EFFECTS OF DIFFERENT TYPES OF FILLER MATERIALS ON HOT ASPHALT CONCRETE

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ABSTRACT

Fillers play vital role on the engineering properties of the bituminous paving mixes. Cement, lime and stone dust are used as conventionally as fillers. In this study, effort has been made to determine the effects of different fillers (non-conventional and conventional) on the Marshall properties of bituminous paving mixes. For this purpose, non-conventional filler such as waste ceramic tiles powder, Wood Ash and pop-cement and conventional filler such as quarry dust were used. These materials were tested in accordance to the standard test procedure of AASHTO. Total 40 of test specimens were prepared by using the selected materials in different proportions in asphaltic mixes as substitute fillers as replacement to that of a conventional filler on HMA, with Quarry Dust serving as the control. The preliminary test was carried out with the production of 24 sample, 6 Runs per sample, Marshal stability and flow test, bulk density etc. were performed on the HMA mixtures giving the result for the optimum bitumen content OBC, determining the feasibility of the selected fillers in comparison to that of the control, from which the Final design mix involved the production of 16 test specimen, 4 runs per sample for WCT, POP-C, WA,QD. The required test was performed on the asphaltic mixes such as, XRF, marshal stability and flow, ITS test, material testing. Etc. revealing the effects of the selected substitute fillers on HMA in comparison control. Roads are among the vital assets of any nation. Apart from carrying people, vehicles, and goods, roads also provide avenues for such service apparatuses as water, electricity, sewerages, etc. thereby serving as a veritable tool for socio-economic development. A close look at the Nigerian road network reveals the enormous infrastructural systems problems. These problems, in the main, are more maintenance-related. Since the provision of roads is cost-intensive, one would have expected appropriate maintenance to safeguard them from total deterioration, which ultimately leads to eventual rehabilitation or reconstruction with its cost implications. Roads, like any other development assets, function maximally over the whole period of their economic life when regular maintenance is applied. This paper, therefore, examined the road maintenance situation in Nigeria and concluded that road maintenance culture in the country is in a good state, but with the use of sustainable methods the performance can be improved. Therefore, proffers proactive road maintenance strategies for sustainable socio-economic development should be adopted. The use of waste recycled material in road construction nowadays is considered a positive means of providing improved pavement performance. This thesis was focused on evaluating the effects of various materials, waste materials inclusive, which can be used as replacement for substitute fillers on hot mix asphalt concrete.

Keywords: Effects, Different, Filler, Materials, Hot Asphalt, Concrete

INTRODUCTION

Soil can be regarded as the structural basis of any construction work as most structures are erected on the soil. In this regard, soil can be considered the foundation of all types of surface construction, including roads (Chen, F. H. 2012). For road construction to be carried out, several soil tests must be carried out before the commencement of the road construction. To understand the nature and properties of soil. Soil tests give insight into the plan and design for the proposed structure to be constructed. The land is therefore set to its desired level, compacted, and stabilized with additives for proper soil stabilization (Wegman, D. E., Sabouri, M., Korzilius, J., Kuehl, R., & Intertec, B. 2017). A wide variety of materials are used in the construction of roads these are soils (either naturally occurring or processed), aggregates (fine aggregates and coarse aggregates obtained from rocks), binders such as lime, bituminous materials, cement, and other miscellaneous materials used as admixtures for improved performance of roads under heavy loads and traffic (Hall, M. R., Najim, K. B., & Dehdezi, P. K. (2012). Road pavement structure is composed of several layers of overlay made of suitable material, each layer receiving load from the surface course which is spread out and then passed on to the layer beneath, providing characteristics such as friction, smoothness, noise control, drainage, preventing the entrance of water to the underlying surface, having sufficient life span without need for much work. Research study over the years shows positive results in the use of quality materials for road construction which encourages road repairs. The use of materials, both organic and inorganic in asphaltic concrete solves the problem of the in-availability of original materials for the construction in asphaltic pavement construction both in the present and future (Trivedy, R. K., Kulkarni, V. S., & Kaul, S. N. 2019), With an increased rate of consumption due to continuous growth of the population, the amount of waste materials generated by the masses has also increased, these wastes generated worldwide are causing disposal problems that are both economically and financially expensive to curb. The application of such waste materials for pavement construction decreases the waste generated saving cost of procuring new materials by making use of waste materials generated as a substitute (Bolden, J., Abu-Lebdeh, T., & Fini, E. 2013). The use of such materials can provide value, satisfying the disposal problem. The two major types of pavements generally laid in Nigeria are flexible and rigid pavements. The flexible pavement consists of the; subgrade, sub-base course, base course, and wearing course. Its top layer is usually a bituminous surface underlain with granular material and a layer of the desired mix of fine and coarse materials. Flexible pavements are preferred over rigid concrete roads due to their certain advantages, such as they can be strengthened and improved in stages with the growth of traffic. Flexible pavement is more economical and durable compared to the rigid pavement, it is cheaper in terms of cost and maintenance. Hot mix asphalt concrete (HMA) is classified as flexible pavement due to the deflection of the pavement's total structure when subjected to loading (Skrzypczak, I., Radwański, W., & Pytlowany, T. 2018). Materials usually used for flexible pavement are; bitumen, fine and coarse aggregate, and filler. The filler material is added to the binder which can improve specific properties and prevents binders from losing their previously dried aggregate, when it is mixed with bitumen and aggregate it fills up voids preventing the formation of cracks and thereby creating a dense mix increasing the viscosity of bitumen so also serving as reinforcement material satisfying the compacting effects required to compact the specimen. Filler is a components of asphalt concrete mixture. materials such as cement and lime are expensive, thus we would be considering waste materials that can be used as a filler (Choudhary, J., Kumar, B., & Gupta, A. 2020), fillers play a significant role on the characteristics and performance of asphalt concrete mixture. It has the ability to increase resistance of particles to move within mix matrix and becomes and active material prior to interaction with the asphalt cement changing the properties of the mastic. Filler added in excess may weaken the mixture by increasing the amount of asphalt needed to cover the aggregates (Skrzypczak, I., Radwański, W., & Pytlowany, T. 2018) , the workability of the mixture if thus affected, due to the interaction of the fillers with asphalt. The performance and properties of a mixture can be improved based on the type of bitumen and filler selected, the physio-chemical features between the filler and bitumen are correlated to adsorption intensity at the filler-bitumen interface, and higher surface activity significantly contributes to stronger bonds at filler-bitumen interface. For this research I considered the effects of various waste materials having asphaltic mixes of different proportions with the substitute fillers as replacement for conventional filler on Hot mix asphalt concrete (HMA). Giving more light to waste materials that are suitable as filler materials in comparison to the control.

MATERIALS AND METHODS

MATERIALS

The main objectives of this study was to incorporate the use of some selected materials, waste materials inclusive as substitute filler materials for production of asphalt pavement, whilst determining their effects and characteristics with comparison to that of a standard asphalt pavement as control to review their performance.

This study is based on laboratory testing as a procedure to achieving the study goals. All required test will be conducted using the equipment and devices available in the Civil Engineering laboratories of landmark university, omu-aran kwara state.

The materials to be used for this study are the basic constituents of hot asphalt mix (HMA) namely: Bitumen, coarse aggregates, fine aggregates, mineral fillers (quarry dust, wood ash, waste ceramic tiles, pop cement).

Coarse aggregate

This material comprises of particle sizes larger than 2.36mm. this was acquired from Landmark University, omu-aran, Kwara state and subjected to the required test.

Fine aggregate

This material comprises of particle sizes less than 2.36mm larger than 0.075mm.The fine aggregates used were riverbed sand obtained within the school premises.

Bitumen: bitumen grade VG 30 (viscosity grade) used for this research work was sourced form a crude oil refinery.

Fillers

These materials had particles of sizes less than 0.075mm. The conventional fillers used was quarry dust and wood ash, broken ceramic tiles, pop cement as substitute filler obtained from Landmark University, omu-aran, kwara state.

