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Evaluation of Mechanical Properties of Asphalt-Concrete Using Baghouse Dust as Filler Material

Usanga, Idorenyin Ndarake [1]
Department of Civil Engineering
Akwa Ibom state University

Imoh, Udeme Udo [2]
Department of Civil Engineering
Akwa Ibom state University

Imitini, Elo Merit [3]
Department of Civil Engineering
Delta state University

Etuke, Julius [4]
Department of Civil Engineering
Delta state University

Abstract:- This paper reports the results on the evaluation of mechanical properties of asphalt concrete using baghouse dust as filler material. Ordinary Portland cement and limestone dust are conventional materials used as mineral fillers in asphalt production. However, an increase in the cost of these materials in recent times has led to some construction companies avoiding their use as mineral fillers. Baghouse dust is a waste obtained from the screening process of asphalt aggregates in an asphalt plant that results in air pollution as these asphalt plants emit the wastes into the environment. This project is aimed at partially replacing limestone dust; a conventional filler material with Baghouse dust at varied proportions to examine its mechanical properties, in order to ascertain whether or not it can be suitable as a filler material for asphalt concrete production. Twelve (12) numbers of asphalt concrete samples were prepared using The Marshall Mix Design Method. Varied proportions of Baghouse dust at 0%, 10%, 20% and 30% were used to examine the various mechanical properties such as bulk density, specific gravity, Marshall-stability and flow, voids in the mix, voids filled, and the stiffness of the asphalt concrete.

The results from this paper will help Civil Engineers in the effective cost reduction of filler materials and will also further reduce the effect of Baghouse dust waste pollution in the environment.

Keywords:- *Asphalt, Baaghouse Dust, Filler, Cement, Recycling, Limestone, Fine And Coarse Aggregates*

I. INTRODUCTION

Continuous generation of wastes arising from industrial by-products and agricultural residue, create acute environmental problems both in terms of their treatment and disposal. The construction industry has been identified as one of the areas where these wastes can be absorbed, with the majority of such materials used as filler in concrete (Antihos et al., 2005). If these fillers have pozzolanic properties, they impart technical advantages to the resulting concrete and also enable larger quantities of cement replacement to be achieved (Hossain, 2003). Approximate utilization of these materials brings ecological and economic benefits. Waste material recycling into useful products has been the current method of solving waste problems (Ahmed, 2006). Material recycling has been a common practice for most of human history with records as far back as Plato in 400 BC (Grosse, 2010). Recycling is a process to change waste materials into new products to prevent hazards associated with waste, thus reducing the consumption of fresh raw materials, and it also reduces greenhouse gas emissions arising from the conventional method of disposing of such wastes (Grosse, 2010). Many highway agencies are conducting a wide variety of studies and research work on the feasibility, environmental suitability, and performance of using recycled products in highway construction (Ahmed, 2006). Baghouse dust from the primary dust collection devices (cyclone collectors) at asphalt mixing plants are routinely recycled as all or part of the mineral filler portion in Hot Mix Asphalt (HMA) paving mixtures. Since these fines are derived from naturally occurring aggregates (crushed stone or sand and gravel), their properties are ordinarily quite similar to those of commonly used mineral fillers, such as stone dust or hydrated lime. Some industrial wastes have been studied for use as supplementary cementing materials such as fly ash (Siddique, 2004; Wang, 2007; Baxter; 2007), silica fume (Lee et al., 2005), pulverized fuel ash (Balendran and Martin Buades, 2000), volcanic ash (Hossain, 2005), rice husk ash (Waswa-Sabuni, et al., 2002) and corn cob ash (CCA) (Adesanya and Raheem, 2011). Elinwa and Ejeh (2004) considered the effect of waste incineration fly ash in cementing pastes and mortar. Cheah and Ramli (2011) investigated the implementation of wood waste ash as a partial replacement for cement in the production of structural grade concrete and mortar. Elinwa, et al. (2008) assessed the properties of fresh self-compacting concrete containing sawdust ash amongst others. A filler material is that fraction of air inert material dust passing the 200-mesh (0.075mm BS sieve size) in a bituminous mixture (Csanyi, 1962). The primary function of filler material is to fill voids in coarser aggregates proportion thus increasing the density, stability, and toughness of a conventional bituminous paving mixture. Baghouse dust is a much cheaper form of filler material and is readily available compared to most of the other fillers. It will also limit the problems encountered in the disposal of this material, reducing its environmental littering and pollution impact. If the results obtained comply with standard aggregate gradation specifications, then it will create a positive turn up in the use of fillers in bituminous mixture.

