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Comparative Analysis of Effects of Filler Materials on Performance of Asphalt

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ABSTRACT - Undulations, rutting, depression, cracks, potholes and any other forms of distresses on Nigeria's flexible pavements roads were primarily due to high traffic volumes and increasing axle loads. Percentage of suitable materials and type of filler used during asphalt production usually help in solving this problem. In a bid to know the best suitable filler for this purpose, three main materials (i.e. hydrated lime, fly ash and stone dust) were taken to laboratory and some tests were conducted on them. Results showed that the fly ash has good stability at 5% Bitumen content and 10% mineral filler, minimum void at 6% and VMA at 7% mineral filler. The hydrated lime has good stability at 6% bitumen contents and 7% mineral filler, minimum void at 6% bitumen content and VMA at 10% mineral filler. While the stone dust has good stability at 5% bitumen contents and 7% mineral filler, minimum void at 4% bitumen content and VMA at 10% mineral filler. These results portrayed that hydrated lime gave best result out of the three materials and most preferred. This is followed by stone dust. It is thus advisable that hydrated lime should be used as filler material for asphalt production due to its best pavement stability and reduction in thickness. This will help in reducing cost of materials.

Keywords: **Asphalt, Filler materials, Road, Stability, Suitable materials.**

I. INTRODUCTION

Ninety percent of Nigeria roads are made of flexible pavements. Most of these roads pavements are failing due to increase in population and industrialization, which brought about current increase in axle loads and traffic volumes. These situation together with seasonal change in temperature which always affect the pavement always result in imminent problems such as undulations, rutting, cracking, bleeding, shoving and potholes etc of bituminous surfaces [6]. Irrespective of different types of asphalt, filler materials play a significant role in Engineering properties of bituminous paving mixers. Generally, fly ash, hydrated lime, stone dust, cement etc were used as filler materials in asphalt production [8]. Over many years, failures had been attributed to poor design of the asphalt mix due to inadequacy of the filler materials used to bind the large particles together [11]. Thus, it has been agreed over time that the amount of filler used in the asphalt plant mix is one of the factors affecting the road pavement [7]. The past research works of [3], [4], [5], [8], [9], [10], [12] and others looked into the use of fly ash, hydrated lime and stone dust as filler materials in asphalt mixtures. This study intends to comparatively analyze these three filler materials. This will help in having reliable scientific facts or knowledge about the characteristics and quality (ies) of the best and most preferred one.

II. MATERIALS AND METHODS

Samples of the three filler materials (fly ash, hydrated lime and stone dust) were mixed separately with bitumen in various percentages ranging from 4% to 6%. Series of tests were carried out on the samples to determine their suitability as filler materials with respect to [1] specifications. The test carried out were stability, softening point, penetration, ductility, flash and fire point tests. To carry out the tests, materials such as mould, Marshall Stability apparatus, Penetrometer and Ductilimeter were used in accordance with [2]. The results of the tests conducted were then compared with [1] specifications as shown in Tables II and IV.

III. RESULTS AND DISCUSSION

The results of the various tests and AASHTO specifications were presented in Tables I to IV. From Table I, it is observed that hydrated lime has maximum Stability of 21.23KN at 6% Bitumen Content making it capable of withstanding heaviest load traffic when compared to others. The air void of hydrated lime reduces drastically from 9.03 at 4% to 2.14 at 6% when compared to others. From Table III, it is also observed that the hydrated lime has the least flow value of 2.39mm at 4% when compared to others. The VMA for hydrated lime at 6% is 17.88% when compared to others. This indicates that the void space between granular particles of asphalt after compaction is low when hydrated lime is used.

Table I: Summary of Results of Bitumen Content Tests in Asphalt Mix.

FLY ASH					
BITUMEN %	Stability value KN	Flow value mm	Unit weight g/cc	% of air void	VMA
4.0	17.01	1.60	2.25	7.03	18.83
4.5	16.97	2.33	2.27	9.50	19.12
5.0	18.63	3.20	2.27	6.57	18.63
5.5	17.51	3.67	2.29	4.97	18.39
6.0	18.52	5.30	2.23	5.14	18.17
HYDRATED LIME					
4.0	12.13	1.60	2.25	9.03	19.55
4.5	16.97	2.43	2.26	7.93	18.83
5.0	18.30	3.20	2.27	6.17	18.51
5.5	19.55	3.67	2.29	4.93	18.38
6.0	21.23	5.30	2.39	2.14	17.88
STONE DUST					
4.0	18.82	3.83	2.31	2.41	20.32
4.5	19.84	3.10	2.34	5.58	19.88
5.0	20.37	3.93	2.34	4.93	19.62
5.5	18.24	4.97	2.35	5.25	19.02
6.0	20.15	5.27	2.36	4.96	19.70

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Table II: AASHTO Standard Specifications for Bitumen Content Tests in Asphalt Mix

