Assessing The Performance Of Periwinkle Shell Ash On Asphaltic Concrete

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***Abstract*—There is incessant pavement failure on the Niger Delta roads due to the climate factors and heavy duty vehicles, necessitating the increase in the strength of the pavement. Periwinkle shell ash as a filler material to improve the performance of the asphaltic concrete is considered. In this study, the mechanistic properties of asphalt concrete mixes modified with Periwinkle Shell Ash as a replacement for mineral filler were evaluated at 20 percent. Bitumen content were evaluated and six replacement rates were used; 5.0, 5.4, 5.8, 6.0, 6.6, and 7.0 percent by weight. The tests were grading test, specific gravity test (bulk and apparent) density test, aggregate impact value test, aggregate crushing value test, and bitumen penetration test. Asphalt concrete mixes were prepared at their optimum asphalt content and then tested to evaluate their engineering properties which include Marshall Stability at 6.2 percent and 3.6 kilo Newtons, Bulk density is 2.37 Grammes per centimeter cube, flow gave 2.5, 2.8, 3.3, 3.7 and 3.9 percent. The Voids in Mix Aggregate was 17 percent and Voids filled with Bitumen was 80 percent.**

***Keywords*— periwinkle Ash, Asphalt, bitumen, Marshall Stability, penetration Aggregates; sieve, grading.**

1. Introduction

The need to produce durable and low cost building components using local building materials and simple technologies is of great importance since the inflationary trend in the economy escalated the cost of road materials. For a country to be able to achieve a sustainable infrastructural development particularly in the area of roads in the nearest future, low cost materials especially those readily available must be exploited to construct roads so as to reduce the overall cost of construction.

The Niger Delta is characterized by wetlands and water bodies with creeks and rivers across the entire region. The area is topographically lowland and is subject to periodical floods and heavy rainfall almost all the year round. The higher lying plains experience 5-7 months of flooding in the year, resulting from the overflowing waters of lower Niger Delta in which whole communities and farmlands are invariably submerged. Flooding and river bank or coastal erosion is the bane of the people. The Niger Delta is, no doubt a difficult terrain. As a result of exposure to flood waters or run-off waters and insufficient drainage capacity the moisture content of the soil in the lowland is high. Therefore, there is need to construct sustainable roads.

Asphalt concrete is very relevant in virtually all highway engineering practice. The growing concern of resource depletion and global pollution has challenged many researchers and engineers to seek and develop new materials relying on renewable resources. These include the use of by-products and waste materials in construction. Many of these by-products are used as fillers for the production of acceptable mix design. With the global economic recession coupled with the market inflationary trends, the constituent materials used for these mix design had led to a very high cost of construction. Hence, researchers in material science and engineering are committed to having local materials to partially or fully replace these costly conventional materials. Numerous achievements have been made in these regard and the subject is attracting attention due to its functional benefit of waste reusability and sustainable development such as Periwinkle shell used for this research. Reduction in construction costs, availability, and the ability to produce adequate mix are added advantages. In continuing quest for more cost - efficient and environmentally acceptable materials, recently, there has been a growing interest in the use of agricultural wastes as pozzolans.

2. Materials and Method

2.1 Materials:

Coarse Aggregate, Fine aggregate, Mineral filler Periwinkle Shell Ash, Bitumen

2.2 Methods

A. CHARACTERIZATION OF ASPHALTIC CONCRETE MATERIALS AND PERIWINKLE SHELLS ASH

Tests were carried out on asphaltic concrete materials and periwinkle shells ash (PSA) in order to determine their conformity with acceptable values of some engineering properties, required for the asphalt concrete mix. The tests were grading test, specific gravity test (bulk and apparent) density test, aggregate impact value test, aggregate crushing value test, and bitumen penetration test.

B. GRADING TEST

The aim of the grading tests was to determine the quality expressed in percentage by weight of the various grain sizes of the samples that would be used, and also to check its compliance with BS 812 (1992). The weight of the sample retained on each sieves were all recorded and expressed as a percentage of the total weight of the sample.

C. SPECIFIC GRAVITY TEST

The specific gravity of any material is defined as the ratio of the weight of the material to be weight of equal volume of water. The test was carried out in accordance to the provision of section 8 of BS 1377:1990.

