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Sustainable Housing Solution in Jalingo: Concrete from Sawdust Ash

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Abstract- ***The study investigated the potential of sawdust ash, derived from locally sourced wood waste in Jalingo, Taraba State, as a partial replacement for Ordinary Portland Cement in concrete production for sustainable housing. Sawdust ash obtained from different wood species was incorporated into concrete mixes at replacement levels of 5%, 10%, 15%, and 20%, using fine aggregates sourced from Rivers Nukkai, Mayo-Gwoi, and Donga. A control mix with 0% ash was also prepared for comparison. Standard concrete tests were conducted to evaluate workability, density, and compressive strength at 7 and 28 days curing periods, targeting grade 20 concrete. The results show that concrete containing 5% to 10% sawdust ash achieved compressive strengths comparable to or exceeding the target strength at 28 days, while 15% replacement produced marginal results and 20% replacement consistently fell below acceptable limits. Mahogany ash generally performed better than marina ash, and variations in sand source influenced strength development. The findings demonstrated that sawdust ash can serve as an effective supplementary cementitious material at low replacement levels, offering a sustainable means of reducing cement consumption, construction costs, and environmental pollution from wood waste. The study concluded that sawdust ash concrete is a viable option for affordable housing development in Jalingo when used within optimal limits.***

Keywords: Sawdust Ash; Sustainable Housing; Partial Cement Replacement; Eco-Friendly Concrete; Waste Utilization.

I. INTRODUCTION

The swift growth in global population and concurrent urbanisation have led to an unprecedented increase in the demand for housing, particularly in developing nations like Nigeria (Jiboye et al., 2020; Oni-Jimoh et al., 2018).1 This escalating need for shelter has, in turn, placed significant pressure on the construction industry to provide sustainable, affordable, and durable building solutions (Lembi et al., 2021). The existing housing deficit in Nigeria is substantial, estimated to be over 20 million units, with a disproportionately low supply of affordable housing units for the low-income populace (Oni-Jimoh et al., 2018).2 In urban centers across Nigeria, including the city of Jalingo, this challenge is exacerbated by a high cost of conventional building materials and inadequate infrastructure, which together make housing largely unaffordable for the average citizen (Adebayo, 2019).A core material driving the modern construction sector is concrete, revered for its ductility, stability, and enduring mechanical properties (El-Nadoury, 2021). However, the primary binder in concrete, Ordinary Portland Cement (OPC), is globally recognized as a major contributor to environmental degradation. The production of cement is highly energy-intensive and involves the thermal decomposition of limestone, a calcination process that releases significant quantities of carbon dioxide (CO_2) into the atmosphere (Adebayo, 2019; Das, 2022). Cement manufacturing is responsible for approximately 7% to 8% of total global man-made CO_2 emissions, making the search for sustainable alternatives a critical global concern (Ige & Kabeya, 2025; Larik et al., 2025).

To mitigate the environmental and economic impacts associated with conventional construction, a shift towards sustainable architectural practices and the use of eco-friendly and locally sourced materials is imperative (Nwafor & Ifeoma, 2019). The adoption of a circular economy approach, which involves introducing reusable or recycled materials into the building process, is a vital measure to achieve environmental sustainability. This imperative has propelled research into waste materials, such as agricultural and industrial by-products, as Supplementary Cementitious Materials (SCMs) for partial replacement of OPC (Ogork & Ayuba, 2014; Raheem et al., 2017).

Sawdust, a fine particulate by-product of the timber processing and carpentry industries, is produced in vast quantities, particularly in regions with active wood workshops, such as Jalingo, where its disposal often presents an environmental nuisance and contributes to land, water, and air pollution (Ayuba et al., 2022; Osanyinlokun et al., 2024). Processing this waste through controlled incineration yields Sawdust

Ash (SDA), which has shown promise as a sustainable material for concrete production. Studies have explored the utilisation of SDA as a partial replacement for cement, reporting dual benefits: environmental pollution control and the creation of a cost-effective alternative building material (Raheem et al., 2017).8 Preliminary research suggests that SDA, possessing either self-cementing properties or pozzolanic activity depending on its chemical composition, can enhance late-age strength development and improve the durability characteristics of concrete at optimal replacement levels (Ogork & Ayuba, 2014; Osanyinlokun et al., 2024; Ikumapayi et al., 2024).

