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Optimization of Palm Oil Fiber Ash in Asphalt Mixture.

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ABSTRACT

Road Pavements have deteriorated more rapidly in recent years as a result of increase in traffic volume. To reduce deterioration and increase durability of a flexible pavement, asphalt layers should be improved upon. The performance properties such as wear, fatique, resistance to permanent deformation, striping and aging must be enhanced. Palm Oil Fiber Ash material shows good potentials to be used as filler in asphalt mixture. Intensive literatures reviewed shows that most of research work deals with the use of Palm Oil Fibre Ash (POFA) in concrete production and limited as pavement material. Therefore, in this study, the performance characteristics of Asphalt mixture with addition of palm oil fiber was investigated. POFA was used as filler material passing 0.009mm into a mixture design ACW20 with varied amount 0% 2.5% 5% 7.5% and 10% by weight of total aggregate and bitumen content 6.1%. The specific gravity properties of each amount of POFA were assessed by marshal volumetric properties. The materials were analyzed using Marshall Stability test. The laboratory results showed that asphalt mixture was improved upon with certain amount of POFA. The maximum performance of Palm oil fiber ash was recorded at 5% which indicated that POFA is a material that shows a good potential to be used as filler in asphalt mixture for better performance and reduction in cost of construction.

KEYWORDS: Aggregates, Asphalt, Bitumen, Fillers, Palm Oil Fibre Ash, Marshall Test.

I. ntroduction

Nigeria is richly endowed with large deposit of natural bitumen in in places like Ilubirin, loda and Agbadu in Ondo state. These areas have been reportedly proven to have reserve of about 42.47 billion tonnes of bitumen which is estimated to be the second largest in the world. Also, Nigeria is blessed with large area of expansion and higher yields palm oil tree. Oil palm industry contributes significantly to the economy of the country. Palm oil fiber is a waste produced at large quantities during extraction of palm oil in the palm mills. Palm oil fiber ash (POFA) is a waste material in the form of ash from burning palm oil fiber. In the palm oil producing countries such as Indonesia, Malaysia, Thailand and Nigeria, the waste derived from the palm oil extraction poses negative environmental impacts. Recycling and the use of oil palm fiber for construction purposes can help to solve problems of wastage and disposal. The use also helps in waste management and reduce the pollution to the environment. Maurer (2016) showed that fibers play a better role in reducing the asphalt subsidence than polymer additives.

2.0 Literature review

Road structures faces deterioration frequently in recent years because of the incremental change in traffic volume, loading and proof maintenance. To reduce or minimize this problem and increase the durability of a flexible pavement, asphalt layers must be improved. Performance properties, such as resistance to permanent deformation, wear, fatigue, striping and aging must be improved upon.

Different types of fibres have been utilized as fillers in asphalt mixes. The fibres were added to improve the properties of the mix. Several types of fibres that were used in asphalt mixture are glass fibre, polyester fibre, cellulous fibre, and mineral fibre (Mahrez, et al., 2010).

Tapkin (2015) revealed that asphalt samples reinforced with polypropylene fibres produced with optimum bitumen content (O.B.C) demonstrated a higher Marshall stability and fatigue resistance while their fluidity and reflective cracks decreased.

Ahmed et al., (2010) conducted a research and used a single axial compression test to check palm oil fibre in palm silty sands. Fibres were coated into acrylic styrene butadiene. The results gotten showed that the use of coated fibres increases the shear strength. Reinforcing the sands with 0.5% of coated fibres at length of 30 mm causes a 25% increase to friction angles and a 35% increases to adhesion.

Some Studies have also shown that fibers have a higher tensile strength than bitumen. It was reported that, fibers have the potential to increase the tensile properties of the bitumen and substantially increase the system cohesion (Zhao, 2016, Boukhattem et al. 2018).

The stability property of asphalt in the atmosphere helps to resist ageing in a comprehensive climate of heat, sunlight and atmosphere for a long time. Low molecular groups will be converted into polymeric groups in the atmosphere comprehensive setting, and the resin will turn into ground asphaltene at a much faster rate than the oil composition into the resin. The oil composition content rises, plasticity, reducing asphalt fluidity and cohesion while increasing hardness and brittleness.

3.0 Methodology

3.1 The materials used for the study are:

1. Coarse aggregate

2. Fine aggregate

3. Bitumen (binder)

4. River sand (filler material)

5. Stone dust

6. Palm Oil Fiber Ash (POFA).

3.2 Asphalt properties

I. Coarse aggregates: Coarse aggregates (Granite) used consists of stone chips sourced from a local supplier with size up to 12.50mm IS sieve size.

ii. Fine aggregates: Fine aggregates of size 3.35 mm and retained on 0.075 mm IS sieve was used. It helps to stiffens the binder and fills the voids in the coarse aggregate.

iii. Filler: Fillers are aggregate passing through 0.075 mm IS sieve. Stone dust was used as filler. It helps to fills the voids and stiffens the binder.

iv. Binder: Binder was used to fill the voids, cause particle adhesion and gluing of all the materials together.

