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Effect of Almond Ash as Partial Replacement of Lime Filler on the Performance of HMA

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***Abstract*—*Ever-growing concern to protect the environment focused on the attention of the society on the possible reprocessing of different agricultural and industrial wastes in road construction. This research looks at the effect of using wastes like almond leave ash (ALA) as partial replacement of conventionally used Quick lime (QL) as fillers in hot-mix asphalt (HMA). Primarily, the hot mix asphalt (HMA) specimens were made in the laboratory with varying proportions ranging from 0.5% to 4.5% of Quick lime by following design mixes according to the Marshall method and the results were compared with control mix as prepared by utilizing 7% QL. The performances of the said mixes were studied through the Marshall test. Results of investigation show better performance of HMA with the addition of ALA and QL at a ratio of 1.8 (i.e 4.5% almond leave ash and 2.5% Quick lime) this is mix ratio that satisfy the marshal criteria for medium and light traffic*.

***Keywords*—** *Almond leave ash, quicklime, hot mix asphalt, marshal stability.*

I. INTRODUCTION

Reprocessing is one of the most convenient and economical way of disposing agricultural waste materials. With ever fading material supply and increasing prices, there has been a transformed interest in reprocessing the waste materials in many fields of construction. Considerable amount of literature has been published on reprocessing of solid and agricultural waste materials as raw materials in Hot Mix Asphalt (HMA). Generally, there are three ways to introduce a waste material into (HMA). One advent is to introduce the waste material as a modifier to the asphalt binder. Studies have shown that, when asphalt binder is modified with addition of rubber, polymer and many other waste materials, HMA exhibit better properties [1-4]. The second improvement is replacement of traditional aggregates of HMA with solid waste material. Conclusions from several studies acknowledge the importance of the filler used in asphalt concrete [5-7]. Moreover, it is globally accepted that the natural filler can be replaced with any suitable material either natural or artificial [8]. Usage of fly ash as filler in asphalt concrete dates back to 1950's. The study of [9] discovered that fly ash act as a good filler. In recent history, many studies tested the suitability of fly ash in terms of mechanical properties of the mix and ended up with positive results upon reprocessing [10-12]. Other waste materials which are proven to give satisfactory results in asphalt concrete are, glass [13], scraped tires and plastics [14], construction and demolition waste [15] and asphalt waste [16-18]. The third method is to use additives such as polymers and fibers to HMA in addition to the binders and aggregates. Recycling of agricultural wastes in HMA is of high interest to an agricultural countries. In related studies, [19], [20] and [21] suggest that Carbonized Rice Husk (CRH) is suitable for usage as a partial replacement of the filler used in an asphalt mix. This study aims to introduce agricultural waste materials, like almond leave, as partial replacement of filler in HMA. It is proven that the addition of certain additive to asphalt mix can improve the performance of road pavement. Filler acts as one of the major constituents in asphalt mixture. Filler not only fill voids in the coarse and fine aggregates but also affect the ageing characteristics of the mix. Road usually show excessive failures at an early stage of the pavement life. A major step in the improvement of the existing performance of roads starts with modification of mix design. The filler plays a major role in the properties and behavior of bituminous paving mixtures [22]. The mechanical properties of bituminous road pavements depend decisively upon the properties of its filler-bitumen [23]. For modification of asphalt paving materials, the high quality additives are quite expensive for the mass production of bituminous mixture, a solution to this problem can be obtained by considering the influence of natural mixture ingredients, such as filler [24], [25]. Filler used in the asphalt mixture are identified to affect the mix design, specially the optimum asphalt content. The term (filler) is often used loosely to term a material with a particle size distribution smaller than #200 sieve. The filler theory assumes that "the filler serves to fill voids in the mineral aggregate and thereby create dense mix"[26]. The addition of filler to the mixture can substantially improve adhesion, cohesion and the reduction of hardening by age and improve the property of flow at low temperature. The function of mineral filler is essentially to stiffen the binder. According to various studies, the properties of mineral filler especially the material passing 0.075mm (No. 200) sieve (generally called P200 material) have a significant effect on the performance of asphalt paving mixtures in terms of permanent deformation, fatigue cracking, and moisture susceptibility [27].

Objective of the Study

To determine the suitability of almond leave ash filler on the mechanical properties of asphalt concrete paving mixture.