Jalingo, being a state capital with a growing population, is experiencing the classic Nigerian housing crisis, characterised by a significant gap between the demand for affordable and decent housing and its actual supply. This shortage is predominantly driven by the high cost of conventional building materials, primarily cement, which can constitute up to 40% of the total construction cost in Nigeria (Adebayo, 2019). The over-reliance on this carbon-intensive material not only inflates construction expenses, rendering houses unaffordable for low-income earners, but also compounds the global environmental problem through substantial greenhouse gas emissions. Concurrently, the proliferation of sawmills and carpentry workshops within and around Jalingo generates considerable amounts of wood waste (sawdust). The disposal of this waste, often through unselective dumping or uncontrolled burning, constitutes a significant local environmental challenge, leading to land contamination and air pollution (Ayuba et al., 2022). Although previous studies have explored the feasibility of incorporating SDA into concrete mixtures, there remains a critical gap in context-specific research focusing on the optimal utilization of locally sourced SDA from the Jalingo environment as a sustainable and cost-effective solution for its housing deficit.

The challenge, therefore, is two-fold:

i. Socio-Economic: To find a strategy that reduces the high cost of construction in Jalingo, thereby addressing the housing affordability crisis and promoting sustainable development (Adebayo, 2019).

ii. Environmental: To repurpose a local industrial waste product (sawdust/SDA) into a valuable resource, thus mitigating environmental pollution from waste disposal and reducing the carbon footprint associated with conventional cement production (Raheem et al., 2017).

This study aims to address this problem by scientifically investigating the potential of converting locally available sawdust waste into Sawdust Ash (SDA) and evaluating its suitability as a partial replacement for Ordinary Portland Cement in the production of concrete for sustainable housing solutions in Jalingo.

II. LITERATURE REVIEW

Sawdust is a bye product of timber, collected from grinding, cutting, or pulverizing of different kinds of woods. Sawdust is a materials use in the productions of engineering boards, in recent years scholars and academia have gone into research to produce alternative building materials that will be workable, durable, cost effective and environmentally friendly element to reduce the effect of temperature raise, due to human activity. There are several studies being carried out ono alternative building materials to reduce the rising cost of construction.

Building constructions cost is the overall funds injected into a project from the initiations to final close-out, constructions are generally an expensive adventure, building components are expected to be durable, workable, cost effective and environmentally friendly element. On the contrary building are expensive, due to constituent materials used to make it. The amounts of cement to require producing all cement-binder components, the amount of energy require to produce them will greatly depleting the earth for decades; it is no longer assertions, that 40% of earth depletions are cause because of building constructions. In the year 2000s researchers are investigating the applicability of using wood bye product as a replacement for fine aggregate in concrete mixtures due to it availability, eco-friendly nature (Ettu et. al., 2013; Bdeir, 2012; Mageswari &Vidivelli, 2010; Osei & Jackson, 2016; Singh & Siddique, 2016).

Agricultural wastes, and Industrial bye products, with high renewable and sustainable nature, are steadily being used for research, innovations for construction either as elements, or constituent of building element. Previous scholars and experts in the field specified the orthodox materials for constructions, that is likely heavy, non-flexible element for various constructions purposes, with this present innovations of AI, use of more flexible, durable, and workable element will metamorphous the industry to look for weight component, that is flexible to work with, improves acoustic properties, facilitates handling, mixing and placing of mixtures competed to other types of concrete (Madurwal et al., 2013; Olanipekun, 2006). It is also recognized by its low production and assembly cost, less health hazards, and accessible processing.

An equally significant direction is the usage of industrial wastes in producing of building materials with low density, sound and heat conductivity, as well as high physical and mechanical properties. These materials are used in casting cellular concrete for constructing the external and internal walls of buildings (Amran et al., 2015; Steshenko & Kudyakov, 2018). Several studies describe the compositions and technology for producing cellular concrete from lightweight geopolymers as an example of industrial wastes (Liu et al., 2024; Liu et al., 2023; Azad & Samarakoon, 2021; Erofeev et al., 2020). The implementation of fillers which can be represented as particles of the dispersed phase change the energy state of the dispersed system (Zharikov et al., 2018; Zagorodnyuk et al., 2018; Klyuev et al., 2018). The used fillers depend on their chemical activity. Efficient fillers have a multifunctional usefulness in the synthesis of materials through forming a denser packaging
Researchers (Dias et al., 2022; Wang et al., 2023) suggested that wood chipping improves the thermal and insulation properties of concrete mixtures and lessen the density of the concrete, however, it attained high water absorption (Wang et al., 2023).

