Research Journal of Recent Sciences ISSN 2277-2502
Vol. **10(1),** 21-27, January **(2021)** *Res. J. Recent Sci.*

Composite brick production from sawdust of *Parkia biglobosa* (Jacq.) G. Don and *Vitellaria paradoxa* C. F. Gaertn as Partial Replacement for sand

David Oriabure Ekhuemelo*, Veronica Eyakamo Abu and Kennedy Odeeh
Department of Forest Production and Products, Federal University of Agriculture Makurdi, Nigeria
davidekhuemelo@gmail.com

Available online at: www.isca.in, www.isca.me
Received 26th July 2020, revised 8th October 2020, accepted 9th December 2020

Abstract

This study was undertaken to investigate sawdust as a fractional substitute for sand to produce bricks with an aim to minimizing production cost and productive use of sawdust waste as profitable resource. Sawdust of V. paradoxa and P. biglobosa was obtained from Timber Shed within Makurdi metropolis. The collected sawdust was treated by boiling it in water to remove lignochemical substances and thereafter, it was sun dried. Recommended ratio of 1:6 of cement to sand was endorsed in this study. Varied percentages of 0, 2, 4, and 6 of sawdust were employed to substitute for sand while quantity of cement for all level was held steady during the mixture of mortar. Tests were carried on the percentage of water absorption (PWA), bulk density (BD), and compressive strength (CS) on bricks made after 28 days of curing. Results revealed that bricks from 4% sawdust substitution for sand had the maximum percentage water absorption of 12.80 and 11.06% for followed by 2% (9.43% and 10.14) and 6% (8.66 and 6.47%) for P. biglobosa and V. paradoxa respectively while 0% sawdust substitution level had 8.21%. Mean compressive strength of 0% sawdust substitution (control) was highest (4.94 N/mm) followed by 2% (3.20 and 3.26 N/mm^3), 4% (3.17 and 3.40 N/mm^3) and 6% sawdust substitution level (3.35 and 3.21 N/mm^3) for P. biglobosa and V. paradoxa sawdust, respectively. Bulk densities of made bricks were between 3600.56 and 1303.33 kg/m^3, highest in 0% and least in 6% V. paradoxa sawdust replacement level. However, bulk densities were higher in V. Paradoxa (1345.78-1318.94) kg/m^3 than in P. biglobosa (1328.60 - 1303.33) kg/m^3. It was concluded that 2% sawdust replacement had the maximum compressive strength and bulk density with the least percentage water absorption. Hence, it was recommended for utilization for construction of non-load bearing walls.

Keywords: Brick, sand, sawdust, partial replacement, compressive strength, *V. paradoxa* and *Parkia biglobosa.*

Introduction

The demand for wood and wood products is ever increasing as a result of upsurge in human population with the corresponding increase in shelter and other societal development[1]. In a related development, there are lots of timber sheds in Makurdi where lumbers are processed into different wood sizes to meet the escalating demand of wood for construction purposes mostly for roofing and furniture. Consequently, there is huge turnout of unutilized sawdust causing environmental menace. Most times, these heaps of sawdust are burnt to reduce its volume and unaesthetic sight.

This burning constitutes environmental pollution through the emission of carbon monoxide (CO), particular emissions (PE), sulfur oxides, nitrogen oxides and volatile organic compounds (VOCs)[2]. Two timber sheds in Makurdi are located close to River Benue. During raining season, some amount of sawdust heaps are eroded into the water body which can result to water pollution. It has therefore become very import to decrease the quantity of wastes released into the environment by utilizing the waste as value added resource.

Inadequate provision of shelter is one of the major challenges in developing countries especially as the population is growing[3]. As a result, there is need to initiate approaches that would support the use of low cost building materials. Sawdust generated from timber sheds in Makurdi can be used as replacements for conventional materials like sand by recycling them into composite new building materials[4]. Therefore, utilization of eco-friendly, light-weight and cheap building materials have created investigation into how this can be accomplished by profiting the environment and maintaining the material requirements to standards[5].

It has remarked that sawdust as waste material has got some attraction as a raw material for lightweight concrete building construction and brick production for some years and that been explored in several countries[6]. As sawdust is available in great quantity and is somewhat inexpensive, researchers have made efforts to examine the appropriateness of the material for a potential use in building construction[3].

In Makurdi, river sand is commonly used for all kinds of civil engineering constructions. The extreme excavation of river sand is generating great environmental concern as soil compression and reduction of vegetation along the river bank has become prominent due to constant movement of tiper truck used in carrying river sand[7].