II. METHODS

Materials used for this research work was obtained after compaction, the mould was inverted with a collar on the bottom, the base was removed and the sample was extracted by pushing it out the extractor.

2.1 Laboratory Tests

A. The following tests were conducted on the Bitumen 60/70:

Penetration test, Softening point test, Specific gravity test, Flash and fire point test.

B. The following tests were conducted on the Coarse Aggregates:

Specific gravity test, Rate of absorption test, and Abrasion test.

C. The following tests were conducted on the Fine Aggregates:

Specific gravity test, Rate of absorption test, and Abrasion test.

D. The following tests were conducted on the Fillers:

Specific gravity test and Filler grading test.

E. The following tests were conducted on the Asphaltic Concrete:

Asphalt compaction test, Marshall-stability test, and Aggregate size distribution test.

2.2 Laboratory Tools and Equipment Used

A. The following are the Tools/ Equipment used for Bitumen Test:

Vicat bitumen penetration test apparatus, flash/fire point apparatus with accessories, specific gravity bottle or pycnometer bottle, laboratory viscometer with accessories.

B. The following are the tools/ equipment used for Coarse Aggregates Test:

Specific gravity bottle or pycnometer bottle, wire mesh basket, hand dryer, electronic weighing balance, recommended sieve set, laboratory oven, water bath, standard sieve set, electronic weighing balance, weighing and receiving pans.

C. The following are the tools/ equipment used for Fine Aggregates:

Specific gravity bottle or pycnometer bottle, hand dryer, electronic weighing balance, standard sieve set, laboratory oven, standard sieve set, quartering pan, weighing and receiving pans.

D. The following are the tools/ equipment used for Fillers:

Specific gravity bottle or pycnometer bottle, standard sieve set, quartering pan, electronic weighing balance, weighing and receiving pans.

III. RESULTS

Below are the results of Asphalt mix proportion and Test properties for asphaltic concrete treated with Baghouse Dust.

Table 3.1: Showing the Trial Mix Proportion by Percentage

AGGREGATE IN THE MIX	***PERCENTAGES OF AGGREGATES IN ASPHALT MIX***			
	ASPHALT WITH MINERAL FILLER (%)	**ASPHALT WITH 10% BHD (%)**	**ASPHALT WITH 20% BHD (%)**	**ASPHALT WITH 30% BHD (%)**
5 – 15 mm [1/2 inch]	27.5	27.5	27.5	27.5
0 – 5 mm [Fine aggregate]	47.5	47.5	47.5	47.5
Mineral Filler: BHD	25: 0	22.5: 2.5	20.0: 5.0	17.5: 7.5
Bitumen content	5.50	5.50	5.50	5.50

Source: from the author's analysis.

Table 2. Showing the Trial-Mix Proportion by Weight

Aggregate in mix	***Weight of Aggregates in asphalt Mix***			
	Asphalt with Mineral Filler (g)	**Asphalt with 10% BHD (g)**	**Asphalt with 20% BHD (g)**	**Asphalt with 20% BHD (g)**
5 – 15 mm [1/2 inch]	275	275	275	275
0 – 5 mm [Fine aggregate]	475	475	475	475
Mineral Filler: BHD	250: 0	225: 25	200: 50	175: 75
Bitumen content	55	55	55	55

Source: from the author's analysis.

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Table 3.2 Showing Marshall Mix Design Properties at 5.50% Optimum Bitumen Content

ASPHALT PROPERTIES	*ASPHALT WITH MINERAL FILLER, (0% BHD)*	*ASPHALT WITH 10% BHD*	*ASPHALT WITH 20% BHD*	*ASPHALT WITH 30% BHD*	*SPECIFICATION LIMIT FOR WEARING COURSE*
Bulk Density (g/cm^3)	2.27	2.33	2.42	2.48	-
Specific gravity	2.49	2.48	2.50	2.49	-
Voids in mix (%)	3.40	3.32	3.10	3.04	3 - 5
Voids filled (%)	76.12	76.46	78.58	79.88	75 - 82
Marshall stability (kN)	10.13	10.35	11.85	12.08	3.5 (MIN)
Flow /0.1mm	2.43	2.85	3.20	3.55	2 - 4
Stiffness (kN/mm)	4.17	3.63	3.70	3.40	-
Bitumen content (%)	5.46	5.48	5.50	5.49	5 - 8

Source: from the author's analysis.

