm is computed and then compared to the standard force attained from the field using the dynamic cone penetration test. The CBR from the field was carried out at periodic intervals of 2, 7, 14, 28, 60 and 90 days for comparison with that obtained from the laboratory Plate VII.

Plate VII: Field Dynamic Cone Penetration Test

3.0 RESULTS AND DISCUSSION

Preliminary tests were conducted in the laboratory in order to determine the index and strength properties of the natural A-6 Lateritic soil. Results obtained are shown in Table I. Sieve analysis was also carried out for RAP to determine its particle size distribution. Results obtained showed it contains 24% sand and 68% gravel particles Figure 1.

Table 1: Index and physical properties of lateritic soil and RAP

Properties	RAP	Lateritic soil
Natural moisture content (%)	0.27	3.43
Liquid limit (%)	-	39.36
Plastic limit (%)	-	24.42
Plastic index (%)	-	14.94
Specific gravity (%)		
Percentage passing BS 200 sieve (%)		48.04
AASHTO classification	-	A-6
USCS classification		CL
Maximum dry density (Mg/m3)		2.163
Optimum moisture content (%)		12.3
California Bearing Ratio (%)		
Colour	Black	Brownish

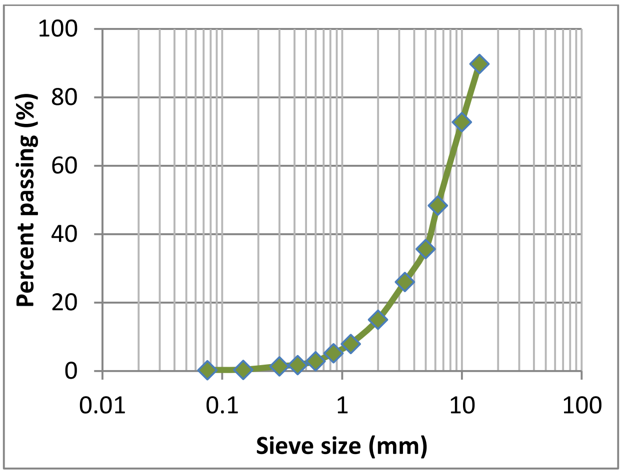

Figure 1: Particle size distribution of RAP

3.1 Compaction Characteristics

Results obtained from the laboratory compaction test are shown on Figures 2 and 3. The OMC is seen to decrease from 12.3% at 0% RAP content to 6.72% at 120% RAP content and hereafter increases to 7.97% at 140% RAP content. While the MDD increases from 2.163g/cm^3 at 0% RAP content to 2.252g/cm^3 at 120% RAP content and then decreases to 2.231g/cm^3 at 140% RAP content. Optimum RAP content is attained at 120% RAP with the highest MDD value of 2.252g/cm^3 and the least OMC value of 6.72%.

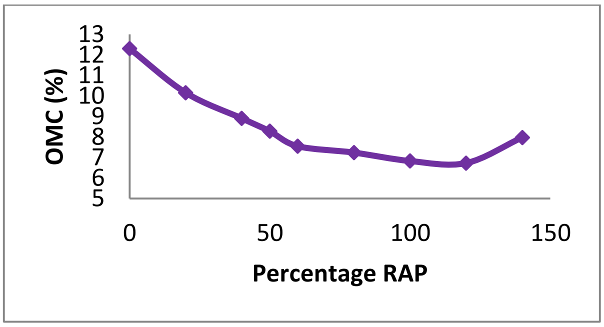

Figure 2: Variation of OMC with RAP content

The decrease in OMC is as a result of increase in RAP content of the mixture. This was attributed to the increase in coarse particles from the RAP, and thereby needing less water to lubricate the mixture. The increase in MDD of the mixtures was attributed to fine particles of the laterite soil filling the void space among the coarse particles of the RAP, which resulted in the formation of a denser matrix (Ochepo, 2014).

The in-situ density obtained from field at various intervals as shown in Table II was also compared to the MDD corresponding to the optimum mixture. Result showed that the in-situ density with a value of 2.282g/cm^3 obtained after 28 days of compaction was closer to the MDD of the mixture obtained in the laboratory with value 2.252g/cm^3.

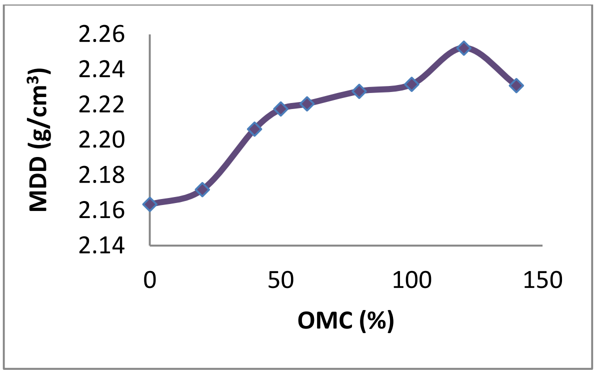

Figure 3: Variation of MDD with RAP content

Table II. In-situ density obtained at various intervals

Number of days	In-situ density(g/cm^3)
1	2.037
28	2.282
60	2.116
90	2.007

3.2 Strength Properties

The CBR obtained from the laboratory at a penetration of 5.0mm was found to be 18.3% and this was compared to that obtained at a depth of 25mm on the field after compaction. The CBR result obtained from the field at various intervals is shown in Figure 4. The result obtained from the field CBR after 2 days with value 19.28% was found to be closer to that obtained in the laboratory. The CBR value decreases further for the first 28 days after which it begins to increase till 65 days and then decreases till 90 days.

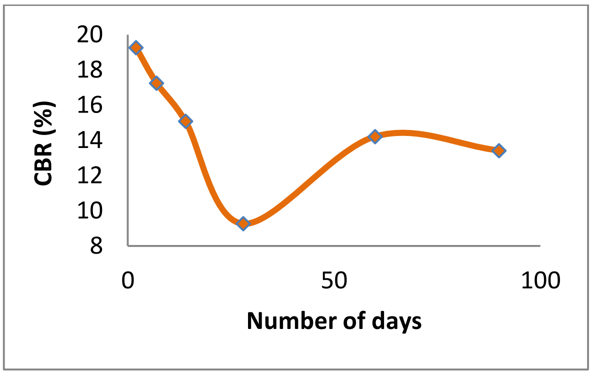

Figure 4: Variation of CBR values with Number of days.

4.0 CONCLUSION

The following conclusions have been reported from this research work.

1. The increase in RAP content of RAP-soil mixtures increases the MDD from 2.163g/cm^3 at 0% to 2.252g/cm^3 at 120% RAP and decreases to 2.231g/cm^3 at 140% RAP. The OMC decreases with increase in RAP content from 12.3% at 0% RAP to 6.72% at 120% RAP and then increases to 7.97% at 140% RAP. The optimum mixture used in the field was found to be the mixture containing 120% RAP with MDD value of 2.252g/cm^3, while the in-situ density obtained in the field 28 days after compaction with value 2.282g/cm^3 was found to be closest to that obtained from the laboratory.
2. The CBR value of 19.28% obtained in the field 2 days after compaction was found to be the closest to that obtained in the laboratory with value 18.3%.

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