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Original Research Article

Assessing the Impact of Cassava Starch on the Structural Properties of Sandcete Blocks Produced from Recycled Paper

Agbi, G.G.[1*] and Uguru, H.[2]
[1]Department of Civil Engineering, Delta State University, Oleh Campus, Nigeria
[2]Department of Agricultural and Bio-Environmental Engineering Technology, Delta State Polytechnic, Ozoro, Nigeria

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***Corresponding author:** Agbi, G.G.

Abstract

Environmental pollution caused by conventional building material, had given borth to treh quest for green technology. This work evaluated the impact of cassava starch on some structural properties of sandcrete blocks produced from recycling paper. The sandcrete blocks were produced by replacement of river bed sand (sharp sand) with waste paper, at the rate of 10%, 20%, 30%, 40%, 50% and 60% partial replacement; while the 1% of the cement was replaced with cassava starch powder. All the sandcrete blocks were produced at a fine aggregate to cement mix ratio of 6:1. The compressive strength, bulk density and water absorption rate of the blocks produced were dome at 28th curing day. Results obtained from the compressive strength test depicted that, regardless of the paper pulp volume, the blocks produced with cassava starch had higher compressive strength, compared to the blocks produced without cassava starch. At curing day 28, the blocks produced 10% and 20% paper pulp and cassava starch, developed compressive strengths of 2.65 N/mm^2 and 2.32 N/mm^2, respectively. In terms of the bocks bulk density, the result portrayed that the weight of the blocks produced with paper pulp were lighter, when compared with the control unit. It was also revealed by the results that the block containing cassava starch power had lower water abortion rate, compared to block produced without cassava starch. This study results had shown that using cassava starch as admixture, paper pulp can be used to produce sandcrete blocks for building walls of a framed structure at a little quantity (1% - 20% partial replacement).

Keywords: Building materials, compressive strength, framed structure, recycling, waste paper.

INTRODUCTION

The abundance of discarded organic (biodegradable) papers in the Nigeria requires their alternate, sustainable and economic use, to prevent environmental degradation and health hazard [1]. According to Atikpo [2] ignorance of turning solid waste into wealth, through recycling had led to creation of illegal dumpsites; hence, making solid waste management to remain a severe task to the government authority [3]. Poor waste management can lead to heavy metals contamination of the environment, through the leachates produced by these solid wastes that flow into the environment [4]. Solid waste recycling management option is a fundamental factor in turning waste-to-wealth, which further leads to a sustainable environment [2, 5]. Solid waste recycling involves fragmentation and modification the waste into a fresh product which has some potential economic values [6, 7, 8]. Mini (household) waste recycling operation will helps to reduce the volume of waste discarded by these households, hence acting a major solution to environmental cleanup and sustainable wealth creation alternative [1].

The continuous utilization of non-renewable materials by the construction industry had become a major threat the existence of these materials; while some of these materials had drastic effect on the environment, hence are contributing to the climate change effect [9, 10, 11]. Recently, the price of construction materials is increasing at geometric sequence rate, therefore attention is now been paid to traditional and sustainable construction materials [12, 13, 14]. These sustainable materials include recycled materials, including “papercrete” [15, 16.] Waste paper had been identified as a major component of solid waste, and its usefulness through recycling into several news products is under evaluation, especially in the construction industry [13]. Wallbaum [9] states that the

application of waste paper as a construction material, will not only help to reduce environmental pollution, but also helps to alleviate the existing pressure on non-renewable materials used by construction industry. Globally paper is in abundance, since over 450 million tons of paper is produced annually, and a large percentage of this is discarded annually [1, 17].

Several authours [1, 13, 14] had evaluated the potential of the partial replacement of sand with recycled or renewable materials, to achieve a sustainable product. But there is no recorded literature on the use of cassava starch as admixture, in sandcrete blocks produced with partial replacement of sharp sand with recycled waste paper. Therefore, the objective of this study is to evaluate the mechanical properties of sandcrete blocks produced with waste paper, and the sustainability of using cassava starch as admixture. Results obtained from this study will be useful in utilization waste paper as a sustainable material in building walls construction.

MATERIALS AND METHODS

Materials

Sharp sand

The sharp sand was procured from local divers collecting sand from the river bed of River Ase in Delta State, Nigeria.

