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The Use of Oyster Shell Dust and Corn Cob Ash as Mineral Filler in Asphalt

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Abstract

This study evaluates the use of oyster shell ash (OSA) and corn cob ash (CCA) as sustainable alternatives to conventional mineral fillers in asphalt mixtures. The physical and mechanical properties of asphalt mixtures with varying OSA and CCA content (0-40%) were investigated through Marshall Stability tests. Results show improved stability (up to 21.7% increase) and flow (33.3% rise), indicating enhanced resistance to deformation and improved workability. The voids content decreased from 0.19% to 0.14%, suggesting better packing efficiency and potential durability gains. Stiffness fluctuated, decreasing at higher OSA and CCA content, highlighting the need for optimal content determination. Using waste materials like OSA and CCA promotes sustainability, reduces environmental impact, and offers a viable solution for improving asphalt performance, contributing to a more circular economy in construction.

KEYWORDS: *Oyster shell, corn cob ash Dust, Mineral Filler, Asphalt, Marshal stability, Aggregates*

1.0 INTRODUCTION

Due to the modernization of the construction industry, the use of wastes is an attractive trend with high potential for many highway researchers, with cleaner manufacturing and viable development as the chief aim. For these researchers, the purpose of their work is primarily to ensure economic, safe, smooth, and sustainable roads in order to carry the expected loads. Under these circumstances, an increased interest has been given toward the finding of road materials that could reduce the deterioration of the structure and increase the functioning of asphalt pavements. The filler is one of the constituents of asphalt mixtures, and it contributes greatly to their behavior and properties, especially the effects of aggregate binding.

Asphalt mixtures are made from bitumen, mineral aggregates, filler, and additives (if necessary). The filler is a very fine aggregate that is obtained from industrial processes or natural rocks. Limestone powder represents the most commonly used filler. The fillers may come in different types of powder forms, with the maximum particle size of 0.063 mm according to EN 13043:2003, and their addition in bituminous or hydraulic mixtures determines specific characteristics. Fillers are impactful in the manufacture of asphalt mixtures, as they can significantly influence the physical and mechanical properties of the mixtures. Although fillers are extensively used in the manufacture of asphalt mixtures, proposing a general classification that describes all the functions done by the fillers used in asphalt mixtures is still challenging. The fillers represent the finest part of the aggregate structure of an asphalt mixture, completing the granulometry, thus contributing to the reduction of the air voids in the mixture.

It majorly functions as an inert constituent that occupies the voids in between the aggregates in the mix and gives rise to a denser and impermeable mix. The flow of asphalt into the voids and reduction in the asphalt film thickness will ultimately result in reduction of relative distance between aggregate particles (Udo and Okafor 2020). Several experimental applications and studies have pointed out that fillers can contribute to the decrease of the asphalt mixtures' thermal sensitivity or the betterment of the mechanical properties of the mastic that covers the coarse aggregates. The fillers must have certain physical and chemical properties that allow for compatibility between the aggregates and the bituminous binder, at the same time guaranteeing a good rheological behavior of the mixture at the different temperatures encountered throughout the life of the asphalt mixture layer. At present, there is a serious global issue caused by environmental pollution from waste products, and it has become a threat to sustainable development policy. It is well known that industrial wastes pose environmental and human health hazards, and combined with an intensive

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exploitation of natural resources, they can determine permanent alterations in the natural environment, such as disturbances in the existing ecosystem, groundwater level, and vegetation degradation.

A new approach for pavement engineering production has emerged from the studies and laboratory tests that investigated a wide range of new materials in the composition of asphaltic mixtures such as byproducts and industrial waste materials during the last 20 years. From an environmental viewpoint, the reuse of various waste materials reduces the space for authorized landfills and deposits, allowing for an economy of natural resources. Moreover, from an economic viewpoint, the reuse of various industrial waste materials and byproducts instead of still expensive new materials represents a more attractive solution.

In practice, a substantial consumption of natural resources, as well as bitumen and mineral aggregates, and the discharge of unsafe emissions into the air are linked to the building of road structures. However, several waste materials have been used as additives in aggregate replacement, concretes, and mortars. The use of waste powder as filler in asphalt mixtures has been trending in the scientific world in the last ten years.

Several research reports dealing with the investigation of potential waste materials able to act as conventional filler materials have been presented in literature. It has also been reported that the properties of bituminous mastic are closely related to the type and percentage of fillers in the asphalt mix. The chemical composition of the filler significantly influences the behavior of asphalt mixtures over their service period as well.

