FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE
JOURNAL OF ENGINEERING AND ENGINEERING TECHNOLOGY

EFFECTS OF WOODASH AND SAWDUST ADMIXTURE ON ENGINEERING PROPERTIES OF BURNT LATERITE CLAY BRICKS

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Falayi, R. F. and Adeduntan, P.A. (2026): Effects of Wood Ash and Sawdust Admixture on Engineering Properties of Burnt laterite clay bricks. FUTA Journal of Engineering and Engineering Technology 20(special), 205-214

Received Date: 15.01.2026 **Accepted Date: 12.03.2026**

Abstract
Over the years, excessive energy consumption is one of the major problems associated with burnt brick production. This study assessed the characteristics of burnt bricks containing sawdust and wood ash as additive. Trial test was prepared from standard mix. It was done in different percentage of additives (0%, 10%, 20%, 30%, 40% and 50%) blend of sawdust and wood ash. One hundred and thirty- two (132) brick samples were cast out of which 99 were used for compressive strength. Specimen samples were fired at temperature 1100ºC. The result obtained showed that the highest compressive strength obtained in the control samples with 6.05 N/mm^2, sawdust with 3.05 N/mm^2 and wood ash 1.58 N/mm^2 when fired at 1100ºC. It was observed that there was a decrease in compressive strength as the percentage of sawdust increases and wood ash increases. The research concluded that regarding the compressive strength, the samples met the requirement specified by (**IS: 1077**) at temperatures of 800ºC, 900ºC, 1000ºC and 1100ºC considered to have good resistance to abrasion. Bricks with those parameters are suitable for use in the construction of building as a walling material. It was also concluded that samples with additives are more stabilized before firing than the control, though higher strength was obtained in the control than samples with additives and both met the standard specification. It is recommended that the firing temperature of bricks made with sawdust and wood ash should not exceed 1100ºC to avoid distortion.

Keywords: *Energy consumption, Bricks, Sawdust, Woodash, Compressive strength, Temperature, Walling material, Distortion.*

Introduction

The necessity of shelter has always been one of the most basic needs of man and the major component of any kind of shelter are its walling material, (Asokan *et al,* 2011). From very early historical records, a burnt brick was the favored walling material in the Mesopotamian civilization while Hewn rock was used in Chinese civilization which present the earliest civilization recognized by man (Asokan *et al,* 2011).

The kind of walling material used always reflected the nature of raw materials available within the region and this trend has continued through successive civilization up to modern time. The discovery of limestone and the consequent development of the technology for manufacture in Britain during the 19th century marked the high point of building civilization. The relative ease of construction resultant from this led to a revolution as it were building industry.

The use of alternative walling material to cement in its various forms continued almost quiet alongside the development of cement and also witnessed a significant degree of development in form and use. The major alternative to cement-based walling especially in Nigeria and in other part of the world is the clay bricks. Developed originally from laterite materials, various processes and techniques have led to the burnt brick in various areas, and this is as a result of the different customs, civilization and availability of raw materials in these regions. In Nigeria, however, these burnt bricks can roughly be grouped into two viz;

- Factory produced burnt bricks
- Locally produced burnt bricks

With the down turn in the economy, cost consideration has continued to be an important factor in any form of construction. One effective way of reducing high housing cost is to encourage the use admixture of wood ash and sawdust on a laterite burnt bricks in housing construction. Public policy is already convenience of the efficacy of the measure. Besides reducing the cost of housing construction and therefore hopefully reducing rents, use of wood ash and sawdust admixtures on burnt bricks produced materials would save substantial foreign exchange for the country. In pursuit of this objective, the federal government of Nigeria has taken a number of measuring: among other things, it has: planned the establishment of seven clay brick factories in the country (at Enugu, Jos, Kaduna, Kano, Ibadan, Lagos and Maiduguri) to produce burnt bricks. over half of these have actually completed. The bricks to be produced are envisaged as effectively replacing cement blocks for building materials and bare out of reach of the great majority of the people (Sampson *et al.,*2024). Besides, good clay for bricks producing is available in abundant qualities and quantities almost everywhere in Nigeria.