Thus, it is essential to investigate promising alternative solution to reduce the utilization of river sand that is facing a serious scarcity. The steady extraction of river sand from the river bed for construction purposes affect the storage capacity of the river which in turn leads to harsh water scarcity during dry season[7].

This situation disadvantages the living organisms in the river for survival which can result to migration due to constant disturbance. Therefore, it is essential to explore alternative materials for replacing natural river sand in brick and concrete production in Makurdi.

Although some researches have been done on the use of sawdust of some wood species in brick production, *P. biglobosa* and *V. pardoxa* sawdust have not been researched. Consequently, this study was aimed at bricks produced from sawdust of *P. biglobosa* and *V. pardoxa* as substitute for sand in Makurdi.

Materials and methods

Collection materials and handling of sawdust: For this study, sawdust was obtained from timber shed located at bank of River Benue Makurdi (Figure-1). The sawdust was boiled for an hour to remove soluble organic components such as carbohydrate, tannins, waxes and resins with regard to standard[8]. After boiling, the residue was rinsed with water and sundry. Standard sieve of 3.5mm (Figure-2) was used to sieve the dried sawdust. Portland cement was purchased from cement shop in North Bank Makurdi.

Mortar Preparation from sand, sawdust and cement: Percentages of 2, 4, and 6 weights of sawdust respectively from each species of *P. biglobosa and V. paradoxa* substitution level were mixed in a proportion of ratio 1:6 of cement to sand. Sufficient water was added to mixture to ensure workability (Table-1). The mixture was manually mixed carefully until a homogenous and uniform colour was reached.

Figure-1: Section of Timber Shed and sawdust deposit at Head Bridge Wurukum, Makurdi.

Figure-2: [A] Sieving of the sawdust samples used for the study [B] Sun drying of sawdust samples.

Table-1: Weight of sand and sawdust substitution level.

Sawdust substitution level	Ratio of Cement to sand	Mixture of sand and sawdust ratios		Quantity of water used
		Sand (kg)	+ Sawdust (kg)	
0%	1:6	120	+ 0	Based on the texture of mixture
2%	1:6	118	+ 2	
4%	1:6	116	+ 4	
6%	1:6	114	+ 6	

Production of bricks from sawdust of *P. biglobosa* and *V. paradoxa:* To form bricks, prepared mortar from each mixture was placed into a mold of 6" of 450mmx225mmx150mm dimensions. The mold was placed onto power machine (5.0 KW) to vibrate the mold with its content to ensure adequate compaction of bricks according to standard[9]. The bricks were shaped on pallets made of wood and removed from the molding power machine and cautiously placed for curing. Repeatedly, the formed bricks were watered twice daily to cure bricks for a period of 28 days. Subsequently, wooden pallets on which bricks were formed were removed. Bricks were afterward transported to Laboratory at Civil Engineering Department, Federal University of Agriculture, Makurdi for tests.

Laboratory test of Bricks: Bricks were tested for percentage of water absorption, compressive strength and bulk density.

Determination of Compressive strength of Brick: Compression machine used for this test is shown in Figure-3. This device was properly connected so that the reading calibration scale was attuned to zero mark. The weight of each brick was noted, recorded and used to calculate the compressive strength in kilo-newton (KN). The sum of ten bricks each was used for respective substitution level. Compressive strength of bricks produced from the study was calculated using the relationship equation-1:

$$\mathrm{CS} = \mathrm{MLF/CA}\ [\mathrm{N/mm}] \quad (1)$$

Where: CS= Compressive Strength; MLF= maximum load at failure; CA= contact area.

Determination percentage of water absorption of brick: The quantity of water absorbed by bricks was evaluated to assess bricks percentage of water absorption. Four breaks from each sawdust substitution levels were used for the test. The dried bricks were weighed (W1) as dry weight and then completely immersed in water a trough for 24 hours. Thereafter, the bricks were removed and left to drain for few minutes and reweigh (W2) as wet weight. The variation in weight (W2-W1) was used to calculate percentage of water absorbed by bricks as shown in equation-2 below.

$$PWA = W2 - W1\ x\ 100/W1 \quad (2)$$

Where: PWA= Percentage of water Absorption; M1= dried weight of brick kg; M2= weight of wet brick in kg.

Figure-3: Brick compressive strength test in the laboratory.

Determination of Bulk density of Bricks: The bulk density of bricks from this study was calculated according to British Standard Institute[10]. Mathematically expressed it is expressed below in equation-3:

$$BD = WB\ (kg)\ /\ DVB\ (mm2) \quad (3)$$

Where: BD = Bulk density; ME= Weight of brick; DVB= Dimensional volume of brick.