Conventionally, mineral fillers used in asphalt production have often been derived from non-renewable sources, such as limestone or other quarried materials. The extraction and processing of these traditional mineral fillers can contribute to land pollution, as it can lead to the disturbance and degradation of natural landscape. In contrast, the use of corn cob dust and oyster shell dust as mineral fillers in asphalt provides a more sustainable and environmentally-friendly alternative. By utilizing these waste materials as mineral fillers, the asphalt industry can reduce the demand for traditionally quarried materials, thereby minimizing the environmental impact associated with their extraction and processing. Additionally, corn cob dust and oyster shell ash are considered waste products from other industries, making them a more cost-effective alternative. This reduction in material costs can translate into lower overall production costs for asphalt, which can ultimately benefit the construction industry and consumers.

Oyster shell ash can enhance the strength, durability and moisture resistance of the asphalt mixture, leading to longer, lasting and more durable pavements. Corn cob dust can improve the flexibility, fatigue resistance, and workability of the asphalt mixture, making it more resilient to traffic loads and thermal stresses. The synergistic effect of combining these two mineral fillers can result in a well-balanced and high-performing asphalt pavement that is resistant to various types of distress, such as cracking, rutting and moisture-induced damage. Utilizing waste materials like oyster shell ash and corn cob dust as mineral fillers reduces the demand for traditional, energy-intensive mineral fillers, such as limestone or fly ash. The recycling of these waste materials can contribute to a more circular economy, as it diverts them from landfills or other disposal methods, reducing the environmental burden associated with their disposal. The lower carbon footprint associated with the production and transportation of these waste-derived mineral fillers can contribute to the overall sustainability of the asphalt mixture. The use of oyster shell ash and corn cob dust as mineral fillers can help reduce the overall material cost for asphalt production, as these waste materials are often available at a lower cost compared to traditional fillers. The improved performance and durability of the asphalt mixture can lead to reduced maintenance and rehabilitation requirements over the pavement lifespan, further contributing to cost savings.

Numerous studies have investigated the use of oyster shell dust and corn cob dust as in asphalt, lightweight concrete, lateritic soils, thermal insulation materials, demonstrating its versatility. Huang et al (2010) evaluated the use of oyster shell dust as a partial replacement for conventional mineral filler in hot-mix asphalt. The results showed that up to 30% replacement with oyster shell dust improved the cracking resistance of the asphalt mixture. Ameri et al (2012), investigated the use of oyster shell dust as a filler in stone mastic asphalt (SMA) mixtures. They found that using 5-10% oyster shell dust enhanced the Marshall stability, flow, and indirect tensile strength of the SMA mixture. Wen et al (2013) evaluated the performance of hot-mix asphalt containing waste oyster shells as a mineral filler. The results showed that up to 50% replacement of conventional filler with oyster shell dust improved the rutting resistance and moisture susceptibility of the asphalt mixture. Kalantar et al (2012) discussed the potential use of corn cob dust as a mineral filler in asphalt mixtures, highlighting its ability to improve the mechanical properties and durability of the mixture. Goh et al (2011) investigated the use of corn cob-based biochar as a partial replacement for mineral filler in asphalt mixtures. They found that using 4-6% corn cob biochar improved the moisture resistance and tensile strength of the asphalt mixture. Muniandy et al (2012) evaluated the use of corn cob ash (a byproduct of corn cob incineration) as a mineral filler in stone mastic asphalt mixtures. The results showed that up to 20% replacement of conventional filler with corn cob ash enhanced the tensile strength and fatigue life of the asphalt mixture. Tapkin (2008) investigated the use of oyster shell dust as a filler in asphalt mixtures modified with polypropylene fibers. The results showed that the combination of oyster shell dust and polypropylene fibers improved the Marshall stability, flow, and indirect tensile strength of the asphalt mixture. Kavussi & Modarres (2010) evaluated the use of oyster shell dust as a replacement for conventional mineral filler in recycled asphalt mixtures. They found that using 5-10% oyster shell dust enhanced the resilient modulus and fatigue life of the recycled asphalt mixture. Yilmaz et al (2015) assessed the performance of asphalt mixtures containing