Unlike cement blocks, clay bricks require neither rendering nor painting. This attributes in it are evidently a cost-reducing one. Explaining widely, the government of Nigeria embarked upon the establishment of these brick factories, for example, the then Head of state stated:

"The Government embarked on the brick works project through-out the federation when it became obvious that we could not meet up with the cement requirement to successfully undertake our housing program. Construction with this factory produced burnt bricks was common all over the country and was sustained for a number of years. But due to lack of spare parts and maintenance expert high rates of capital recovery and inefficient resource usage arising from inadequate managerial capacity, which result in lack of consistent availability of the burnt brick and hence its inability to complete favorably with the cement (sandcrete) block. Consequently, attention was reverted back to cement walling despite its high cost of production. Thus, the hope of the average Nigeria to own his house was fast becoming a mirage as many Nigerians had to abandon hope for building and owing own houses. At about the same however, there was a re-emergence of local clay bricks into local building industry.

The locally produced, non-standardized, burnt clay bricks are an alternative to the factory produced, standardized clay bricks (Ayangade *et al.,* 2019 and Okunade, 2015)

They are non-standardized because the production processes and mix productions vary from maker to maker. The technology for their production is almost wholly indigenous and requires a relatively lower input in terms of machinery, scientific skill and organization. These bricks are highly favored because of their cheap cost, durability, and continuity of satisfactory and pleasing appearance even after long-term weathering.

Dreams for construction of houses, which were hitherto abandoned, are now becoming realized as a result of re-emergence of local clay brick. The term re-emergence is used in reference to these bricks because they were once very popular within the local construction industry with their presence in Nigeria dating back to the turn of the century. Structures constructed around this period can still be seen around. Examples of these are structure like the Government College Umuahia and Holy Ghost cathedral Makurdi as well as chief Ayoosu house Mbakyaha Ute, Vandeikya. In spite of the great and commendable efforts being made at official levels to popularize the use of indigenous and locally produced burnt bricks, some problems still inhibit the acceptance of these materials for building.

These questions we intend to analyze in this study. Wayne Nelson once said "This is a great step towards making housing affordable, so that everyone God has created can have at least a simple and descent place to live." therefore, the study seeks to break new ground in the housing industry with the main aim of mass production of housing unit to alleviate average Nigerian need for shelter. (Shelter to the rich is not a problem). Everyone is urged to embrace the available local material as alternative to cut-down construction and life -span cost of building and ensuring a viable economy in local building material sector.

Recycled materials such as Sawdust and wood ash are wastes that are generated from either postconsumer or post – industrial (pre – consumer) sources. The research work of Emmanuel *et al.,* (2014) revealed that the bulk of waste generated in Nigeria constitute about 57% food waste, 13% plastic waste and 8% paper waste. These wastes amongst others contribute to degradation of our environment (Asokan *et al;* 2011 and Rajput,2019). Clay is the most important raw material for burnt bricks. They usually acquire strength when they are heated to redness. Problems associated with high energy consumption in burnt bricks production and environmental degradation motivated researchers to work on alternative ways of solving these problems. Quarrying operations for obtaining the clay are energy intensive, adversely affect the landscape, and generate high level of wastes. The high temperature kiln firing not only consumes significant amount of energy, but releases large quantity of greenhouse gases. Clay bricks, on average, have an embodied energy of approximately 2.0kWh and release about 0.41kg of carbon dioxide (CO_2) per brick (Emmanuel *et al;* 2014) recommended that these problems can be reduced by addition of fuels to the clay such as sludge, polystyrene, sawdust, rice husk etc. High cost is involved in cleaning up waste from disposal sites and activities to do away with such waste which causes air pollution through burning fossil fuel, gas, coal, and oil amongst others and releases harmful gases such as carbon dioxide, carbon monoxide, nitrogen oxides, Sulphur dioxide, and tiny solid particles into the atmosphere. These wastes must, in no way, present a threat to human health, to the air, to surface water and groundwater, or to the land. One possible means of safe disposal would consist of high – temperature incineration under rigidly controlled conditions. Effective utilization of these wastes will likely help to reduce the negative effects of their disposal. However, in order to reduce these problems, the potential wastes can only be recycled if the properties and the environmental pollutant of the new manufactured brick meet the specific requirements and comply with the relevant standards (Aeslina and Abbas, 2018 and Sojobi, 2016).

According to Saibal (2021), the sustainable waste management is therefore critical in ensuring both the current and future generation have access to a clean and productive environment. It was stated that proper waste management structure such as recycling and collection of waste from the point source should be enacted to prevent further accumulation of solid waste. Also, extensive waste management on how to recycle, reuse, reduce and respond to waste. Waste management is a challenge, but there are sustainable solutions to it.