Table 4. Showing the Physical Properties of Bitumen 60/70

PROPERTIES	*BITUMEN (GRADE 60/70)*	*SPECIFICATION LIMIT*
SOFTENING POINT (°C)	**50**	**48 – 56**
PENETRATION (°C /0.1MM)	**64**	**60/70**
FLASH AND FIRE POINT (OPEN CUP TESTER) °C	**252**	**250 MIN. TEMP.**

Source: from the author's analysis

IV. DISCUSSION

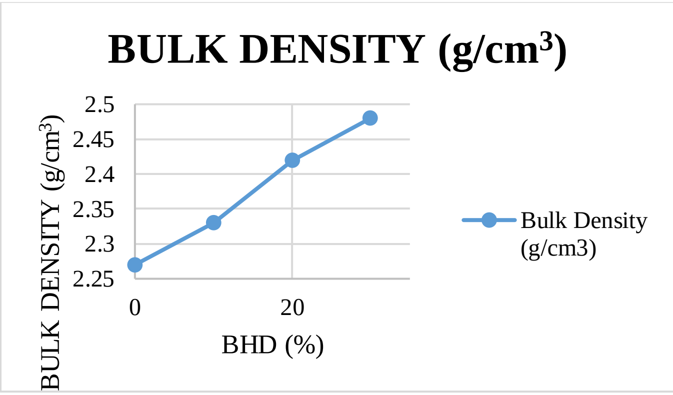

Figure 1: A Graph Showing Relationship between Bulk Density and Baghouse Dust.

From Figure 1, it can be observed that there is a geometric increase in the values of the bulk density as individual proportions of baghouse dust was introduced to the mix. At 0% baghouse dust (only quarry dust), the value of bulk density was observed to be 2.27g/cm^3. At 10% baghouse dust, it increased geometrically to 2.33 g/cm^3, thus exhibiting a 0.06 g/cm^3 increment. At 20% baghouse dust, it increased geometrically to 2.42 g/cm^3, thus exhibiting a 0.15 g/cm^3 increment. At 30% baghouse dust, there was a geometric increment to 2.48 g/cm^3, thus exhibiting a 0.21 g/cm^3 from the control (0% baghouse dust).

Bulk density of asphalt is an important property to examine when determining the quality of asphalt concrete. The above relationships show how the increased variation of baghouse dust proportions has increased the bulk density of the samples.

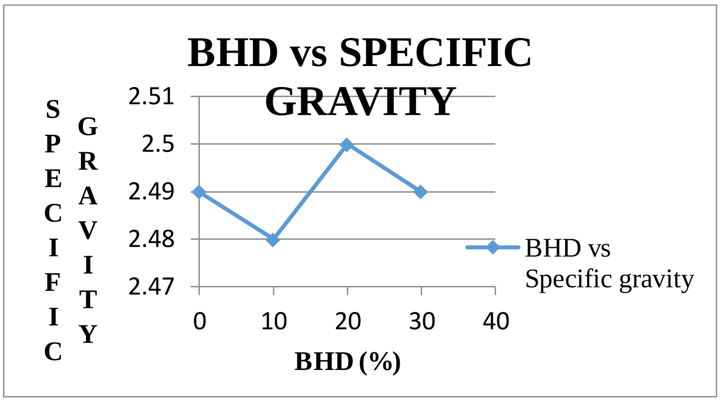

Figure 2: A Graph Showing Relationship between Specific Gravity and Baghouse Dust.

From Figure 2, it can be observed that the specific gravity values are gradually increasing and decreasing as individual proportions of baghouse dust was introduced to the mix. At 0% baghouse dust (only quarry dust), the value of specific gravity was observed to be 2.49. At 10% baghouse dust, it reduced geometrically to 2.48, thus exhibiting a 0.01 decrease. At 20% baghouse dust, it increased geometrically to 2.50, thus exhibiting a 0.01 increment. At 30% baghouse dust, the value remained the same as that of control.