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oyster shell dust, waste marble dust, and waste glass powder as mineral fillers. The results showed that using 4-6% oyster shell dust improved the Marshall stability, flow, and moisture resistance of the asphalt mixture. Goh & You (2012) investigated the use of corn cob-based biochar as a partial replacement for mineral filler in asphalt seal coats. They found that using 4-6% corn cob biochar improved the adhesion, skid resistance, and durability of the seal coat. Muniandy et al (2013) evaluated the use of corn cob ash (a byproduct of corn cob incineration) as a mineral filler in stone mastic asphalt mixtures. The results showed that up to 20% replacement of conventional filler with corn cob ash enhanced the rutting resistance and fatigue life of the asphalt mixture. Xiao et al (2011) found out that incorporating oyster shell dust into asphalt mixtures increases the resistance to permanent deformation and enhances the fatigue life of the asphalt. Wen et al (2014) evaluated the performance of hot-mix asphalt containing waste oyster shells as a mineral filler. Results showed that oyster shell dust-filled asphalt mixtures show improved resistance to stripping and better adhesion between the aggregate and the binder. Adesanya & Raheem (2009) investigated the chemical composition of CCA. Factory production of the CCA - blended cement was carried out by replacing 0%, 2%, 4%, 6%, 8%, 10%, 15%, 20% and 25% by weight of Ordinary Portland Cement clinker with CCA. The 0% replacement serves as the control. The results showed that CCA is a suitable material for use as a pozzolan as it satisfied the minimum requirement of combined SiO2 and Al2O3 of more than 70%, which a good pozzolan for manufacture of blended cement should meet. The blended cements produced also satisfied both NIS 439:2000 and ASTM C 150 requirements especially at lower levels (<15%) of CCA percentage replacement. Based on the test results, it was concluded that CCA could be suitably used in blended cement production. Akindahunsi et al (2022).

1.1 Objectives of the Study

- To determine the specific gravity of the mineral filler and how it affects the overall density of the asphalt.
- To determine the physical and mechanical properties of asphalt-corn cob dust/oyster shell ash composite.
- To obtain the Marshall stability of the asphalt mixture.
- To determine the indirect tensile strength of the asphalt-corn cob/oyster shell dusts composite.

1.2 Research Hypothesis

The use of OSA and CCA as mineral fillers in asphalt mixtures improves their physical and mechanical properties, leading to enhanced pavement performance and durability.

1.3 Limitations of the Study

- Availability and consistency of waste materials: Obtaining a consistent supply of oyster shells and corn cobs can be challenging, as the availability of these waste materials may vary depending on the location and industry activities.
- Determining the optimal particle size, gradation, and chemical composition of the oyster shell dust and corn cob dust to achieve the desired performance characteristics in the asphalt mixtures can be a complex process.

2.0 METHODOLOGY

The method used for this project research is the laboratory method. The procedures used were in accordance with known Standards (AASHTO, 2000a,b, 2001, ASTM, 2015; BSI PD6691, 2015; BS EN 12697, 2020). The test specimens were mixed and compacted at the appropriate temperatures based on the viscosity of the asphalt, and at the specified number of blows.

2.1 Oyster Shell and Corn Cob Ash Preparation

Oyster shell and corn cob wastes were sourced from a market dump site in Uyo Local Government Area of Akwa Ibom State. Surfaces of the oyster shells were washed and brushed to remove dirt's and impurities. Washed oyster shells were naturally dried and then calcined at a high temperature using thermogravimetric analysis to control the temperature, before being grinded using a stone mill. The same procedure was done for the corn cob.

2.2 Aggregate Preparation

Coarse aggregate used in this study was obtained from Alpha Grade Marble and Granite Limited in Uyo, Akwa Ibom State, Nigeria, with angular particles and rough surface texture/roughness, whereas fine aggregates was sourced at a local river sand mining site in Mkpat Enin L.G.A of Akwa Ibom State. Aggregates retained on the sieves of aperture size less than 5mm was classified as coarse aggregate, whereas aggregates on sieves of aperture size less than 5mm but retained on sieves of aperture size 0.075mm were classified as fine aggregate. Particle size distribution test was done according to specifications of the AASHTO T27 – 20 classification system.

2.3 Bitumen

Asphalt binder penetration grade of PG64-22, sourced from China Civil Engineering Construction Company (CCECC) Uyo, Akwa Ibom State was utilized as bitumen. Laboratory analysis was done on the chosen bitumen for determination of penetration (AASHTO T 49-15), Specific gravity (AASHTO T229), Ductility (AASHTO T51-09), Softening point (AASHTO T53-09), Flash point (AASHTO T 48-18), Viscosity (AASHTO T 72-10). These were evaluated with standard/conventional values.

2.4 Mix Preparation

The mix followed standard procedures for asphalt pavement (Asphalt institute, 2003; BS EN 12697, 2020). The aggregate content was kept constant throughout the mix, while the percentage of the corn cob ash and oyster shell ash contents in the mix were varied. The asphalt binder content remained constant. For each mix with specified asphalt content, three samples were prepared to contain 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40% of the oyster shell ash (OSA) and corn cob ash (CCA) content with stone dust used as a

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conventional mineral filler. The OSA and CCA acts as filler in the OSA/CCA-filled asphalt concrete. The addition of different OSA and CCA content in the mix was to determine the optimum mix proportion and also to develop the mix design model. Details of the design mix is as presented in table 2.1.

