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Valorising Corn Cob Ash and Bamboo Leaf Ash as fillers in Asphaltic concrete

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Abstract: *The study investigated the performance characteristics of asphaltic concrete incorporating Corn Cob Ash (CCA) and Bamboo Leaf Ash (BLA) as partial replacements for conventional filler materials. Marshall Stability, Flow, and Marshall Quotient, were conducted to evaluate the properties of the asphalt mix. The results showed that the index properties of aggregates and bitumen met standard specifications, leading to an optimal mix design of 65.7% coarse aggregate, 7% fine aggregate, 21% filler, and 6.3% bitumen content. The stability and flow values increased with CCA-BLA proportion, reaching peak stability of 20.9 kN, a flow of 3.4 mm, and a Marshall quotient of 6.1 KN/mm at 30% ash replacement (50% CCA, 50% BLA). This composition exhibited superior rutting resistance and mechanical performance. The study concluded that incorporating agricultural waste materials as fillers enhances asphalt Stability and aligns with sustainable construction practices. The research recommends 50% SDA and 50% BLA at 30% combined ash replacement for natural filler substitution in Nigerian asphalt production. Additionally, further field research is suggested to examine the long-term performance and durability of CCA-BLA-modified asphalt. This innovative approach promotes cost-effective, eco-friendly solutions in road construction while reducing reliance on conventional fillers.*

KEYWORDS: *Asphaltic concrete, Corn Cob Ash, Bamboo Leaf Ash, Marshall Stability, Sustainable Development Goal*

1. INTRODUCTION

Asphaltic concrete is an essential material in modern road construction, offering durability and flexibility to withstand varying traffic loads and environmental conditions (Okon et al., 2025). A critical component of asphaltic concrete is the mineral filler, which enhances its mechanical properties, increases cohesion, improves resistance to deformation, and influences the mixture's overall performance. Conventionally, cement, limestone dust, and stone dust have been used as fillers due to their availability and compatibility with bituminous materials. However, concerns about

environmental sustainability, particularly the high carbon footprint associated with cement production, have prompted researchers to explore alternative fillers derived from industrial and agricultural waste materials (Subedi et al., 2025).

The production of cement, a widely used filler in asphaltic concrete, contributes significantly to global CO_2 emissions, with estimates suggesting that cement manufacturing accounts for nearly 8% of the world's carbon emissions (Suarez-Riera et al., 2024). As the construction industry moves toward more sustainable practices, there is a pressing need for environmentally friendly, cost-effective, and mechanically efficient substitutes for conventional fillers. Identifying suitable replacement materials requires a comprehensive evaluation of their mineralogical composition, particle size distribution, surface area, and chemical reactivity, as these factors influence the overall performance of asphalt mixtures (Sukhija and Coleri, 2025).

Various waste materials have been explored as potential fillers in asphalt mixtures, including copper slag powder (Modarres & Alinia, 2019), bauxite residue (Choudhary et al., 2019), empty palm fruit bunch ash (Lukjan et al., 2022), and coffee husk ash (Tessema et al., 2022). These studies have demonstrated that waste-based fillers can improve the mechanical properties of asphalt while simultaneously addressing waste disposal challenges. Among the promising alternatives, agricultural waste materials such as corn cob ash (CCA) and bamboo leaf ash (BLA) have garnered attention due to their pozzolanic nature and high silica content, which contribute to enhanced bonding and durability in asphaltic concrete (Farahi et al., 2025).

Corn cob ash (CCA) is derived from the combustion of corn cobs, an agricultural by-product generated in large quantities globally (Ajagbe et al., 2020). The use of CCA in asphalt mixtures offers several advantages, including its fine particle size, which allows for better integration within the asphalt matrix, and its pozzolanic reactivity, which contributes to improved stiffness and long-term performance of the pavement (Endashaw, 2022). Studies have shown that incorporating CCA into asphalt mixtures enhances resistance to deformation, reduces moisture susceptibility, and lowers the overall binder content

required for the mix. By replacing conventional fillers with CCA, the ecological impact of quarrying and material extraction can be minimized, contributing to more sustainable road construction practices (Ahmad et al., 2023).