Fig3.1 waste ceramic tiles

3.2 Fig pulverized waste ceramic tiles

3.3Fig quarry dust

Fig 3.4 wood Ash

(Add pic for pop-cement)

METHODS

The method used involved three phases which are:

1. Test of material.
2. Production
3. Marshall stability test

Test of materials

The materials testing would be done to determine the suitability of the materials for this project research and especially in suitability of the production of hot asphaltic concrete and the test to be executed concluded.

The samples will be prepared in "100" mm diameter moulds is removed from the mould Which are fitted with a base and collar the sample is compacted using a hammer consisting of a sliding weight which falls onto a circular foot. During compaction the mould is held on a hardwook which is rigidly fixed to a concrete base. The sample is removed from the Mould using an extraction plate and press and heated to the test temperature of 60º C in a water bath.

When it is required to determine the most satisfactory bitumen content, given a sample of mixed aggregate, an initial estimate of the required bitumen content can be made from a knowledge of the compacted density of the Mixed Aggregate (CDMA). The CDMA is most conveniently determined using a standard 100 mm

The cylindrical specimens are tested on their sides between test heads similar to those shown. The flow is measured with a dial gauge and the stability is measured with a proving ring. A motorized load frame is required for the test. during the mix design phase is also valid during the control phase of the mixture.

Coarse aggregate

- Specific gravity test
- Sieve analysis
- Aggregate crushing test
- Aggregate impact test
- Bulk density test
- Void percentage

- Los Angeles abrasion test

Fine aggregate test

- Sieve analysis

Well labelled empty moisture cans are weighed. The selected samples of wet soil are placed in the cans and weighed after which it is placed in the drying oven at a temperature of 105 degrees for a duration of 20-24 hours. We compute the moisture content as follows;

Water content = $(w_{2} - w_{3}) / (w_{3} - w_{1}) \times 100$

where; w1 = weight of can

W2= weight of wet soil + can

W3= weight of dry soil + can.

Test on bitumen

a. Ductility Test

Ductility is the property of bitumen that permits it to undergo great deformation or elongation. Ductility is defined as the distance in cm, to which a standard sample or briquette of the materials will be elongated without breaking. Dimensions of briquette thus formed is exactly 1 cm square. The bitumen sample is heated and poured the molded assembly which is placed on the plate. The molded samples are cooled in the air and then in the water bath on a plate. These moulds are cooled in the air and then in water bath at 27 degrees. The excess bitumen is cut off the surface is levelled using a hot knife. The molds containing the samples is kept in a water bath of the ductility machine for about 90 minutes. The sides of the molds are removed, and the clips are hooked on the machine and the machine is operated. The distance up to the point of breaking of thread is the ductility value which is reported in cm. the ductility value is affected by factors such as pouring temperature, test temperature, rate of pulling etc.

b. Softening point Test

softening point denotes the temperature at which the bitumen reaches a certain degree of softening under the required condition of the test. The experiment is carried out by using ring and ball apparatus. A brass ring containing test sample of bitumen is suspended in liquid i.e. glycerin at a given temperature. A steel ball is placed on the bitumen sample the liquid is then heated at a rate of 5 degrees per min. the take note of the temperature when the softened bitumen is in contact with the metal plate which is at a specified distance below. A high softening point generally indicates lower temperature susceptibility and this is preferred in hot climate.

c. viscosity test

Viscosity test is used to describe the property of the fluid in the bituminous material, this also provides the resistance to flow. These characteristics has significant influence on the strength of the resulting paving mixes, at the application of temperatures. Both Low or high yield viscosity during mixing has been observed to lead to values of lower stability. At high yield it resists effort of compaction which there by leads to a heterogeneous mixture, resulting in low stability values. And at low viscosity the aggregate particles are lubricated. The use of orifice type viscometer directly finds the viscosity cutbacks and emulsions which are liquid binders. The time taken for the 50ml bitumen material to pass through the orifice cup is the viscosity measured in seconds, under standard test and given temperature. Viscosity of a cutback is measured with a 4.0mm orifice at 25 degrees or 10mm orifice 25 degrees or 40 degrees. I.e. Flash and Fire point test

volatiles are very hazardous and are highly flammable, and at height temperatures bitumen materials depending of their grade leave out volatiles. Hence due to the nature of volatiles it is required that the temperature for each grade of bitumen is qualified. BIS described The ash point to be the temperature at which the vapor of the bitumen catches fire for a moment in form of ash under specified test conditions. The fire point is described to the lowest temperature at which the bituminous material gets ignited and burns, under specified test conditions.

d. specific gravity test

The specific gravity of bitumen is the ratio of mass of given volume of known bitumen content to the mass of equal volume of water at 27 degrees. This was measured with the use of a pycnometer. The density property is used to classify a binder in paving jobs. The density of pavement is affected by its chemical composition. An increase in aromatic type mineral impurities cause an increase in specific gravity.

E. penetration test

The penetration test measures the hardness or softness of bitumen by measuring the depth in tenths of millimeter to which a standard needle penetrates vertically downwards in a space of 5seconds. British international standard (BIS) has a standard equipment and test procedure. The penetrometer consists of a needle with a total weight of 100g and a device that releases and locks in any position.

The bitumen is softened to a pouring consistency and then stirred properly, after which it is poured into containers at a depth of at least 15mm in excess of the expected penetration. The penetration test should be carried out at a specified temperature of 25 degrees. Taking into cognizance that the penetration value is affected by any inaccuracy with regard to the size of the needle, the pouring temperature, the weight is applied on the needle and the test temperature.

F. loss on heating test

bitumen loses volatility and gets hardened when heated. About 50 grams of the sample is weighed after which it is heated to a temperature of 163degrees for a duration of 5 hours in a specified oven for this test. The sample is then weighed again after the heating period, the weight loss experienced is expressed in percentage (%) by the weight of the original sample. The bitumen used in pavement mixes are not expected to indicate a loss more than 1% in weight, but for bitumen having penetration values of 150-200, a weight loss of 2% is permitted. The specific gravity of bitumen varies from the range of 0.97 to 1.02.

G. water content test

Bitumen must contain a desirable amount of water content to prevent foaming of the bitumen when heated above the boiling point of water. The amount of water in bitumen is determined by the mixing known weight of the specimen in pure petroleum distillate from water, heating and distilling of the water. The weight of water is expressed in percentage by the weight of the original sample. The maximum allowable water content should not exceed 2% by weight.

BLENDING OF AGGREGATES

Asphalt mix requires the combination of two or more aggregate, with various gradations with the aim of producing an aggregate blend that meets the gradation specifications for a specific asphalt mix.

The available aggregate material; fine and coarse are combined in other to achieve the proper gradation within the permitted limits according to ASTM specifications using the mathematical trial method. This method involves the suggestion of various trial proportions for aggregate materials from the whole gradation. The percentage for each size of aggregate is computed and compared to the excising specification limits. No further adjustment is required if the calculated gradation falls within the allowable limits, else adjustments are made to the proportions and calculations are repeated. The trials are repeated until the percentage of each size of aggregate are within allowable limits.

MARSHALL MIX DESIGN

This design is the most commonly used. The main objectives are to determine the aggregate mixing and optimum bitumen content that blends, producing stable, durable, flexible, having adequate voids, can be treated, economical and of good quality. The procedure for Marshall design is summarized as the selection of grading, testing flow, and stability, determination of mixing compaction temperature, determination of specific gravity of combined aggregate, preparation of compacted specimens and selection of optimum content.

The Marshall properties of the asphalt mix such as flow, stability, density air voids in total mix and voids filled with bitumen percentage would be obtained for various bitumen content (%).

Marshall stability method: this method will be used in pavement design to determine the Optimum Binder Content in asphalt concrete.

Marshall stability and flow: The Marshall stability of the mix is defined as the maximum load carried by the specimen at a standard temperature of 60ºC. The flow value is the deformation that the test specimen undergoes during loading up to the maximum load. Flow is measured in 0.25 mm units.