Table 2.1: Proportions of constituent's mix

Mix Description	0% CCA & OSA	5% CCA & OSA	10% CCA & OSA	15% CCA & OSA	20% CCA & OSA	25% CCA & OSA	30% CCA & OSA	35% CCA & OSA	40% CCA & OSA
Bitumen content %	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
% of CCA & OSA combination	0%	5%	10%	15%	20%	25%	30%	35%	40%
Filler combination Ratio (GD:CCA/OSA	100% SD	(95:5)%	(90:10)%	(85:15)%	(80:20)%	(75:25)%	(70:30)%	(65:35)%	(60:40)%
Fine Aggregate	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Coarse aggregate (20-22)mm %	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50
Coarse aggregate (5-15)mm %	25.30	25.30	25.30	25.30	25.30	25.30	25.30	25.30	25.30
Total % in mix	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

3.0 PRESENTATION OF RESULTS

The Marshal test properties of the oyster shell ash and corn cob ash filled asphaltic concrete were performed at various percentages of OSA and CCA content (0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40%). The test properties investigated include stability, density, flow, void in the mixture (VIM) and stiffness. The data presented in Tables 3.1, 3.2, and 3.3 shows the Marshall Stability Test results for asphaltic concrete with varying percentages of Oyster Shell Ash (OSA) and Corn Cob Ash (CCA) content.

Table 3.1: Marshall Stability Test Data for 0% - 10%

Mix Description	**0% CCA&OSA**		**5% CCA&OSA**		**10% CCA&OSA**	
Specimen Identification	A	B	A	B	A	B
Wt. of specimen in air(g)	1191.5	1195.5	1191.6	1195	1192	1195.2
Wt. of specimen in water(g)	666.5	663.0	663.3	663.1	662	663.4
Wt. of specimen in air after soaking(g)	1194.5	1197.0	530	533	1196.5	1197
Volume of specimen(cm^3)	525.0	532.5	2.25	2.25	531.5	520.2
Density of test specimen(g/cm^3)	2.27	2.25	2.25	2.26	2.25	2.26
Average density(g/cm^3)	**2.26**		**2.25**		**2.26**	
Wt. of water absorbed after soaking	3.00	1.50	29	1.51	28.5	1.50
Void in test specimen (%)	0.25	0.13	0.24	0.13	0.23	0.12
Average Voids (%)	**0.19**		**0.18**		**0.18**	
Stability reading(/0.01mm)	31.0	28.5	31.5	29	32	29
Flow(mm)	2.00	1.89	2.1	1.9	2.2	1.92

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Average flow(mm)	**1.95**		**2.00**		**2.06**	
Correlation factor	0.93	0.93	0.94	0.92	0.94	0.91
Corrected Stability (kN)	5.29	4.87	5.35	4.9	5.5	5.1
Average corrected Stability (kN)	**5.08**		**5.13**		**5.30**	
Asphalt Marshall stiffness(kN/mm)	**2.61**		**2.60**		**2.67**	

Table 3.2: Marshall Stability Test Data for 15% - 25%

Mix Description	**15% CCA&OSA**		**20% CCA&OSA**		**25% CCA&OSA**	
Specimen Identification	**A**	**B**	**A**	**B**	**A**	**B**
Wt. of specimen in air(g)	1195.5	1195	1196	1194.8	1196	1192
Wt. of specimen in water(g)	661	664.5	662.5	665.5	664	661.5
Wt. of specimen in air after soaking(g)	1197.5	1175	1198.5	1196.3	1197	1191
Volume of specimen(cm^3)	532.3	531.4	533.5	532.3	545	531
Density of test specimen(g/cm^3)	2.24	2.26	2.24	2.26	2.2	2.24
Average density(g/cm^3)	**2.25**		**2.50**		**2.22**	
Wt. of water absorbed after soaking	26.5	1.5	2.5	1.5	2.0	1.8
Void in test specimen (%)	0.22	0.13	0.21	0.13	0.18	0.15
Average voids (%)	**0.17**		**0.17**		**0.16**	
Stability reading (/0.01mm)	32.5	29.5	33	30.5	33.5	34
Flow (mm)	2.3	1.94	2.4	1.95	2.45	2.3
Average flow(mm)	**2.12**		**2.18**		**2.38**	
Correlation factor	0.95	0.92	0.96	0.93	0.96	0.93
Corrected Stability (kN)	5.7	5.15	5.82	5.21	5.71	5.75
Average Corrected Stability (kN)	**5.40**		**5.52**		**5.73**	
Asphalt Marshall Stiffness (kN/mm)	**2.54**		**2.53**		**2.41**	

