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ASSESSMENT OF THE ENGINEERING PROPERTIES OF ASPHALTIC CONCRETE MODIFIED WITH PLASTIC WASTES

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ABSTRACT

Recycling is considered to be one of the most important bases of sustainability. Almost all the products we make use of, whether they are metal, wood glass or even plastic, will eventually turn into waste that must be disposed. The best way to deal with this waste is recycle and reduce them as modifiers. This will reduce the drain on the natural resources of the raw materials, and it will reduce the spaces used as landfills. Among these wastes are plastics, which are widely used in our daily life. Waste plastic has been used in the road construction as a substitute to bitumen in the hot asphalt mix in many countries so as guarantee the sustainable management of the plastic waste. The aim of this study is to assess the engineering properties of asphaltic concrete modified with Plastic waste. Two types of plastic were used which are Low Density Polyethylene (LDPE) and High Density Polythylene (HDPE). Aggregate properties were conducted using Sieve analysis, Aggregate crushing test, Aggregate impact test and Abrasion test. The plastics were gathered, shredded, heated and blended into various proportions such as 10%, 20%, 30%, 40% and 50% for both LDPE and HDPE. Bitumen tests such as ductility test, penetration test and softening point test were carried out to compare the effect of HDPE had better properties from its less penetration and its increase in temperature for the softening point. 56% coarse aggregates, 24% fine aggregates, 15% filler and 5% bitumen was used for mixture. Marshall stability test was carried out to find out the Marshall properties of the bituminous concrete mixtures. The stability values for HDPE were higher than the values of LDPE.

Keywords: *Assessment; Engineering properties, Asphaltic concrete, modified, plastic wastes.*

INTRODUCTION

Owing to the rapid economic growth and continuously increased consumption, a large amount of waste material is generated (Wu et al, 2003). The vast quantities of waste (such as scrap tires, glass, blast furnace slag, steel slag, plastics, construction and demolition wastes) accumulating in stockpiles and landfills throughout the world are causing disposal problems that are both financially and environmentally expensive. Dealing with the growing problem of disposal of these materials is an issue that requires coordination and commitment by all parties involved. One solution to a portion of the waste disposal problem is to recycle and use these materials in the construction of highways (Arnold et al,2008).

The use of waste ,materials (recycline) in the construction of pavement has benefits in not only reducing the amount of waste materials requiring disposal but can also reduce construction costs. The use of these materials can actually provide value to what was once a costly disposal problem (Jony et al,2011).

The addition of waste plastics to highway materials has become a feasible option for not only improving the physical properties of asphalt mixtures but also for being a safe method of disposal of the waste material. Despite the larger number of polymeric products, relatively few are suitable for modification of asphalt cement and are also compatible with it. Polymers used for asphalt modification can be grouped into three main categories: thermoplastic elastomers, plastomers, and reactive polymers. Thermoplastic elastomers are obviously able to confer good elastic properties on the modified binder; while plastomers and reactive polymers are added to improve rigidity and reduce deformations under load. (Afroz and Prasad, 2012).

AIMS AND OBJECTIVES

a) Aim

The aim of this research is to assess the engineering properties of asphaltic concrete modified with plastic wastes.

b) Objectives

I. To study the engineering properties of plastic modified bitumen (PMB).

II. To compare the effect of High Density Polyethylene (HDPE) and Low Density Polyethylene (LDPE) on the standard engineering properties of bitumen.
III. To study the Marshall properties of plastic modified bituminous concrete mixture (PMBCM).

MATERIALS AND METHOD

This chapter highlights the materials and the methods employed in this research including laboratory tests on aggregates, plain bitumen and bituminous concrete. It explains the procedures used to archieve the objectives of the research.

MATERIALS

Two categories of the plastic wastes were utilized in the research namely; High Density Polyethylene (HDPE) which include shampoo bottles and bleach bottles and Low Density Polyethylene (LDPE) which include plastic water bottles and waste bin bags. The shampoo bottles were gotten from the beauty saloon in Landmark University campus and in Omu-Aran town. The plastic waste water bottles were sourced from the halls of residence and the cafeteria within the University Campus. The waste bin bags were collected from landmark university waste disposal site. The fine aggregates, coarse aggregates and the filler were obtained from a construction site. In landmark university. The binder (bitumen) with penetration grade of 40/50 use for this research was gotten from the highway and geotechnical engineering laboratory of landmark university.

METHOD

In this research, bitumen of penetration grade 40/50 was used for the production of all test specimens after a penetration test was carried. Other standard laboratory test for physical properties such as, ductility, softening point, and specific gravity for this bitumen grade were conducted in the highways and geotechnical engineering laboratory of landmark university. Laboratory tests on fresh aggregates such as particle size analysis, aggregate crushing test, aggregate impact test, abrasion test and specific gravity test were carried out on the coarse aggregate (1/2inch and 3/8 inch) fine aggregates used.