The samples will be prepared in 100 mm diameter moulds and removed from the mould Which are fitted with a base and collar the sample will compacted using a hammer consisting of a sliding weight which falls onto a circular foot. During compaction the mould is held on a hardwood which is rigidly fixed to a concrete base. The sample will be removed from the mould using an extraction plate and press and heated to the test temperature of 60 degrees in a water bath.

The cylindrical specimens will be tested on their sides between test heads similar to those shown. The flow will be measured with a dial gauge and the stability will be measured with a proving ring. A motorized load frame

The following graphs will be plotted.

a) Flow vs bitumen content
b) Stability vs bitumen content
c) Bulk, specific gravity vs bitumen content.

These graphs are employed to get the optimum bitumen content.

Determination of optimum bitumen content

The (OBC) optimum bitumen content for the chosen mix is the average of three values of bitumen content, which includes:

a) Bitumen content at highest stability (%) stability
b) Bitumen content at the highest value of bulk density (%mb) bulk density
c) Bitumen content at the median of allowed percentage of air voids (VA=3-5%) (%mv) VA

The marshal graphs are employed to get the values above.

$$OBC \text{ (optimum bitumen content)} = \frac{(\%)\text{stability} + (\%)\text{bulk density} + (\%)\text{volume of void}}{3}$$

The properties of the asphalt mix using optimum bitumen content such as VMA, stability, volume of voids (Vv), bulk density and flow would be gotten and checked in line with specification rang

Energy dispersive X-ray Fluorescence Spectrometer

The X-ray fluorescence (XRF) is widely used in various industries, it is a powerful analytical technique used to determine the elemental composition of various materials. the XRF is generally recognized for its ability to perform accurate, rapid and non-destructive testing. An example is the skyray EDX3600B it's a high-end energy dispersive spectrometer (EDXRF) having a large sample chamber that's able to support most sample sizes.

It has a vacuum pump for light elements detection and uses helium injections for liquid analysis. It is a multifunctional rapid analyzer that can be used for variety of applications.

The systems software is easy to operate which is suitable for all users. The system provides a color camera system for viewing and alignments. It takes a time frame of 10seconds for the operator to have a visual of the main elements contained in that sample. Full results are acquired shortly after an additional period.

Main features

- The latest version of the application provides the critical information's on one screen. Gives a visual on the element spectrum, camera imaging and measurement, etc.
- Large-volume sample chamber is large enough to accommodate different sized samples.
- High resolution inbuilt camera sample viewing system provides easy sample alignment.
- Vacuuming system for sample chamber enhances the sensitivity detection of light elements i.e. (Na, Mg, Si) etc.
- High stability spellmanTM and high voltage supply with maximum 50KV voltage.
- High cost-performance thermoelectric cooling Si-PIN detector and optional advanced silicon drift detector (SDD) for excellent energy resolution for better test precision and accuracy.
- High excitation efficiency is provided by oxfordTM 50W X-ray tube.
- Inbuilt signal-to-noise enhancer, improving effective signal processing

Fig 3.6 XRF Machine

RESULTS AND ANALYSIS

This chapter is a presentation of the results of laboratory tests on control sample selected as well as the replaced samples. The laboratory tests include, grain size analysis, ductility test, softening point test, ductility test, penetration test, aggregate impact test, aggregate crushing test, etc.., Marshall stability test, X-RAY florescence test and analysis of materials. The study was conducted through standardized laboratory test methods following the set standards and specification. All tests asides X-RAY florescence test (XRF) and analysis of materials were conducted at Geotechnical / Highway laboratory of the Department of Civil Engineering, Landmark University. X-RAY florescence test and Analysis of Materials was conducted at National steel raw materials exploration agency, kaduna.

TEST ON FINE AGGREGATE

Particle Size Distribution Result

The particle size distribution curve of the fine aggregate used in the preparation of asphalt is shown in fig 4.1

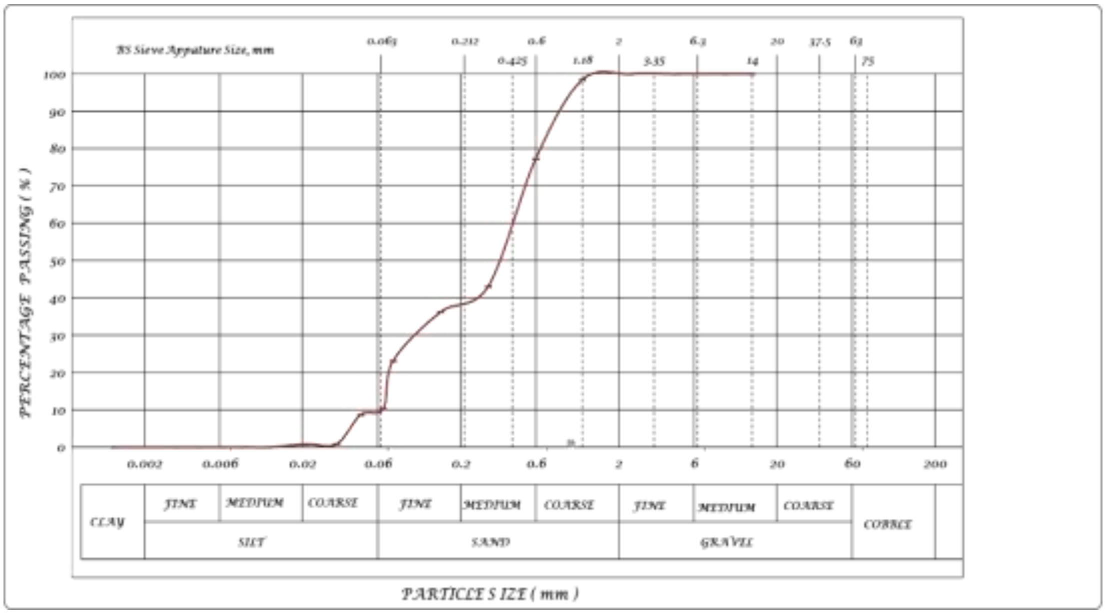


Figure 4.1 particle size distribution of fine aggregate.

COARSE AGGREGATE (CA) GRADATION FOR WEARING COURSE

Table 4. 1 Sieve analysis of coarse Aggregate

SIEVE SIEZE (mm)	**PERCENTAGE PASSING OF COARSE AGGERGATE**			
	GRADATION			COMBINED GRADING
	12.5mm	9.5mm	6.35mm	
12.5	100.0	100.0	100.0	100.0
9.5	68.0	92.0	97.0	99.2
6.35	59.0	73.2	15.0	19.3
2.36	83.0	22.0	0.0	6.5
1.18	75	0.0	0.0	2.0
0.60	46.0	0.0	0.0	5.3
0.300	37.0	0.0	0.0	4.8
0.150	34.0	0.0	0.0	4.7
0.075	43.0	0.0	0.0	0.0

Table 4. 2 AGGREGATE IMPACT TEST RESULT SHEET

Sample ID	***A***	**B**	**C**
Mass of empty mould (g)	2994.5	2994.5	2994.5

Mass of mould + sample (g)	3392	3485	3468
Mass of sample passing through 2.36mm sieve (g)	67.0	74.5	68.5
AIV (%)	16.9	15.2	14.5
AVERAGE	15.50		

TABLE 4.3: AGGREGATE CRUSHING TEST RESULT SHEET

Sample ID	**A**	**B**	**C**
Mass of empty mould (g)	6500	6500	6500
Mass of mould + sample (g)	7097	7150	7115
Mass of sample passing through 2.36mm sieve (g)	76.5	82.5	90.5
AIV (%)	12.8	12.7	14.7
Average	13.41		

TABLE 4.3: ELONGATION AND FLAKINESS INDEX TEST RESULT SHEET

Sample ID	A	B
TOTAL WEIGHT OF SAMPLE	1560	1560
TOTAL WEIGHT OF SAMPLE PASSING THROUGH THICKNESS GUAGE (g)	383.5	369.0
FLAKINESS INDEX (%)	24.6	23.7
AVERAGE	24.1	
TOTAL WEIGHT OF SAMPLE RETAINED ON VARIOUS LENGTH GUAGE (g)	349.0	314.0
ENLONGATION INDEX (%)	22.4	20.1
AVERAGE	21.25	

Test on Fine Aggregate, Coarse Aggregate and Filler

Table 4.2 shows the summary of test conducted on fine and coarse aggregates and mineral. fillers. From the table, it can be deduced that both fine and coarse aggregate used for this research meets the requirement as specified by General Specifications (Roads and Bridges) Volume II Revised 1997 (GOVERNMENT OF THE FEDERAL REPUBLIC OF NIGERIA (put citation in your work)

TABLE 4.4: TEST CARRIED OUT ON COARSE AGGREGATE.