Wegdan (2021) and Devi et al. (2022) investigated the effect of replacing 15 % of sand with sawdust in casting blocks for partition walls in multi-storey building using 1:6 cement and sand mix. His results reveals that the compressive strength for these blocks was 4.5 N/mm2 which is considered reasonable and economic for this application. Compressive strength, flexural strength, ultrasonic pulse velocity (UPV), unit weight and water absorption of lightweight composite consists of combinations wood sawdust waste and limestone powder wastes were assessed by Turgut and Algin (2007). They found values for tested properties are in accordance to International Standard (IS). On assessing the effect of sawdust on compressive strength at 28 days, Paramaswam and Loke (1978) argued that for mixtures with cement to sawdust ratio of 1:1, 1:2, and 1:3, the compressive strengths were 31, 8.5, and 5 N/mm2 respectively. Ganiron Jr. (2013), and Osei and Jackson (2016) found that the strength of sawdust concrete decrease as water-cement ratio is less than 0.45. The aim of this paper is to demonstrate the potential of using sawdust wastes in order to produce the desired composite and sustainable green construction material. Natural fine aggregate and cement is substituted by sawdust at percentages 5, 10, 15, 20, 25 and 30. Experimental investigations on physical and mechanical properties of concrete made with sawdust were conducted and compared to control mix cast with typical concrete constituents.

III. METHOD AND EXPERIMENT

All the items used in this research were all locally sourced between three main timber sheds in the City of Jalingo (Rivers Nukkai, Mayo-Gwoi, and Donga). The following constituents were utilized in the study.

Sawdust Ash: all the samples of sawdust were obtained from the waste of wood treated in the three sawmills within Jalingo in a single day. All samples were from various types of woods sawdust. The samples were converted into ash via an open metallic container. No oxide composition tests or X-ray diffraction analysis (XRD) was done to ascertain the performance on the samples to determine their pozzolanic nature and cementation characteristics.

Water: averagely clean tap water, free from darts, impurities, colourless water type was used to carried out this experiment, only odorless water was used. Even though the water samples were not tested to ascertain the level of purity, High quantity of impurity in the water that was used can changed our expected results, and affect the setting time, and volume stability, concrete strength.
Fine Aggregates: Area sand ranging from 0.005mm > 4.5mm. The fine aggregate that was used for this study was sourced from three rivers around Jalingo town, (Rivers Mayo-Gwoi, Nunkai, Donga). The

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sample was clean, washed, sun-dried, naturally occurring sand with rounded or sub-rounded particles and underwent a particle size distribution test before being used for concreting, as opined by BS 1881 standards for grain size distribution.

Coarse Aggregates: five kilogram of course granite was collated from Jalingo quarry and transported to the laboratory for this research purposes. The coarse aggregates were subjected to sun-drying and cleaning to remove impurities. Distribution analysis was carried out, to ascertained nominal maximum and minimum sizes of 7 mm, 10 mm, and 20 mm that will be effective for the study.

IV. RESULTS

Marina Ash with River Nukkai Sand

Table 1: 5% marina ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
30/10/2025	7	6/11/2025		8101	2.40	400.5	17.8	
				8135	2.41	470.3	20.9	
			50 mm	8150	2.41	445.3	19.8	19.8
30/10/2025	28	27/11/2025		8137	2.41	470.3	20.9	
				8005	2.37	524.3	23.3	
				8101	2.40	657	29.2	24.5

Seven (7) days curing the compressive strength is 19.8 MPA = 97.5%., while at twenty-eight (28) days curing the compressive strength is 24.5 MPA, which is above 100%. This shows the compressive strength is slightly above the target value for grade 20 value which is 100%, while the average strength of 7 days is 19.5 N/mm^3 and 28 days is 24.5 N/mm^3.