Aggregates

The aggregate used for this research and their specification are presented in Table 3, 1

Table 3.1: Aggregate specifications

Types of aggregate	Particle size (inchea)	Particle size (mm)
COARSE	½	13.2
	3/8	9.5
FINE		0.6
FILLER		% passing no. 200 and retained on the pan

Aggregates properties

Laboratory tests have been conducted to evaluate the physical properties of used aggregates. Gradation tests were conducted to determine the physical properties the size distribution for each aggregate type.

Particle Size Analysis

Particle size analysis was carried out to determine the particle size distribution of the course and the fine aggregate. This test was performed in accordance to ASTM C136-06 determine the proportion of different particle sizes passing each of the sieves. The apparatus used for this test are weighing balance, set sieves, cleaning brush and the sieve shaker. The following procedure was use, the weight balance, set of sieve as well as the bottom pan to use in the analysis ere recorded. The aggregate sample was weight, the sieve was weighed, and sieves were assembled in an ascending order of the sieve numbers. The pan was placed below the on. 200mm sieve. Carefully the aggregate was poured into the top sieve and covered with a cap; the sieve stack was placed in the mechanical shaker for 10minutes. The stack was removed and was carefully weight and the weight of the each sieve with its retained aggregate was recorded. The gradation test for the coarse aggregation and fine aggregate has the results presented below in chapter four.

Aggregate Impact Value

The aim of this test is to assess the sustainability of aggregate as regards the toughness for use in pavement constitution. The major advantage of aggregate impact test is that test equipment and the test procedure are quite simple and it determines the resistance to impact of stones simulating field condition. The test can be performed in a short time even at construction site or at stone quarry, as the apparatus is simple and portable. Apparatus used for this test include mould, compaction hammer and sieve. Procedures used include the following, Aggregate passing through 12.5mm IS sieve was retained of 10mm sieve and filled in the cylindrical measure (W_1). Sample was transferred from the cylindrical measure to the cup of aggregate impact testing machine and tamped 25 times. The hammer was raised to height of 38cm above the upper surface of the of the aggregates in the cup and was allowed to fall freely on the specimen. After subjecting the test specimen to 25blows, the crushed aggregate is sieved through 2.36mm sieve. The fraction passing through IS 2.36mm sieve (W_2) was weighed. The results are presented in chapter four of this study.

Los Angeles Abrasion Test

This test is carried out to determine the suitability of different aggregation size. It is resistance to wear or hardness of aggregate. IT is significant because road aggregate at the top are subjected to wearing action. Apparatus used for the test include oven, sieve, weigh balance and abrasion test machine. Aggregate was dried in oven at 105-110$^0{}_c$ to constant weight conforming to any one of the grading. Aggregate weighting 5kg or 10kg was placed in cylinder of the machine (W_1 gms). Machine was rotated at 30=33rpm for 500 revolutions, machine was sropped and completes the taken out including dust. IT was sieved through 1.7mm sieve. Weight passing was determined by washing thee portion retained, oven drying and weight (W_2 gms), aggregate abrasion value is determined. The results are presented in chapter four this study.

Aggregate Crushing Test

Aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load. Aggregate are subject to high stress during rolling and sever abrasion under traffic. This test was carried out to determine the crushing value of the Aggregate. Compression machine, sieve and weight balance were the apparatus used. Surface dry aggregates passing 12.5mm and retained on 10mm were selected 3.25kg aggregate was required for one test sample. Cylindrical measure was filled with aggregate in 3 layers, tamping each layer 025 times. After leveling the aggregate at the top surface the test sample was weighed. The cylinder was placed on the base plate. The cylinder with the test sample and plunger in position was placed on the compression machine. Load was applied at rate of 4 tonners per minute up to 40 tonners. The crushed aggregate was taken out, sieved through 3.36mm IS sieve and weighed to get material passing. Aggregate crushing value was determined. The results are presented in chapter four of this study.

Specific Gravity test

Specific gravity is the ration of the mass of unit volume of aggregate to the mass of the same volume of gas free distilled water at a stated temperature. Specific gravity bottle, aggregate samples and analytical balance were used for the test. The results of this test are presented in chapter four.

Melting and Modification Process

The LDPE and the HDPE were melted into separate containers. For the LDPE plastic, the water bott7les and waste bin gages were shredded to small pieces and heated and the same process was done for the HDPE (Shampoo bottles). Bitumen was weighed into each of the containers. The following proportions were used for the modification: 10% =200m1, 20%= 400m1, 30%= 6001, 40%= 800m1 and 50%= 100m1

Engineering properties of plastic modified bitumen

Laboratory tests were conducted on all the bitumen samples, including the plain bitumen and the modified bitumen. The results obtained were used to comparatively evaluate their engineering properties and the procedures are explained below.