TEST CONDUCTED	**RESULTS OBTAINED**	**STANDARD TEST VALUES**
A. Coarse Aggregate		
Aggregate impact Test	15.50%	30% maximum
Bulk Density	1840 kg/m^3	-
Aggregate Crushing Test	13.14%	45% maximum
Specific gravity	2.8	3 maximum
Los Angeles Abrasion Test	23.06%	60% maximum
Flakiness Index	24.1%	30% maximum
Elongation Index	21.25%	30% maximum
B. Fine Aggregate		
Specific Gravity	2.6	3 Maximum
Bulk Density	2172 kg/m^3	-
Cc	1.8	1≤Cc≤3.
Cu	4.4	≥4
C. Mineral Filler (Specific Gravity)		
Quarry Dust	2.1	-
Pulverized Waste Ceramic Tiles	2.38	-
Wood Ash	2.24	-
Pop Cement	2.25	-

TABLE 4.5: SPECIFIC GRAVITY TEST RESULT SHEET ON FILLER MATERIALS.

SAMPLE ID	WEIGHT OF EMPTY PYCONMETER (g)	WEIGHT OF PYCONMETER +SOIL (g)	WEIGHT OF PYCONMETER+SOIL+ WATER (g)	WEIGHT OF PYCONMETER+ WATER (g)	GS (M2-M1)/(M4-M1)-(M3-M2)

QD	18.5	38	109	99.0	2.1
WA	18.5	37.5	109.5	99.0	2.24
WCT	18.5	34.0	108.0	99.0	2.38
POPC	18.5	38.5	110.5	99.0	2.25

TABLE 4.6: SPECIFIC GRAVITY RESULT SHEET ON COARSE AND FINE AGGREGATE.

SAMPLE ID	FA	CA
MASS OF BOTTLE + SAMPLE + WATER (M3)	77	480
MASS OF BOTTLE + SAMPLE (M2)	32.2	188.5
MASS OF BOTTLE FULL OF WATER ONLY(M4)	67	426
MASS OF BOTTLE (M1)	16	105
MASS OF WATER USED(M3-M2)	44.8	291.5
MASS OF SAMPLE USED (M2-M1)	16.2	83.5
VOLUME OF SAMPLE (M4-M1)-(M3-M2)	6.2	29.5
gs=(m2-m1)/(m4-m1)-(m3-m2)	2.6	2.8
average gs		2.40

Chemical Test on Pulvurized Waste Ceramic Powder, Wood Ash and Pop-Cement

Chemical composition of WCT

Table 4.3 represents the relative proportions of each element present in the substance, which were obtained through an X-ray fluorescence (XRF) test. XRF analysis is a technique used to determine the elemental composition of materials by measuring the characteristic X-ray emissions produced when the material is exposed to high-energy X-rays.

Pozzolans are characterized as siliceous and aluminous materials that may not have significant cementitious value on their own According to ASTM C 618. However, when finely divided and in the presence of moisture, they chemically react with calcium hydroxide at ordinary temperatures, forming compounds with cementitious properties.

Upon analyzing the provided chemical composition, it is evident that the main component is silicon dioxide (SiO_2), which accounts for 62.030% of the composition. SiO_2 is a crucial characteristic of pozzolanic materials, as it is responsible for their reactivity with calcium hydroxide ($Ca(OH)_2$).

Additionally, the presence of other oxides such as aluminum oxide (Al_2O_3) which accounts for17.240% , iron (III) oxide (Fe_2O_3) accounting for 4.360% of the composition, potassium oxide(K_2O) accounting for 3.690%, titanium dioxide (TI02) accounting for 2.102% and calcium oxide (CaO) accounting for 8.737% of it composition further suggests a potential for pozzolanic reactivity.

Based on the composition data provided, there are indications that the material could potentially exhibit pozzolanic properties. However, it is important to note that further testing and analysis, including specific pozzolanic activity tests, would be required to confirm its pozzolanic behavior and suitability for use as a supplementary cementitious material

Chemical composition of POPC (Pop-Cement)

The provided chemical composition showed the presence of gypsum which is a non metallic mineral that forms naturally, it has the ability to prevent the flash set of cement, and can found as a rock or sand composed of 70.1% calcium sulphate ($CaSO_4$) and water by weight ($2H_2O$). the chemical formula is $CaSO_4.2H_2O$.

Tricalcium silicate (C_3S) and Dicalcium silicate are the most important compounds which are responsible for the strength of hydrated cement paste, the presence of (C_3A) is undesirable and not required, (C_4AF) is present but in small quantities, in comparion with the other three mention it doesn't have any significant effect on its behavior.

Chemical composition of WA (wood ash)

Upon analyzing the provided chemical composition, it is evident that the main component is calcium oxide (CaO) which accounts for 43.162% of the composition materials, as it is responsible for their reactivity with calcium hydroxide (Ca (OH)2). Additionally, the presence of other oxides such as aluminum oxide (Al2O3) which accounts for 4.636%, iron (III) oxide (Fe2O3) accounting for 4.979% of the composition, potassium oxide(K2O) accounting for 14.123%, chlorine S(CL) accounting for 2.150% and silicon dioxide (SiO2), which accounts for 17.389% of the composition. SiO2 composition further suggests a potential for pozzolanic reactivity.

Based on the composition data provided, there are indications that the material could potentially exhibit pozzolanic properties. However, it is important to note that further testing and analysis, including specific pozzolanic activity tests, would be required to confirm its pozzolanic behavior and suitability for use as a supplementary cementitious material.

Table 4.6 X-RAY FLOURESCENCE (XRF) RESULT

Table 4. 3: WCT XRF Result

Chemical Formula	**SiO_2**	**$Al2O_3$**	**Fe_2O_3**	**MgO**	**CaO**	**MnO**	**TiO_2**	**Cl**	**K_2O**	**SO_3**
% Composition	62.030	17.240	4.360	0.000	8.737	0.085	2.102	0.622	3.690	0.348

TEST ON BITUMEN

The result on the test of bitumen were recorded in the table below.

Table 4.4 Test result on bitumen.