D. PENETRATION TEST

This is a consistency test that seeks to establish the hardness of bitumen. It is expressed as a distance that a standard penetration needle vertically penetrates a sample of bitumen under a standard load of 100gm. freely falling in 5 seconds at a temperature of 25 ˚C. Softer bitumen will have higher penetration while harder asphalt will have lower penetration test. The test is also used to designate grades of bitumen. (ASTM, 2004).

E. ASPHALTIC CONCRETE MIX DESIGN

The procedure involved the selecting of a trial aggregate gradation, a compaction level and number of blows. Which involves selection of aggregate grading, determination of the proportion of each aggregate size required to produce the designed grading, obtaining the Specific gravity of the aggregate combination and asphalt cement. Then trial specimens with varying asphalt contents were prepared, thus; 5.0, 5.4, 5.8, 6.2, 6.6 and 7.0% and the specific gravity of each compacted specimen was determined. Stability tests were performed on the specimens before the percentage of air voids and percentage of voids filled with bitumen in each specimen were computed. After this, the optimum binder content was selected from the data obtained and the design was evaluated with the design requirements i.e. Marshall Stability and Flow.

F. PREPARATION AND MODIFICATION OF MARSHALL MIX DESIGN PROCESS

The aggregates mixes were heated to a temperature range of 175 °C to 190 °C. The aggregates were then separated into individual grains sizes by dry sieving, selected according to the mix design formula, which gave the best grading distribution curve and met the requirement specified in General Specifications for Roads and Bridges (FMWH, 1997). The bitumen was also heated to a temperature range of 121 °C – 138 °C before mixing. The asphaltic concrete sample was prepared from the 3000 g mix of river sand, quarry dust, bitumen and periwinkle shell ash, in proportions of 20 % filler of size 0.075 mm (river sand), 30% of quarry dust, 25 % crushed stone of size 10 mm, and 5 % crushed stone of size 12.7 mm with 20 % of periwinkle shell ash introduced into the mix to modify the asphaltic concrete. Bitumen of penetration grade 60/70 was added at 5.0, 5.4, 5.8, 6.2, and 7.0 % by weight of total design mix. Asphaltic concrete of 1200g was place into the mould assembly and then placed in the compaction pedestal and given 75 blows of a 4.5 kg compacting hammer falling from a height of 457.2 mm, the specimen in the mould was reversed and given the same treatment on the other side. The specimen was carefully extruded from the mould, allowed to cool to room temperature, coated with paraffin wax and stored in the oven for bulk density, Marshall and flow test to be carried out.

The samples were then brought to the compaction temperature of 10 °C less than the corresponding mixing temperature using a Marshall mechanical compactor. The specimens were compacted using 75 heavy – duty Marshall blows for each face, corresponding to a tire pressure of 1.379 kPa. Samples with a variety of fibre sizes and percentages of the asphalt were tested by Marshall Immersion.

The specimen was removed from the oven and placed in the lower segment of the breaking head, after which the complete assembly was placed in position on the testing machine. The flow meter was placed in position over one of the guide rods and adjusted to zero while holding the sleeve firmly against the upper segment of the breaking head. This was followed by the application of the crushing load. The load was measured when the maximum load is reached and the load decreased as indicated by the load dial. Consequently, the flow meter sleeve was released instantly as the maximum load begins to decrease and the indicated flow value was measured. The values of Marshall Stability were obtained to determine the effect of PSA in the production of asphaltic concrete.

3. Results and Discussion

3.1 Aggregate Impact Value Test (A.I.V)

Initial weight of coarse aggregate before test = 550 g

Weight of the aggregate after test = 5429 g

Weight of coarse passing sieve 2.36 (7) = 8 g

Height of fall 380mm

Weight of hammer 14kg

A.I.V = $\frac{8}{550} \times 100$ = 1.6% pass result

3.2 Aggregate Crushing Value Test (A.C.V)

Initial weight of aggregate = 3000 g

Weight of crushed aggregate passing sieve 2.36mm (7) 500 g

AIV =$\frac{500}{3000} \times 100 = 16.7\%$

The test passed since the value of the result is less than 30%

3.3 Flakiness Test

TABLE 3.1: FLAKINESS TEST

Sieve		Retained before Test	Passing
Passing	Retained	A	B
38.1mm	25.4mm		
25.4mm	9.1mm		
19.1mm	12.7mm	838	25
12.7mm	9.5mm	281	81
9.5mm	6.35mm	81	19
TOTAL		1200	350

Flakiness=$\frac{A}{B} \times 100$

$\frac{350}{1200} \times 100 = 29.16$ =29.2%. Flakiness = 29.2

3.4 Specific Gravity

The result of the specific gravity for 9.5 mm crushed aggregate, 12.7 mm crushed stone, 19 mm crushed stone, quarry dust, PSA, bitumen and river sand were 2.7, 2.7, 2.66, 2.5, 1.02 and 2.5 respectively. These values show that PSA is the same as sand and therefore helps to reduce the air voids within the asphaltic concrete, thereby enhancing its stability. The bitumen is suitable since it is less than 1.00 (ASTM, 2011).