Bitumen penetration test

The penetration test was used to determine the hardness and softness of bitumen. The bitumen grade is specific in terms of the penetrative value. Apparatus used for this test are 15mm container, water bath, a needle and the automatic penetrometer. This test was done for both the normal bitumen and the modified bitumen in their different percentages. The bitumen was heated to softening point +90 $^{0}{}_{c}$ and poured into a container of about 15mm above the expected penetration. All the sample container were placed to cool in atmospheric temperature for 1 hour. Then the sample container were placed in temperature controlled water bath at temperature 25 $^{0}{}_{c}$ 1 $^{0}{}_{c}$ for a period of 1hour. The transfer dish was filled with water completely to cover the container. The sample containers were removed and placed under the middle of the pentrometer. The needle was adjusted to make a contact with the surface of sample. The initial reading was taken from the diaguage and the needle was released for 5 seconds. This was done three different points on each sample at right angle to each other, then the average was taken. All the reading were recoded, and the difference between the initial and final reading was taken as the penetration value in 1/10th results are presented in chapter four of this study.

Ductility Test

The binder material of low ductility would crack and thus provide pavement surface. The ductility of bitumen improves the physical interlocking of the aggregate bitumen mixes. The test was believed to measure the adhesive property of bitumen and its ability to stretch. Ductility and penetrating go together, in general, but exception can happen. Ductility is the distance in cm to which a standard briquette of bitumen can be stretched before the thread breaks. Ductile materials are ones which elongates when held in tension. The following apparatus were used for the test mould, brass plate and water bath and ductility machine. The bitumen sample was heated to temperature 0f 75$^{0}{}_{c}$ to 100$^{0}{}_{c}$ above the approximate softening point until was fluid. It was poured in a mould assembly and placed on brass plate, after a solution of glycerine was applied overt all surface of the mould exposed to bitumen. Third to fourth minute after the sample was poured into mould, the plate assembly along with the sample was placed in water bath maintained at 27$^{0}{}_{c}$ for 30minutes. The sample and mould assembly were removed from water bath and excess bitumen material is cut off by leveling the surface using hot knife. After trimming the specimen, the mould assembly containing the sample was replaced in water bath maintained at 27$^{0}{}_{c}$ for 89 to 90 minutes. The slide of the mould was then removed and the clips were carefully hooked on the machine without causing any initial strain. The pointer was set to read zore. The machine started and the two clips were thus pulled apart horizontally, while the test was in operation, it was checked whether the sample was immersed in water up to a depth of at least 10mm. The distance at which the bitumen thread break was recorded (in cm) and reported as ductility value. This test was performed on both the normal bitumen and all the modified bitumen,. The results are presented in chapter four of this study.

Softening Point Test

Bitumen does not melt, but change gradually from solid to liquid. Softening point is the temperature at which the bitumen attains particular degree of softening under special tests conditions. Ring and ball apparatus was used for the test. The bitumen was head to a temperature between $125^{0}{}_{c}$ to $_{150}{}^{0}{}_{c.}$ The rings were heated at the same temperature on a hot plate and place on glass plate coated with glycerin. The rings were filed up with bitumen. It was cooled for 30 minutes in air and the surface was leveled with a hot knife. The rings were set in the assembly and placed in the bath containing distilled were at $50^{0}{}_{c}$ and maintained for 15 minutes till the ball passed through the rings. The temperate at which each of the balls and sample touches the bottom plate of the support was noted. Temperature was recoreded as the softening points of the bitumen. This test was carried out on both the normal bitumen and all the modified bitumen. The results are in chapter four of this study.

Asphalt Mix Process

The asphalt mixture materials were weighed according to the mix designed, including the coarse aggregate, fine aggregate, filler and the bitumen. The coarse aggregate as heated to a temperature of $160\text{-}180^{0}{}_{c.}$ The mixture of the aggregate, filler and the bitumen was done in a head pan. It was mixed probably and the compaction mould was assembled by placing the loading and filter paper. The asphalt mixed was poured into the and compacted in three layers given 25blows each, the asphalt was removed after well compacted and place into the water bath. This was done for all the bitumen samples and the mix design is shown in table

Table 3.2: Asphalt Mix Proportion

Material	Percentage (%)
Coarse Aggregates	56
Fine Aggregates	24
Filler	15
Bitumen	5
Total	100

MARSHALL PROPERTIES OF ASPHALTIC CONCRETE

Marshall Stability and Flow of Asphaltic Concrete

This test was carried the laboratory using a testing machine producing a uniform vertical movement of 50.8mm per minute (2 in /min), breaking heads having an inside radius of curvature of 2-in, ring dynamometer; flow meter, bath, and hand gloves. The compacted asphalt was brought to a temperature to 60 ^{0}c by immersing it in a water bath 30 to 40 minutes. The specimen was remove from the water bath, dried and placed on the lower segment of the breaking head. The upper segment of the breaking head was place on the specimen and the testing machine was completely assemble assembled in position. The flow meter was adjusted to zero while holding the sleeve firmly against the upper segment of the breaking head. The load was applied to the specimen by means of the constant rate of movement of 2 in/min until the maximum load was reached and the load decreased. The elapse time for the test, from the removal of the test specimen from the water bath t the maximum load determination didn't exceed 40 seconds. The Marshall stability and the Marshall flow were recorded. The results are presented in chapter four of this study.