To study the effect of new material of filler on the properties of asphalt mixtures and comparing it with traditional filler (Quick Lime)

II. MATERIAL AND METHOD

2.1 Materials

The Materials used in this study are locally available and selected from the currently used materials in road construction in Port Harcourt, Rivers of Nigeria. The materials used for the

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research include coarse aggregates, fine aggregates, River sand, Almond Leave Ash, Quick lime (QL) and bitumen. The coarse and fine aggregates were collected from Nkalagu quarry in Ebonyi State, Nigeria. The fillers used are the almond leave ash and quick lime (QL). The 80/100 penetration grade bitumen was chosen for the study.

2.1.1 Asphalt cement binder

HMA mixes prepared for this experiment used 80/100 penetration grade bitumen. It was sourced from SDPC. Table 1 show the specifications of 80/100 penetration grade bitumen as specified by the supplier.

TABLE 1. Physical properties of asphalt cement

Test	Unit	Results
Specific Gravity (g)	(g)	1.04
Penetration (mm)	mm	80
Viscosity (sec)	(Sec)	66
Softening Point(ball and ring)	°C	56

2.1.2 Aggregate

One source of crushed aggregate was used in this study, which was brought from Nkalagu crush rock. The physical properties of the aggregates are shown in Table 2.

TABLE 2. Physical properties coarse and fine aggregate

Properties	Coarse Aggregate	Fine Aggregate
Bulk specific gravity(g)	2.88	2.65
Apparent specific gravity (g)	2.87	2.66

2.1.3 Mineral filler

It has been long recognized that the filler plays a major role in the performance of the asphalt mixtures. The importance of fillers in asphalt mixtures has been studied comprehensively.

2.1.3.1 Almond leave ash

Almond leave ash was selected for this study. The leave sample was taken from choba campus in university of Port Harcourt were it was found in abundance as waste in large quantity. Almond leave was picked in large quantity and was burn in a conserved container to ensure there was no loss in chemical properties, and it was separately sieved on Bs No. 200sieve (<0.075mm) to obtain the necessary amount of filler content. Chemical Tests was carried out on the almond leave ash which shows the following properties in Table 3.

TABLE 3. Physical/Chemical properties of almond leave ash

Properties	Percentage (%)
pH	8.40
Calcium oxide (CaO)	5.8
Aluminum oxide (Al_2O_3)	9.02
Specific gravity (g)	0.375
% passing sieve No. 200	90

2.1.3.2 Quick lime

Limestone (Calcium Carbonate– $CaCO_3$) when **burnt** in a kiln gives off Carbon Dioxide (CO_2) gas and forming Calcium Oxide (CaO) which is commonly known as Quicklime or Lumplime. It needs to be **burnt** to 900°C to ensure that a good material is produced.

2.2 Preparation of Mix Design

In this study filler passing sieve No. 200 (75 µm) was used to prepare and characterize hot-mix asphalt concrete. The same mix design methods that are commonly used for hot mix asphalt paving mixtures are also applicable to mix in which almond leave ash filler is used. The percentages of almond leave ash incorporated into the design mix were (0.5%, 1.5%, 2.5%, 3.5% and 5.5%), respectively replacing a percentage of Quick lime to determine which percentage ratio satisfied all the required design criteria. Test result is shown Table 4.

TABLE 4. Marshall stability results

% Ratio of Almond ash/Lime	Stability (KN)	Flow (0.25mm)	G_{mm}	VTM (%)	VMA (%)	VFA (%)
0	9.16	3.15	2.453	7.356	18.787	44.061
0.08	7.86	3.13	2.329	4.846	20.576	70.001
0.27	7.56	2.15	2.175	1.87	20.71	95.607
0.56	7.24	2.63	2.087	1.505	24.531	97.864
1	6.78	2.32	2.074	1.338	28.232	98.759
1.8	6.76	2.83	2.043	1.348	30.485	98.82

III. Result and Discussion

3.1. Effect of Mineral Fillers on the Volumetric Properties of HMA

The HMA samples were prepared in the laboratory; it was tested in the laboratory to determine the properties of asphalt concrete mixes, such as, Marshall Properties (Stability, bulk density, air voids, voids filled with asphalt, voids in mineral aggregate), to evaluate their effect on the HMA behavior. Figures (1, 2,3,4,5 and 6) shows that the relations between almond ash/lime filler content and Marshall Properties is typical to common trend in asphalt content mixes. It can be seen from Figures, that these volumetric properties are checked against the requirements