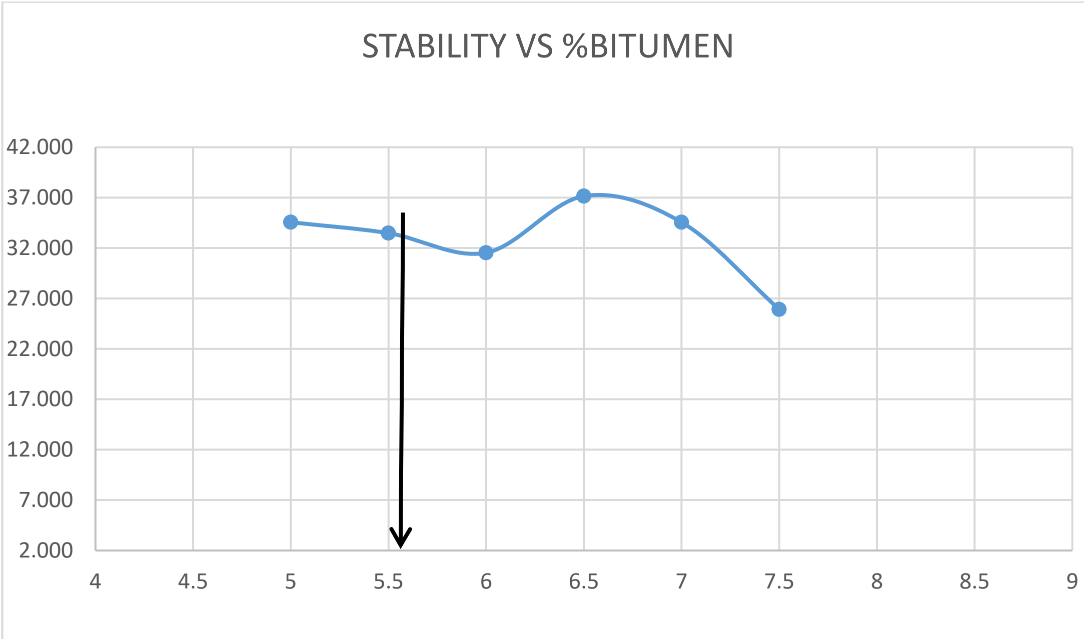
PARAMETERS	**A**	**B**	**C**	**RESULTS**	**SPECIFICATION**	**TEST METHOD**

Penetration @25C	71	69	65	68	60-75	EN1426, IS1203 & ASTM D-5
Ductility @25C	110	113	116	113	100MIN.	IS1208 & ASTM D-113
Softening point	53	56	59	56	52-60	EN1427, ISIS1205 & ASTM D-36
Loss on heating (WT)%	0.13	0.14	0.16	0.14	0.2MAX.	ASTM D-6
Specific gravity @25C	0.97	0.96	1.02	0.98	0.98-1.06	ASTM D-70
Flash & fire point	2658	2566	2735	2653	2400MIN	IS1206(PART2) & ASTM d-2171
Viscosity	276	283	287	282	≥250	EN ISO25292 & ASTM D-92

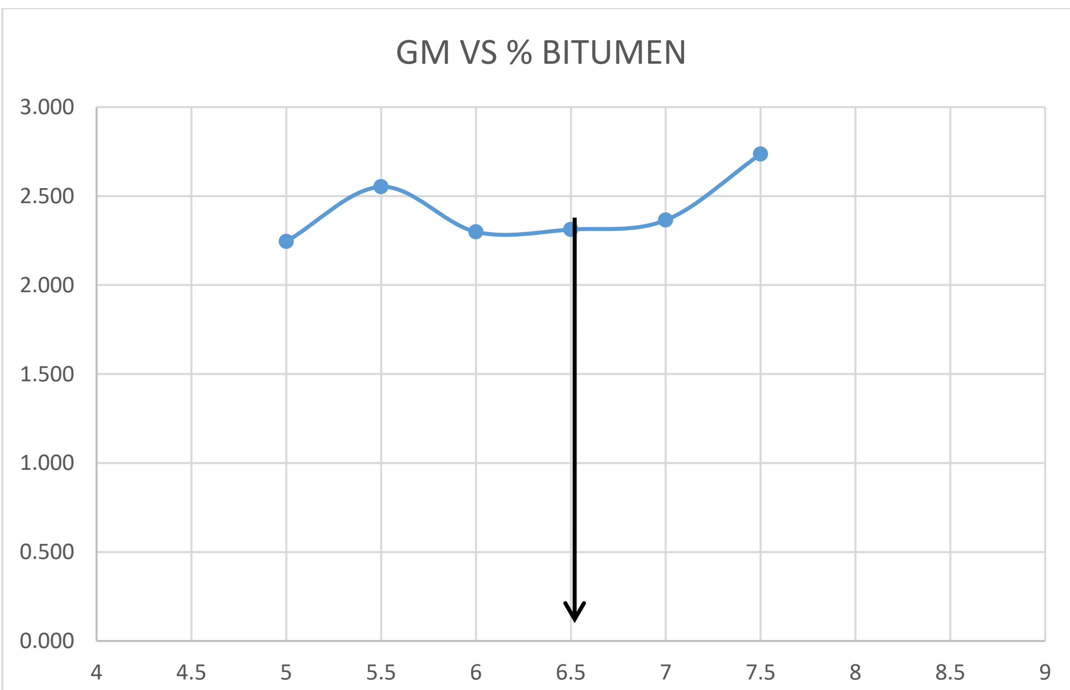
The table above shows a brief summary of the results of the tests conducted on bitumen, and from the above results, it can be said that the bitumen is suitable for use

DETERMINATION OF OPTIMUM BITUMEN CONTENT

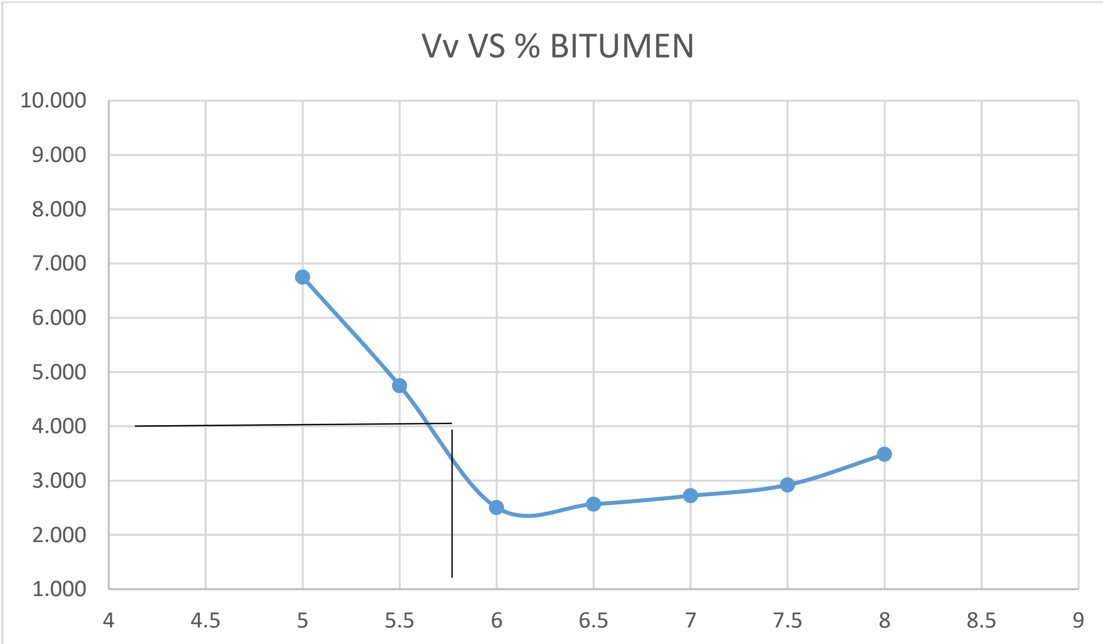
A preliminary design mix and test was carried out which involved the production of a total of 24 samples, of which 6 samples per aliphatic mix containing the various fillers (WCT, QD,POPC,WA) were produced . The various substitute material samples Were examined and differences in the attributes of various materials with varied bitumen contents (5%-7.5%), were establish to get the OBC for the material samples, the value was bitumen content at maximum stability, maximum GM and Vv at 4% were added together and divided by 3 materials which was gotten to be 5.93%.