Bulk Density:

This test was done immediately after the Marshall Stability and flow test. Apparatus' and material used include the asphaltic concrete mixture, buckets of water and a spring attached to the weighing balance. Each of the specimens were placed on the spring on air to weight in air, on the same spring the specimen were placed in a bucket of water to get weight in water. The weight in air and the weight in air was recorded to calculate the bulk density, the results for all the samples are shown in chapter four of this study.

RESULTS AND DISCUSSION

Particle Size Analysis

Table 4.1 shows the particle size for coarse aggregate and fig 4.1 shows the particle size distribution cure for coarse aggregate. While Table 4.2 shows the particle size for from aggregate and Fig 4.2 shows the particle size distribution curve for fine aggregate

Table 4.1: Particle size Distribution for Coarse Aggregates

Sieve no (#)	Sieve size (mm)	Weight aggregate retained on each sieve (g)	% retained on each sieve	Cumulative % retained on each sieve	Cumulative % passing
3/4	19	0	0	0	100
1/2	12.7	526	28.56	28.56	71.44
3/8	9.52	3 75	20.36	48.92	51.08
4	4.75	155	8.41	57.33	42.67
10	2.00	234	12.70	70.03	29.97
16	1.18	95	5.16	75.19	24.81
30	0.6	175	9.50	84.69	15.31
40	0.425	181	9.83	94.52	5.48
50	0.3	44.5	2.42	96.94	3.06
100	0.15	33.5	1.82	98.76	1.24

Table 4.1: Particle size Distribution for Fine Aggregates

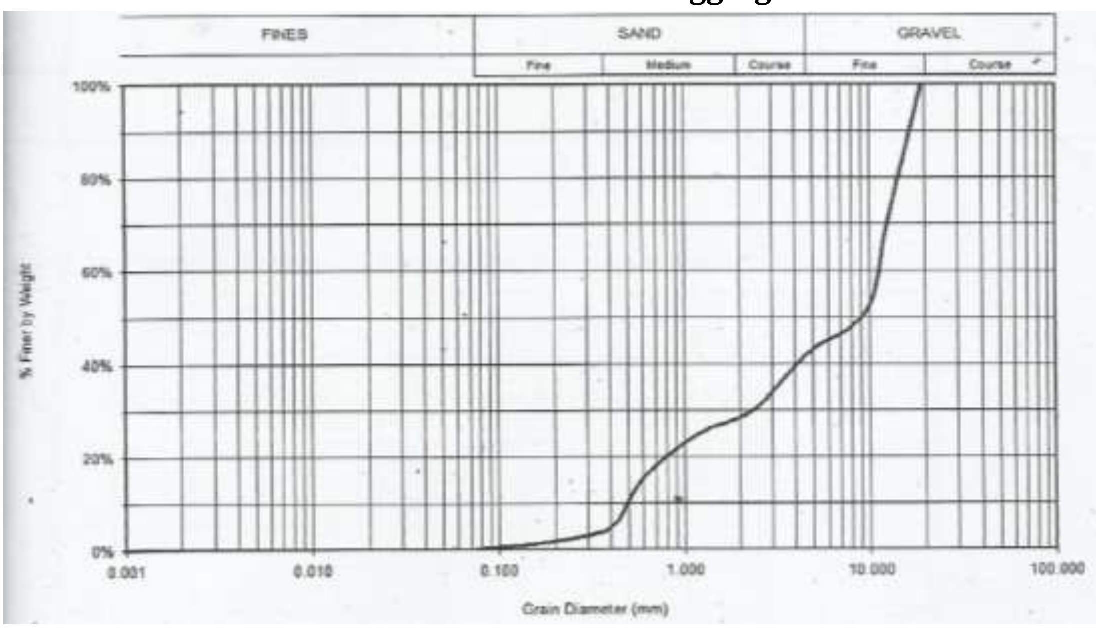
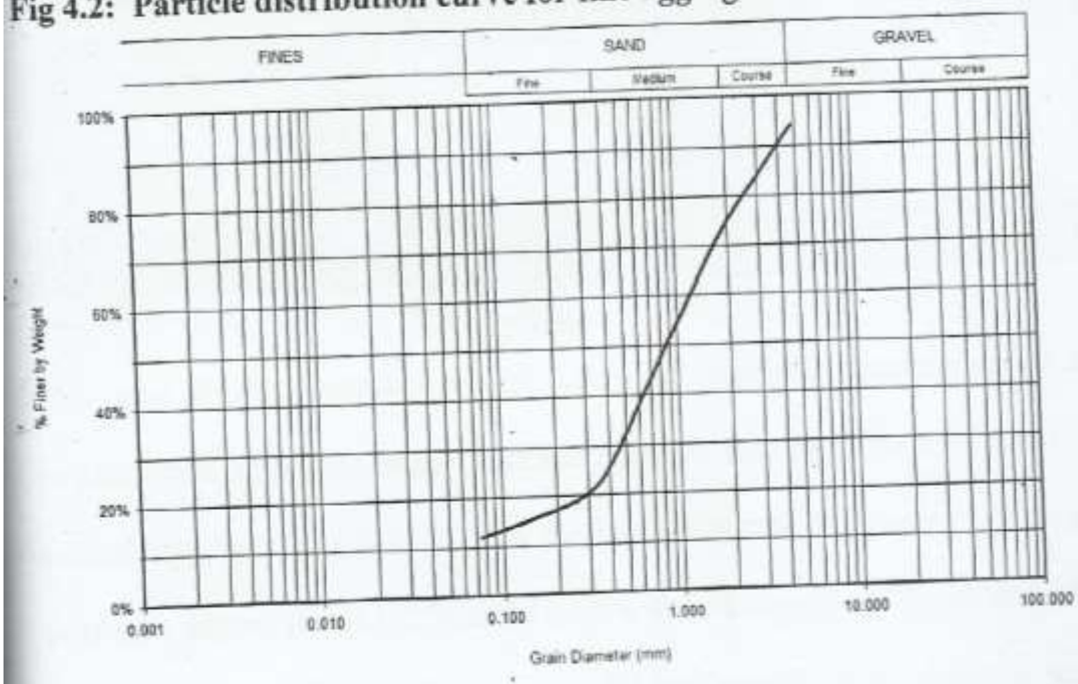


