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Cassava Peel Ash as Void filler for Flexible Pavement Surface Course: Case Study of Heavy Traffic Volume

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Abstract
The need to improve void properties of asphalt concrete roadway pavement and the use of waste materials has long been a priority in highway engineering. The current study sought measures to improve void properties in order to increase the lifespan of the roadway pavement. Based on this, Cassava Peel Ash (CPA) was used to modify asphalt concretes, which are used interchangeably to represent wearing course of the pavement, with the aim of improving void properties. This was done at 2.5%, 5.0%, 7.5% and 10% by weight of the total mix respectively. Results revealed that at 7,5% modification of asphalt concrete using CPA, the void properties meet the required standards.
Key Words: *Cassava Peel Ash, Air Void, Filler, Modified Asphalt*

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I. Introduction

The idea of pavement material characterization is that it allows the civil/pavement engineer to determine a material is suitable to realize the anticipated results in terms of effectiveness, performance and functionality during the pavement lifespan. Pavement material re-characterization is based on the fact that some constituents that make up the pavement structure fall below the required standards. This has resulted in thoughtful efforts to either improve the properties of a few pavement structure elements or the pavement structure's general characteristics. In doing so, modifiers and additives have been introduced to remedy the short falls. This remediation procedure is aimed at improving the overall behavior/performance of the roadway structure over the course of its useful life (Igwe *et al* 2016).

In the context of this article, voids in asphaltic concrete are properties that define the amount of air contained within an asphaltic concrete. In practice, it refers to the amount of air voids and voids in mineral aggregate particles contained within a wearing course of the pavement. The flow property, on the other hand, governs the movement of binder (asphalt)when there is high temperature and vehicular loads acting on the pavement simultaneously. Having a concrete that will meet design standards or specifications in any condition is important. It is important to note that in mix design, the properties of asphaltic concrete are classified into five categories: stability, density, flow, air voids, and voids in mineral aggregate.

Extreme temperature rises in tropical areas can cause bleeding/flow of binder on the wearing course. According to some researchers, void properties of asphaltic concrete have effect on the strength properties, specifically stability and density. These parameters, determines the stiffness, strains and response/behavior of the pavement in terms of fatigue life during the pavement's design life whether in soaked or unsoaked conditions (Igwe *et al* 2016; Igwe *et al* 2016; Igwe & Ottos 2016; Igwe & Ottos 2017; Otto & Akpila 2020; and Otto *et al* 2020).

According to Wu *et al* (2003), a large amount of waste is generated with speedy economic growth and a continuous increasing rate of consumption. The massive amounts of waste (such as car/scrap tires, glass, blast furnace slag, steel slag, plastics, agro waste, construction and demolition wastes,) that are gathered in dump sites and landfills around the world causes disposal issues that are costly and have environmental challenges. In order to take care of the rising issue of disposal of these materials, there is need for harmonization and commitment from all stakeholders. Recycling and reusing waste materials in road pavement construction is one solution to waste disposal problem. Also, according to Jony, *et al* (2011). using waste materials in the building roads have a lot of positive effects in that it reduces the quantity of waste that must be disposed and it can also provide substantial funds over time. These constituents reused, can really add worth to what was previously an expensive disposal issue (Otto & Amadi-Oparaeli 2019; and Otto & Awarri 2021)

Cassava production in Nigeria is estimated to be 54 million tons (Sanni, 2019). Cassava is a versatile food that can be prepared in numerous ways. It is a major staple in the tropics, and more of it is being farmed per capita. Cassava peel is an important industrial raw material in Nigeria for the animal feed, pharmaceutical, and chemical industries (Sanni, 2019). Cassava peel is extracted from the cassava plant's roots. The roots are washed and peeled before being sun-dried. After drying, it is ground and sieved and ready for use. Because cassava peel is widely available in Nigeria and Rivers State, where this study was conducted, using cassava peel to improve the anti-stripping characteristics of flexible pavement is a viable option.