Ordinary Portland Cement (OPC)

Dangote cement brand, with a standard cement grade of 42.5 was used for the sandcrete block production.

Waste paper

The waste paper was obtained from various sources, mostly within the university environment.

Cassava starch

The cassava starch powder was procured the local market at Ozoro, Delta State of Nigeria

Methods

Paper pulp production

The waste papers were shredding and submerged in water for three days, after which the pulp was extracted by filtration method.

Mixing method

The mechanically mixing method was used for the production of the sandcrete block. The cement and sand were batched in the ratio of 1:6 and mixed thoroughly until uniform color and consistency appeared.

Sandcrete block production

For the purpose of this study, volumetric batching method was adopted. Also cement to fine aggregate ratio of 1:6. The sandcrete blocks were produced by replacement of sharp sand with waste paper, at the rate of 0%, 10%, 20%, 30%, 40%, 50% and 60% partial replacement. 0% partial replacement was taken as the control experiment. Two major set of sandcrete blocks were produced.

One set was produced with only partial replacement of the sharp sand with waste paper pulp; while the other set of sandcrete blocks was produced with partial replacement of the sharp sand with waste paper pulp and also partial replacement of the cement with 1% (by weight) by cassava starch powder. The first set of sandcrete blocks were tagged “Paper pulp”; while the second set of sandcrete blocks were tagged “Paper pulp + Starch”.

America Standard Testing Material (ASTM) International mould size (100 x100 x 100 mm^3) was used for the sandcrete blocks production. During the sandcrete block production, the mixed constituents were poured into the mould, rammed for 36 times, leveled with a flat stainless steel trowel, removed from the mould and left to cure under a shady environment, as described by Akpokodje [10]. The sandcrete blocks were cured through irrigation method, and their compressive strength, bulk density and water adsorption capacity were tested after 28 days.

Engineering properties determination

The compressive strength of the sandcrete block was measured in accordance with America Standard Testing Materials (ASTM) International procedures. Concrete Compression Testing Machine (model: STYE 2000) was used for the compression testing. The compressive strength, bulk density and water absorption rate of the sandcrete blocks were evaluated from equations 1, 2 and 3 [1, 21].

$$\text{Compressive strength} = \frac{\text{Crushing force}}{\text{Net cross sectional area of sandcrete block}} \quad (1)$$

$$\text{Bulk Density} = \frac{\text{Mass}}{\text{Volume}} \quad (2)$$

$$\text{Water absorption} = \frac{M_a - M_b}{M_b} \times 100 \quad (3)$$

Where:

M_a = Weight of sandcrete block after soaking in water,

M_b = Weight of sandcrete block before soaking in water [10].

RESULTS AND DISCUSSION

The compressive strengths of the sandcrete blocks are shown in Figure 1. As shown in Figure 1, the compressive strength of the sandcrete blocks produced with partial replacement of the cement, with cassava starch was higher than the compressive strength of the sandcrete blocks produced with only cement. This could be attributed to the admixture nature of the cassava starch. Starch has the properties of organic admixture; hence it enhances the compressive strength and durability concrete and sandcrete blocks [11, 19]. Furthermore, it was observed from the results (Figure 1) that at curing day 28, the compressive strength of the sandcrete blocks declined with an increased in the paper pulp volume. This could be attributed to the poor compressive strength of the paper pulp. As revealed by the results, regardless of the paper pulp volume used, the sandcrete block produced with the addition of cassava starch power, had higher compressive strength compared to the sandcrete blocks produced with only cement. This further affirmed the admixture properties of cassava starch, as earlier stated by [19, 27]. Akindahunsi [19] observed that the compressive strength of concrete containing 1% (weight of cement) of cassava starch was 61.43 N/mm^2, which was higher than the 58.53 N/mm^2 obtained for the concrete produced without cassava starch.