Table 4.2: Particle size distribution for fine aggregates

Sieve no (#)	Sieve size (mm)	Weight aggregate retained on each sieve (g)	% retained on each sieve	Cumulative % retained on each sieve	Cumulative % passing
4	4.75	120	5.70	570	94.30
10	2.00	410	19.46	25.16	74.84
16	1.18	320.5	15.21	40.37	59.63
30	0.6	450.9	21.40	61.77	38.23
40	0.425	230	10.92	72.69	27.31
50	0.3	150	7.12	79.81	20.19
100	0.15	95.1	4.51	84.32	15.68
200	0.075	80.5	3.82	88.14	11.86
-	Pan	250	11.86	100	0

Fig 4.2: Particle distribution curve for fine aggregate



The results of particle size analysis carried out on coarse aggregate shows that the material is fairly graded while the particle size carried out on aggregate shows that the material is well graded from their various gradation curves.

Table 4.3: Aggregate Characterization

Properties	1/2 coarse aggregate (%)	3/8 coarse aggregate (%)	Fine aggregate	Filler
Aggregate impact value test (AIV) W_2/W_1	15.35	19.15		
Aggregate crushing value test (ACV) W_2/W_1	15.00	15.30		
Los Angeles Abrasion test	16.40	17.00		
Specific gravity	2.8	2.8	2.4	2.5

This table shows the values for the following aggregate characterization such as aggregate cruising test, aggregate impact test and abrasion test. Both the 15% and the 15.30% did not exceed standard IS: 2386 of 30% for surface course for the aggregate crushing test. For aggregate impact test, 15.35% and 19.15% was obtained for ½ and 3/8inch respectively using BS 812-112:19900. Both values did not exceed 30% is maximum value for bituminous wearing surfaces. For Abrasion test, 16.40% and 17% was obtained and it corresponds with the standard specification. The specific gravity for coarse aggregate, fine aggregate and filler using ASTM C127-12 are 2.8 2.4 respectively. The aggregate used passed all the tests, therefore the aggregate are strong good for using in asphalt.

EFFECT OF HDPE AND LDPE ON THE STANDARD ANGINEERING PROPERTIES OF BITUMEN

PENETRATION TEST RESULT

Results for the penetration test for both plain bitumen and modified bitumen with LDPE and HDPE as discussion in chapter three are as follows. Table 4.4