Specific gravity of asphalt is an important property to examine when determining the quality of asphalt concrete. Hence, baghouse dust has minimal/negligible influence on the asphalt Specific gravity property.

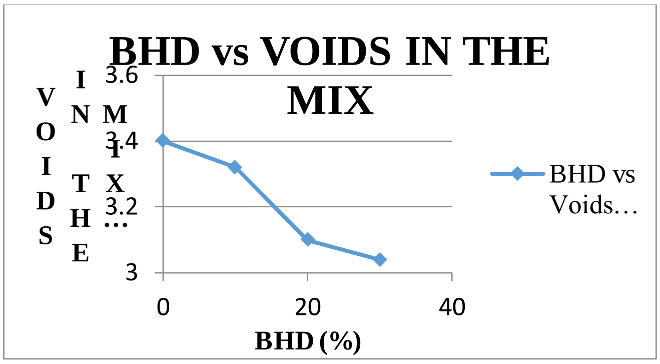

Figure.3 A Graph Showing Relationship Between Voids in Mix and Baghouse Dust.

From Figure.3, it can be observed that there is a geometric decrease in the values of the voids in the mix as individual proportions of baghouse dust was introduced to the mix. At 0% baghouse dust (only quarry dust), the value of voids in the mix was observed to be 3.40%. At 10% baghouse dust, it reduced geometrically to 3.32%, thus exhibiting a 0.08% decrease. At 20% baghouse dust, it decreased geometrically to 3.10%, thus exhibiting a 0.30% decrease. At 30% baghouse dust, the value decreased further to 3.04%, thus exhibiting a 0.36% decrease in voids.

Voids in the asphalt mix is an important property to examine when determining the quality of asphalt concrete. Voids in the mix indicate the degree of moisture and air susceptibility. From the test results it was observed that an increased proportion of baghouse gave a geometric reduction in the voids in the asphalt concrete mix as the voids in the mix got filled with the filler-baghouse dust ratio, thus, resulted in high resistance to moisture and air susceptibility.

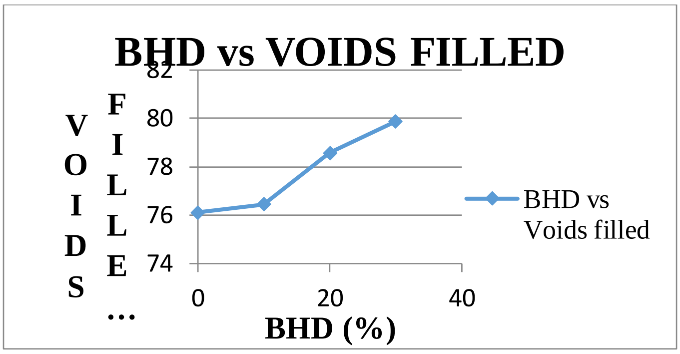

Figure 4: A Graph Showing Relationship between Voids Filled and Baghouse Dust.

From Figure 4, it can be observed that there is a geometric increase in the values of the voids filled as individual proportions of baghouse dust was introduced to the mix. At 0% baghouse dust (only quarry dust), the value of bulk density was observed to be 76.12%. At 10% baghouse dust, it increased geometrically to 76.46%, thus exhibiting a 0.34% increment. At 20% baghouse dust, it increased geometrically to 78.58%, thus exhibiting a 2.46% increment. At 30% baghouse dust, there was a geometric increment to 79.88%, thus exhibiting a 3.76% from the control (0% baghouse dust).

Voids filled is a complementary substitute of voids in the mix as these voids get filled by baghouse dust. Voids filled in the asphalt mix is an important property to examine when determining the quality of asphalt concrete. The above relationships show how the variation of baghouse dust proportions has geometrically increased the voids filled in the mix of the samples, thus, resulted in high resistance to moisture and air susceptibility.

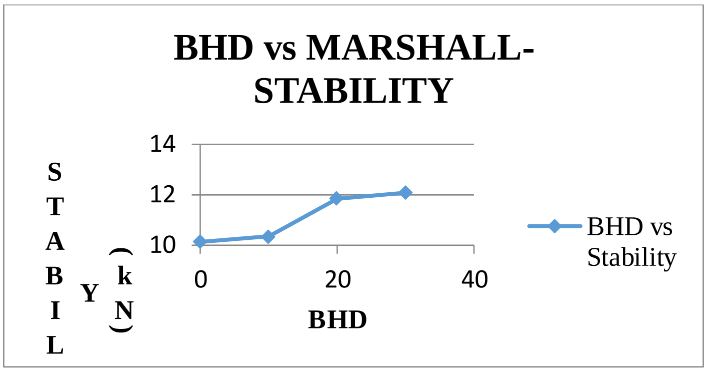

Figure.5: A Graph Showing Relationship Between Marshall-stability and Baghouse Dust.