Also, Bamboo Leaf Ash (BLA), another agro-waste product, is obtained from the incineration of bamboo leaves. BLA is rich in silica and alumina, making it highly pozzolanic and suitable for use in asphaltic concrete (Khan et al., 2024). The inclusion of BLA in asphalt mixtures has been found to enhance strength, increase resistance to rutting, and improve durability against environmental factors such as moisture and temperature fluctuations. Additionally, utilizing bamboo leaf ash as a filler aligns with sustainable construction initiatives by repurposing agricultural residues and reducing landfill waste.

The integration of alternative fillers such as corn cob ash (CCA) and bamboo leaf ash (BLA) in asphaltic concrete aligns with the principles of circular economy and sustainable development. These materials, often considered agricultural waste, can be repurposed to enhance the performance of asphalt pavements while reducing reliance on non-renewable resources. Research has demonstrated that agro-waste fillers improve the stiffness modulus, fatigue resistance, and overall strength of asphalt mixtures, leading to longer-lasting pavements (Akinleye et al., 2020). Additionally, utilizing agricultural residues helps reduce the carbon footprint associated with cement production and aggregate quarrying, contributing to global efforts to mitigate climate change (Vural et al., 2025). The use of locally available waste materials also lowers construction costs, providing an economically viable alternative to conventional fillers (Akinleye and Tijani, 2017). Furthermore, recycling agricultural waste into construction materials minimizes environmental pollution and supports international waste management policies, including those advocated by the United Nations' Sustainable Development Goals (SDGs).

While studies on the use of CCA and BLA as fillers in asphalt mixtures have reported promising results, most research has focused on their individual effects on specific performance aspects such as stiffness, moisture resistance, and rutting resistance. However, there remains a significant gap in the literature regarding the combined influence of CCA

and BLA as a hybrid filler system in asphaltic concrete. This study seeks to bridge that gap by evaluating the mechanical performance of asphalt mixtures incorporating both CCA and BLA, examining their effects on strength parameters, fatigue resistance, and overall pavement durability. Through the assessment of the feasibility of using these agro-waste materials as mineral fillers, this research contributes to the development of sustainable and high-performance asphaltic concrete. The findings of this study have the potential to guide infrastructure engineers and policymakers in adopting environmentally responsible materials for road construction, ultimately fostering sustainable development in the transportation sector.

II. MATERIALS AND METHODS

2.1 Materials

Fine and coarse aggregates were utilized in the production of asphaltic concrete, with cement, bamboo leaf ash (BLA), and corn cob ash (CCA) serving as fillers, while bitumen functioned as the binder. Various standard tests, including sieve analysis, water absorption capacity, specific gravity, moisture content, aggregate abrasion, impact, and crushing values, were conducted to evaluate the physical and mechanical properties of the aggregates. Crushed granite samples were sourced from a local quarry in Ede, Osun State, and subjected to these tests to ensure compliance with engineering standards. Fine aggregates, primarily composed of sharp sand obtained from the same quarry, were similarly characterized through sieve analysis, water absorption, specific gravity, and moisture content assessments.

Quarry dust, sourced from Ede, Osun State, was subjected to the same series of tests to determine its suitability as a filler material. Bamboo leaves were g Equations 1, 2 and 3 respectively.

collected from villages around Adeleke University, Ede, Osun State, and processed by drying and incinerating in a controlled furnace environment at 700°C for two hours. The resulting ash was sieved through a U.S. Sieve No. 200 (75 µm) to obtain fine particles suitable for use as a mineral filler in asphaltic concrete production. The chemical composition of BLA was analyzed using X-ray Fluorescence (XRF) spectroscopy.

Similarly, corn cobs were sourced from villages around Adeleke University, Ede, Osun State, and subjected to controlled combustion to produce CCA. The resultant ash was sieved using a U.S. Sieve No. 200 (75 µm) and incorporated as a mineral filler in asphaltic concrete formulations. The chemical composition of CCA was also determined using XRF analysis.