Graph of stability vs % of bitumen



Graph of specific gravity vs % bitumen



Graph of vv against % bitumen

RESULT TEST AT OBC

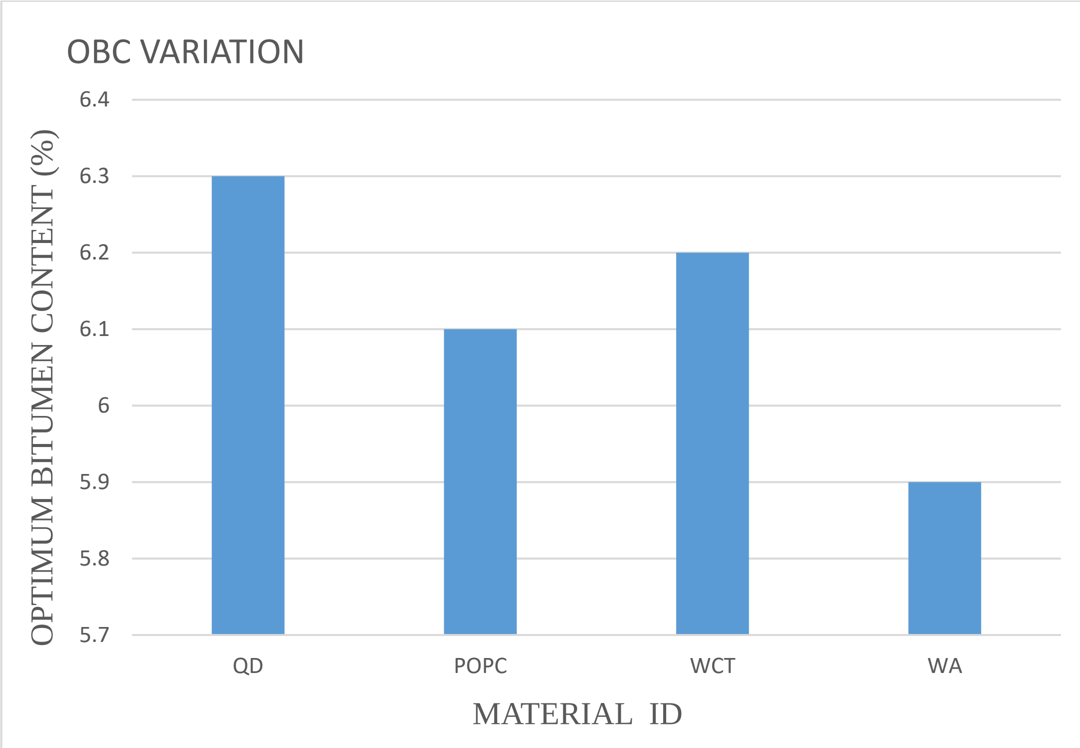
PROPERTIES OF ASPHALT

Table 4. 4: Properties of Compacted Asphaltic Concrete

Property	**Base-course**	**Wearing- course**
Optimum Bitumen Content	4.5% - 6.5%	5.0% - 8.0%
Stability, not less than	3.5KN	3.5KN
Flow	2mm - 6mm	2mm - 4mm
Voids in total mixture	3%-8%	3%-5%
Voids filled with bitumen	65% - 72%	75% - 82%

SOURCE: General Specifications (Roads and Bridges) Volume II Revised 1997 (GOVERNMENT OF THE FEDERAL REPUBLIC OF NIGERIA)

A final mix design was employed which involved the total production of 16 samples, 4 samples per asphaltic mix where produced. The values obtained for bitumen content at maximum stability, maximum GM and Vv at 4% were added together and divided by 3 and the result was 6.3% which is the optimum bitumen content for control sample (QD). This was done for all the other 3 experimental runs and the result for OBC.



The material with the highest OBC value must be taken into account in order to establish the ideal bitumen content. In this instance, QD, which has an OBC value of 6.3, is the material with the highest OBC value. The best bitumen content, according to the information given, is 6.3.

We can see from the statistics that the bitumen content of the various materials varies slightly. The OBC percentage fluctuates from 5.9 to 6.3 percent.

We can take into account performance factors like the asphalt mix's compactability, stability, and durability to calculate the ideal bitumen content. Laboratory tests such as the Marshall Stability test or the Indirect Tensile Strength test can be used to analyze these properties.

Additional information, such as the outcomes of laboratory tests (such as Marshall Stability, Flow, or Density), or particular performance requirements, would be required in order to precisely establish the ideal bitumen content. These testing would provide light on how each material performed and aid in determining the bitumen content that results in the appropriate properties for the pavement or asphalt mix.

Table 4.5 The Mix design used after determining the OBC The data show that various bitumen contents have been tested for each material (QD, POPC, WCT, WA), and the corresponding values for OBC (Optimum Bitumen Content) have been recorded

MIX DESIGN

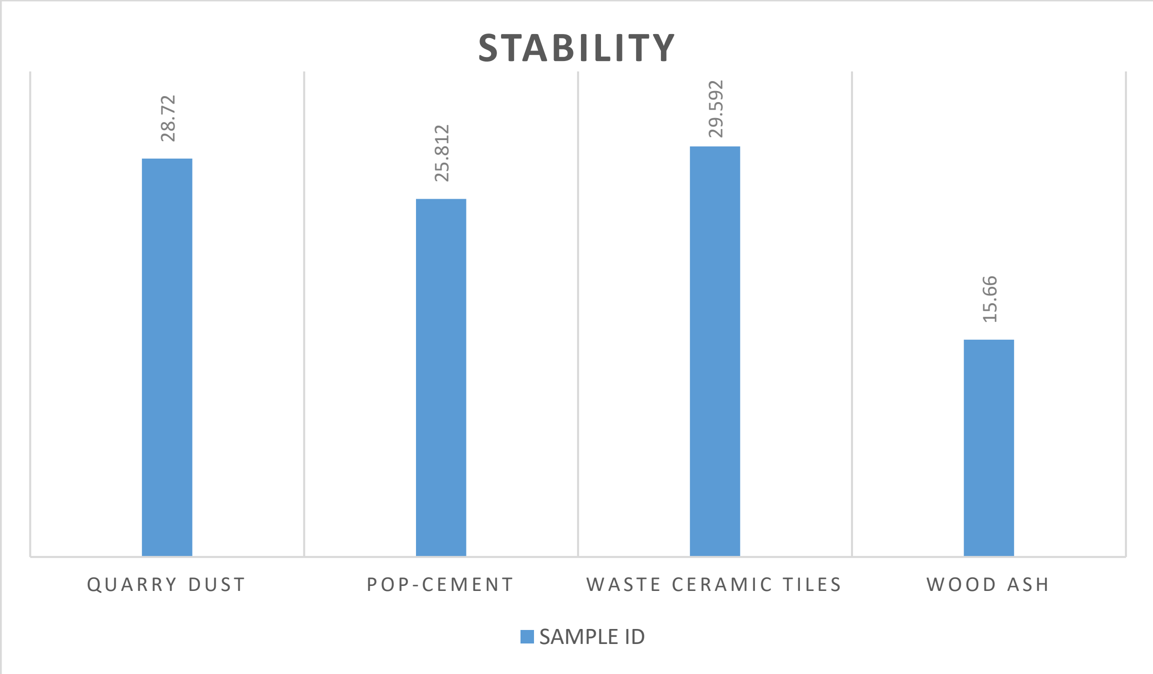
SN	MATERIALS	OBC	MIX DESIGN	CA	FA	FILLER	BITUMEN
1	QD	6.3	58.7: 20: 15: 6.3	704.4	240	180	75.6
2	POPC	6.1	58.9: 20: 15: 6.1	706.8	240	180	73.2
3	WCT	6.2	58.8: 20: 15: 6.2	705.6	240	180	74.4
4	WA	5.9	59.1: 20: 15: 5.9	709.2	240	180	70.8

Fig : Table of Final Design Mix

MARSHALL STABILITY AND FLOW TEST

STABILITY

Figure 4.7 depicts the variation in the stability based on the data collected among the different asphalt mixtures. The stability values range from 15.66 to 29.592. The asphalt mixure with the higest stabilty was that having waste ceramic tiles (WCT) used as its substitute filler, it had a value of 29.592 in comparison to that of the control with quarry dust (QD), which had a stability value of 28.72, indicating a more stable mixture which can resist cracking and deformation when subjected to traffic loading. Pop-cement (POPC) had a stability of 25.812. The asphaltic mixtures containing WCT and POPC may be suitable for high-traffic areas and heavy loads. The asphalt mixture with wood ash (WA) as substitute filler had the lowest stability 15.660, indicating a less stable mixture that may be more susceptible to cracking and deformation under traffic loads.