From Figure 5, it can be observed that there is a geometric increase in the values of the Marshall-stability as individual proportions of baghouse dust was introduced to the mix. At 0% baghouse dust (only quarry dust), the value of Marshall-stability was observed to be 10.13kN. This value is above ASTM D 1559 minimum specification of 8kN, hence it was adequate. At 10% baghouse dust, it increased geometrically to 10.35kN, thus exhibiting a 0.22kN increment. At 20% baghouse dust, it increased geometrically to 11.85kN, thus exhibiting a 1.72kN increment. At 30% baghouse dust, there was a geometric increment to 12.08kN, thus exhibiting a 1.95kN increment from the control (0% baghouse dust).

Marshall-stability of asphalt is an important property to examine when determining the quality of asphalt concrete. The above relationships show how an increment in the proportions of baghouse dust increases the Marshall-stability of the asphalt concrete. The more the stability value, the more the strength of the asphalt concrete.

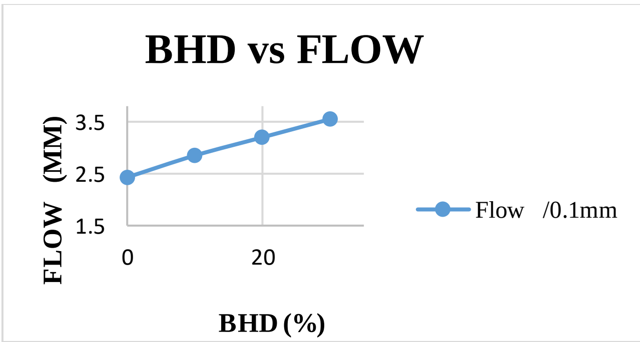

Figure 6: A Graph Showing Relationship between Flow and Baghouse Dust.

From Figure 6, it can be observed that there is a geometric increase in the values of the flow as individual proportions of baghouse dust was introduced to the mix. At 0% baghouse dust (only quarry dust), the flow value was observed to be 2.43mm. At 10% baghouse dust, it increased geometrically to 2.85mm, thus exhibiting a 0.42mm increment. At 20% baghouse dust, it increased geometrically to 3.20mm, thus exhibiting a 0.77mm increment. At 30% baghouse dust, there was a geometric increment to 3.55mm, thus exhibiting a 1.12mm increment from the control (0% baghouse dust).

The flow of asphalt is an important property to examine when determining the quality of asphalt concrete. The more the flow value, the more the flexibility of the asphalt concrete (and the lesser the stiffness of the asphalt). Observation from the test result reveals that an increment in the proportions of baghouse dust resulted in a geometric increment in the flow values of the asphalt concrete.

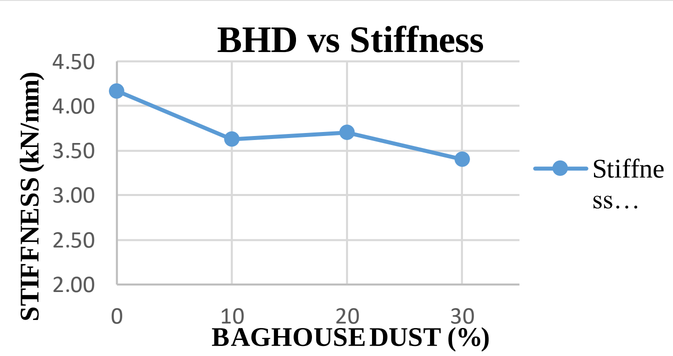

Figure.7: A Graph Showing Relationship between Stiffness and Baghouse Dust.