Grade 60/70 asphalt cement (bitumen) obtained from a bitumen plant in Ogun State was employed as the binding agent. The bitumen underwent standard characterization tests, including penetration, flash point, ductility, and softening point evaluations, to ensure its suitability for asphaltic concrete production.

2.2 Methods

a) Aggregate Gradation: This was accomplished by screening the aggregates In line with ASTM C 136-92 and BS 812: Part 103.1: 1985. To the closest 0.1 percent, the findings were computed and shown as the proportion by weight of the total sample that passed through one sieve and was retained on the next smaller sieve, as well as the cumulative percentage by weight of the entire sample. The coefficient of curvature Cc and uniformity coefficient Cu was determined in order to classify the aggregates usin

$$Percentage\ \mathrm{Re}tained\ =\ \frac{Weight\ of\ aggregate\ retained}{Total\ weight\ of\ aggregate} \times 100 \qquad 1$$

% passing this sieve = % passing the previous sieve - % retained on this sieve

$$C_u = \frac{D_{60}}{D_{10}} \qquad\qquad 2$$

$$C_c = \frac{D_{30}^2}{D_{60} \times D_{10}} \qquad\qquad 3$$

Where: C_u is the Coefficient of Uniformity, C_c is the Coefficient of Curvature, D_{60} is the Particle diameter of which 60% by weight of aggregate is finer, D_{30} is the Particle diameter of which 30% by weight of aggregate is finer, and D_{10} is the Particle diameter of which 10% by weight of aggregate is finer.

b)   Moisture Content: In compliance with BS 812: Part 109: 1990, this test was conducted to ascertain the water content of aggregates using the oven drying method. The water content is represented as shown in Equation4.

$$W = \frac{M2 - M3}{M3 - M1} \, x \, 100$$

Where: M_1 is the mass of dry container and its lid in g; M_2 is the mass of the container, lid, and wet test portion in g; M_3 is the mass of the container, lid, and dry test portion in g.

c)   Specific Gravity: The procedure involved determining the specific gravity of soil particles following ASTM C 127-93 and BS 1377: 1990 standards. A 400 g sample was prepared according to the guidelines for disturbed soil sample preparation.

$$Specific gravity, G_s = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$$

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Where: W_1 is the Weight of empty pycnometer bottle, W_2 is the Weight of empty pycnometer bottle + sample, W_3 is the Weight of empty pycnometer bottle + sample + water, W_4 is the Weight of empty pycnometer bottle full of water. The sample's specific gravity was recorded with a precision of 0.01g.

d)   Los Angeles Abrasion Value: According to BS 812: Part 113: 1990 (Draft), this test was conducted to establish the coarse aggregates' abrasion value. ASTM C131-89 and ASTM C535 also contain the information. The weight loss between W1 and W2 of the test sample was calculated as a percentage of its initial weight and presented according to Equation 3.4.

$$AAV = \frac{W1 - W2_1}{W1} \, x \, 100$$

Where: W_1 is the mass of specimen before abrasion (in g), W_2 is the mass of specimen after abrasion (in g); d represents the particle density of the aggregate (on a saturated surface-dry basis, measured in mg/m³), as specified in Clause 5 of BS 812-2:1995.

e)   Aggregate Impact Value (AIV): To ascertain the aggregate impact value of coarse aggregates, this test was conducted in accordance with BS 812: Part 112: 1990. The percentage was determined by calculating the ratio of the fines' weight to the total sample weight, following the method outlined in Equation 7.

$$AIV = \frac{W_1}{W_2} \times 100\%$$

7

Where: W_1 is the Weight of materials passing through sieve size 2.36 mm, W_2 is the overall weight of the specimen.

f)   Aggregate Crushing Value (ACV)
An aggregate's resistance to crushing is indicated by its aggregate crushing value. The aggregate's strength, or capacity to withstand crushing, increases with decreasing value. To calculate the ACV, BS 812: Part 110: 1990 was consulted. The aggregate crushing value (ACV) is the percentage of the initial mass that is the fine material that is produced after passing through a 2.36 mm screen (W2). whichwascalculatedusingEquation8.