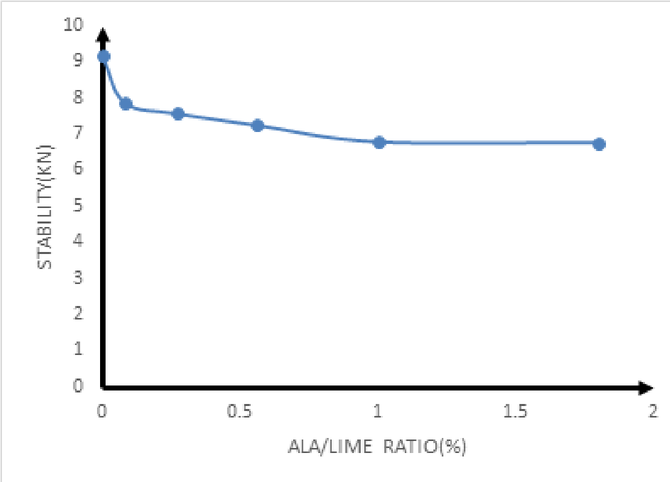

Fig. 1. Variation of Almond Leaf Ash/Lime Content (%) with Stability (KN)

3.1 Effect of Almond leaf Ash on Stability

The relationship between almond leaf ash /cement ratio and stability is presented in Figure 1.it indicates that at 0.08 ratio, the value of stability is 7.86KN which is higher than the other values of stability except (0% almond / 7% Lime ratio) with 9.16KN which was used as a control.

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3.2 Effect of Almond leaf Ash on flow

The relationship between flow and almond leaf ash/ lime ratio as partial replacement for cement is shown in Figure 2 which shows that there is variation in flow with increment of almond leaf ash content.

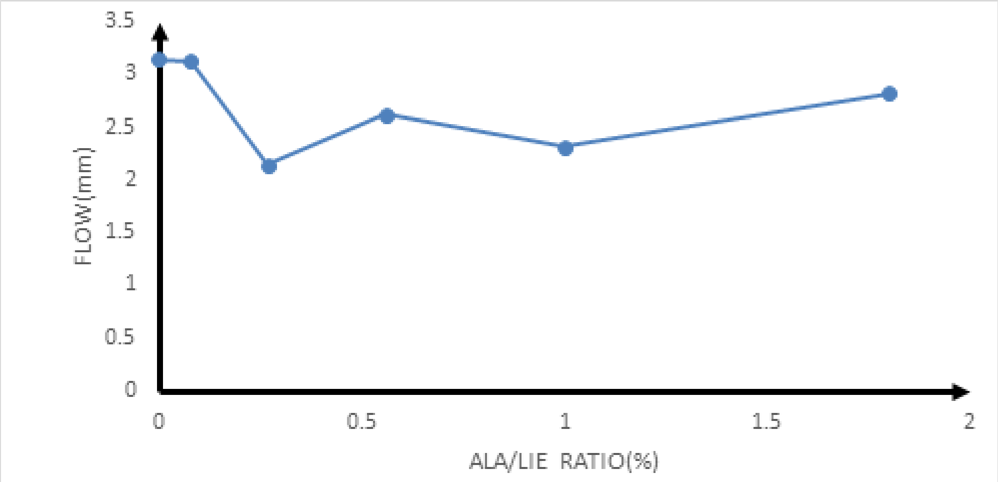

Fig. 2. Variation of Almond Leaf Ash /Lime Content (%) with Flow (mm)

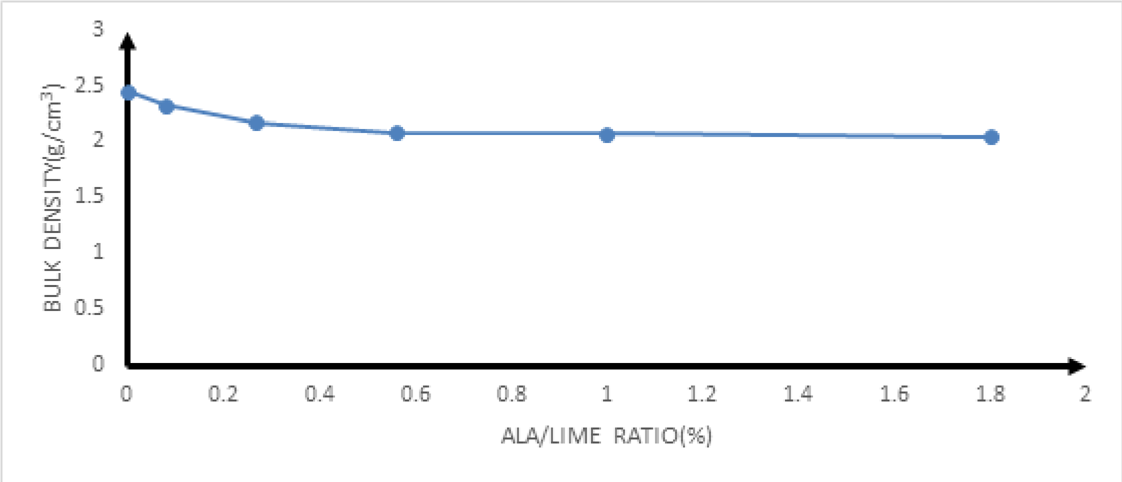

Fig. 3. Variation of Almond Leaf Ash / Lime Content (%) with Bulk Density (g/cm^3)