FLOW AND MARSHALL QUOTIENT

Figure 4.8 shows the variation in both flow and MQ values among the different asphalt mixtures. The flow values was shown to be ranging from 3.888 to 4.675, while the MQ values range from 3.735 to 7.442.

Some of the mixtures had a higher flow and a higher MQ, which indicates a more workable and desirable mixture. Waste ceramic tiles (WCT) had a flow of 3.975 and an MQ of 7.442, pop-cement (POPC) had a flow of 3.888 and a MQ of 6.653.

It can be deduced from these mixtures fore mentioned in their respective order from WCT to POPC, will be easier to place and compact while also providing good stability and resistance to deformation, with comparison to that of the control which was quarry dust (QD) having a flow of 4.675 and MQ of 6.153. Wood Ash (WA) having a lower flow and MQ, indicated to be a less workable and less desirable mixture in comparison to that of the control, WA had a flow of 4.188 and an MQ of 3.735.

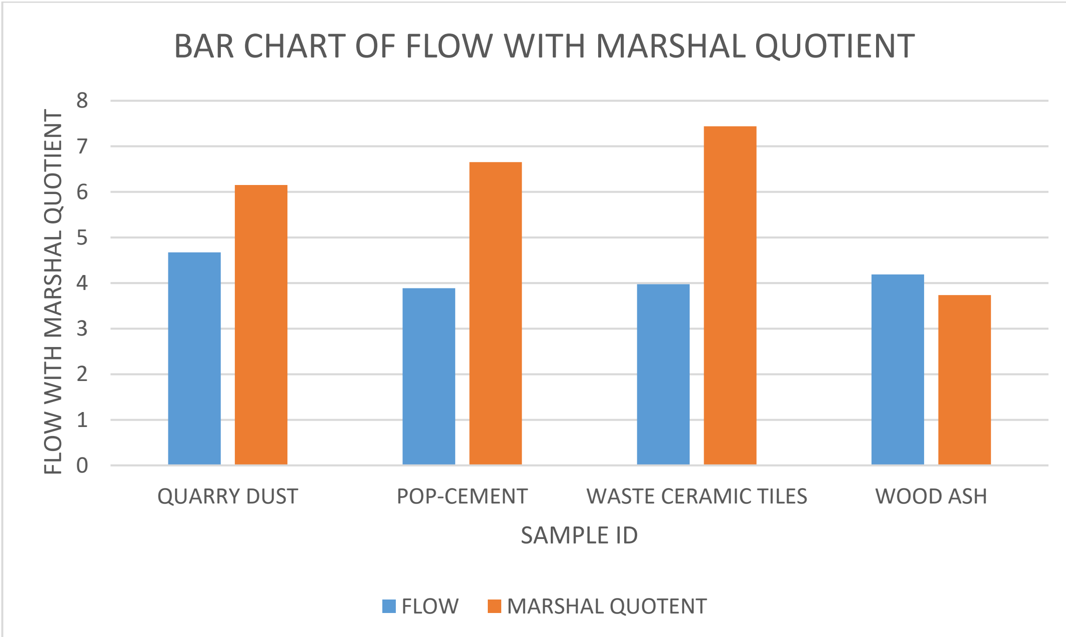


Figure 4.8: Bar Chart of flow with Marshal Quotient

ITS table (take this to appendix dara)

ID	PEAK LOAD (WET)	PEAK LOAD (DRY)	ITS WET (KN/m2)	ITS DRY (KN/m2)	TSR (%)
QD	7.344	5.756	736.178	576.993	127.589
	7.687	6.225	770.561	624.007	123.486
AVERAGE			753.370	600.500	125.538
POP CEMENT	9.936	7.972	996.005	612.254	162.678
	10.445	7.9	1047.029	791.912	132.215
AVERAGE			1021.517	702.083	147.447
WCT	5.508	3.648	552.133	365.683	150.987
	6.755	4.455	677.135	446.578	151.627
AVERAGE			614.634	406.131	151.307
WA	2.16	1.475	216.523	147.857	146.441
	2.855	1.789	286.191	179.333	159.586
AVERAGE			251.357	163.595	153.014

Indirect Tensile Strength

A typical test method to determine the tensile strength of asphalt mixtures is indirect tensile strength (ITS). In order to conduct the test, a cylindrical specimen of the asphalt mixture must be loaded vertically, and the deformation must be recorded. To determine how sensitive the mixture is to moisture, the test is run on both wet and dry specimens..

The ITS test provides valuable information about the tensile strength of the asphalt mixture, which is a good indicator in determining its resistance to cracking and deformation under traffic loads. Higher tensile strains before failure indicate greater tensile strength and better resistance to cracking and deformation compared to that with lower tensile strain and early failure. (Figure 4.9) Some of the mixtures have a higher ITS, indicating a higher tensile strength. For example, Quarry dust has an ITS wet of 753.37 KN/m2 and an ITS dry of 600.5 KN/m2, while pop-cement has an ITS wet of 1021.517 KN/m2 and an ITS dry of 702.083 KN/m2, waste ceramic tiles had an ITS wet of 614.634 KN/m2 and an ITS dry of 406.131 KN/m2. These mixtures may be more suitable for areas with heavy traffic loads or where deformation and cracking are a concern. The other mixture " wood ash" had a lower ITS, indicating a lower tensile strength. It had an ITS wet of 251.357 KN/m2 and an ITS dry of 163.595 KN/m2. Mixtures involving such material might be suitable for mild or very low-traffic areas. or where deformation and cracking is not a major consideration

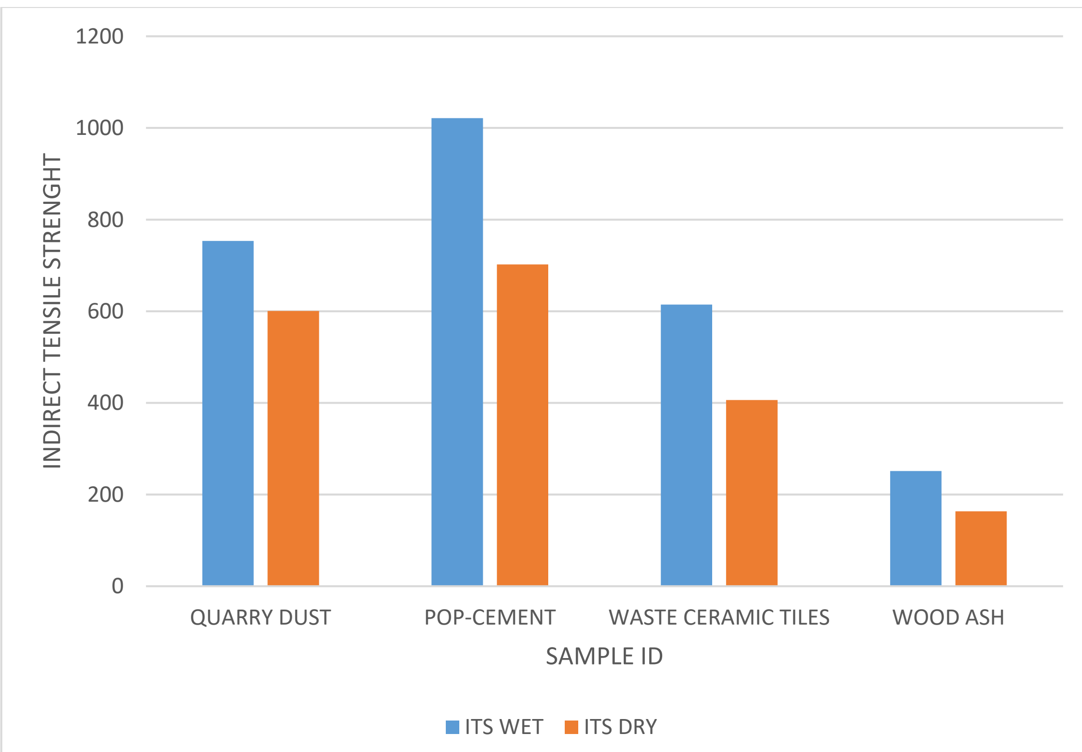


Figure 4.9: Bar chart of ITS wet with ITS dry

Details of the result can be seen in the appendix.