The use of burnt bricks in building is not very common as compared to concrete blocks despite the availability of clay used in its production. it also common that certain additives are added to burnt bricks raw mixes to produce different effects in the finished product. It is expected that the additives used in this research will serves as fuels which will provide more heating to the firing process thereby reducing the fuel and power consumption in burnt bricks production. It will also provide pores in the bricks which will allow the heat from the firing to quickly reach the innermost part of the bricks cores and as a result avoid the unburnt bricks (Mawusi,2023)

According to (Emmanuel *et al.,*2014), the additives act as a consolidating or fusing agent. It also expected that the additives used in this research will help to increase the bonding of the particles and such help to increase the strength of the bricks and also increase its resistance abrasion. Introduction of this waste material as additives will help to reduce the waste in the environment and reduce cost of purchasing clay for bricks. According to Olusola *et al;*2004, the cost of materials in construction account for two- third of the total construction cost.

The objective of the research work is to access the combined effect of sawdust and wood ash on the properties of burnt bricks with view to establishing their suitability for use in brick industries.

Materials and Methods

Experimental Site

The research work was carried out at The Federal University of Technology, Agricultural Engineering laboratory, Obakekere, Akure, Ondo state, Nigeria. Akure metropolis is located between latitude 7.2500ºN and longitude 5.1590º E. It has elevation of about 356.2m above the sea level.

Materials

Materials used for this study are laterite soil, sawdust and wood ash. Sawdust was obtained from a sawmill industry in Akure, Ondo state Nigeria. Some portions of sawdust were burnt in order to generate the wood ash. However, potable water that was free from organic materials and dirt was used. One hundred and thirty-two bricks were moulded for the study. The bricks were then fired at uniform temperature of 1000ºC in kiln while the compressive strength was performed after 7days, 14days, 21days, and 28days.

Methods

The laterite soil was excavated from borrowing pit and stacked in heaps in the open for rain to wash out the soluble salts which might later cause scum on the product. After the soil had been thoroughly washed, it was stored in open storage area until when they are ready for use. Before putting it to use, water was then added to the soil to form a paste. The laterite paste was then poured into a mould of 200 mm x100 mm x 100 mm and bricks were moulded. Nine (9) set of bricks were molded with ordinary laterite soil which serves as control. Then another forty-five (45) set of brick were mixed with sawdust, while the third set of forty-five (45) bricks were also mixed with wood ash. The percentage replacement of laterite soil by sawdust and wood ash were varied from 0%, 10%, 20%, 30%, 40% and 50%. The freshly produced bricks were stored under the shed in the open air in rows. They were covered with dried grasses to ensure protection against adverse weather condition. This ensures that there is proper or desired drying before burning. This depends on the weather condition and can take as from 4 – 6 weeks of proper or desired burning.

Table 1: Percentage of sawdust in replacement by laterite soil

Percentage (%)	Weight of laterite (kg)	Weight of sawdust (kg)	Number of bricks molded
0	0	0	0
10	35	3.5	09
20	45	16.5	09
30	55	26	09
40	65	37.5	09
50	75	45.5	09

Table 2: Percentage of wood ash in replacement by laterite soil

Percentage of sawdust (%)	Weight of laterite soil(kg)	Weight of sawdust replacement(kg)	Number of bricks molded
0	0	0	0
10	40	4.0	09
20	50	10.0	09
30	60	18.0	09
40	70	28.0	09
50	80	40.0	09

Ninety- nine 100mm x 100mm x200mm bricks were produced for the whole study, forty- five (45) each were produced from the mixture of sawdust and wood ash while the remaining nine bricks containing only pure laterite soil were produced as control of the study. Sawdust was collected from one reputable sawmill in Akure, Ondo without pretreatment. It was sundried for some days so as to enable it burn for the generation of the wood ash.

During production, the laterite soil was mixed with water by using hand molding method; the clay was forced in the mold in such a way that it fills all the corners of the mold. Extra clay was removed by wooden strike. Mold was then lifted up and raw brick was left on ground. Sawdust and wood ash were also mixed with laterite soil in different percentages (0%, 10%, 20%, 30%, 40%, and 50%).

Air Drying of Bricks

The moulded bricks were air drying by placing them in sheds with open sides so as to ensure free circulation of air and protection from bad weather and rainfall. The bricks were allowed to dry till they are left to 5 to 7 percent moisture content. The molded bricks were allowed to dry for 28days.