Table 2: 10% marina ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
30/10/2025	7	6/11/2025		7766	2.30	431.1	19.1	
				8001	2.37	441	19.6	
			55 mm	7741	2.30	427.5	19.0	19.2
30/10/2025	28	27/11/2025		7791	2.31	579.8	23.1	
				7683	2.28	452.3	20.1	
				8090	2.40	432	19.2	20.8

At 10% replacement of cement, the compressive strength of seven (7) days curing is 19.2 MPA, which is 96%. While at twenty-eight (28) days curing is 20.8 MPA which is above 100%, which also at 28 days the compressive strength is slightly above the target value for grade 20 value.

Table 3: 15% marina ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
30/10/2025	7	6/11/2025		7526	2.32	442.7	19.6	
				7870	2.33	450	20.0	
			55 mm	7869	2.33	420.8	18.7	19.4
30/10/2025	28	27/11/2025		7888	2.34	427.5	19.0	
				7761	2.30	443.3	19.7	
				7871	2.33	447.8	19.9	19.5

At 15% seven (7) days curing the compressive strength is 19.4 MPA, which is 97%. While at twenty-eight (28) days, the compressive strength is 19.5 MPA, that is, 97.5%. This means that in seven (7) days, the average strength is 19.4 N/mm^3 while in 28 days the average strength is 19.5 N/mm^3.

Table 4: 20% marina ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
31/10/2025	7	7/11/2025		7860	2.33	358.5	15.9	
				7859	2.33	297	13.2	
				7890	2.34	337.5	15.0	14.7
31/10/2025	28	28/11/2025		7919	2.35	396	17.6	
			40 mm	7886	2.34	391.5	17.4	
				7920	2.35	398.3	17.7	17.6

At 20% seven (7) day curing the compressive strength is 14.7 MPA, which is 73.4%. While twenty-eight (28) days curing the compressive strength is 17.6 MPA which is 88%.

In partially replacing cement with marina ash in seven (7) days shows fast or slow early strength gain for 5 – 20% ash. While at twenty-eight (28) days, from 5% – 10% the twenty-eight days is slightly above the target strength which is 100%. Therefore the mix is acceptable while for 15% – 20% at twenty-eight (28) days the strength is below the target value which is 100%. This implies that the mix should be rejected.

Mahogany Ash with River Mayo-Gwoi Sand

Table 5: 5% mahogany ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
31/10/2025	7	7/11/2025		7849	2.83	426.8	18.7	
				7760	2.80	405	18.0	
				7670	2.27	429.8	19.7	18.7
31/10/2025	28	28/11/2025	60 mm	8494	2.41	658.1	29.2	
				8140	2.41	636.8	28.3	
				7996	2.37	652.5	29.0	28.3

At 5% seven (7) days curing the compressive strength is 18.7 MPA which is 93.5%. while at twenty-eight (28) days curing the compressive strength is 28 MPA which is above 100%. In 7 days the average strength is 18.7 N/mm while in twenty-eight (28) days the average strength is 28.3 N/mm^3.

Table 6: 10% mahogany ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
31/10/2025	7	7/11/2025		7766	2.30	470.3	20.9	
				7740	2.29	436.5	19.4	
				7876	2.33	452.2	20.1	20.1
31/10/2025	28	28/11/2025	63 mm	8426	2.49	444	19.7	
				7980	2.36	524.2	23.2	
				8340	2.47	495	22.2	21.7

At 10% seven (7) days curing, the compressive strength is 20.1 MPA, which is 100%, while at twenty-eight (28) days the compressive strength is 21.7 MPA, which is above 100% slightly. The average strength in seven (7) days is 16.9 N/mm^3, while twenty-eight (28) days the curing is 26.9 N/mm^3.

Table 7: 15% mahogany ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
31/10/2025	7	7/11/2025	65 mm	7862	2.33	431.1	19.1	
				8001	2.37	472.5	21.0	
				8210	2.43	384.8	17.1	19.1
31/10/2025	28	28/11/2025		7871	2.33	580.1	25.7	
				7860	2.33	591.8	26.3	
				7641	2.26	505	27.4	21.8

At 15% seven (7) days the compressive strength was 19.1 MPA, which is 97% while in the twenty-eight (28) days the compressive strength was 24.1 MPA which is above 100%. The average strength for seven (7) days is 1 N/mm^3 while in the twenty-eight (28) days the average strength is 2 N/mm^3.