$$ACV = \frac{W_1}{W_2} \times 100 \%$$

8

Where: W_1 is the Weight of materials passing through sieve size 2.36 mm, W_2 is the total weight of the sample

2.3   Bitumen

The tests on bitumen were done to determine the properties of the materials to determine its fitness for construction activities. The test included penetration (ASTM D5-06, ASTM D1321), flash point and fire point (ASTM D3143-19), ductility (ASTM D113-17), softening point (ASTM D36-06),

2.4   Asphalt Production and Testing
A total of six (6) modified asphalt mixtures was used for test specimen production consisting of 0, 2, 4, 6, 8, and 10% SHA and CCA. The Marshall Stability and flow of asphalt concrete were tested using the steps in the ASTM D6927-05 test technique. As seen in Plate 1, samples of grade 60/70 asphalt cement (bitumen) were utilized to create the asphaltic concrete.

Plate 1: Asphalt samples

2.5   Marshall Stability Test

The maximum load that a compacted specimen can support at a normal test temperature of 60ºC is known as the mix's stability. During the stability test, the flow was determined by measuring the deformation in increments of 0.25 mm between the specimen's maximum load and zero load. Alternatively, the flow value can be assessed using deformation units of 0.1 mm. The purpose of this test is to identify the optimal binder content for the specific aggregate mix and traffic conditions. This test, which was carried out in compliance with BS EN 12697-34: 2007, aids in the measurement of Marshall Stability vs bitumen percentage.

2.6   Design Mix for the Modified Asphalt

The percentage replacement of quarry dust used is varied from 0% to 100% at interval of 10% by weight, meanwhile the combined percentage of other fillers (CCA and BLA) varied from 100% to 0% by weight at interval of 10%. Furthermore, the percentage of each CCA and BLA were gotten from the combined percentage and it varies from 0% to 100% for CCA and 100% to 0% for BLA at interval of 10% for each combined percentage replacement as shown in Table 1.

Table 1: Design Mix

Sample	Q.D (%)	CCA (%)	BLA (%)	Combined (%)
S1	100	0	100	0
S2	90	10	90	10
S3	80	20	80	20
S4	70	30	70	30
S5	60	40	60	40
S6	50	50	50	50
S7	40	60	40	60
S8	30	70	30	70
S9	20	80	20	80
S10	10	90	10	90
S11	0	100	0	100

2.7 Data Analysis

The data collected from laboratory tests were systematically analyzed to evaluate the performance characteristics of asphaltic concrete incorporating Corn Cob Ash (CCA) and Bamboo Leaf Ash (BLA) as filler materials. Statistical and graphical methods were used to interpret the results of Marshall Stability, Flow, Marshall Quotient, and other asphalt mix properties. Comparative analysis was performed to identify trends in stability, flow, and rutting resistance across different ash replacement percentages. The study also employed descriptive and inferential statistical tools to assess the significance of variations in the asphalt mix properties. Findings were compared with standard specifications such as FMW (2016) to determine compliance and suitability for asphalt production.

III. RESULT AND DISCUSSION

3.1 Characterisation of Aggregate Materials Used for Asphalt Mix Production

The particle size distribution of fine aggregates, mineral filler and coarse aggregates result is presented in Table 2 and the graph is as shown in Fig. 1. The data shows the individual particle size distribution. The D_{10}, D_{30} and D_{60} for the fine aggregate was 0.33, 0.56 and 0.9 mm respectively, with corresponding computed values of Cu (D_{60}/D_{10}) and Cc ($D_{30}^2/[D_{60} \times D_{10}]$) of 2.7 and 1.06 respectively. From ASTM D-2487, the fine-grained aggregates are poorly graded because Cu < 6. Similarly, the corresponding values for the particle sizes of the mineral filler are 0.16, 0.22 and 0.25 mm with Cu and Cc of 1.6 and 1.19 respectively. Also, from ASTMD-2487, soil classification of the mineral filler is a well graded sample because $1 \leq Cc \leq 3$. Those for the coarse aggregates are 5.3, 6.85 and 9 mm with Cu and Cc of 1.7 and 0.98 respectively. This outcome also satisfied the ASTMD-2487 soil classification for a well graded material of $1 \leq Cc \leq 3$. Additionally, the 85% specification of finer than 75 microns for the mineral filler was satisfied at 92%.