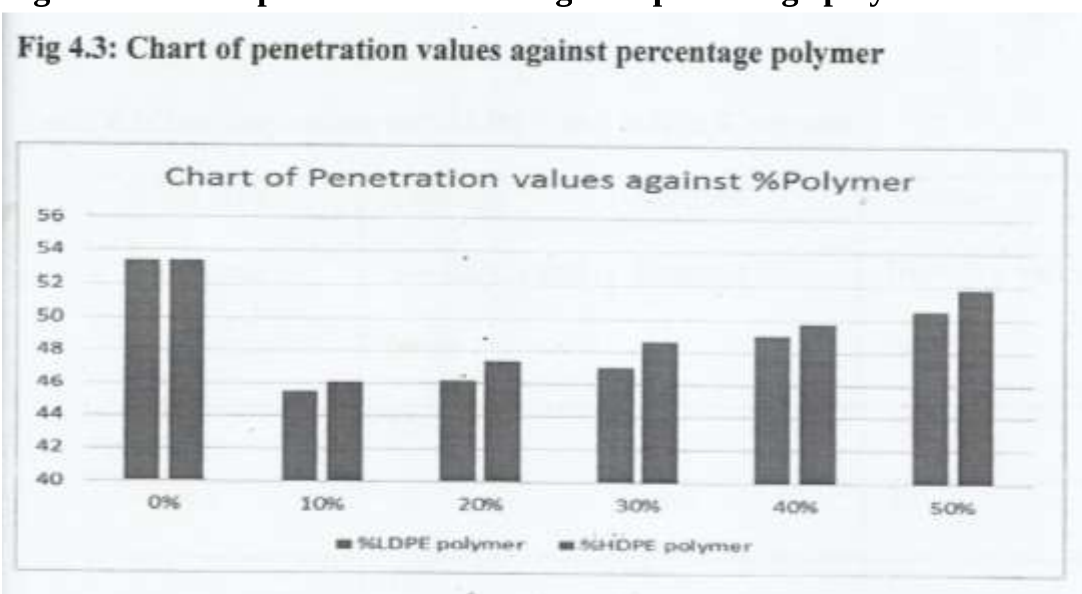
shows the penetration values for)% polymer modified bitumen and 10% to 50% of bitumen modified with LDPE and HDPE,

Fig 4.3 shows the chart of penetration value against% LDPE and % HDPE POLYMER.

Table 4.4: Penetration value for % LDPE polymer

% LDPE POLYMER	Mean Penetration Value (mm)	% HDPE Polymer	Mean Penetration Value (mm)
0%	53.41	0%	53.41
10%	45.5	10%	46.10
20%	46.2	20%	47.4
30%	47	30%	48.6
40%	49.0	40%	49.7
50%	50.50	50%	51.8

Fig 4.3: Chart of penetration values against percentage polymer



For LDPE the penetration for 0% which is the plain bitumen was 53.40mm while 10% 45.50mm, 20% - 46.20mm, 30% - 49.00mm and 50% -50.50mm. while for HDPE the penetration for 0% which is the plain bitumen was 53.40mm while 10% - 46.10mm, 20% - 47.40mm, 30% - 48.6mm, 40% -49.

70mm and 50% - 51.80mm.It was observed that the penetration value was at 50%, therefore the higher percentage polymer added the lower penetration.

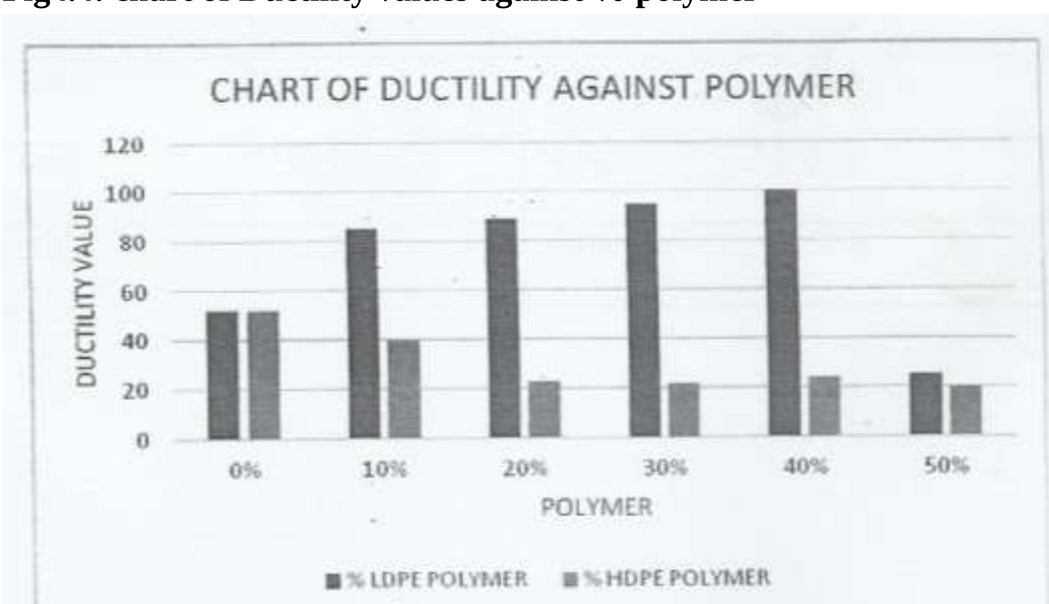
Ductility Test Result

Ductility tests for non-modified and modified bitumen with LDPE and HDPE as discussed in chapter three are as follows. Table 4.5 show the ductility values for LDPE modified bitumen and HDPE modified bitumen. Fig 4.4 shows the chart of ductility against% LDPE and %HDPE polymer.