3.3 Aggregate Crushing Value Test

Aggregate crushing value test was conducted to determine the percentage aggregate crushed by applying compressive load. A standard size of aggregate was used i.e. aggregate passing 14mm and retained on 10mm sieve size.

3.4 Preparation of Palm Oil Fiber Ash modified Bitumen.

High-shear mixer was used to prepare a modified bitumen. Firstly, the bitumen was heated until it became a well-melting fluid at approximate temperature of 160ºC in an iron container. The Palm Oil Fiber Ash was then added into the bitumen at 0% as control, 2.5%, 5%, 7.5%, and10%. The mixture was blended at 800rpm for 60mins to ensure that there is uniform dispersion of the POFA. The neat bitumen was used as the controlled sample.

3.5 Preparation of Test Specimens

The coarse aggregate, fine aggregate and the filler materials were proportioned. The required quantity of the mix was taken to produce compacted bituminous mix specimens of thickness 63.5 mm. 1200 g of aggregates and filler are required to produce the desired thickness. Three sample specimen were prepared for each percentage of bitumen. The aggregates were heated to a temperature of about 175° to 190°C. Compaction moulds were assembled, cleaned and kept pre-heated to a temperature of 100°C to 145°C. The bitumen was then heated to a temperature of 121°C to 138°C. The required amount of first trial of bitumen is added to the heated aggregate and thoroughly mixed. The mix was placed in a mould and compacted with 75 numbers of blows at both side of the specimen as specified. After The sample was taken out of the mould after few minutes using sample extractor.

3.6 Marshall Stability and Flow Test ASTM D1559 (ASTM, 2001).

Marshall Test was carried out to determine Optimum Bitumen Content in ACW20 design. It can also determine the maximum content level of Palm oil fiber ash as filler in asphalt pavement. In conducting the stability test, the specimen was immersed in a bath of water at a temperature of 60° ± 1°C for a period of 45 minutes. After that, it was placed in the Marshall Stability testing machine and loaded at a constant rate of deformation of 5mm per minute until failure. The total maximum load in KN (that causes failure of the specimen) was taken as Marshall Stability. The stability values obtained were corrected for volume. The total amount of deformation is units of 0.25 mm that occurs at maximum load was recorded as Flow Value.

Figure1: Manual and Mechanical Marshal Compactor

4.0 Result

Table1. Aggregate Gradation

Aggregate	%
Coarse aggregate 1/2″ (passing sieve 12.5 mm)	23%
Coarse aggregate 3/8″ (passing 10mm)	12%
Stone dust	43%
River sand	22%
Total	100%

Table2: Sieve Analysis Result and Blending of Aggregate

GRADATION OF MATERIAL AND COMBINED GRADATION FOR WAERING COURSE												
Sample At.									Date. 06/05/2022			
Determination of combined grading 0 - 12.5mm												
Type	Size (mm)	75 (µm)	150 (µm)	300 (µm)	600 (µm)	1.18 (mm)	2.36 (mm)	4.75 (mm)	9.50 (mm)	12.50 (mm)	19.00 (mm)	25.00 (mm)
Crushed Stone	**1/2''**	0.0	0.0	0.0	0.1	0.1	0.1	11.3	30.5	49.7	100.0	100.0
Crushed Stone	**3/8''**	0.2	0.2	0.2	0.2	0.3	0.3	30.2	50.3	70.0	100.0	100.0
Stone Dust	**0 - 5**	11.5	20.4	31.0	44.3	63.3	73.3	85.4	95.5	100.0	100.0	100.0
River Sand	**0 - 5**	9.5	20.0	36.5	63.4	92.3	96.8	99.5	100.0	100.0	100.0	100.0
25.00												
Grain Size	**%**	75 (µm)	150 (µm)	300 (µm)	600 (µm)	1.18 (mm)	2.36 (mm)	4.75 (mm)	9.50 (mm)	12.50 (mm)	19.00 (mm)	25.00 (mm)
Crushed Stone	**23**	0.0	0.0	0.0	0.0	0.0	0.0	2.6	7.0	11.4	23.0	23.0
Crushed Stone	**12**	0.0	0.0	0.0	0.0	0.0	0.0	3.6	6.0	8.4	12.0	12.0