Fig. 1 shows the particle size distribution curve which provides insight into the grading and texture of the soil sample analysed. The results indicate that the majority of the soil particles are retained on the 5.00 mm sieve, with 94.5% retained, meaning the soil contains a high proportion of coarse particles, likely indicating a gravelly or sandy composition. The percentage passing values drop sharply for finer sieves, with nearly 0% passing beyond the 0.6 mm sieve, confirming the absence of fine-grained particles such as silt or clay. This suggests that the soil is well-graded or poorly graded coarse material, which influences its engineering properties, including permeability, compaction, and shear strength. The near-zero percentage passing values for the finer sieves indicate that the soil has minimal fine content, which may result in higher drainage properties but lower cohesion (Akinleye et al., 2023). This grading analysis is crucial for applications in foundation design, road construction, and other geotechnical engineering projects, where soil stability and load-bearing capacity are key considerations.

From the particle size distribution graph above, the values of D10, D30 and D60 on the coarse aggregate curve was traced to be 5.3, 6.85 and 9 respectively. The value of Cu and Cc were gotten to be:

$$Cu = \frac{D60}{D10} \qquad = 9/5.3 \qquad : \qquad Cu = 1.7$$

$$Cc = D30\text{^}2/D60*D10, \qquad = 6.85\text{^}2 \ / \ 9 * 5.3 :$$
$$Cc = 0.98$$

From ASTMD-2487 soil classification, it can be said that the Coarse aggregate soil is a well graded soil sample because $1 \leq Cc \leq 3$

Table 2 shows the aggregate properties which indicate that the tested material meets Nigerian standards for construction applications. The Aggregate Impact Value (19.2%) and Crushing Value (42.4%) are within the permissible limits of 30% and 45% maximum, respectively, suggesting that the material has adequate resistance to sudden impact and compressive loads. Similarly, the Los Angeles Abrasion value (48.92%) is below the 60% maximum, signifying sufficient durability and resistance to wear. The Flakiness Index (28.62%) and Elongation Index (29.53%) are within the 30% limit, ensuring a good shape and texture for compaction and bonding in construction. The density of 1500.20 kg/m³ suggests a moderately dense material, while the specific gravity of 3 aligns with the maximum requirement, confirming that the aggregate has an appropriate weight-to-volume ratio. The results indicate that the material is adequate for use in road construction and other structural applications, ensuring

strength, durability, and stability (Akinleye and Jimoh, 2020; Shi et al., 2025; Kedar and Patel, 2025; Ruki et al., 2025).

Table 2: Physical and Mechanical Properties of Coarse Aggregate for Asphalt Mixes