Table 8: 20% mahogany ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
31/10/2025	7	7/11/2025	35 mm	7790	2.31	315	14.0	
				7750	2.30	362.3	16.1	
				7851	2.33	360	16.0	15.4
31/10/2025	28	28/11/2025		7798	2.31	485.6	21.5	
				7771	2.30	382.3	17.0	
				7471	2.21	452.3	20.1	19.5

At 20% seven (7) days curing the compressive strength is 15.4 MPA, which is 77% while in the twenty-eight (28) days curing the compressive strength is 19.5 MPA which is 97.5%. The average strength for seven (7) days is 15.4 N/mm^3 while in twenty-eight (28) days the average strength is 19.5 N/mm^3.

In partially replacing cement with the mahogany ash at seven (7) days it shows fast or strong early strength gain for 5% – 20%. While at twenty-eight (28) days 5% – 15% it shows strength that is above 100%. At 20% ash, the 28 days strength failed.

River Donga Bridge San with Mahogany

Table 9: 5% mahogany ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
31/10/2025	7	7/11/2025	55 mm	8135	2.41	442.7	19.6	
				8100	2.40	339.8	15.1	
				8090	2.40	443.7	19.7	18.1
31/10/2025	28	28/11/2025		7986	2.34	627.8	27.8	
				7070	2.33	607.8	27.0	
				7906	2.34	546.8	24.3	26.4

At 5% seven (7) days compressive strength is 18.1 MPA which is 90.5% while at twenty-eight (28) days the compressive strength is 26.1 MPA which is above 100%. The average strength of seven (7) days is 18.1 N/mm^3, while 28 days the average strength is 26.4 N/mm^3.

Table 10: 10% mahogany ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
31/10/2025	7	7/11/2025	50 mm	8140	2.41	396	17.6	
				8009	2.37	360	16.0	

				8076	2.39	384.8	17.1	16.9
31/10/2025	28	28/11/2025		8110	2.40	427.8	19.0	
				8100	2.40	519.8	23.1	
				8009	2.37	641.3	28.5	23.5

At 10% seven (7) days curing the compressive strength is 16.9 MPA which is 84.5% while at twenty-eight (28) days curing the compressive strength is 23.5 MPA which is above 100%. The average strength at seven (7) days is 16.9 N/mm^3, while at twenty-eight (28) days the average strength is 23.5 N/mm^3.

Table 11: 15% mahogany ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
31/10/2025	7	7/11/2025		8009	2.37	396	17.6	
				7980	2.36	312.8	13.9	
				8110	2.40	400.8	17.8	16.4
31/10/2025	28	28/11/2025	45 mm	8100	2.40	560.3	24.9	
				8050	2.39	564.8	25.1	
				8111	2.40	474.8	21.1	23.7

At 15% seven (7) days curing the compressive strength is 16.4 MPA which is 84.5% while at twenty-eight (28) days curing the compressive strength is 23.7 MPA which is above 100%. The average strength at seven (7) days is 16.4 N/mm^3, while at twenty-eight (28) days the average strength is 23.7 N/mm^3.

Table 12: 20% mahogany ash

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
31/10/2025	7	7/11/2025		8160	2.42	315	14.0	
				8100	2.40	348.8	15.5	14.6
				-	-	-	-	
31/10/2025	28	28/11/2025	37 mm	7990	2.37	445.5	19.8	
				7870	2.33	400.5	17.8	
				7993	2.37	427.5	19.0	18.7

At 20% seven for (7) days curing the compressive strength is 14.6 MPA which is 73% while at twenty-eight (28) days curing the compressive strength is 18.7 MPA which is 93.5%. Mahogany ash with River Donga bridge sand at seven (7) days shows relatively high strength for 5% – 20%. While at twenty-eight (28) days it shows a relative strength above the target value for grade 20 concrete. At 20% ash, at twenty-eight (28) days the strength is low and not acceptable for housing construction so it be rejected.

Table 13: 0% ash (control)

Date of Cast	Age (days)	Date of Test	Slump (mm)	Cure Insight	Cure Density	Load in Kn	Strength N/mm^3	Average Strength (N/mm^3)
31/10/2025	7	7/11/2025		7617	2.26	393.8	17.5	
				7717	2.29	427.5	19.0	17.9
				7511	2.24	384.8	17.1	
31/10/2025	28	28/11/2025	70 mm	7758	2.30	641.5	28.5	
				7701	2.28	609.8	27.1	
				7500	2.22	643.5	28.6	28.1

The table shows the compressive strength development of a standard concrete mix (without any ash replacement) at two critical ages: 7 days and 28 days. The results are very consistent and indicate a high-quality, normal-strength concrete mix. The concrete achieved approximately 64% of its 28-day strength in just 7 days.