Table 4.5: Ductility values for %LDPE and %HDPE polymer

%LDPE Polymer	Average Ductility value (mm)	%HDPE Polymer	Average Ductility value (mm)
0%	52	0%	52
10%	85	10%	40
20%	89	20%	23
30%	95	30%	22
40%	100	40%	24
50%	25	50%	20

Fig4.4: chart of Ductility values against % polymer



From the chart above , the ductility of the bitumen increased as result of the LDPE polymer added. 0% (plain bitumen) could stretch to just 52mm while 40% was able to stretch to its maximum. While there was low ability for the bitumen to stretch for long for HDPE modified bitumen.

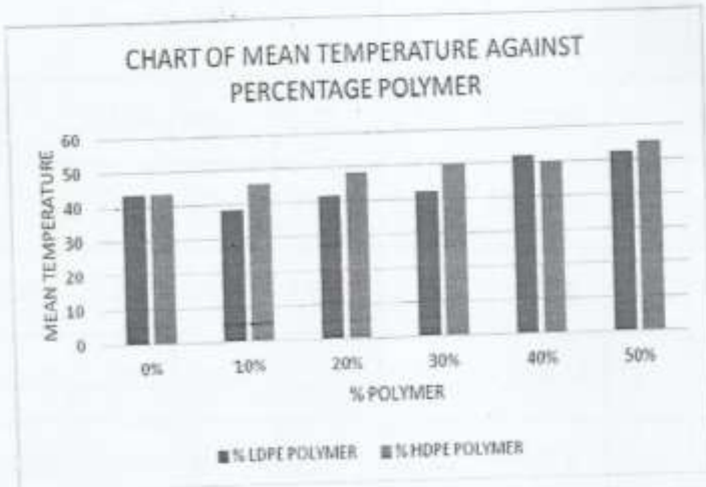
4.2.3 Softening Point Result

As discussed in chapter three the test results are shown in the table below. Table 4.6 shows the temperature values for LDPE and HDPE modified bitumen. Fig 4.5 shows the chart of mean temperature values against % LDPE polymer and % HDPE polymer.

Table 4.6: Temperature values for %LDPE and %HDPE polymer

%LDPE Polymer	Mean Temperature ($^{o}{}_{c}$)	%HDPE Polymer	Mean Temperature ($^{o}{}_{c}$)
0%	43.4	0%	43.4
10%	38.2	10%	45.5
20%	41.6	20%	48.5
30%	42.1	30%	49.8
40%	51.9	40%	50.1
50%	52.2	50%	55.5

Fig 4.5: Chart of temperature values against %polymer



Using test method ASTM D70 the specific gravity for the bitumen was gotten to be 1.04

4.3 MARSHALL PROPERTIES OF BITUMINOUS CONCRETE MIXTURES

The Marshall properties obtained from the asphaltic concrete include stability, flow, the volume of the bitumen (V_b), air void, VFB, VMA and the density. Tables below shows the properties for both the LDPE polymer modified bituminous concrete mixtures and HDPE polymer bituminous concrete mixtures.

Table 4.7: Marshall Properties for LDPE polymer

% Polymer	PMB	Weight in air (g)	Weight in water (g)	Density g/cm^3	Vol of bitumen (V_b)	Stability (Kg)	Flow (mm)	Vv (%)	VMA	VFB (%)
0	-	1160.8	680.4	2.42	0.15	1422.45	10	0.82	0.97	15.46
10	LDPE	1500.2	945.5	2.7	0.16	1814.85	8	10.65	10.81	1.48
20	LDPE	1140.6	670.2	2.42	0.15	1373.4	11.08	0.82	0.97	15.46
30	LDPE	1318.3	710.9	2.17	0.13	2099.34	13	11	11.13	1.17
40	LDPE	1240.9	705.5	2.32	0.14	1569.6	11.8	4.91	5.05	2.77
50	LDPE	1440.6	680.4	1.89	0.12	1471.5	13	22.54	22.66	0.53

Table 4.8: Marshall Properties for HDPE polymer

% Polymer	PMB	Weight in air (g)	Weight in water (g)	Density g/cm^3	Vol of bitumen (V_b)	Stability (Kg)	Flow (mm)	Vv (%)	VMA	VFB (%)
0	-	1400.1	920.2	2.92	0.18	1765.8.	14	19.67	19.85	0.91
10	HDPE	1702.4	1009.8	2.46	0.15	2648.7	13	0.82	0.97	15.46
20	HDPE	1204.3	714.5	2.46	0.15	2109.15	9	0.82	0.97	15.46
30	HDPE	1200.8	610.4	2.03	0.12	2403.45	13.2	16.8	16.92	0.71
40	HDPE	1820.6	1150	2.71	0.16	3041.1	13.2	11.06	11.22	1.43
50	HDPE	1950.7	1120.8	2.35	0.14	3090.15	15	3.69	3.83	3.65