Plate 1. Cassava Peel Dump Site

II. Materials and Methods

2.1 Materials

River sand (fine aggregate), gravel (coarse aggregate), asphalt (bitumen), and cassava peel ash were used in this study. The fine and coarse aggregates used in this project were obtained from the local building materials market located along the Abuja bypass, Mile III, Diobu Port Harcourt, Rivers State, Nigeria. In addition, the asphalt (grade 60/70) used was obtained from the materials laboratory of Rivers State University's Civil Engineering Department in Port Harcourt, Rivers State, Nigeria. Cassava tubers were sourced locally from farmers in Kaani, Khana Local Government Area, Rivers State, Nigeria. Cassava peels were obtained from tubers.

2.2 Methods

The Bruce Marshall method of preparing samples as presented in National Asphalt Pavement Association (1982), Roberts et al (1996), and Asphalt Institute (1997), were used to prepare samples in this study. The procedure entailed preparing a number of test samples for a variety of asphalt contents so that test data curves revealed well-defined optimum values. The tests were planned in 0.5 percent additions of asphalt binder, with at least three above and below the optimal content. Three test samples were prepared for every asphalt content in order to provide adequate data. The fine and coarse aggregates were heated for 5 minutes. Thereafter, binder was added to allow for proper absorption into the aggregates during the preparation of the pure and modified asphalt concrete samples. The mixture was then poured into a mould and compacted on both faces with 75 blows from a height of 450mm using a 6.5kg-rammer. Compacted specimens were tested for bulk specific gravity, stability and flow, density, and voids at temperatures of 60degrees Celsius as specified by the AASHTO Design Guide (2002). The obtained results were used to calculate the optimum asphalt content of pure asphalt concrete. The cassava peel ash was then added to the samples at optimum asphalt content in varying amounts (2.5 - 10.0 percent of the total mix) and redesigned using the same Marshal Design Procedures as previously stated to produce modified concretes with varying mix design properties, particularly air voids content.

III. Results and Discussions

Results of the mix design properties of the modified asphalt concrete are presented in Table 1.

Table 1: Marshall Mix Design Properties of CPA Modified Asphalt

% CPA	Stability(N)	Density (kg/m^3)	Flow(mm) (0.25mm)	% Air Voids	% VMA	% VFA
0.00	23450	2159	8.28	5.898	18.268	67.71
2.50	26560	2165	9.27	5.390	18.047	70.13
5.00	28280	2171	10.25	5.003	17.818	72.66
7.50	35140	2177	11.07	4.358	17.596	74.23
10.00	29270	2148	12.13	5.349	18.667	71.34

The results presented in Table 1 are plotted in Figures 1, 2 and 3 to show a graphical view of the behavior of CPA modified asphalt concrete in terms of voids.

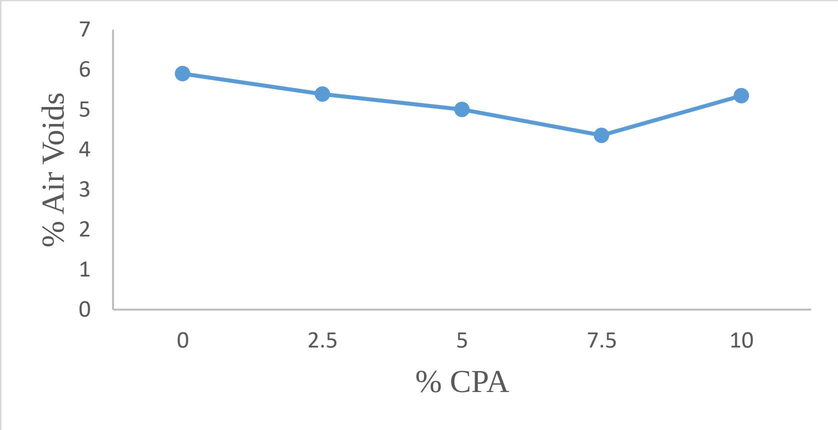

Figure 1.0 Variation of % Air Voids against % Cassava Peel Ash (CPA)

The air void result presented in Figure 1.0 shows that an increase in CPA reduces air voids up to 7.5% modification. But as the percentage of modification increases beyond 7.5%, the air void value increased. Considering the acceptable limit of the air voids for heavy traffic volume as presented in the Asphalt Institute MS-2 (2017), the value of air void (4.358%) at 7.5% is between 3% and 5%. This is acceptable.