Grading Test and Quantity of Lateral Paste Replaced with Adhesives

The grading test of laterite sand and sawdust were determined by sieve analysis. A sample of both materials of known weight was passed through a series of sieves with progressively smaller opening. Weighing balance and test sieves were used for the test. Thirty-five (35) kg of laterite soil was used to mould nine (9) bricks which serve as control. The quantity of lateral paste replaced with adhesive during research were shown in tables 1 and 2

Brick Burning/Firing

The gas kiln was used for the bricks. Here the temperature of the kiln was raised slowly, brought to the peak temperature, sustained for the necessary duration and slowly decreased. The bricks are carefully arranged in such a manner as to leave spaces for gas and hot air circulation. The gas was fed into the kiln by a burner connected with the hose of the gas cylinder through the vent's tunnels designed in the kiln. The gas was kept at temperatures to ensure full drying of the bricks before being increased to the peak temperature. A brick is fully fired when the temperature is about 800^0C to 1000^0C. The kiln was slowly brought to cooling after which the bricks are unstacked. The total duration for firing ranges between 8 hours to 12 hours depending on the fire intensity and the number of bricks fired.

Table 3: Average Compressive Strength of Sawdust

Control	10%	20%	30%	40%	40%
1.27	1.77	0.87	0.22	0.11	0.11
1.09	1.74	0.84	0.28	0.13	0.10
1.08	1.94	0.65	0.23	0.12	0.11
1.06	1.63	0.84	0.27	0.12	0.12
1.21	1.80	0.79	0.25	0.12	0.11
1.04	1.80	0.62	0.28	0.13	0.12
0.94	1.94	0.97	0.28	0.12	0.12
0.81	1.81	0.63	0.28	0.12	0.13
1.29	1.79	0.64	0.28	0.13	0.11
Average	Average	Average	Average	Average	Average
1.30	1.80	0.76	0.26	0.12	0.11

Compressive Strength

The compressibility test was carried out. This test is ability of the brick to resist load. The 28th day strength is taken as the characteristic strength of the brick. However, brick compressive strength can be determined at 7 or 14days to check development in strength. Compressive testing machine and weighing balance were used for the test. The bricks were weighed and their masses were recorded; the bricks dimensions were determined to check any distortion in shape. Each brick was then centrally aligned on the base of the compression testing machine. They were then loaded gradually while turning the fine straining knob to prevent sudden failure. Upon failure, the load applied was determined from the appropriate scale and recorded. Compressive test on the bricks was carried out on the 28th day from the date of casting.

Data Analysis

Experimental data were analysed using Analysis of Variance (ANOVA) and Microsoft Excel spread sheet. Graphical representations were generated and estimated using statistical packages.

Results and Discussion

Results presented in this section are based on the test carried out on the type of materials and brick samples used for this research.

Compressive strength of bricks fired at 1000^0C

The compressive strength of burnt bricks at the same temperature of 1000ºC shows that the control sample fired at 1000ºC meet up with the minimum strength requirement of second-class bricks. The bricks had strength of 7.80N/mm2, while sawdust and wood ash sample at this temperature are third class bricks as specified by (Hendry et al.,2017 and Olusola et al., 2023). The wood ash burnt in the bricks and thereby reduce the strength of the brick during firing while the sawdust burns to ashes. Samples with sawdust and wood ash had a lesser strength with increase in wood ash and sawdust content. This implies that when the percentage of sawdust and wood ash increases the compressive strength did not comply with NBRRI (2023) recommendation of burnt bricks and can't be used for construction of buildings as a walling material.

The results for the compressive strength carried out on the bricks as shown in tables 3 and 4 revealing average compressive strength values of 4.35N/mm^2 for sawdust, 2.88N/mm^2 for wood ash, and 7.80N/mm^2 for control. The control was noted to be very stronger and harder than sawdust and wood ash.

Table 4: Average compressive strength of wood ash

Control	10%	20%	30%	40%	50%
1.27	0.50	0.29	0.19	0.28	0.12
1.09	0.66	0.39	0.20	0.37	0.15
0.63	0.66	0.39	0.28	0.27	0.11
1.06	0.38	0.35	0.21	0.39	0.13
1.81	0.55	0.33	0.29	0.25	0.12
1.04	0.67	0.33	0.28	0.28	0.12
0.94	0.33	.033	0.53	0.28	0.13
0.81	0.48	0.35	0.39	0.21	0.13
1.29	0.57	0.39	0.49	0.27	0.12
Average	Average	Average	Average	Average	Average
1.30	0.53	0.34	0.31	0.28	0.12

Compressive Strength

The compressive strength is a mechanical strength property used in bricks specifications, which has assumed great importance for two reasons. Firstly, with higher compressive strength, other properties are relatively difficult to evaluate, the compressive strength is easy to determine. From quality control point of view, the compressive strength decreases with increasing porosity but strength is also influenced by clay composition and firing. In these results, group A contains control and 10% of sawdust, group B contains 20% of sawdust and group C contain 30%, 40% and 50% of sawdust. Differences between means that share a letter are not statistically significant. All the percentages sawdust do not share a letter, which indicates that they are all statistically significant but control and 10% of sawdust has a significantly higher mean than 30%,40% and 50% of sawdust.