The stability values obtained using 10%, 20%, 30%, 40% and 50% of LDPE were 1814.85, 1373.4, 2099.34, 1569.6 and 1471.5kg with flow values of 8, 11.08, 13, 11.80 and 13mm respectively. While the stability values obtained for HDPE were 2648.7, 2109.15, 2403.45, 3041.1 and 3090.15kg with flow values of 13, 9, 13.2, 13.2 and 15mm respectively. The stability values for both LDPE and HDPE passed the minimum values for light traffic 340kg, medium 544kg and heavy traffic 815kg as specified by Asphalt Institute.

$$Gt = \frac{W1+W2+W3+Wb}{\frac{W1}{G1}+\frac{W2}{G2}+\frac{W3}{G3}+\frac{Wb}{Gb}}$$

where, Gt is the specific gravity of the asphalt mix, W1 is the weight of coarse aggregate in the total mix, W2 is the weight of fine aggregate in the total mix, W3 is the weight of filler in the total mix, Wb is the weight of bitumen in the total mix, G1 is the apparent specific gravity of coarse aggregate, G2 is the apparent specific gravity of fine aggregate, G3 is the apparent specific gravity of filler and Gb is the apparent specific gravity of bitumen.

Bulk density $Gm = \frac{Wm}{Wm-Ww}$

Where, Wm is the weight of mix in air, Ww is the weight of mix in water.

Air Void $Vv = \frac{Gt-Gm*100}{Gt}$

% Volume of bitumen $Vb = \frac{\frac{Wb}{Gb}}{\frac{W1+W2+W3+Wb}{Gm}}$

Voids in minerals VMA $= Vv + Vb$

Voids filled with bitumen VFB $= \frac{Vb*100}{VMA}$

Conclusion and Recommendation

Conclusion

The main objectives of this study were to study the engineering properties of plastic modified bitumen compare the effect of Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE) on the standard engineering properties of bitumen and to study the Marshall properties of plastic modified bituminous concrete mixture (PMBCM).

From this research the modification of Low Density and High Density Polyethylene affects the standard engineering properties of bitumen. This was observed from the penetration test carried out that the penetration values for the modified bitumen are lower than the values for the normal bitumen. The penetration values for LDPE are lower than that of the HDPE, this implies that there is less penetration on HDPE compare to LOPE. The penetration value for the plain bitumen was 53.40mm which got reduced to 45.5, 46.2, 47, 49.0, 50.5at different proportions of 10%, 20%, 30%, 40% and 50% respectively. While HDPE reduced from 53.40mm to 46.1, 47.4, 48.6, 49.7, 51.8 at different proportions of 10%, 20%, 30%, 40% and 50%respectively. Ductility test results was affected after the addition of LOPE and HOPE. Using ATM D113 it was observed that the ductility value was higher on the LOPE modified bitumen compare to HDPE modified bitumen. The plain bitumen ductility value was gotten to be 52mm it increased with the addition of LOPE to 85, 89, 95, 100 at 1Oo/o 20% 30% and 40% respectively while it reduced at 50% to 25m.m. It decreased when HDPE was added from 52mm to 40 23, 22, 24 and 20 at 10% 20%, 30%, 40% and 50% respectively. It was observed that there was increase in temperature for the softening point test for both LDPE and HDPE, using ASTM D-36, LOPE increased from 10% to 50%, while HDPE had its increase from 10%-50% with 45.5 48.5,42.8 *50.1* and 55.5^{0}C respectively.

The Marshall properties of plastic modified bituminous concrete mixture (PMBCM) were determined from the results of the'Marshall Stability test. The properties that were tested for include stability, flow, density, VMA, VFB and air void. It was observed that the stability was higher on HDPE modified bituminous conretete compare to the LDPE modified bituminous concrete. This implies that both LDPE and HDPE polymer can be used as a suitable material for modifying bitumen in bituminous concrete mixture, both polymers can be used for low traffic medium traffic and heavy traffic roads. The flow values were within the range of 8-14 according to Asphalt Institute for heavy traffic at 7Sblows except for 50% which gave 15mm. The lower the flow the higher the mixture to resistance deformation.

RECOMMENDATIONS

From this study, I recommend that other modifiers should be used on asphalt binder by other researchers to compare plastic modified bitumen with other modifiers. I also recommend that much proportions should be tested on for any modifier used, so this will enable researchers to get the best proportion before recommending for use. I recommend both LOPE and HOPE should be used as modifiers in bitumen that will be used for road constructions, thereby red ucing the plastic wastes disposed to the environment.

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