TABLE 3.2 SPECIFIC GRAVITY OF MATERIALS

Asphaltic Concrete materials	Specific Gravity (Grs)
Crushed Stone (9.5 and 12.7mm)	2.7
Quarry Dust	2.66
Periwinkle Shell Ash (PSA)	2.5
Bitumen (60/70)	1.02
River sand	2.5

TABLE3.3: THE PROPERTIES OF BITUMEN USED

Penetration grade 60/70 ASTMD 5	
Penetration (25 °C, 100 g, 5 s, mm) 63.0	ASTM D 5
Specific gravity 1.02	ASTM D 70
Softening point (°C)	51 ASTM D 36
Flash point (°C) 250	ASTM D 92
Ductility (25 °C, 5 cm/min)	99 ASTM D 113

3.5 Sieve Grading Analysis of Fine Aggregate

Sieve grading analysis and bitumen extraction shows that the aggregates met the recommended quality requirement for coarse and fine aggregates for use in premix asphalt and falls within the envelope for General Specifications of Roads and Bridges (FMWH, 1997) grading zone standards.

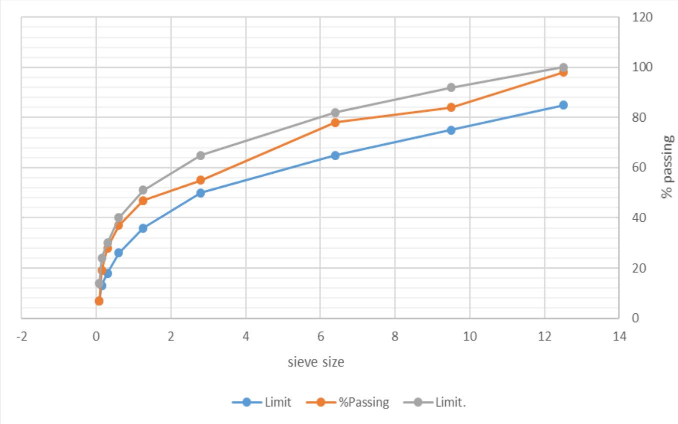

Figure 3.1 - Sieve Grading Analysis of Fine Aggregate

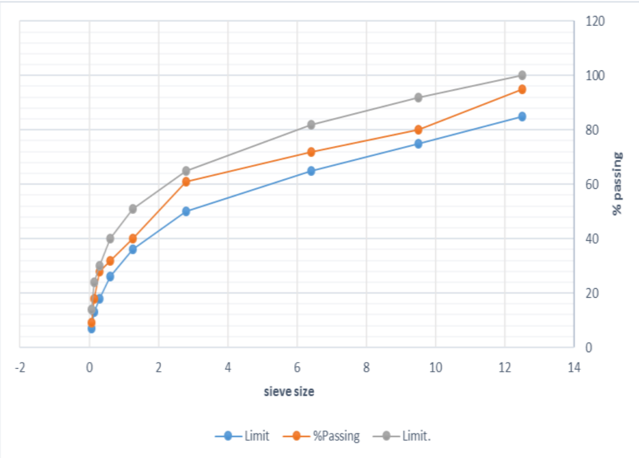

Figure 3.2. Bitumen Extraction and Sieve Analysis of *Aggregate*

3.6 Effects of Periwinkle Shells Ash (PSA) on Modified Asphaltic Concrete Mix

A. MARSHALL STABILITY

The stability of modified asphalt mixture in Fig. 3.3 increased as PSA content increased reaching its peak at 6.1% and steadily dropping at 6.6 and 7 %. This indicates that the optimum percentage for PSA – modified asphaltic concrete is at 6.1%, which also conforms to FMWH standard and other international specifications. At 6.2% is 3.6 kN the stability met the requirement properties of compacted asphaltic concrete i.e., stability not less than 3.5kN.