Data Analysis: Data recorded from this study were analyzed descriptively with one-way Analysis of Variance (ANOVA). Follow up test with Duncan Multiple Range Test (DMRT) used for mean separation was where significant differences exist.

Results and discussion

Percentage water absorption results are presented in Table-2. Results reveal that 4% sawdust substitution level has the maximum percentage water absorption of 12.80 and 11.06%

followed by 2% (9.43% and 10.14) and 6% (8.66 and 6.47%) for *P. biglobosa and V. paradoxa* respectively while 0% sawdust replacement was 8.21%. There was no significant difference (p>0.05) between replacement level 2% and 4% but both differ significantly from 6% sawdust replacement level.

Table-2: Result of Water Percentage absorption by bricks made from partial substation of sawdust.

Treatment (Sawdust replacement Level)	*Parkia biglobosa* Mean±Std	*Vitelliaria paradoxa* Mean±Std
2%	9.43±1.90[a]	10.14±0.40 [a]
4%	12.80±1.64[a]	11.06±0.28[a]
6%	8.66±1.20[b]	6.47±3.56[b]
0% (Control)	8.21±0.47	

Compressive strength results from hollow bricks made from *P. biglobosa and V. paradoxa* sawdust replacement for sand are shown in Table-3. Mean compressive strength of 0% sawdust replacement (control) was highest (4.94N/mm). This was followed 2% sawdust replacement (3.20 and 3.26N/mm^3), 4% sawdust replacement level (3.17 and 3.40N/mm^3) and 6% sawdust replacement (3.35 and 3.21N/mm^3) for *P. biglobosa* and *V. paradoxa* sawdust. There exist no significant difference (p>0.05) among levels of sawdust replacement.

Figure-4 to 10 show the photographs of hollow bricks produced from of 0%, 2%, 4% and 6% of *V. paradoxa* and *P. biglobosa* sawdust replacement levels for sand.

Table-3: Compressive Strength of bricks produced from partial replacement of Sawdust.

Treatment (Sawdust replacement Level)	*Parkia biglobosa* Mean±Std	*Vitelliaria paradoxa* Mean±Std
2%	3.20±0.10[a]	3.26±0.20[a]
4%	3.17±0.05[a]	3.40±0.06[a]
6%	3.35±0.05[a]	3.21±0.24[a]
0% (Control)	4.94±0.19	

Results of bulk density from hollow bricks are presented in Table-4. Bulk densities were between 3600.56 and 1303.33 kg/m^3, highest in 0% sawdust replacement and least in 6% *V. paradoxa* sawdust substitution level. However, bulk densities were higher in *V. paradoxa* (1345.78 - 1318.94) kg/m^3 than in *P. biglobosa* (1328.60-1303.33) kg/m^3. There was no significant different (p>0.05) between the bulk densities of 2% and 4% sawdust replacement levels but they differ significantly from the densities of 6% bricks for both wood species.

Table-4: Results of Bulk Density of bricks made from partial substitution of Sawdust

Treatment (Sawdust replacement Level)	*Parkia biglobosa* Mean±Std	*Vitelliaria paradoxa* Mean±Std
2%	1328.60±8.21[a]	1345.78±1.76[a]
4%	1317.14±10.99[a]	1338.91±6.44[a]
6%	1303.33±7.77[b]	1318.94±6.19[b]
0% (Control)	3600.56±7.17	

Figure-4: Hollow bricks of 2% *P. biglobosa* sawdust replacement for sand.

Figure-5: Hollow bricks of 2% *V. paradoxa* sawdust replacement for sand.

Figure-6: Hollow bricks of 4% *P. biglobosa* sawdust replacement for sand.

Figure-7: Hollow bricks of 4% *V. paradoxa* sawdust replacement for sand.

Figure-8: Hollow bricks of 6% *P. biglobosa* sawdust replacement for sand.

Figure-9: Hollow bricks of 6% *V. paradoxa* sawdust replacement for sand.

Figure-10: Hollow bricks of 0% sawdust replacement of replacement for sand.

Discussion: Percentage water absorption obtained in this study increased from 12.80% for 0% sawdust replacement to 9.43 - 10.14% and 12.80 -11.06% for 2% and 4% sawdust replacement levels and then decreased from 8.66 - 6.47 6% for 6% sawdust replacement level with respect to *P. biglobosa* and *V. paradoxa* sawdust respectively. These values recorded in this study are within the allowable value which is 12% with regard to BS 5628: Part 1: 2005. The result is lower than 12.38% reported for 5% and 10.22 - 11.40% recorded for 2%, 4%, 6% and 8% *Daniellia oliveri* sawdust replacement levels[11,12].