From the figure1, there was a decrease in the compressive strengths of the brick with the addition of sawdust from 0%, 10%, 20%, 30%, 40% and 50%. The average mean shows that the compressive strength of the sawdust decreases from 1.104 to 0.144. Average mean of 1.104 was obtained from control samples. The lowest strength of 30%, 40% and 50 % decrease were obtained from the ANOVA table which shows that the values are not significantly different. The control sample and sawdust sample at 10% having the strength above 10N/mm^2 are classified as first class burnt bricks and they are recommended for flooring, masonry structures and reinforced brick works while the sample B at 20% which also have appreciable strength above 7N/mm^2 are classified as second-class bricks (NBRRI, 2023 and NBC,2006).

Confidence Level

The confidence intervals indicate the following as shown in Figure 2

*The confidence interval for the difference the means of wood ash that the range does not include zero indicates that the difference between the means is statistically significant.

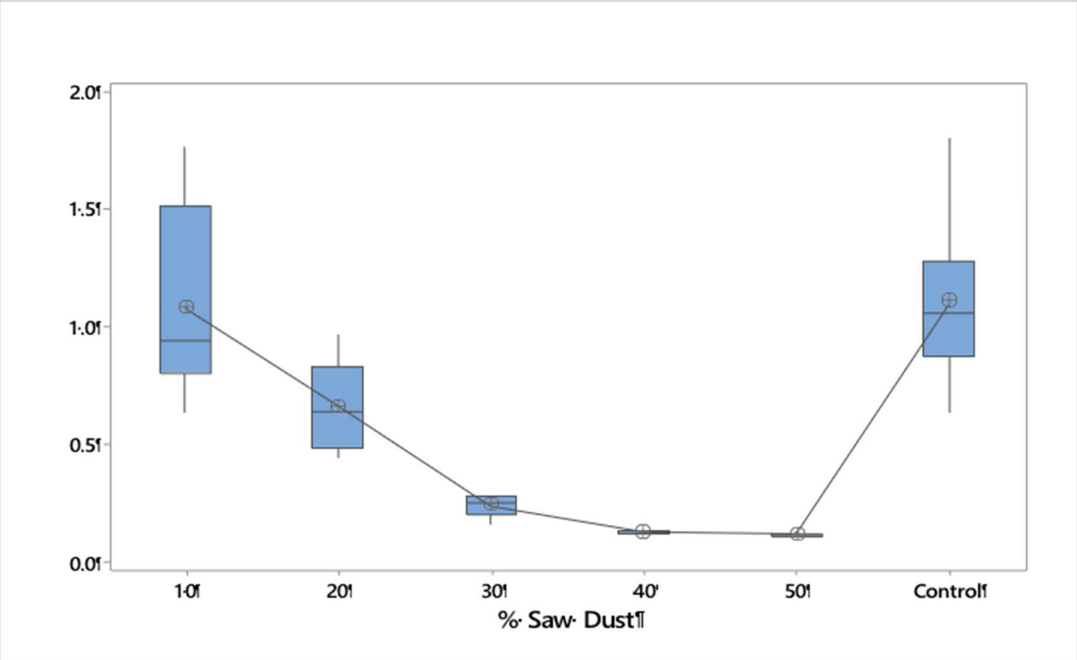

Figure 1: Chart of Mean (Crushing Strength (N/m^2)