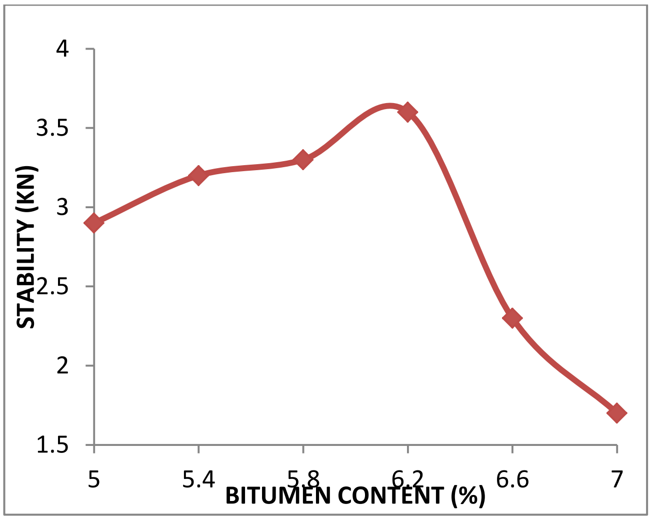

Figure 3.3. Effects of PSA on Marshall Stability

B. AIR VOIDS AGGREGATES

Fig. 3.4 shows result of air voids in aggregate mix conforms to FMWH (1997) standards for asphaltic concrete pavement. It was observed that volume of air voids of periwinkle shell ash (PSA) – modified asphaltic concrete decreased gradually as the PSA content increased through and 6.2 % before dropping at 6.6 to 7%. The effect was influenced by the presence of PSA, which filled up the air voids within the asphaltic concrete mix. This has made the bitumen to have a better mix performance and achieve void reduction which is low enough to prevent permeability of air and water. Meanwhile, the drop of air void at 7 % is caused by entrapped air within the mix. This indicates that the bitumen content in the mix has increased beyond the optimum.

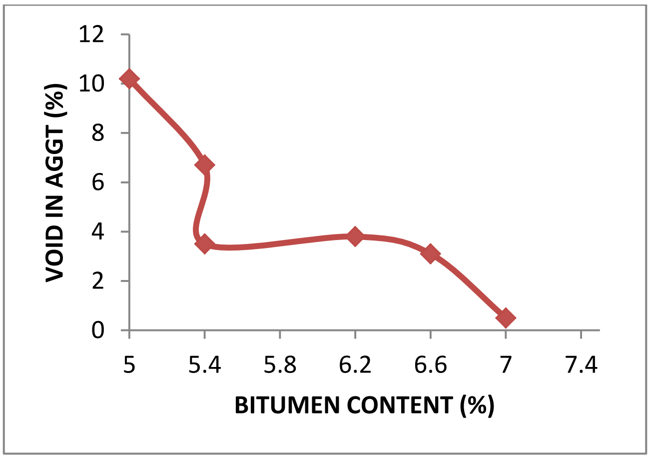

Figure 3.4. Effects of PSA on Air Voids in Aggregate

C. MARSHALL FLOW

Figure 3.5 shows the flow result of the modified asphaltic. It conforms to FMWH (1997) standards for asphaltic concrete pavement. The deformation of the test specimen at maximum loading increased from 2.5 mm till it reached 3.9 mm at 6.6% before getting to 4.5mm at 7 %, Therefore it shows that at 5.0 to 6.6% which gave (2.5 to 3.9mm) it met the requirement properties of compacted asphaltic concrete 2mm-4mm. the optimum percentage of periwinkle shell ash – modified asphaltic concrete is 6.2 % This may be attributed to the reduction in viscosity of the binder with increase in bitumen.