From Figure 7, it can be observed that there was a reduction in the flow values at increased proportions of baghouse dust. It is to be noted that as the stiffness value reduces, the higher the asphalt's resistance to elastic deformation. At 0% baghouse dust, the stiffness value was observed to be 4.17kN/mm. At 10% baghouse dust, it reduced geometrically to 3.63kN/mm, thus exhibiting a 0.54kN/mm increment in its elastic deformation property. At 20% baghouse dust, it reduced geometrically to 3.70kN/mm, thus exhibiting a 0.40kN/mm increment in its elastic deformation property. At 30% baghouse dust, there was a geometric reduction to 3.40kN/mm, thus exhibiting a 0.77kN/mm increment in its elastic deformation property from that of the control (0% baghouse dust).

The stiffness of asphalt is an important property to examine when determining the quality of asphalt concrete. Observation from the test result reveals that an increment in the proportions of baghouse dust resulted in a geometric increment in the stiffness values of the asphalt concrete because the more the stiffness value, the more the pavement resistance to elastic deformation when wheel load is applied.

Generally, an increment in the Filler: Baghouse dust proportion resulted in enhanced properties of the asphalt concrete mix.

V. CONCLUSION

A good pavement material should be durable, strong, moisture and air resistant, etc. Baghouse dust as condemned dust from the screening process of asphalt aggregates at the dust collection units (cyclone) of asphalt plants recycled into bituminous mixes partially replacing conventional limestone dust that has been used over the years after analysis, was found to have Marshall Properties greater than that of limestone dust only as filler.

Studying the effect of introducing Baghouse dust to partially replace a conventional filler such as limestone dust in this project has been of significant importance as there was a significant increase in the Marshall properties of the mix. As the stiffness values increased, there was a resultant increase in the resistance of the material to elastic deflection under wheel loading. Counteracting the effect of wheel loading on the asphalt pavement is a dominant feature in the durability of pavement material. Rutting of road pavements is a result of low stiffness value. Several properties are of significant importance in the service life of a road pavement material, such as Marshall Stability and flow which ensures that the pavement is of sufficient strength and flexibility respectively. Also, voids filled counteracts the possibility of moisture and air penetration into the pavement membrane thus, maintaining a durable pavement material. Properties such as bulk density and specific gravity are insignificance as they seldom affect the asphalt pavement service life.

REFERENCES

[1]. Adesanya, D. A., and Raheem, A. A, (2009a). A Study of the Workability and Compressive Strength Characteristics of Corn Cob Ash Blended Cement Concrete Construction and Building Materials, 23: 311-317.
[2]. Adesanya, D. A. and Raheem, A. A. (2009b), Development of Corn Cob Ash Blended Cement, Construction and Building Materials, 23: 347 – 352.
[3]. Ahmed, H. Y.; Othman, A. M. and Mahmooud, A. A. (2006), Effect of Using Waste Cement Dust on the Mechanical Properties of Hot Mix Asphalt, 9(1).
[4]. Ahmed, Y. A.; Ayman, M. O. and Afaf, A. M. (2006). Effect of Using Waste Cement Dust as Mineral Filler on the Mechanical Properties of Hot Mix Asphalt. Ass. Uni. Bull Environ. Res., 9(1): 55-59.
[5]. Al-Abdulwahab, H. I. (1981). The Effects of Baghouse Fines and Mineral Fillers on Asphalt Mix Properties in the Eastern Province of Saudi Arabia. (Unpublished master's thesis), King Fahd University of Petroleum & Minerals Dhahran.
[6]. Anderson, D. A.; Tarris, J. P. and Brock, J. D. (1982). Dust Collector Fines and Their Influence on Mixture Design, Proceedings of the Association of Asphalt Paving Technologists, 51:363-397.
[7]. Antiohos, S.; Maganari, K.; Tsimas, S. (2005). Evaluation of Blends of High and Low Calcium Fly Ashes for Use as Supplementary Cementing Materials, Cement & Concrete Composites, 27:349-356.

ISSN No:-2456-2165

[8]. Atkins, H. N. (1997). Highway Materials, Soils and Concretes. Prentice Hall, Upper Saddle River New Jersey.

[9]. Balendran, R. V. and Martin-Buades, W. H. (2000). The Influence of High Temperature Curing on the Compressive, Tensile and Flexural Strength of Pulverized Fuel Ash Concrete", Building and Environment, 35(5): 415-423.