Test Carried Out	Test Results	Standard (Nigerian)	Remarks
Aggregate Impact Value	19.2%	30% maximum	Adequate
Aggregate Crushing Value	42.4%	45% maximum	Adequate
Los Angeles Abrasion	48.92	60% maximum	Adequate
Flakiness Index	28.62	30% maximum	Adequate
Elongation Index	29.53	30% maximum	Adequate
Density	1500.20 kg/m³	-	-
Specific Gravity	3	3 Maximum	Adequate
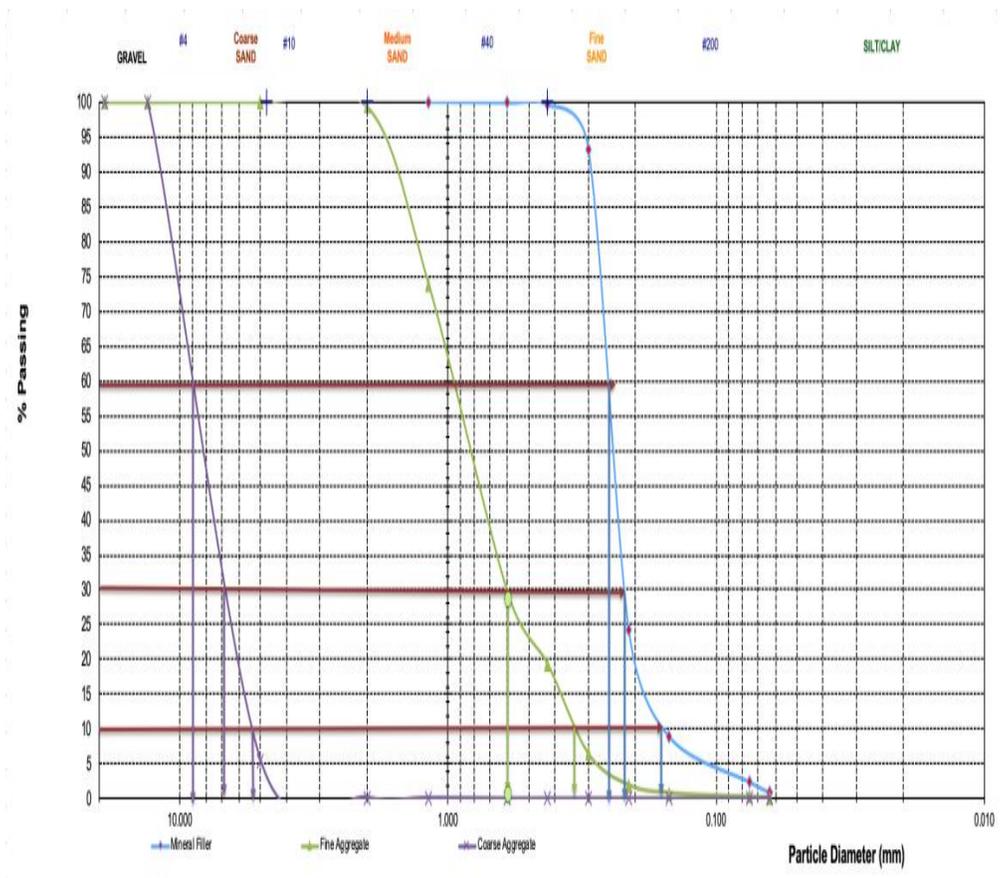
Fig. 1: Combined Graph of Mineral Aggregate (CA, FA & MF)

3.2 Properties of Bitumen

Table 3 shows the properties of bitumen used for the study. The table reveals the average penetration value for the bitumen as 70mm which is in compliance with both FMW and ASTM standards for bitumen penetration range between 60/70 as shown in Table 3. Also, the softening point value of the bitumen complies with both the ASTM and FMW standards. Meanwhile, the ductility value of 90cm complies with the FMW and BIS standard. Furthermore, the specific gravity of 0.97 falls within the range of ASTM standard but deviate from FMW standard. Additionally, flash point value falls within the specifications of FMW and ASTM standards while the viscosity shows compliance with the BIS standard. The overall results gotten shows the properties of the bitumen used for the study fall within the specification of the standards (Caki and Bas, 2025; Mohsin and Latief, 2025).

Table 3: Properties of the bitumen used for asphaltic production

	Penetration (mm)	Softening (ºC)	Ductility (cm)	Viscosity (secs)	Flash Point (ºC)	Fire Point (ºC)	Specific Gravity
	70	48	90	76	255	308	0.97
FMW	60-70	48-56	≤100	-	Min.250	-	1.01-1.06
ASTM	60-70	47-58	-	-	Min. 230	-	0.97-1.06
BIS	-	-	≥75	≥70	-	-	-
AI	-	>50	5-100	-	-	-	