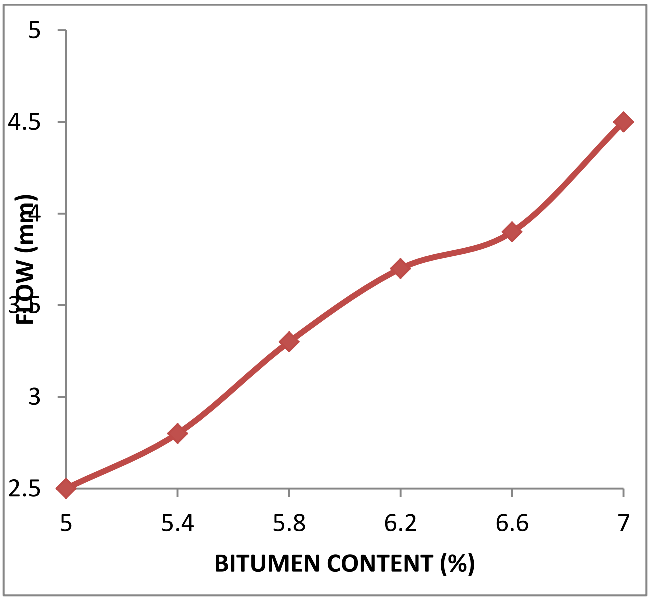

Figure 3.5. Effects of PSA on Marshall Flow

D. BULK DENSITY

Figure 3.6 shows the bulk density result. It conforms to FMWH (1997) standards for asphaltic concrete pavement. It can be observed from the plot that the bulk density of (PSA) modified asphaltic concrete experienced a steady increment from 2.24 g/cm^3 to 2.31 g/cm^3 at 5.4 % addition; 2.31 g/cm^3 to 2.36 g/cm^3 at 5.8 %; 2.36 g/cm^3 to 2.37 at 6.2 % and dropped from 2.37 g/cm^3 to 2.44 % at 6.6 %; 2.44 g/cm^3 to 2.31g/cm^3 at 7 %. The significant increase in bulk density is due to the effect of PSA which has helped to increase the bulk volume and compactness of asphaltic concrete materials by filling up tiny spaces that aggregates would not occupy, thereby leading to a reduction of the air voids.

Density is one of the most important parameters in construction of asphalt mixtures. A mixture that is properly designed and compacted will contain due to plastic flow but low enough air voids to prevent permeability of air and water. (Brown, 1990).

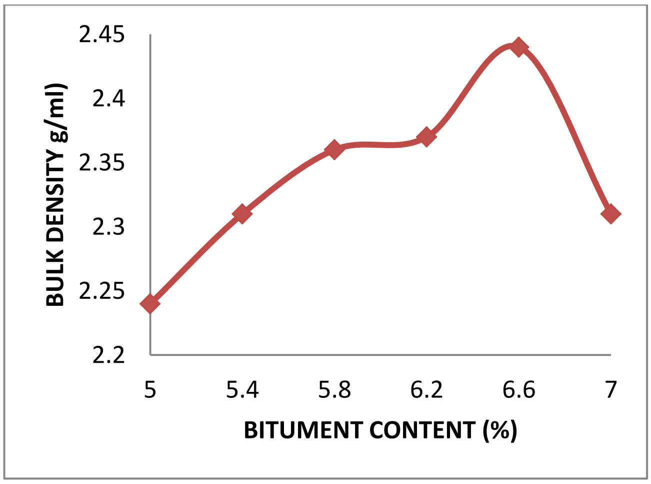

Figure 3.6. Effects of PSA on Bulk Density

E. VOID FILLED WITH BITUMEN (VFB)

Figure 3.7 shows result of void filled with bitumen (VFB). It conforms to FMWH (1997) standards for asphaltic concrete pavement. The VFB increased continuously as the bitumen content increased. The VFB values increased from 52, 64.9 and 80% at 5, 5.4, and 5.8% and dropped at 78 % at 6.6% before increasing from 78, 83.2 and 97.1% of. This is because voids that existed between the aggregate particles in the compacted mix were filled with bitumen; an effect of finer particles of PSA being able to fill the voids.

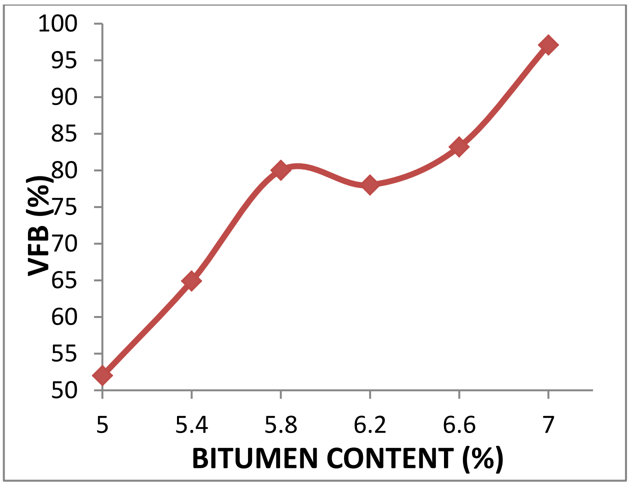

Figure 3.7. Effects of PSA on Void Filled with Bitumen

F. VOID IN MIX AGGREGATE (VMA)

Figure 3.8 shows result of void in mineral aggregate. It conforms to FMWH (1997) standards for asphaltic concrete pavement. It was observed that the VMA decreases continuously as the pulverized coconut fibre content increased at the Modified Asphaltic Concrete Mix is 17 %. As stated in the general specifications of roads and bridges (1997) vol II.