[10]. Bouchard, G. P. (1992) Effects of Aggregate Absorption and Crush Percentage on Bituminous Concrete, Effect of Aggregates and Mineral Fillers on Asphalt Mixtures Performance, ASTM STP 1147, Richard C. Meininger, Ed., American Society for Testing and Material, Philadelphia.

[11]. Brennan, M. J. and O'Flaherty, C. A. (2002). Highways, the Location, Design, Construction and Maintenance of Road Pavements. Butterworth-Heinemann. USA.

[12]. Cheah, C. B., and Ramli, M. (2011). The Implementation of Wood Ash as a Partial Cement Replacement Material in the Production of Structural Grade Concrete and Mortar, Resources, Conservation and Recycling, 55(1): 69-685.

[13]. Chen, J. S. and Peng, C. H. (1998). Analysis of Tensile Failure Properties of Asphalt-Mineral Filler Mastics, Journal of Materials in Civil Engineering, 256.

[14]. Collins, R. J. and Stanley K. C. (1994). Recycling and Use of Waste Materials and By-Products in Highway Construction. National Cooperative Highway Research Program Synthesis of Highway Practice No. 199, Transportation Research Board, Washington, DC.

[15]. Eick, J. H. and Shook, J. F. (1978). The Effects of Baghouse Fines on Asphalt Mixtures, The Asphalt Institute Technical Report RR-78(3): 3-44.

[16]. Elinwa, A. U.; Ejeh, S. P. and Mamuda, A. M. (2008). Assessing of the Fresh Concrete Properties of Self-Compacting Concrete Containing Sawdust Ash, Construction and Building Materials, 22(6): 1178-1182.

[17]. Federal Ministry of Works and Housing General Specifications for Roads and Bridges, Volume II. (1997).

[18]. Fischer, W. K., (2002). Effect of Percentage Baghouse Fines on the Amount of Antistripping Agent Required to Control Moisture Sensitivity, 11.

[19]. Garber, N. J. and Hoel, L. A. (2010). Traffic and Highway Engineering, Fourth Edition. University of Virginia. Publisher Raju Sarkar, Delhi Engineering College, India.

[20]. Grosse, F. (2010). Is Recycling Part of the Solution? The Role of Recycling in an Expanding Society and a World of Finite Resources.

[21]. Hossain, K. M. (2003), Blended Cement using Volcanic Ash and Pumice, Cement and Concrete Research, 33: 1601-1605.

[22]. Huang, B.; Shu, X. and Chen, X. (2007). Effects of Mineral Fillers on Hot-Mix Asphalt Laboratory-Measured Properties, Department of Civil and Environmental Engineering, The University of Tennessee, Knoxville, TN, USA, International Journal of Pavement Engineering, 8(1): 1-9.

[23]. Kandahl, A. and Prithvi, S. (1981). Evaluation of Baghouse Fines in Bituminous Paving Mixtures. Proceedings of the Association of Asphalt Paving Technologists, 50: 150-210.

[24]. Kim, Y. R.; Little, D. N. and Song, I. (2003). Mechanistic Evaluation of Fatigue Resistance and Fundamental Material Characteristics (Paper Submitted to the Transportation Research Board for Presentation and Publication at the 2003 Annual Meeting in Washington, D.C).

[25]. Siddique, R. (2004), Performance Characteristics of High-Volume Class F ly Ash Concrete, Cement and Concrete Research, 34(3): 487-493.

[26]. Shahrour, M. A. and Saloukeh, B. G. (1992). Effect of Quality and Quantity of Locally Produced Filler (Passing Sieve No. 200) on Asphaltic Mixtures in Dubai, ASTM Digital Library, STP24218S: STP24218S.

[27]. Taha, R.; Al-Rawas, A.; Al-Harthy, A. and Qatan, A. (2002). Use of Cement Bypass Dust as Filler in Asphalt Concrete Mixtures, ASCE, 14(4): 338-343.

[28]. Wang, S. and Baxter, L. (2007). Comprehensive Study of Biomass Fly Ash in Concrete: Strength, Microscopy, Kinetics and Durability", Fuel Processing Technology, 88: 1165-1170.

[29]. Waswa-Sabuni, B.; Syagga, P. M.; Dulo, S. O. and Kamau, G, N. (2002), Rice Husk Ash Cement – An Alternative Pozzolana Cement for Kenyan Building Industry, Journal of Civil Engineering, JKUAT, 8: 13-26.