Stone Dust	**43**	4.9	8.8	13.3	19.0	27.2	31.5	36.7	41.1	43.0	43.0	43.0
River Sand	**22**	2.2	4.4	8.0	13.9	20.3	21.3	21.9	22.0	22.0	22.0	22.0
Total	**100.0**	**7.1**	**13.2**	**21.4**	**33.0**	**47.6**	**52.9**	**64.8**	**76.1**	**84.8**	**100.0**	**100.0**
		14.0	**24.0**	**30.0**	**40.0**	**51.0**	**65.0**	**82.0**	**92.0**	**100.0**		
		7.0	**13.0**	**18.0**	**26.0**	**36.0**	**50.0**	**65.0**	**75.0**	**85.0**	**100.0**	

Table 3: Aggregate Crushing Value.

Test	Test Method	Result Obtained
Aggregate crushing value test: M12.5mm	BS 812: Part 110: 1990	28.95

Table 4: Test Sample Material Used for Experiment.

Optimum Binder Content (%)	6.1				
POFA (%)	0	2.5	5	7.5	10
Coarse aggregate 1/2″ (passing sieve 12.5 mm) %	23	23	23	23	23
Coarse aggregate 3/8″ (passing 10mm) %	12	12	12	12	12
Stone dust (%)	43	43	43	43	43
River sand (%)	22	22	22	22	22
Total (%)	100	100	100	100	100

Table 5: Specific gravity values for each material

Material	Specification
Aggregate 12.5	2.661
Aggregate 10	3.024
Stone dust	2.472
River sand	2.641
POFA	2.22
Bitumen	1.016

Table 6: Marshall Test Table.

Samples 0%	A	B	C	Average
weight of specimens	1203.33	1200.42	1212.588	1205.446
weight in wet	685.32	690.65	686.41	687.46
Marshall stability	2.1	4.1	2.2	2.8
Marshall flow	3.8	2.25	4	3.35

Samples 2.5%	A	B	C	Average
weight of specimens	1197.07	1194.85	1197.18	1196.367
weight in wet	693.43	682.96	695.31	690.56
Marshall stability	3.25	2.7	4.5	3.483333
Marshall flow	3.45	2.451	4.1	3.333667

Samples 5%	A	B	C	Average
weight of specimens	1198.22	1197.87	1201.23	1199.107
weight in wet	689.15	688.82	689.22	689.06
Marshall stability	4.52	4.8	4.9	4.733333
Marshall flow	4.12	4.4	4.25	4.25

Samples 7.5%	A	B	C	Average
weight of specimens	1200.97	1203.29	1200.9	1201.72
weight in wet	689.72	689.51	688.04	689.09
Marshall stability	2.52	3	2.95	2.816667
Marshall flow	3.59	4	3.58	3.723333

Samples 10%	A	B	C	Average
weight of specimens	1200.19	1198.39	1198.29	1198.957
weight in wet	687.28	683.09	687.28	685.88
Marshall stability	3.14	3.51	3.77	3.606667
Marshall flow	3.87	4.91	5.05	4.61

Table 7: Test samples result of POFA

Samples	% of Binder (OBC)	6.1%				
	% POFA	Stability (KN) % > 3.5	Flow (0.25mm) 2 -4	VFB (%) 75 – 82	% Void in mix 3 – 5	Unit weight
CONTROL		6.1	3.17	77.10	3.91	6.8110
C1	0	2.1	3.82	81.13	3.49	6.8746
C2	2.5	3.2	3.45	80.90	3.06	6.9056
C3	5.0	4.5	4.14	81.67	4.04	6.8906
C4	7.5	2.5	3.59	86.28	1.56	6.8909
C5	10	3.1	3.87	71.39	5.35	6.8588

5.0 Conclusion

In this study, the effect of palm oil fibre on asphalt samples was investigated. The results showed that the asphalt mixture was improved upon with certain amount of POFA and showed that POFA have the good potential as alternative filler material in asphalt mix. And also the flow gradually decreased when the content of Palm oil fiber ash was increased. Addition of Palm oil fiber ash improves the stability of asphalt mixes. The maximum palm oil fiber ash (POFA) in ACW20 content was determined using 6.1% of bitumen and tested with Marshall Test. The results showed that the flow gradually decreased when the content of Palm oil fiber ash was increased. The most important value is stability. The stability for 0% POFA have the lowest marshal stability values followed by 2.5% and 5% have the highest Marshall Stability values followed by 7.5% and 10% respectively. The maximum performance of Palm oil fiber ash was recorded at 5% and using 6.1% bitumen content shows a stated mixture that fulfill the JKR/SPJ/1988. POFA helps to minimize the disposal of palm oil fiber and helps in management of palm oil fiber waste.

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