Quantity of water absorption is central to determining bricks' quality. The rate of water absorption of a unit brick is directly influenced by the porosity of bricks. High water absorption by brick increases the swelling of the soil particles which have been solidified and will resultantly decrease the strength property of the bricks[13]. Water to cement ratio has been the most important determining factor of strength and ease of working with bricks. The ease of working with a brick is pivotal in appraising the density of a brick. Low water to cement ratio will in bricks enhances the strength and hardness of bricks which reduces its workability. Conversely, a high water to cement ratio increases workability of mortar during the production process of bricks. Bricks with excellent workability support the production of high-density brick. These features elucidate the existence of changes in brick density that exists among all sawdust substitution level tested[13]. Water absorption of composite brick is a key factor in categorizing its durability. In general, composites of low water absorption will afford better protection to reinforcement within it[14].

Compressive strength is a very significant characteristic in appraising the load bearing ability of a brick[13]. There was decrease in compressive strength of bricks made in this study with an increase in the amount of sawdust in substitution for sand. This agrees with finding of Bustamante from mechanical and physical properties of composite brick made from composites of cement mortar, fly ash and rubber crumbs[15]. The compressive strength bricks produced from *P. biglobosa* (3.26, 3.40 and 3.21) Nmm^{-2} replacement levels was higher than the ones from *V. paradoxa* (3.20, 3.17 and 3.35) Nmm^{-2}. The compressive strength obtained in this study is greater than the least amount of required standard for load bearing walls of 2.0 N mm^{-2} reported for National Building Code of Nigeria and 2.75N mm^{-2} recorded for Ghana Building code[16,17]. A range of 2.5N/mm^2 to 3.45N/mm^2 as lowest amount of strength of brick is indicated in the Nigeria Industrial Standard NIS 87:2000[18]. However, the compressive strength values from this work are within 3.5N mm^2 stipulated by British Standard and above 1.45 N mm^{-2} required for non-load bearing walls[20,21]. It has been that reported that compressive strength of a brick is majorly determined by the quantity of cement in mortar, the nature of raw material and the water content of a cement brick[13]. The main reason for decrease in compressive strength of bricks is poor aggregation of the composites materials by cement to the surface of particles of raw material[22].

Densities of bricks from the mixtures of sawdust replacement levels were decreasing with increasing amount of sawdust. This is may be due many voids in the bricks ready to be filled with water during hydration and wet curing. Densities of hollow bricks (1303.33-1345.78) kg m^{-3} as obtained in this work are lower than the least amount of 1,500kg m^{-3} proposed for first grade sand crated blocks by Nigerian Industrial Standard 087 for load bearing walls[23]. Decrease in density is an attractive attribute in many applications with architectural applications like nailing concrete, interior construction stone backing and false facades[24]. It has been reported that the density of cement bricks is influenced by the nature of composite material and the production process[13]. In this study, the decrease in the density of bricks was due to the influence of the increase the amount of sawdust in the mixtures[15].

Conclusion

Consequent upon the results of this study, it can be concluded that: the increase of sawdust substitution levels led to reduction of the compressive strength of composite bricks made. There was also decline in bulk density with the percentage increase of sawdust substitution levels majorly due to decrease in specific gravity of sawdust compared to sand. The water absorption of bricks critically increased as the quantity of sawdust increased. *Vitelliaria paradoxa* composite bricks had higher compressive and bulk density strength and lower percentage water absorption compared to *P. biglobosa* composite bricks. The best sawdust replacement level for sand was 2% because it had the highest compressive strength and bulk density with the lowest percentage water absorption. Therefore, bricks obtained from sawdust replacement level 2% are recommended for non-load bearing walls.

References

1. Elias P. and Boucher D. (2014). Planting for the Future. How Demand for Wood Products could be friendly to Tropical Forests. Union of Concerned Scientists. Pp 41. Available online: https://www.ucsusa.org/resources/planting-future (accessed on 16 June, 2020).

2. Deac, T., Fechete-Tutunaru, L., and Gaspar, F. (2016). Environmental Impact of Sawdust Briquettes Use – Experimental Approach. *Ener. Proced.*, 85, 178–183.

3. Kupolati W. K., Grassi S. and Frattari A. (2012). Environmental Greening through Utilization of Sawdust for Production of Bricks. *OIDA Inter. J. of Sust. Develop.*, 4(12), 64 78.