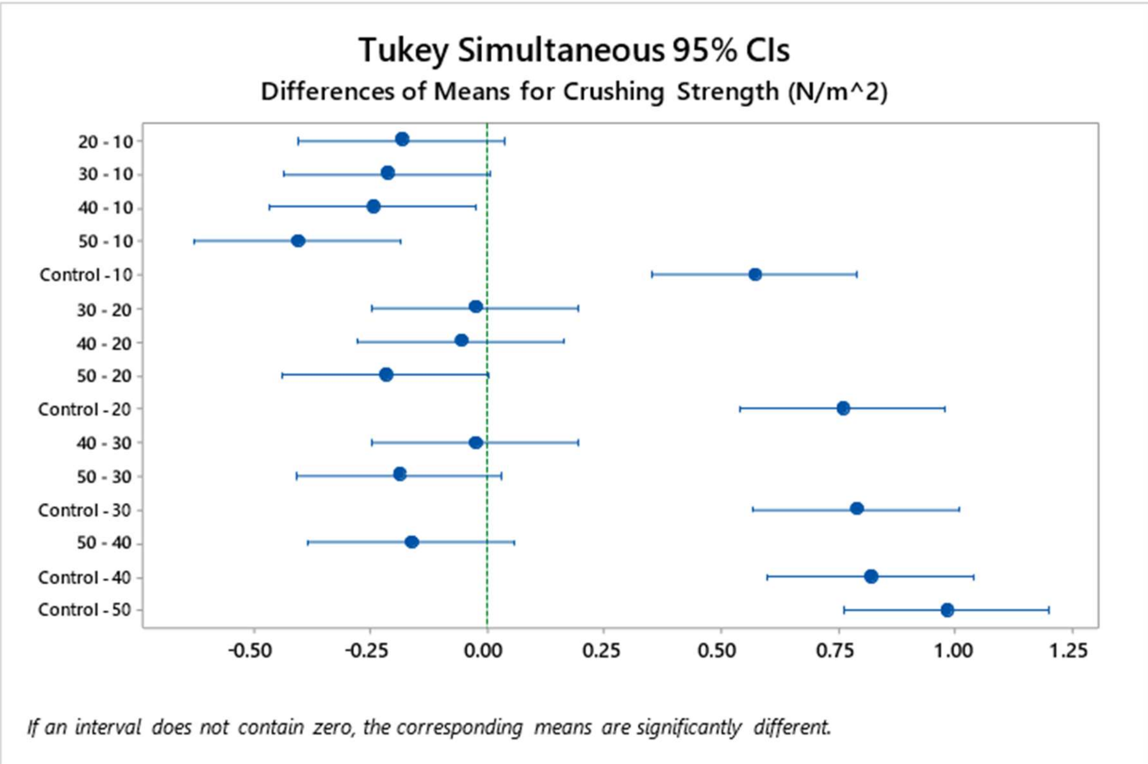

Figure 2: Difference of Means for strength (N/m$^{2)}$ Simultaneous

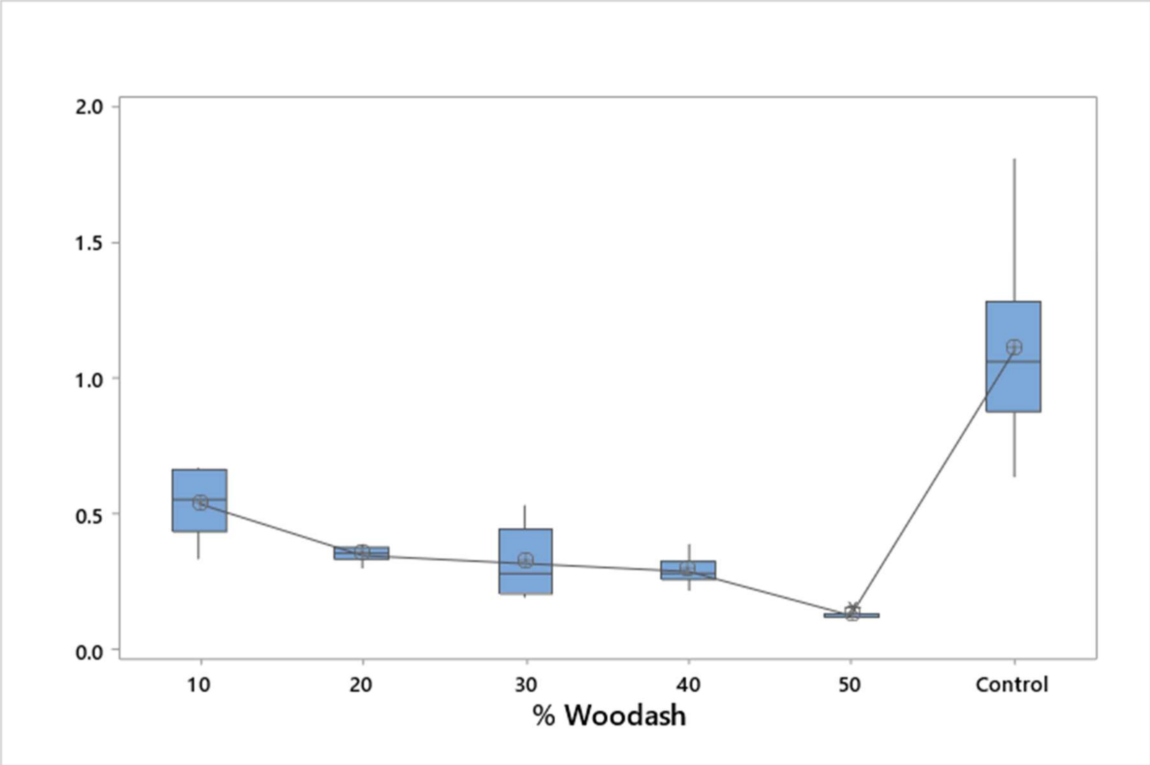

Figure 3: Boxplot of Crushing Strength (N/m^2)