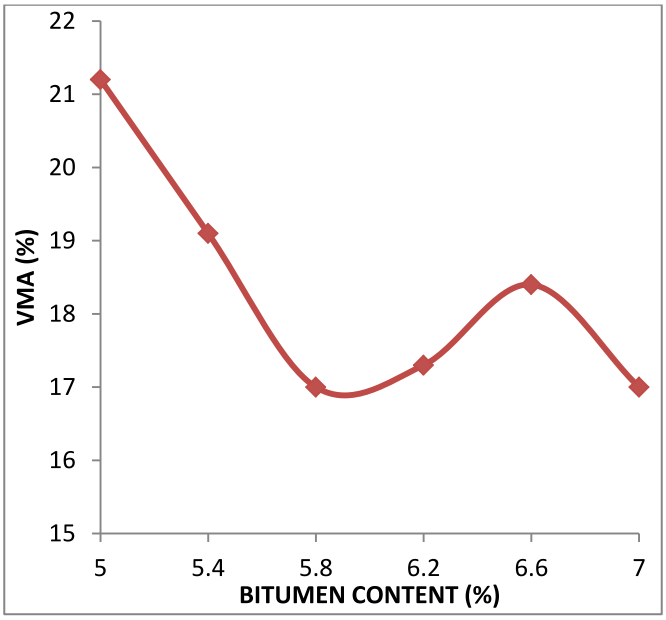

Figure 3.8. Effects of PSA on Void in Mixed Aggregate

4.0 Conclusion

Considering the results analyzed and based on discussion the outcome of the research on the effects of adding periwinkle shell ash (PSA) to asphaltic concrete, the objectives of the thesis was achieved and leads to the following conclusions:

Asphaltic concrete materials and periwinkle shell Ash (PSA) were characterized for sieve grading analysis, specific gravity, density, flakiness, penetration and the results were in conformity to BS, IS, ASTM and FMWH (1997) specifications. Asphaltic concrete mix was modified by introducing periwinkle shell ash (PSA) at 20%.

The effects of PSA on the asphaltic concrete was evaluated and the results summarized as follows:

The optimum percentage of using PSA as an additive in asphaltic concrete production is 6.1 % and properties of compacted asphaltic concrete:

Stability:

The stability of Modified Asphaltic Concrete Mix at 6.2% bitumen content and 20% of PSA from my result is 3.6 kN which is greater than 3.5 kN as stated in the general specifications of roads and bridges (1997) vol II.

Flow:

The flow of Modified Asphaltic Concrete Mix at 6.2% bitumen content and 20% of PSA from the result is 3.9 mm which is between (2 mm - 4 mm), as stated in the general specifications of roads and bridges (1997) vol II.

Voids filled with Bitumen:

Voids filled with bitumen of Modified Asphaltic Concrete Mix at 5.8, 6.2, 6.6% bitumen content and 20% PSA which is 80, 78, 82.3 % which is between (75 - 82 %), as stated in the general specifications of roads and bridges (1997) vol II.

Bulk Density:

Modified Asphaltic Concrete Mix of bulk density at 6.2% bitumen content and 20% which is 2.37 g/ml, as stated in the general specifications of roads and bridges (1997) vol II.

VMA:

Modified Asphaltic Concrete Mix is 17 %. As stated in the general specifications of roads and bridges (1997) vol II.

Air Voids in Aggregate:

Modified Asphaltic Concrete Mix is 3.5, 3.8, and 3.1 % as stated in the general specifications of roads and bridges (1997) vol II.

There was increase in the values of stability, flow, bulk density and voids filled with bitumen (VFB), but decrease of voids in mineral aggregates (VMA), voids in aggregates (VA) when the addition of PSA to the asphaltic concrete mix increased beyond 6.2 %.

It can be concluded that the PSA – modified mixture is durable and has the potential to reduce permanent deformation.

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