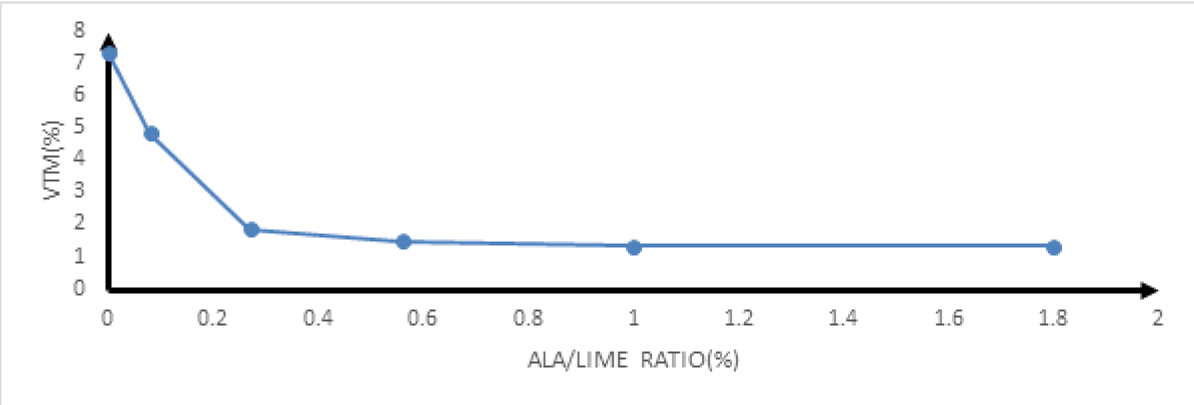

Fig. 4. Variation of Almond Leaf Ash/ lime Content (%) with Voids in Total Mix (%)

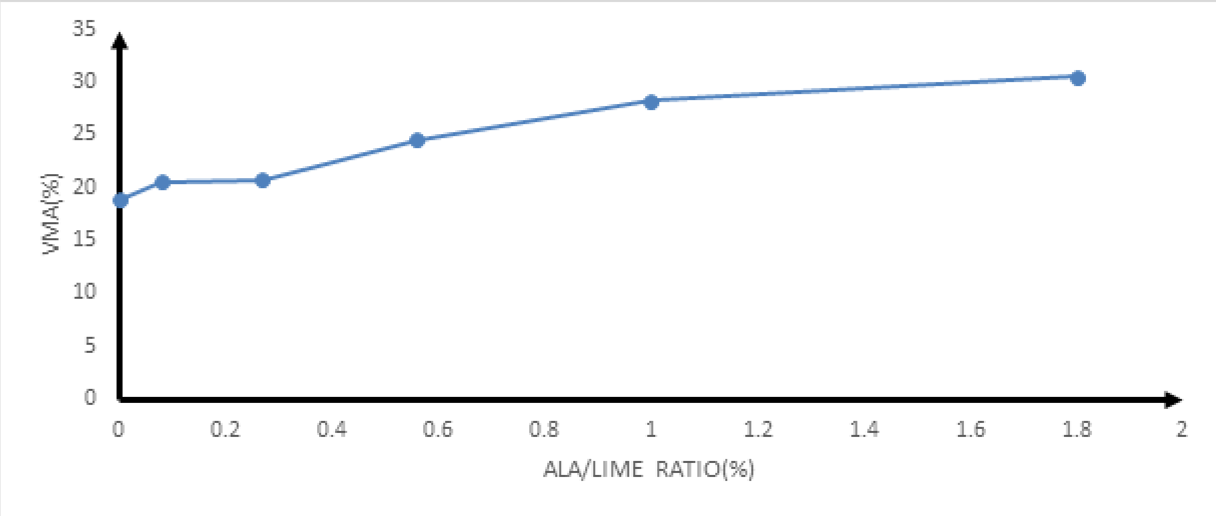

Fig. 5. Variation of Almond Leaf Ash /Lime Content (%) with Voids Mineral Aggregate (%)