MOISTURE CONTENT (%)	STABILITY (KN)	FLOW (mm)	BULK DENSITY (g/cm^3)	UNIT WEIGHT	% OF AIR VOID	VMA (%)
4.0	8.40	1.00	2.31	2.2	6.0	14.58
4.5	8.70	1.20	2.33	2.25	5.0	13.59
5.0	9.30	1.50	2.35	2.27	4.0	13.59
5.5	9.00	2.50	2.29	2.29	3.0	16.07
6.0	8.10	3.00	2.27	2.30	2.0	17.00

Table III: Summary of Results of Performance of Filler Contents in Asphalt Mix

% OF FILLER BY WEIGHT OF TOTAL MIX.	STABILITY VALUE (KN)	FLOW VALUE (mm)	BULK DENSITY (g/cm^3)	VMA (%)
FLY ASH				
4	10.18	2.57	2.38	14.85
7	10.83	2.85	2.35	14.01
10	11.65	2.86	2.45	14.50
HYDRATED LIME				
4	8.23	2.39	2.37	17.34
7	10.91	3.04	2.41	14.93
10	8.76	2.66	2.96	14.00
STONE DUST				
4	8.04	3.09	2.39	15.93
7	10.89	2.69	2.41	14.66
10	7.64	2.55	2.48	13.88

Table IV: AASHTO Standard Specifications for Performance of Filler Contents in Asphalt Mix

FACTORS IN ASPHALT MIX	PERCENTAGE INCREASE OF FILLER CONTENT (%)		
	4	7	10
STABILITY (KN)	8 – 10.5	10 – 12.5	7.5 – 13.0
FLOW (mm)	2 – 3.5	2.5 – 3.5	2.5 - 4.0
BULK DENSITY (g/cm^3)	2 – 2.5	2.3 – 2.5	2.4 - 3.0
VMA (%)	10 -20	10 – 16	10 - 15
AIR VOID (%)	3.0 – 4.5	3.5 – 4.5	3.8 - 4.5

IV. CONCLUSION AND RECOMMENDATION

This study showed that hydrated lime gives the expected maximum Stability at 6% Bitumen Content and 7% mineral filler of the total asphalt mix. It also gives minimum air voids and VMA at 6% Bitumen Content and 10% Filler Contents. This portrayed that it requires less percentage of Bitumen Content of total asphalt mix in other to have a minimum flow that gives a durable pavement. At 10% of filler content to total asphalt mix, it gives a stability that corresponds with [1] specifications. Thus, the use of hydrated lime will result in reduction in pavement thickness when compared to other fillers. It is also preferable because of its low voids in total mix (VTM) which makes the compaction of asphalt mix quicker and easier. However, there is need to continue further study on these findings.

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REFERENCES

[1] American Association of State Highway and Transportation Officials (AASHTO), "Standard specification for mineral filler for bituminous paving mixtures", USA, Washington DC, M07 – 17, 1997.

[2] American Society for Testing and Materials (ASTM), "ASTM-C618: Standard specification for fly-ash and raw or calcined natural pozzolan for use as mineral admixture in Portland cement concrete, annual book of ASTM standards", USA, Pennsylvania, West Conshohocken, 2005.

[3] Asphalt Task Force (ATF), "Hydrated lime: A proven additive for durable asphalt pavement", Report to the European Lime Association, 2010.

[4] S. Chandra, and R. Choudhary, "Performance characteristics of bituminous concrete with industrial wastes as filler", Journal of Materials in Civil Engineering, Vol. 25 (11), pp. 1666 – 1673, 2013.

[5] S. Chandra, V. Sharma, and R. Choudhary, "Characterization of fly-ash bituminous concrete mixes. Journal of Materials in Civil Engineering, Vol. 22 (12), pp. 1209 – 1216, 2010.

[6] Federal Highway Administration (FHWA), "American Coal Ash Association (ACAA): "Fly ash facts for highway engineers" FHWA-IF-03-079, 2003.

[7] B.M. Galloway, "A review of the use of mineral filler in asphalt, aggregate mixtures", Proceedings of the fly ash application in 1980 conference, USA, Texas, College Station, 1980.

[8] T. W. Kennedy, and J. N. Anagnos, "Lime treatment of asphalt mixtures", USA, Texas: Centre for Transportation Research, 1983.

[9] D. Lesueur, J. Petit, and H.J. Ritter, "The mechanism of hydrated lime modification of asphalt mixtures: A state of the art review. Road Materials and Pavement Design, Vol. 14 (1), pp. 1 – 16, 2013.

[10] V. Mouillet, D. Sejourne, V. Delmotte, H. J. Ritter, and D. Lesueur, "Method of quantification of hydrated lime in asphalt mixtures. Construction and Building Materials of Elsevier (ScienceDirect) Journal, Vol. 68, pp. 348 – 354, 2014.

[11] G. Nicholas, and H. Lester, "Traffic highway engineering", UK, England, Virginia: Cengage Learning, 2007.

[12] A. Rahman, S. A. Ali, S. K. Adhikary, and Q. S. Hossain, "Effects of fillers on bituminous paving mixes: An experimental study. Journal of Engineering Science, Vol. 3 (1), pp. 121 – 127, 2012.

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