The compressive strength results of the paper pulp reinforced sandcrete blocks, obtained in this study are in conformity with previous findings [1, 13]. Atikpo [1] reported that the compressive strength of sandcrete block produced with 10% of paper pulp volume was 1.81 N/mm^2, while Atikpo [13] reported that the compressive strength of sandcrete block produced with 10% of paper pulp volume was 1.78 N/mm^2. The differences in the results obtained (compared to previous authors) could be attributed to the geotechnical properties of the fine aggregate (sand) used and the mixing/moulding methods adopted by the various researchers, and the admixture added. Agbi [11] states that the specific gravity, moisture content and particle grading of the fine aggregate used for the production of sandcrete blocks generally influenced their compressive strength. The sandcrete blocks produced with lower volume (10% and 20%) of paper pulp and cassava starch, had relative high compressive strength (2. 65 N/mm^2 and 2.32 N/mm^2) at curing day 28, and the values were within the minimum compressive strength of 2.5N/mm^2 recommended by Standard Organisation of Nigeria (SON) for sandcrete blocks to be used for building wall construction (NIS 87:2000) [20]. This study depicted that waste paper than be used as a substitute for fine aggregate, if organic admixture is used for the sandcrete production.

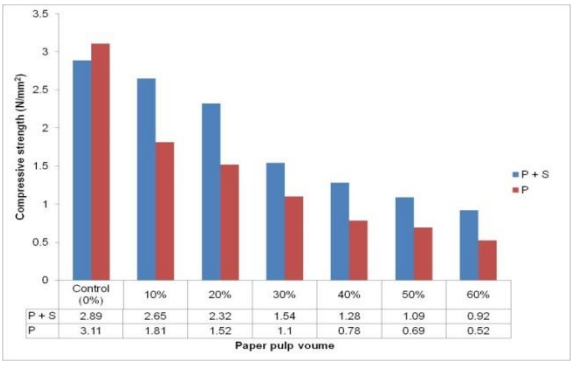

Fig-1: Compressive strength of the sandcrete blocks

Bulk density

The results of the bulk densities of the sandcrete blocks produced from the paper pulp and cassava starch are presented in Figure 2. As shown in Figure 2, the density of the sandcrete blocks decreased with increased in the paper pulp volume. Regardless of the paper volume, the results revealed that the density of the blocks produced with the combination of cement and cassava starch was relatively higher, compared to the blocks produced with only cement. At curing day 28, control blocks (produced with cement and cassava starch) had the highest density of 1868 kg/m^3; while the sandcrete block containing 60% paper pulp, and produced with only cement had the lowest density of 1302 kg/m^3. Similar results were reported by Boob [22], when the density of blocks produced with partial replacement of sand with sawdust decreased from 2400 kg/m^3 to 1800 kg/m^3, as the sawdust volume increased from 0% to 20%.

The higher densities observed in sandcrete blocks produced with cassava starch, could be ascribed to the higher compaction level experienced by the sandcrete blocks during production. According to Okafor [21] starch solution had the ability of increasing the compaction of concrete during production, hence increasing the concrete density. Results obtained by [11] buttressed the findings of this study, as the density of concrete blocks produced with fresh cassava water, was higher than the density of the control blocks at curing day 28.

As seen in the results, the sandcrete blocks produced with 30% paper pulp volume, either with only cement or with cassava starch power and cement, met the British Standard (BS) of maximum density of 1500 kg/m^3 for load bearing walls [23, 24]. Although the sandcrete blocks produced with higher percentage (30% and above) and cassava starch had lower compressive strengths, their lower densities is an advantage, as they can be used to build partitions walls in framed structures.

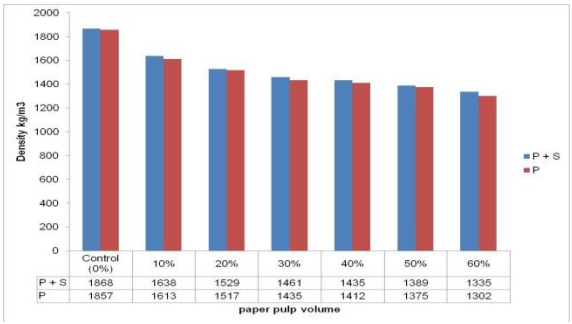

Fig-2: Bulk Densities of the sandcrete blocks

Water absorption rate

The results of the water absorption rate of the paper pulp reinforced sandcrete blocks are presented in Figure 3. As depicted by the results, the sandcrete blocks produced with cassava starch had a lower water sorption rate, when compared to the blocks produced with only cement. This could be attributed to soil particle binding effect of the cassava starch solution, which will prevent the sand and paper pulp from water absorption. Cassava starch solution tends decreased the void ratio with the sandcrete blocks, and formed impermeable coating around the paper pulp, thus decreasing the ability of the sandcrete block to absorb moisture from the surrounding [25].