Table 3.3: Marshall Stability Test Data for 30% - 40%

Mix Description	**30% CCA&OSA**		**35% CCA&OSA**		**40% CCA&OSA**	
Specimen Identification	**A**	**B**	**A**	**B**	**A**	**B**
Wt. of specimen in air(g)	1196	1191	1190.5	1191.6	1192.5	1192
Wt. of specimen in water(g)	662.5	664.5	661.5	663	662	664
Wt. of specimen in air after soaking(g)	1198	1193	1198	1189.5	1182.5	1190
Volume of specimen(cm^3)	553	533	551	532.5	550	531
Density of test specimen(g/cm^3)	2.24	2.26	2.2	2.23	2.15	2.24
Average density(g/cm^3)	**2.25**		**2.22**		**2.20**	
Wt. of water absorbed after soaking	1.5	2	1.5	2.1	1.5	2.15
Void in test specimen (%)	0.13	0.17	0.12	0.18	0.1	0.19
Average voids (%)	**0.15**		**0.15**		**0.14**	
Stability reading (/0.01mm)	34.8	36	35	37	37	38
Flow (mm)	2.38	2.55	2.5	2.6	2.55	2.65
Average flow(mm)	**2.47**		**2.55**		**2.60**	
Correlation factor	0.96	0.93	0.97	0.94	0.97	0.94
Corrected Stability (kN)	5.73	6.32	5.75	6.45	5.8	6.55

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Average Corrected Stability (kN)	**6.03**	**6.10**	**6.18**
Asphalt Marshall Stiffness (kN/mm)	**2.46**	**2.39**	**2.37**

3.1 Discussion

The results presented in the tables show the Marshall Stability Test properties of asphaltic concrete with varying percentages of Oyster Shell Ash (OSA) and Corn Cob Ash (CCA) content.

3.1.1 Density

The addition of OSA and CCA to the asphalt mixture results in a varying density trend compared to the 0% addition, where the density is 2.26 g/cm³ as shown in Fig 3.1. While some percentages of OSA and CCA (e.g., 20%) show a slight increase in density to 2.50 g/cm³, others exhibit similar or slightly lower density values. For instance, at 5% and 15% OSA and CCA content, the density values are 2.25 g/cm³, similar to the 0% addition. However, at higher percentages (25% and above), the density tends to decrease, with the lowest value of 2.20 g/cm³ observed at 40% OSA and CCA content. This suggests that the addition of OSA and CCA can potentially improve density at optimal percentages but may also lead to decreased density at higher contents. Also, possibly due to excessive filler content disrupting the asphalt's structure or increasing void content. The variation in density values indicates that the interaction between OSA, CCA, and asphalt binder plays a crucial role in determining the mixture's density.

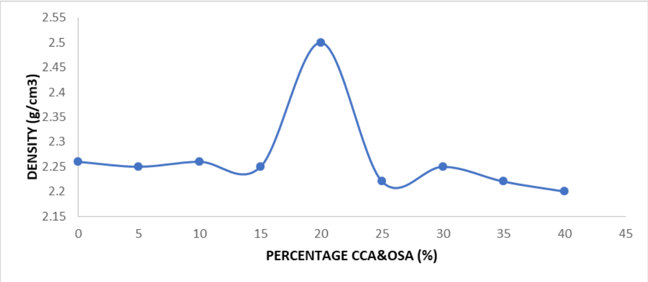

Fig 3.1: Effect of CCA & OSA on Density

3.1.2 Voids

The consistent decrease in voids content with increasing OSA and CCA content, from 0.19% at 0% to 0.14% at 40% as shown in Fig 3.2, suggests that the filler materials effectively fill voids and improve packing