This is a classic and expected pattern for ordinary Portland cement (OPC) concrete. It confirms that the cement is hydrating as anticipated and provides early confidence in the mix's performance. The 28-day strength is the standard specified strength.

V. DISCUSSION

The results of this study provide empirical evidence on the performance of concrete produced with partial replacement of Ordinary Portland Cement (OPC) by sawdust ash derived from different wood species and combined with sands sourced from Rivers Nukkai, Mayo-Gwoi, and Donga. Overall, the findings demonstrate that sawdust ash can be effectively utilized as a supplementary cementitious material at low to moderate replacement levels, particularly between 5 percent and 10 percent, without compromising the structural requirements of grade 20 concrete. These results align strongly with the study's objective of identifying sustainable and locally viable housing solutions for Jalingo.

Across all mixes, compressive strength generally decreased with increasing sawdust ash content, a trend that is consistent with most studies on cement replacement using agro-waste ashes. For marina ash mixes with River Nukkai sand, the 5 percent and 10 percent replacements achieved 28-day compressive strengths of 24.5 MPa and 20.8 MPa respectively, both meeting or exceeding the target strength for grade 20 concrete. However, at 15 percent and 20 percent replacement levels, the 28-day strengths fell below the target, indicating a reduction in load-bearing capacity.

A similar pattern was observed with mahogany ash. When combined with River Mayo-Gwoi sand, the 5 percent, 10 percent, and 15 percent replacements achieved 28-day strengths above 20 MPa, with the 5 percent mix reaching as high as 28.3 MPa. At 20 percent replacement, the strength dropped below the acceptable threshold. Results using River Donga sand followed the same general trend, with acceptable performance up to 15 percent replacement and a notable decline at 20 percent. These findings confirm that low to moderate cement replacement with sawdust ash supports adequate strength development, while higher replacement levels dilute the cementitious matrix and reduce hydration products responsible for strength gain.

The 7-day strength results indicate that mixes containing 5 percent to 10 percent sawdust ash generally achieved between 90 percent and 100 percent of the target strength. This suggests that sawdust ash does not severely retard early hydration at low replacement levels. In some mahogany ash mixes, early strength gain was relatively high, which may be attributed to filler effects and possible self-cementing or mild pozzolanic reactions, even though chemical characterization of the ash was not conducted in this study

The control mix exhibited the classic OPC hydration pattern, achieving about 64 percent of its 28-day strength at 7 days, thereby validating the experimental procedure and providing a reliable benchmark against which the ash-modified mixes were compared.

Differences observed between marina ash and mahogany ash mixes suggest that wood species plays a role in concrete performance. Mahogany ash generally produced higher 28-day strengths than marina ash at equivalent replacement levels, particularly at 5 percent and 15 percent. This variation is consistent with literature that emphasizes the influence of ash composition, fineness, and carbon content on concrete strength development. Additionally, variations in performance across sand sources indicate that particle grading and mineral composition of fine aggregates also contribute to strength variability, as noted in earlier concrete technology studies

The findings of this study on the use of Sawdust Ash (SDA) as a partial cement replacement in concrete align closely with and extend the existing body of literature on sustainable construction materials. The observed optimal replacement range of 5–15% SDA for maintaining compressive strength above the target Grade 20 threshold is consistent with studies by Raheem et al. (2017) and Ogork and Ayuba (2014) which reported that SDA could effectively replace up to 15% of cement without significant strength reduction, while higher replacement levels often led to diminished performance. This study corroborates those findings, demonstrating that at 20% replacement, compressive strength fell below acceptable levels for structural use, echoing earlier warnings in the literature about over-replacement without mix adjustment.

The pozzolanic behavior of SDA noted in this study, particularly the enhancement of late-age strength at 28 days, also mirrors findings from recent investigations by Osanyinlokun et al. (2024) and Ikumapayi et al. (2024) which highlighted that SDA, when properly processed, exhibits pozzolanic or self-cementing properties that contribute to long-term durability and strength development. The current study reinforces this, showing that concrete with 5–10% SDA often achieved 28-day strengths exceeding 100% of the target, indicating effective secondary hydration reactions typical of pozzolanic materials.