TENSILE STRENGHT RATIO

To ascertain a bituminous mixture's moisture susceptibility, the ITS test is a performance test that is frequently employed. Tensile strength ratio is used to determine water sensitivity (TSR). It measures the difference between the tensile strength of a water-conditioned specimen (ITS wet, 60 °C, and 24 hours) and a control specimen (ITS dry). A higher TSR indicates that the mixture will function effectively and be resistant to moisture damage. The strength will be less affected by soaking in water or more resistant to water depending on the TSR number. Looking at Figure. 4.10 below The TSR values varied among the various asphalt blends, as was evident. Higher TSR values increase the resistance of combinations to moisture degradation.

Wood Ash has a TSR of 153.014 percent and waste ceramic tiles have a TSR of 125.538 percent, indicating that these mixtures may be used more in areas with high moisture content, particularly in areas where there is a lot of rain and sometimes snowmelt.

Both pop-cement and quarry dust had TSR values that are less resistant to moisture degradation, at 132.215 percent and 125.538 percent, respectively. When exposed to moisture, these mixes could be more prone to cracking and deformation.

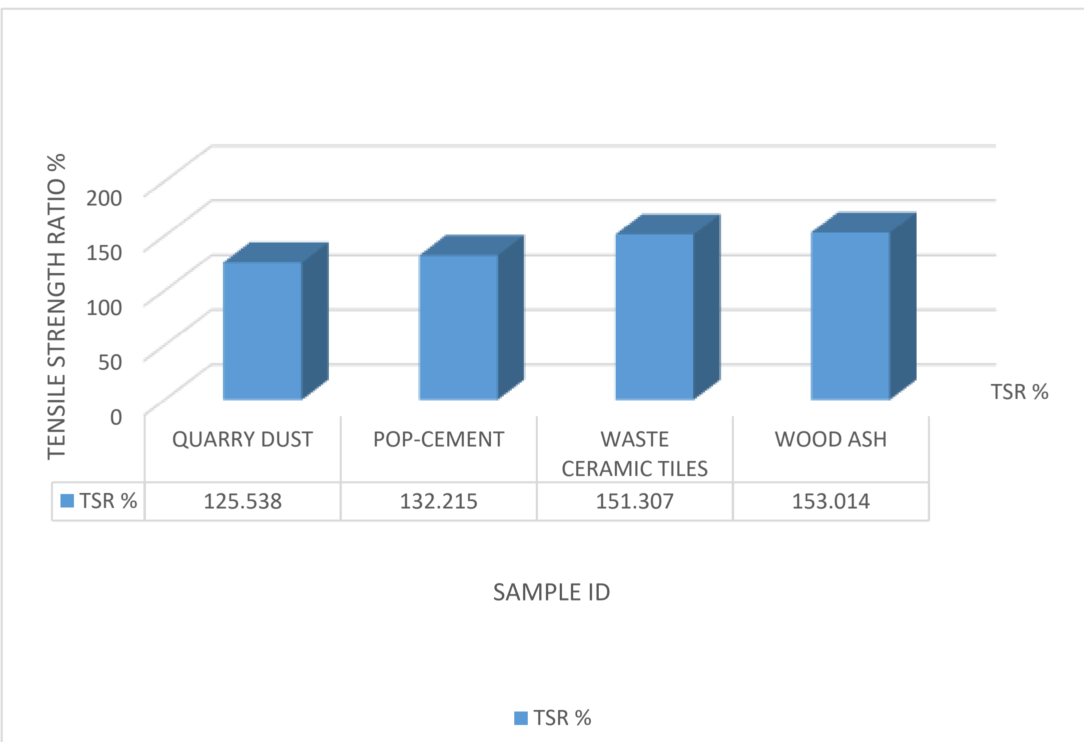


Fig graph of tensile strength ratio

Futher details of the result can been seen in the appendix.
A higher TSR denotes the mixture will operate well and will be resistant to moisture damage. The greater the TSR number, the less the strength will be reduced by water soaking, or the more water-resistant it will be.

CONCLUSION AND RECOMMENDATION

CONCLUSION

In this study, the impacts of bituminous mixtures containing crushed waste ceramic tiles, pop-cement, wood Ash, and quarry dust were compared to quarry dust used as a control. The objective was to investigate the viability of using these waste products for environmentally friendly asphalt pavement construction. The aim was to explore the potential of utilizing these waste materials for sustainable asphalt pavement construction. . The experimental evaluation included a variety of tests, such as those for Marshall stability, flow, indirect tensile strength, and X-RAY Flouresence, giving this researchers a thorough grasp of the characteristics and behavior of the chosen materials.
The findings of this investigation demonstrated that bituminous mixes containing crushed waste ceramic tiles, cement and wood ash, produced favorable results, such as pop-cement, whose performance was close the standards of the conventional filler (quarry dust). The addition of these waste materials exhibited notable improvements in key performance indicators. Key performance metrics showed a noticeable improvement with the incorporation of these waste products. Indicative of high resistance to deformation and improved load-bearing capability, the adjusted mixes displayed improved stability, decreased flow, increased tensile strength, and improved modulus values. Moreover, the XRF analytical technique was used to determine the elemental composition of various materials, by determining the chemistry of a sample by measuring the flouresecent x-ray emitted from the sample when exicited by a primary x-ray source .
Through the investigation of potential of waste materials in asphalt pavement construction, this study highlights the feasibility of sustainable alternatives to conventional asphalt mixes.

The results provide a foundation for further research on optimizing the composition and proportions of waste materials, maximizing their beneficial impact on the performance of asphalt mixes. Embracing innovative solutions and promoting sustainable practices in the construction industry can lead to environmentally friendly and long-lasting infrastructure.

RECOMMENDATION

Based on the findings of this study on the durability and micro-structural evaluation of pulverized plastic bottles, waste glass, and quartz-modified bituminous mixes, the following recommendations can be made:

1. Further Research: Continue investigating the long-term performance and durability of the modified bituminous mixes over extended periods. This involves monitoring the mixes under various environmental conditions, traffic loads, and aging processes. By doing so, researchers and engineers can gather valuable data to assess how the modified mixes perform over time and how they withstand different challenges.

2. Optimal Mix Design: Further investigation is necessary to ascertain the ideal combination and ratios of waste materials in bituminous blends. By refining the mixture design, it is possible to achieve additional enhancements in the stability, flow, tensile strength, and modulus values, ultimately boosting the overall performance and longevity of the asphalt pavement.

3. Standardization: Encourage the advancement and adoption of industry standards and specifications for incorporating waste materials in bituminous mixes. Establishing guidelines will ensure consistent quality control and enable widespread adoption of sustainable asphalt pavement construction practices.

4. Economic Feasibility: Perform an extensive economic evaluation to analyse the cost-effectiveness of incorporating waste materials in bituminous mixes. This assessment should consider the potential savings in terms of raw material usage, waste disposal costs, and environmental benefits. By quantifying these factors, it is possible to determine the economic feasibility and incentives for adopting these sustainable practices.

5. Collaboration and Knowledge Sharing: Promote collaboration among researchers, government agencies, and industry stakeholders to exchange knowledge, experiences, and best practices concerning the integration of waste materials in the construction of asphalt pavements. This collaborative effort will encourage innovation and expedite the adoption of sustainable solutions across the construction sector.

By implementing these suggestions, the construction industry can progress towards more environmentally friendly and sustainable practices in asphalt pavement construction. This will involve reducing waste, conserving resources, and enhancing the long-term durability of infrastructure.

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