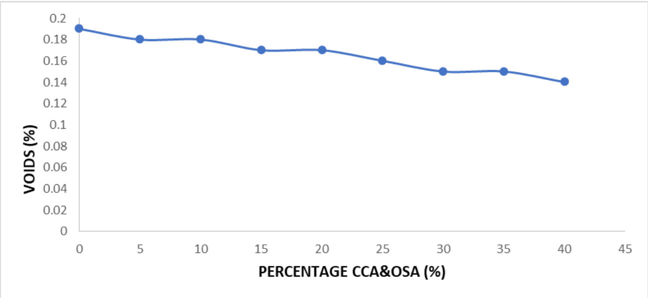

Fig 3.2: Effect of CCA & OSA on Voids

Efficiency. Compared to the control mixture, the addition of OSA and CCA reduces voids content, which could be due to the fine particle sizes, thus allowing it to effectively fill gaps between larger aggregates, potentially leading to improved durability and stability. This reduction in voids content can minimize water infiltration and damage, enhance the overall performance of the asphalt pavement and indicate that OSA and CCA can be viable filler materials for improving asphalt mixture properties and is in line with a work done by Abbas *et al., (*2019); Wu *et al*., (2020); Caroles *et al, (*2021), where they concluded that the voids of an asphaltic concrete decreased with increasing percent of asphalt or filler.

3.1.3 Stability

The stability of the asphalt mixture consistently increases with the addition of OSA and CCA, from 5.08 at 0% to 6.18 at 40%, as shown in Fig 3.3, representing a notable 21.7% improvement. Compared to the control mixture, the addition of OSA and CCA filler materials enhances the stability, likely due to improved aggregate interlock, filler effect, and asphalt-filler interaction, which collectively contribute to a more robust and deformation-resistant mixture. This increase in stability suggests that OSA and CCA can be effective additives for improving the performance and durability of asphalt pavements, potentially leading to reduced maintenance costs and extended pavement lifespan.

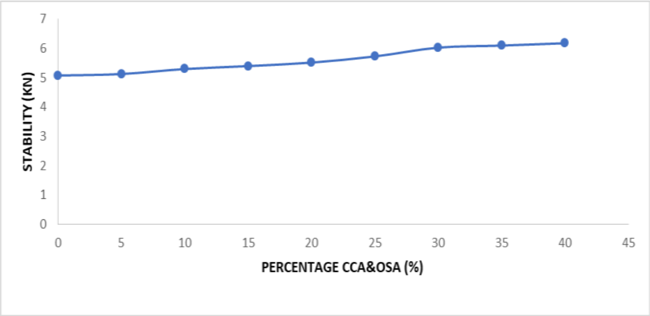

Fig 3.3: Effect of CCA & OSA on Stability

3.1.4 Flow

The flow values of the asphalt mixture consistently increase with the addition of OSA and CCA, from 1.95 at 0% to 2.60 at 40%, as shown in Fig 3.4, representing a notable 33.3% rise. Compared to the control mixture, the addition of OSA and CCA filler materials enhances the flow, likely due to improved asphalt-filler interaction and cohesion within the mixture, which allows the mixture to deform more under load. This increased flow may impact the mixture's resistance to deformation and rutting, and while stability values also increased, the balance between stability and flow is crucial to ensure optimal pavement performance and durability.

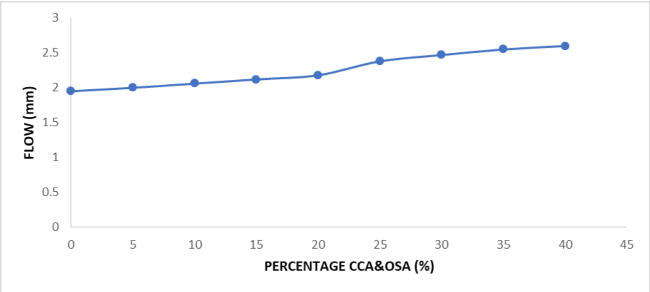

Fig 3.4: Effect of CCA & OSA on Flow

3.1.5 Stiffness

The stiffness of the asphalt mixture exhibits a fluctuating trend with increasing OSA and CCA content, starting at 2.61 at 0% and ultimately decreasing to 2.37 at 40%, a 9.2% reduction, as shown in Fig 3.5. Compared to the control mixture, the addition of OSA and CCA initially maintains or slightly increases stiffness up to

10%, but higher percentages lead to a softening effect, reducing stiffness and potentially compromising the mixture's rigidity and load-bearing capacity. This trend highlights the importance of optimizing OSA and CCA content to balance stiffness with other performance characteristics, such as stability and flow, to ensure optimal pavement performance and durability.