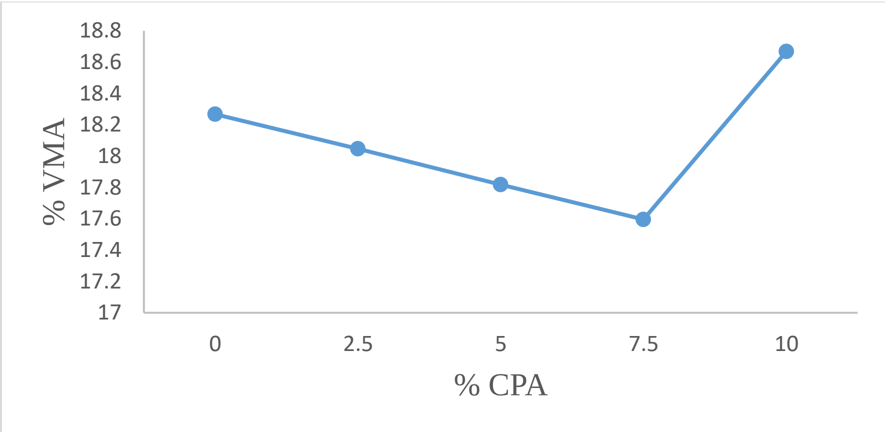

Figure 2.0 Variation of % Voids in Mineral Aggregates (VMA) against % Cassava Peel Ash (CPA)

Also, the results of percentage VMA presented in Figure 2.0 shows that an increase in CPA reduces percentage VMA up to 7.5% modification. But as the percentage of modification increases beyond 7.5%, the VMA value increased. This behavior is similar to that of the air voids. Considering the acceptable limit of the air voids for heavy traffic volume as presented in the Asphalt Institute MS-2 (2017), the value of VMA (17.596%) at 7.5% is acceptable at No 4 and No 8 sieve sizes. Nevertheless, it is important to note here that the values of VMA presented in Table 1 and Figure 2, meets the requirement for sieve sizes of No 4. No 8 and No 16.

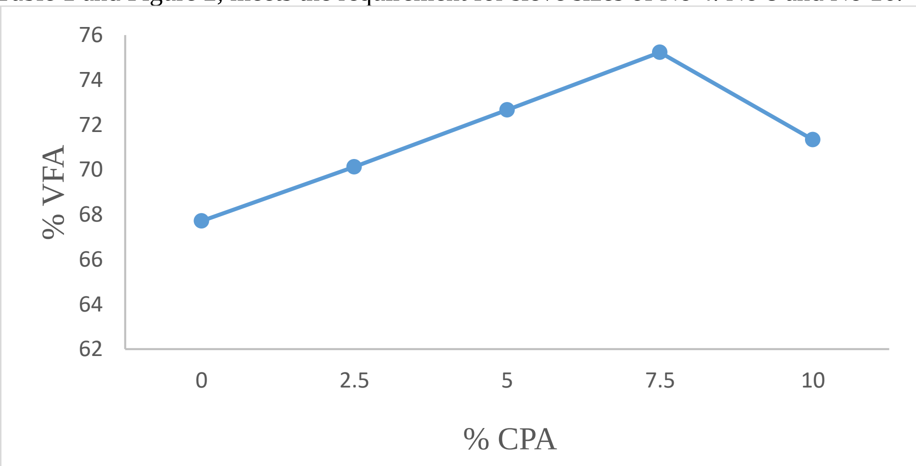

Figure 3.0 Variation of Voids Filled with Asphalt (VFA) against % Cassava Peel Ash (CPA)

In Figure 3.0, the results shows that an increase in CPA increases VFA up to 7.5% modification. But as the percentage of modification increases beyond 7.5%, the VFA value reduces. Considering the acceptable limit of the VFA for heavy traffic volume as presented in the Asphalt Institute MS-2 (2017), the values of VFA in Tale 1 and Figure 3 meets the requirements. This is acceptable because it is between 65% and 75%.

IV. Conclusion

In the current study, the use of CPA as a filler revealed consistency of results. It was discovered that adding CPA filler improves the properties of asphalt mixtures by reducing voids. As a result, CPA filler has the ability to improve the structural resistance to road pavement distress. When likened to the control mix, the CPA filler of 7.5 percent by weight of total mix had the best air void, VMA, and VFA. However, when the filler content exceeds 7.5 percent, there were negative changes noticed.

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