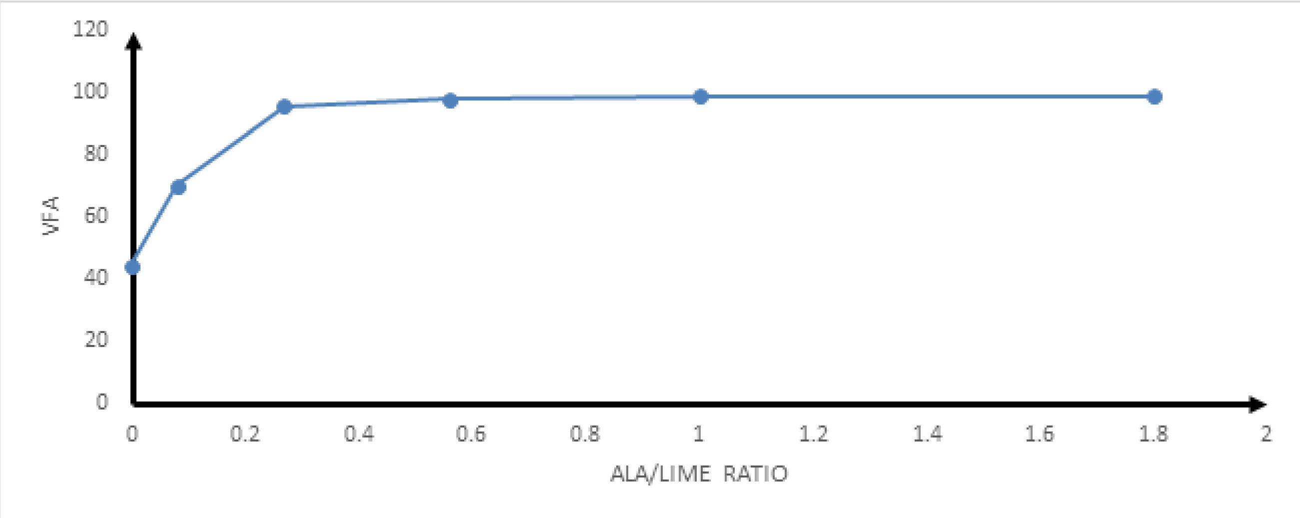

Fig. 6. Variation of Almond Leaf Ash /Lime Content (%) with Voids Fill in Aggregate (%)

3.3 Effect of Almond Leaf Ash on Bulk Density

Figure 3. Indicates that at 0.08 ratio of almond leaf ash/ lime content, the value of bulk density is 2.329g/cm^3 which was higher than the other values of bulk density exception of control with bulk density of 2.453g/cm^3. This shows that as the percentage of almond leaf ash increased, there was a corresponding reduction in the value of bulk density. The reason for the reduction in bulk density is in view of the fact that almond leaf ash has low specific gravity.

3.4 Effect of Almond Leaf Ash on Voids in Total Mix

Figure 4 shows that as the percentage of almond leaf ash content increases, there is a corresponding decrease in the percentage of voids in the total mix. Fewer voids are created in the asphalt mix as the percentage of almond leaf ash increases, thus decreasing the volume of voids in the total mix. At control sample the percentage of void in total mix was 9.36% and at 0.5% replacement the percentage of Voids in total mix was 0.348%. This is due to low specific gravity of almond leaf ash.

3.5 Effect of Almond leaf Ash on Voids in Mineral Aggregate

Figure 5 shows that an increase in percentage of almond leaf ash content, there is also a corresponding increase in percentage of voids in mineral aggregate. The increase in voids in mineral aggregates is as a result of low specific gravity of almond leaf ash 0.375. Thus, a given percentage weight of almond leaf ash will occupy a greater volume than that of lime, the conventional filler.

3.6 Effect of Almond leaf Ash on Voids in Filler Aggregate

Figure 6 shows that with control sample, the percentage of voids in filler aggregate has the lowest value of 44.06% and highest at 1.8 ratio of almond leaf / lime content with 98.82%. This shows that there is an increase in VFA with an increase in almond leaf ash content.

IV. CONCLUSION

Based on the general findings and results of tests carried out on asphalt concrete modified with almond leaf ash as partial replacement of mineral filler, the following conclusions are made:

1) Almond leaf ash when used as partial replacement for lime does not improve the properties of asphalt mixture compared to the control used, but if it should be used as a partial replacement (1.8 ratio) of almond leaf ash / lime can be used since it gives the optimum stability and satisfy other criteria of marshal test for medium and light traffic after replacement.
2) Almond leaf ash can be successfully incorporated as mineral filler in HMA without degrading the engineering properties of the mix because the stability and flow values were above that of light and medium traffic.

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