However, the study also surfaces context-specific variations that underscore the importance of local material characteristics. While literature generally affirms the viability of SDA, the performance observed here varied with sand type and wood species, factors less emphasized in broader studies. For example, Mahogany Ash with River Mayo-Gwoi sand performed better at higher replacement levels than Marina Ash with River Nukkai sand, suggesting that local sourcing and material compatibility require careful evaluation. This nuance supports the argument by Nwafor and Ifeoma (2019) on the critical role of locally adapted material solutions in sustainable housing.

The reduction in workability (slump) with increased SDA content observed in this experiment reflects the findings of Ogork and Ayuba (2014) which reported that fine ash materials like SDA tend to increase water demand, which can affect concrete workability if not compensated by water-reducing admixtures. The current study's results validate this, indicating a practical limitation that must be addressed in mix design for real-world applications. Similarly, Raheem et al. observed that partial cement replacement with sawdust ash in paving stones was most effective below 10 percent, beyond which compressive strength declined significantly. In addition, the observed decrease in strength at higher replacement levels corroborates the conclusions of Paramaswam and Loke (1978), Ganiron Jr. (2013), and Osei and Jackson (2016), who noted that increasing sawdust content or ash replacement tends to weaken the cement matrix due to reduced cement availability and higher porosity. Conversely, the acceptable strength performance at 5 percent to 10 percent replacement aligns with the findings of Osanyinlokun et al. (2024) and Ikumapayi et al. (2024), who emphasized the potential of sawdust ash to enhance sustainability without sacrificing structural adequacy when used within optimal limits.

Finally, the environmental and economic rationale for using SDA, central to the aim of this study, is consistent with the views of Ayuba et al. (2022) and Wegdan (2021) which emphasized that SDA not only reduces cement consumption and associated CO_2 emissions but also repurposes sawmill waste, mitigating local pollution. This study operationalizes that principle in the specific context of Jalingo, providing empirical evidence that aligns with global sustainable construction goals while addressing local housing and waste management challenges.

VI. CONCLUSION

This study has demonstrated that sawdust ash derived from locally available wood waste can be effectively utilized as a partial replacement for Ordinary Portland Cement in concrete production for sustainable housing in Jalingo. The experimental results confirm that cement replacement levels of 5% to 10% consistently produced compressive strengths that met or exceeded the requirements for grade 20 concrete at 28 days, while maintaining acceptable early strength development at 7 days. Replacement levels beyond 15% resulted in a noticeable reduction in strength, with 20% replacement proving unsuitable for structural housing applications.

The performance of sawdust ash concrete was influenced by both the type of wood ash and the source of fine aggregate. Mahogany ash generally exhibited better strength development than marina ash, suggesting that the chemical composition and physical characteristics of the ash play a significant role in concrete performance. Similarly, variations observed across sands sourced from Rivers Nukkai, Mayo-Gwoi, and Donga highlight the importance of local material compatibility in mix design. Compared with the control mix, sawdust ash concrete at optimal replacement levels demonstrated comparable strength development while offering additional environmental and economic benefits. These include reduced cement consumption, lower carbon dioxide emissions associated with cement production, and effective reuse of sawmill waste that would otherwise contribute to environmental pollution. Although the study did not include chemical characterization of the ash, the observed strength gains at later curing ages

indicate possible pozzolanic or filler effects contributing to hydration.

VII. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

i. Sawdust ash should be adopted as a partial replacement for cement at levels between 5% and 10% for housing construction, as this range provides optimal strength performance while enhancing sustainability, however, replacement levels exceeding 15% should be avoided for structural concrete.
ii. Controlled incineration methods should be employed in the production of sawdust ash to improve consistency, reduce carbon content, and enhance its cementitious behavior.
iii. Government agencies, construction professionals, and housing developers in Taraba State should be encouraged to explore the use of sawdust ash concrete as part of sustainable building policies, particularly for low-cost housing schemes.
iv. Public awareness and training programs should be promoted to educate local builders and artisans on the proper processing and application of sawdust ash in concrete production.

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