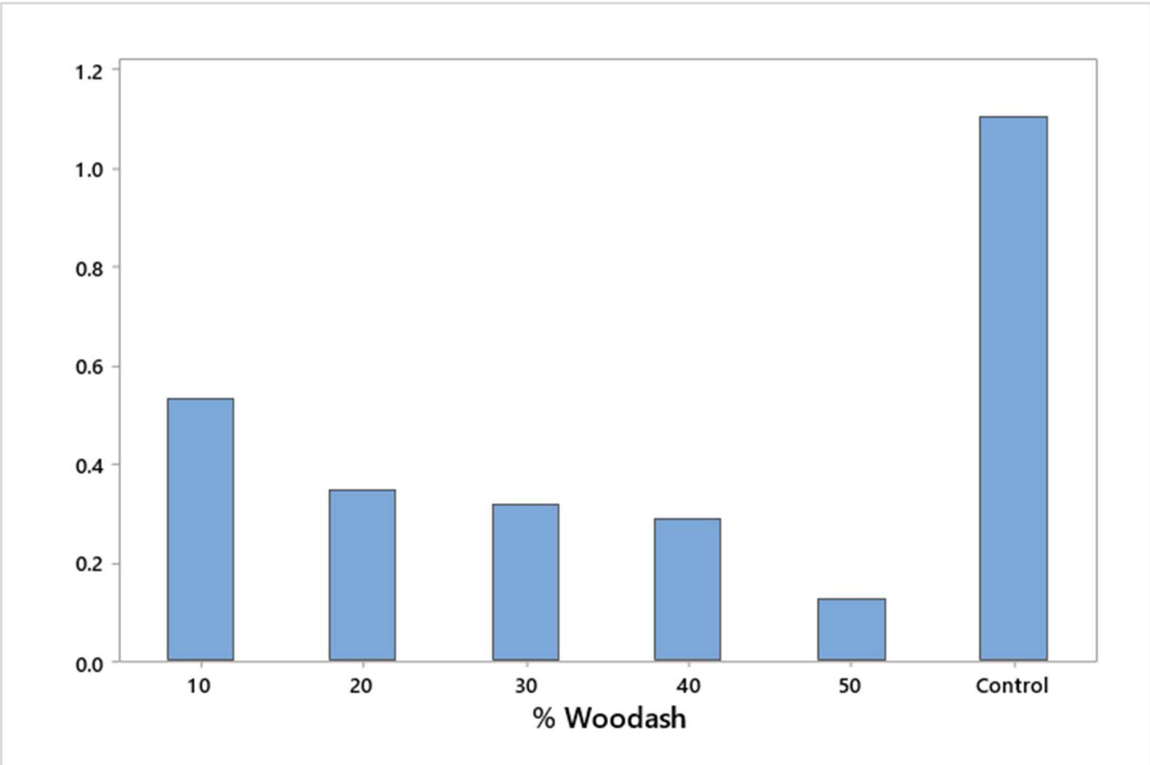

Figure 4: Chart of Mean (Crushing Strength N/m^2)

*The confidence intervals for the remaining pairs of means all include zero, which indicates that the differences are not statistically significant.
*The 95% simultaneous confidence level indicates that we can be 95% confident that all of these confidence intervals contain the true differences.
*Each individual confidence interval has a confidence level of 99.54%. This result indicates that you can be 99.54% confident that each individual interval contains the true difference between a specific pair of group means. The individual confidence level for each comparison produces the 95% simultaneous confidence level for all six comparisons.
As shown in figure 3, the control mix has the highest crushing strength which indicate that the control is stronger than the wood ash bricks. The compressive strength decreases with the addition of wood ash.
Based on the height of the bars in Figure 4, it is clear that the mean of crushing strength for control has the highest followed by 10%,20%,30%,40% and 50 % for wood ash.