3.3 Marshall Test Result for Asphalt Mix Proportion (Design)

The Marshall Test results for asphalt mix design reveal critical insights into the stability, flow, and strength of modified asphaltic concrete containing varying proportions of Corn Cob Ash (CCA) and Bamboo Leaf Ash (BLA). The optimum bitumen content (OBC) for the asphalt mix

was determined to be 6.3%, aligning with FMW (2016) specifications, resulting in a mix design ratio of 65.7:7:21:6.3 for coarse aggregate, fine aggregate, filler, and bitumen, respectively. The stability and Marshall Quotient values indicate the asphalt's capacity to bear traffic loads and its resistance to deformation. For 10% ash replacement (Table 4), stability values ranged from 13.6 to 17.2 KN, with flow values between 3.3 and 3.9 mm, and Marshall Quotient values from 4.2 to 5.3 kN/mm, indicating a steady increase in stability up to sample 10F before slight declines. At 20% ash replacement (Table 4.5b), stability improved further, reaching a peak of 18.6 kN for sample 20F, with flow values maintaining an optimal range of 3.3 to 3.9 mm and Marshall quotient increasing to 5.9 kN/mm, reflecting better strength properties. The 30% ash replacement results (Table 4) showed a stability range of 16.2 to 19.8 KN, with flow values of 3.1 to 3.9 mm, and Marshall Quotient peaking at 5.7 kN/mm, confirming enhanced durability. However, at 40% ash replacement (Table 4) a decline in stability was observed, ranging from 14.8 to 18.4 kN, with a decreasing trend in flow values (2.7 to 3.9 mm) and a slight reduction in Marshall quotient (3.5 to 5.3 kN/mm), suggesting a reduction in load-bearing capacity at higher ash content. The results indicate that moderate ash replacement, particularly at 20% and 30%, enhances asphalt properties, while exceeding 30% may lead to diminished structural performance (Hin et al., 2025; Sani, 2025; Chen et al., 2025).

Table 4: Summary of Marshall Properties for Different Ash Replacement Levels

S/N	Sample Label	Ash Replacement (%)	Weight in Water	Weight in Air	Stability (kN)	Flow (mm)	Marshall Quotient (kN/mm)
1	10A	10	0.695	1.112	13.6	3.9	4.2
2	10F	10	0.695	1.144	17.2	3.6	5.2
3	20A	20	0.720	1.138	14.3	3.9	4.6
4	20F	20	0.680	1.088	18.6	3.6	5.5
5	30A	30	0.715	1.172	16.2	3.9	4.1
6	30F	30	0.630	1.024	20.9	3.4	6.1
7	40A	40	0.685	1.128	14.8	3.9	3.5
8	40F	40	0.670	1.018	18.4	3.4	5.1

Key for Sample Labels:

Sample Label	Total Ash Replacement (%)	CCA (%)	BLA (%)
10A	10%	0%	100%
10F	10%	50%	50%
20A	20%	0%	100%
20F	20%	50%	50%
30A	30%	0%	100%
30F	30%	50%	50%
40A	40%	0%	100%
40F	40%	50%	50%

3.4 Marshall Stability and flow for 100% Ash replacement

The results showed that Marshall Stability values increased with an increase in Corn Cob Ash (CCA) content in the mix, reaching peak stability at specific CCA-BLA mix proportions before declining at full CCA replacement. For 10% and 20% ash replacement, the highest stability was recorded at 60:40 CCA-BLA mix proportions, with peak values of 17.2 KN and 18.6 KN, respectively. However, at 30% and 40% ash replacement levels, peak stability occurred at 50:50 and 50:50 CCA-BLA mix proportions, with values of 20.9 KN and 18.4 KN, respectively. This trend suggests that a balanced incorporation of CCA and BLA optimizes asphaltic concrete stability, but excessive CCA reduces performance. Meanwhile, flow

values decreased as CCA content increased, with the highest flow values consistently recorded at 100% BLA replacement (3.9 mm) and the lowest flow values observed at 100% CCA replacement, which decreased progressively from 3.3 mm (10% ash) to 2.7 mm (40% ash) as shown in Table 5. This indicates that while BLA enhances flexibility, CCA contributes to stiffness in the asphalt matrix. All obtained values meet the Federal Ministry of Works (FMW, 2016) specifications (2–6 mm for flow), but they deviate from Asphalt Institute (AI, 1991) standards (8–16 mm for flow), likely due to different test procedures. Ultimately, the study confirms that incorporating both CCA and BLA improves asphalt performance, with optimal performance achieved at 50–50% CCA-BLA mix ratios depending on the total ash replacement percentage.