4. Uchechukwu E., A. (2006). Effect of addition of sawdust ash to clay bricks. *Civ. Eng. & Enviro. Sys.*, 23(4), 263-270.

5. Turgut, P., and Murat Algin, H. (2007). Limestone dust and wood sawdust as brick material. *Buil.& Envir.*, 42(9), 3399-3403

6. Paramasivam, P., and Loke, Y. O. (1980). Study of sawdust concrete. *Inter. J. Cem. Comp. & Lightw. Con.*, 2(1), 57-61.

7. Dixson J. P., Karthikeyan S., Manikandan G. and Velmurugan.S. (2017). Experimental Study on Properties of Concrete by Partial Replacement of Cement with Silica Powder and Fine Aggregate with Saw Dust Ash. *Inter. J. Civ. Eng. & Tech.*, 8(3), 680–687.

8. Vaickelionis G, Vaickelioniene R (2006). Cement hydration in the presence of wood extractives and pozzolan mineral additives. *Ceramics-silikaty.*, 50(2), 155-122.

9. Raheem, A.A. (2006). Comparism of the Quality of Sandcrete Blocks Produced by LAUTECH Block Industry with others within Ogbomoso Township. *Sci. Foc.*, 11(1), 103-108.

10. British Standard Institute (BSI) (1975). Precast concrete blocks: BS2028. London.

11. Ekhuemelo, D.O., Ademu O. and Tembe, E.T., (2016). Physical and strength properties of bricks produced from Portland cement and saw dust of *Danielia oliverii* wood. *PRO LIGNO, Sci. J. wood. Engin.*, 12(4). 53 - 60.

12. Ekhuemelo, D., Tembe, E. T., & Versue, A. M. (2017). Some aspects of physical and mechanical properties of hollow blocks procuced from hot water treated sawdust. *Sustainability, Agri, Food and Environmental Research*, 5(4), 82-97.

13. Ali, N., Mohd Yusup, N. F., Sheikh Khalid, F., Shahidan, S., and Abdullah, S. R. (2018). The Effect of Water Cement Ratio on Cement Brick Containing High Density Polyethylene (HDPE) as Sand Replacement. MATEC Web of Conferences, 150, 03010. doi:10.1051/matecconf/201815003010 .

14. Omoniyi, T.E. Akinyemi B.A. and Fowowe A.O. (2014). Effects of Waste Glass Powder as Pozzolanic Material in

Saw Dust Cement Brick. *Scho. J. Eng. and Tech.*, 2(4A), 517-522.

15. Bustamante D., Dablo G. M., Sia R. and Arazo R. (2015). Physical and Mechanical Properties of Composite Brick from Cement Mortar, fly ash and Rubber Crumbs. *Inter. J. Res. Eng. & Tech.*, 4(10), 1-5.

16. National Building Code (NBC) (2006). Building Regulations, National Building Code. Lexis Nexis Butterworths, Ohio.

17. Bamfo-Agyei E. (2020). Establishing the Compressive Strength of Sandcrete Blocks Produced in the Central Region, Ghana. *https://www.academia.edu/2606907/Establishing_The_Compressive_Strength_of_Sandcrete_Blocks_Produced_In_The_Central_Region_Ghana?auto=download*

18. NIS (2000). Nigerian Industrial Standard: Standard for Sandcrete blocks. Standard Organisation of Nigeria, Lagos, Nigeria. NIS, 87, 2000.

19. National Committee on Building Regulation and Codes (1989). GHANA Building Code. Ministry of Works and Housing: Kumasi, Ghana.

20. Baiden B.K., and Asante C.K.O. (2004). Effects of orientation and compaction methods of manufacture on strength properties of sandcrete blocks. *Const. & Buil. Mat.*, 18, 717–725.

21. British Standards Institution (2005). Code of Practice for the use of Masonry. BS 5628: Part 1, British Standards Institution, London

22. Thomas, B. S., Gupta, R. C., Kalla, P., and Cseteneyi, L. (2014). Strength, abrasion and permeation characteristics of cement concrete containing discarded rubber fine aggregates. *Const. Buil. Mat.*, 59, 204–212.

23. Nigerian Industrial Standard (NIS) (2000). Standard for Sandcrete Blocks. Standards Organisation of Nigeria. Lagos, Nigeria.

24. Siddique, R. and Naik, T. (2004). Properties of concrete containing scrap-tire rubber – An overview. *Waste Managem.*, 24: 563-569.