Conclusion
In the study, the effect of sawdust and wood ash admixtures on engineering properties of a burnt laterite clay bricks on the compressive strength and density were investigated. The compressive strength of the burnt brick reduced as the percentage replacement of laterite by sawdust and wood ash increased. Since sawdust may be obtained at virtually no cost, the cost of laterite burnt bricks can potentially be reduced by replacing laterite with sawdust and wood ash in burnt brick.
The control mix is stronger than sawdust and wood ash in the term of compressive strength but in term of weight, the wood ash is lighter in weight by 10 per cent compared to clay bricks. It is said that wood ash absorbs less water compared to clay bricks (10 to 12 per cent as against to 15 to 20). Bricks fired at higher temperatures are more durable. Light Weight bricks are manufactured when sawdust and wood ash are used in the production of burnt bricks and also contribute to internal heating within the bricks. The bricks at temperature of 800^0C, 900^0C, 1000^0C and 1100ºC could be used for load bearing walls and non-load bearing walls as they met the NIS 87: 2004 specification which stipulates a compressive strength of 2.8N/mm^2 for load bearing walls and 2.0N/mm^2 for non- load bearing wall

Recommendation
The following points are recommended for further study:
(i). To achieve a better result in the use of sawdust for brick production, the percentage replacement of laterite should be minimal not exceeding 20% replacement.
(ii) Whenever building weight is an important factor, then sawdust and wood ash brick could be a good option.
(iii) Sawdust and wood ash bricks are good in term of cost efficient.
(iv) Firing temperature of bricks made with sawdust and wood ash should not exceed 11000C because above this
temperature bricks with additives are badly distorted which could be attributed to the heating contributed by the
additives.
(v) Further studies should be carried out using higher percentages of the additives of 50- 100% replacement and its
behavior in aggressive environment assessed.

References

Aeslina A.K and Abbas M (2018). Bricks: An excellent building material for recycling wastes. Proceedings of the IASTED International Conference Environmental Management and Engineering, July 4 – 6 2011 Calgary, AB, Canada. DOI: 10.2316/p.2011. 736 – 029.

Asokan P, Mohini S and Shyam R.A(2011). Solid Wastes Generation in India and their Recycling Potential in Building Materials. Canadian Journal on Environmental, Construction and Civil Engineering, Vol 2, No 3, 265-275.

Ayangade, J. A., Olusola K. O., Ikpo, I. J. and Ata O. (2019). Effect of granite dust on the performance characteristics of Kernelrazzo floor finish. Building and environment,39, 1207 – 1212.

Emmanuel I.U, Dickson A, Famuyibo (2014). Analysis of the Effect of Blending Nigeria Pure.Clay with Rice Husk: A Case Study of Ekulu Clay in Enugu State. American Journal of Material Engineering and Technology Vol 2, No1, 34-37

Hendry, A.W., Sinha, B. P., and Davies, S. R. 2017). Load bearing brickwork design. (2nded.). England: Ellis Horwood Ltd.

Mawusi SK, Shrestha P, Xue C, Liu G. (2023). A comprehensive review of the production, adoption and sustained use of biomass pellets in Ghana. Heliyon. 2023;9(6):1–22. https://doi. org/ 10. 1016/j. heliy on. 2023. e16416.

National Building code (2006).” Building Regulation”, LexisNexis Butterworths, Ohio. Nigerian Industrial Standards. NIS

087:2000. Specification for Sandcrete Blocks.

Standards Organisation of Nigeria.NBRRI (2023). Housing in Nigeria (A Book Reading). A Manual of Proceeding of Seminar.

Okunade, E.A. (2015). The effect of wood ash and sawdust admixtures on the engineering properties of a burnt laterite –clay brick. J. Applied Sci., 8, pp 1042- 1048.

Okunade, E.A. (2015). The effect of wood ash and sawdust admixtures on the engineering properties of a burnt laterite –clay brick. J. Applied Sci., 8, pp 1042 – 1048.

Olusola K.O, Ogunbode E.B and Kyenge S.S (2023). Performance Assessment of Makurdi Burnt Bricks. https://www.slideshare.net.slide show.

Rajput, R. K (2019). "Engineering Materials (Including Construction Materials). A Textbook for Engineering Students of B.E., Section -B of A S. Chand & Company Limited, New Delhi, India.

Saibal G (2021). The Eastern Ghats Belts INDLA – A New Look at an Old Orogen. Journal of Geological Survey India spl, No 48 pp: 75-100.

Sampson A., Charles K.K., Kwadwo A.A., Russell O.A. and Jones O.T. (2024). Effects of Burnt Sawdust Ashes from Timber Species on the Strength Properties of Laterite-Interlocking Blocks. Journal of Discover Civil Engineering, (2024) 1:87 |https://doi.org/10.1007/s44290-024-00093-9.