Table 5: Combined Table of Marshall Stability and Flow Results

Ash Replacement (%)	Sample with Peak Stability	Peak Stability (kN)	Sample with Highest Flow	Highest Flow (mm)	Sample with Lowest Flow	Lowest Flow (mm)
10%	1G (60:40 CCA-BLA)	18.9	1A (0% CCA, 100% BLA)	3.9	1K (100% CCA, 0% BLA)	3.3
20%	2G (60:40 CCA-BLA)	18.6	2A (0% CCA, 100% BLA)	3.9	2K (100% CCA, 0% BLA)	3.3
30%	3F (50:50 CCA-BLA)	20.9	3A (0% CCA, 100% BLA)	3.9	3K (100% CCA, 0% BLA)	3.1
40%	4F (50:50 CCA-BLA)	17.2	4A (0% CCA, 100% BLA)	3.9	4K (100% CCA, 0% BLA)	2.7

3.5   Stability

The study assessed the stability, flow, and Marshall Quotient of asphalt concrete with varying percentages (10%, 20%, 30%, and 40%) of Corn Cob Ash (CCA) and Bamboo Leaf Ash (BLA) replacement. Results indicated that stability values increased with CCA content up to a peak at 60% CCA and 40% BLA for 10% and 20% ash replacement, and at 50% CCA and 50% BLA for 30% and 40% ash replacement, after which stability declined (Table 6). The highest stability value of 20.9 KN was recorded at 50% CCA and 50% BLA for 30% ash replacement, demonstrating its suitability for asphalt concrete production. Flow values decreased with increasing CCA content, indicating improved stiffness but reduced workability, with maximum flow recorded at 3.9 mm, aligning with findings from Asebiomo et al. (2024). The Marshall quotient followed a similar trend, peaking at 6.1 kN/mm for 30% ash replacement (50% CCA and 50% BLA), highlighting better rutting resistance and load distribution similar to the findings of Utanga et al. (2025); Karam and Noorvand (2025); and Saharia and Singh (2025). All stability and flow values met FMW (2016) specifications, confirming the feasibility of CCA-BLA as a filler material in asphaltic concrete production.

Table 6: Summary of Stability, Flow, and Marshall Quotient Results

Ash Replacement (%)	CCA:BLA Ratio	Stability (kN)	Flow (mm)	Marshall Quotient (kN/mm)
10%	60:40	18.5	4.2	5.2
20%	60:40	18.6	3.9	5.4
30%	**50:50**	**20.9**	**3.4**	**6.1**
40%	50:50	17.8	4.0	4.8

This analysis confirms that 30% ash replacement (50% CCA, 50% BLA) offers the best mechanical performance, making it the most promising blend for asphalt concrete production.

IV. CONCLUSION

This study evaluated the performance of asphaltic concrete incorporating Corn Cob Ash (CCA) and Bamboo Leaf Ash (BLA) as filler materials. The results showed that the index properties of aggregates and bitumen met standard specifications, producing a mix design of 65.7:7:21:6.3 (coarse aggregate, fine aggregate, filler, and bitumen). Marshall stability and flow increased with CCA-BLA proportion, with the highest stability of 20.9 KN, a flow of 3.4 mm, and a Marshall quotient of 6.1 KN/mm recorded at 30% ash replacement (50% CCA, 50% BLA), demonstrating optimal rutting resistance. The findings indicated that recycling agricultural waste, such as corn cob and bamboo leaves, in asphalt production enhances the mechanical properties of asphaltic concrete. Additionally, using these waste materials as fillers contributes to sustainable construction practices by reducing reliance on conventional fillers. The study recommends adopting 50% CCA and 50% BLA at 30% combined ash replacement for natural filler substitution in asphalt production in Nigeria. This approach can improve road pavement durability while promoting environmental sustainability. Furthermore, additional field research on the long-term performance and durability of asphalt with CCA and BLA as filler materials is encouraged to validate these findings under real-world conditions.

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