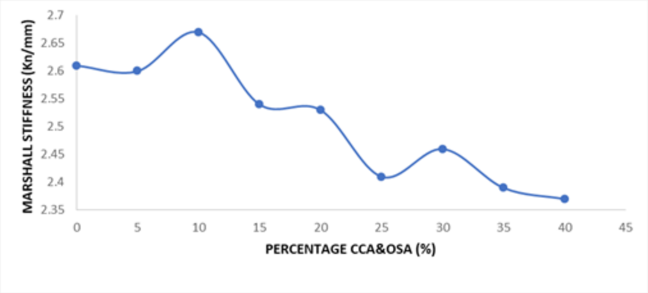

Fig 3.5: Effect of CCA & OSA on Stiffness

4.0 CONCLUSION

The research aimed to evaluate the suitability of oyster shell ash (OSA) and corn cob ash (CCA) as mineral fillers in asphalt mixtures. The results demonstrate that both fillers significantly influence the physical and mechanical properties of asphalt.

The study's findings indicate that the incorporation of OSA and CCA in asphalt mixtures has shown promising results, with notable improvements in stability and a consistent increase in flow values. However, the stiffness trend indicates a potential softening effect at higher percentages of OSA and CCA content. Overall, the optimal percentage of OSA and CCA content appears to be a balance between enhancing stability and maintaining desirable stiffness and flow characteristics as excessive amounts may compromise stiffness and potentially impact pavement durability. These findings suggest that OSA and CCA can be viable additives for improving asphalt mixture performance. but further research is necessary to determine the optimal content and ensure satisfactory pavement durability and resistance to deformation. By optimizing OSA and CCA content, pavement engineers can create more durable, sustainable, and high-performance asphalt mixtures.

4.1 RECOMMENDATIONS

To fully leverage the benefits of OSA and CCA, further research should focus on determining the ideal content range, investigating long-term performance, and exploring potential applications in various pavement types and environmental conditions.

Author Contribution Statement

All authors contributed to the study in the aspect of conception, design, analysis and manuscript writing. Formal analysis of laboratory outcome was jointly carried out by all the authors

Johnny Udo made significant contributions to the work, handled conception and revised it serially for intellectual input. He did the last level technical reviewing and editing as the corresponding author.

Sunday Udoh handled data/results analysis

Mary Akpan handled materials preparation and laboratory investigations.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data Availability Statement

All materials used in this work and the data gathered during the investigation are original to the authors and will only be provided upon request. In accordance with ethical publication norms, all other relevant work has been appropriately acknowledged and referenced in the manuscript. The manuscript contains all the data sets created during the research study's findings.

REFERENCES

1. AASHTO (2000a). AASHTO Provisional Standards, April 2000 Interim Edition. American Association of State Highway and Transportation Officials. Washington, D.C.
2. AASHTO (2000b). Provisional Standards, Interim Edition. American Association of State Highway and Transportation Officials. Washington, D.C.
3. AASHTO (2001). Provisional Standards, Interim Edition. American Association of State Highway and Transportation Officials. Washington, D.C.
4. Abbas, H., Ibrahim, M., Al-Hadidy, A., Al-Maamori, S. (2019). Evaluation of the effect of filler and asphalt content on the volumetric properties of asphalt concrete mixtures. International Journal of Pavement Research and Technology, 12(5), 506-515.
5. Adesanya, D.A., Raheem, A.A. (2009). Development of corn cob ash blended cement. Construction and Building Materials 23(1), 347-352.
6. Akindahunsi, A.A., Ogune, C.N., Ayodele, A.L., Fajobi, A.B., Olajumoke, A.M. (2022). Evaluation of the performance of corncob ash in cement mortars. Journal of Building Pathology and Rehabilitation 7(1), 72.
7. Ameri, M., Mansourian, A., Ashani, S. S., & Yadollahi, G. (2012). Technical study on the use of waste materials as filler in stone mastic asphalt mixtures. Construction and Building Materials, 36, 386-391.
8. Asphalt Institute (2003). MS-2, Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types Asphalt Institute. Lexington, KY.
9. ASTM D1559 Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures using Marshall Apparatus. American Society for Testing and Materials, USA.

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10. ASTM, A. (2015). D6927-15 Standard Test Method for Marshall Stability and Flow of Asphalt Mixtures. ASTM International: West Conshohocken, PA, USA.
11. BS EN 12697 (2020). European Standards for bituminous mixture-test method, part 1: soluble binder content, British Standards Institution, UK.
12. BSI PD6691 (2015). Guidance on the use of BS EN 13108 bituminous mixture, material specifications, British Standards Institutions, 389, Chiswick High Road, London, W4 4AL, UK.
13. Caroles, L., Tumpu, M., Rangan, P.R. (2021, October). Marshall properties of LASBUTAG asphalt mixes with pertalite as a modifier. In IOP Conference Series: Earth and Environmental Science (Vol. 871, No.1, p.012064). IOP Publishing.
14. Etim, R., Attah, I., Yohanna, P. (2020). Experimental study on potential of oyster shell ash in structural strength improvement of lateritic soil for road construction. International Journal of Pavement Research and Technology, 13, 341-351.
15. Goh, S. W., Akin, M., You, Z., & Shi, X. (2011). Effect of deicing solutions on the tensile strength of micro-cracked asphalt mixtures. Construction and Building Materials, 25(1), 195-200.
16. Goh, S. W., & You, Z. (2012). Evaluation of coal-tar seal coats and biobased seal coats using advanced performance tests. Journal of Materials in Civil Engineering, 24(10), 1338-1345.
17. Huang, B., Shu, X., & Vukosavljevic, D. (2010). Laboratory investigation of cracking resistance of hot-mix asphalt field mixtures containing screened reclaimed asphalt pavement. Journal of Materials in Civil Engineering, 22(11), 1178-1185.
18. Hu, C., Zhong, D., Li, S. (2023). A study on effect of oyster shell powder on mechanical properties of asphalt and multiple degrees of modification mechanism. Case Studies in Construction Materials 18, e01786.
19. Kalantar, Z. N., Karim, M. R., & Mahrez, A. (2012). A review of using waste and virgin polymer in pavement. Construction and Building Materials, 33, 55-62.
20. Kavussi, A., & Modarres, A. (2010). A model for resilient modulus determination of recycled mixes with cement and waste materials. Construction and Building Materials, 24(11), 2252-2259.
21. Li, G., Xu, X. Chen, E., Fan, J., Xiong, G. (2015). Properties of cement-based bricks with oyster-shell ash. Journal of Cleaner Production, 91, 279-287.
22. Mistry, R., & Roy, T.K. (2020). Predicting Marshall stability and flow of bituminous mix containing waste fillers by the adaptive neuro-fuzzy inference system. *Revista de la construccion*, 91, 279-287.
23. Muniandy, R., Aburkaba, E., Jakarni, F. M., & Hassim, S. (2013). Effect of mineral filler particle size and type on the rheological and dynamic mechanical properties of stone mastic asphalt mixtures. Advances in Materials Science and Engineering, 2013.
24. Muniandy, R., Aburkaba, E., Mahdi, L., & Yunus, R. (2012). Effects of mineral filler particle size and type on the tensile strength of stone mastic asphalt mixtures. Australian Journal of Basic and Applied Sciences, 6(3), 400-411.
25. Nciri, N., Shin, T., Lee, H., Cho, N. (2018). Potential of waste oyster shells as a novel bio-filler for hot-mix asphalt. Applied Sciences 8(3), 415.
26. Shen, J., & Amirkhanian, S. (2005). The influence of crumb rubber modifier (CRM) on the rheological properties of asphalt binders. Petroleum Science and Technology, 23(9-10), 1051-1063.
27. Singh, K., Singh, J., Sarvesh, K. (2018). Evaluation of corncob ash as partial replacement of cement in concrete. Agricultural Research Journal, 55(4).
28. Tapkin, S. (2008). The effect of polypropylene fibers on asphalt performance. Building and Environment, 43(6), 1065-1071.
29. Udo, J.J; Okafor, F. O "Effect of Air Voids Content on Ageing Characteristics of Bituminous Mix". Journal of Scientific and Engineering Research, 2020, 7(5): 297 - 322
30. Wang, X., Wu, S., Zhang, S. (2021). Effects of asphalt and filler contents on the performance of asphalt pavement. Construction and Building Materials, 279, 122483.
31. Wen, H., Bhusal, S., & Wen, B. (2013). Laboratory evaluation of waste oyster shells as a replacement for mineral filler in hot-mix asphalt. Journal of Materials in Civil Engineering, 25(7), 871-876.
32. Wen, H., Bhusal, S., & Wen, B. (2014). Laboratory evaluation of waste oyster shells as mineral filler in hot-mix asphalt. Journal of Materials in Civil Engineering, 26(2), 312-318.
33. Wu, S., Wang, F., Huang, R., Xue, Y. (2020). Investigation of the influence of asphalt content and filler type on the mechanical performance of asphalt mixture. Journal of Construction and Building materials, 259, 119804.
34. Xiao, F., Amirkhanian, S., & Juang, C. H. (2011). Rutting resistance of rubberized asphalt concrete mixtures with warm mix asphalt technology. Construction and Building Materials, 25(3), 1239-1247.
35. Yilmaz, A., Çeloğlu, M. E., Yalçın, E., & Kök, B. V. (2015). Effects of waste materials as mineral filler in hot mix asphalt concrete. Construction and Building Materials, 93, 337-344.

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