As revealed by the results, an increased in the paper pulp volume generally led to increase in the water absorption rate of the sandcrete block. At 10% paper pulp volume, the sandcrete block produced with cement and cassava starch, had water absorption rate of 13.9%, which then increased to 36.5% at 60% paper pulp volume. This conforms with previous work [26] which states that the volume of paper in a sandcrete block is directly proportional to its water absorption rate, but inversely proportional to its compressive strength. The water absorption rates recorded for all the paper pulp volumes, used in this study were above the maximum allowable limit of 12%, specified by the Nigerian Industrial Standard (NIS 87, 2000) [20]. This implied that the sandcrete blocks produced with paper pulp cannot be used in areas exposed to high humidity or moisture levels. Blocks which are susceptible to high moisture content, usually experienced high level of swelling at high moisture level, and shrinkage at low moisture content, therefore leading to cracking of the building walls with time [14, 22].

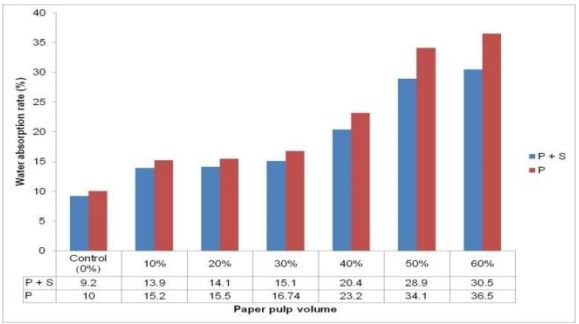

Fig-3: Water absorption rates of the sandcrete blocks

CONCLUSION

The creation of wealth from waste materials, through their effective recycling, had become a tread in the society. This study was carried out to determine the potential of using waste paper in producing sandcrete blocks that can meet NIS standard. Two sets of sandcrete blocks were produced from waste paper pulp. 1% of organic admixture (cassava starch) was used as partial replacement for one set; while the other set was produced with only cement, without adding any admixture. Both sandcrete sets were produced by partial replacement of sharp sand with waste paper pulp, at the rate of 0%, 10%, 20%, 30%, 40%, 50% and 60%. The results of the compressive test revealed that, the sandcrete blocks produced with cassava starch had higher strength than those produced without cassava starch. The results showed that the sandcrete blocks produced from 10% partial replacement of sand and cassava starch, can used for the wall construction in framed buildings. In terms of the bulk density, the results revealed that sandcrete blocks produced with paper pulp exhibited lower density, compared to the blocks produced from paper pulp and cassava starch. sandcrete blocks produced with 20% and 30% water pulp and cassava starch can used to build partition wall of framed structures due to their lightweight. Additionally, the study revealed that water absorption rate of the blocks increased, with an increased in the paper pulp volume. Regardless of the cassava starch added, the water absorption rates of the blocks were 12% specified by NIS. This made the blocks produced from the paper pulp not suitable wall constructions in areas exposed to high moisture level.

REFERENCES

1. Atikpo, E. & Ukala, D.C. (2018), Performance evaluation of building blocks produced from recycled waste paper. Journal of the Nigerian Association of Mathematical Physics, 46:395-398
2. Atikpo, E., Osarenmwinda, J.O. & Ariavie, O.J. (2009). Characterization of solid waste in Okada town of Edo State in Nigeria. J. Civi. Envi, Syst. Eng., 10 (2): 45-57.
3. Awomeso J. A., Taiwo A. M.., Gbedebo A. M. & Arimoro A. A. (2010). Waste disposal and pollution management in Urban areas: A workable remedy for the environment in developing countries. Am. J. Environ. Sci., (6): 26-32.
4. Ogbaran, A. N. & Uguru, H. (2021). Evaluating the contamination degree and risk assessment of heavy metals around active dumpsite environment: A case study of Ozoro community, Delta State, Nigeria. Physical Science International Journal. 25(1): 39-51,
5. Orebiyi E. O., Awomeso J. A., Idowu O.A., Martins, O., Ountoke A. & Taiwo A. M. (2010). Assessment of pollution hazards in Shallow well water in Abeokuta and environs, South West Nigeria. Am. J. environ. Sci., 6: 50-56.

6. Martin, M. (2010). Solid wastes, poverty and the environment in developing country cities: Challenges and opportunities, WIDER Working Paper, No. 2010/23, ISBN 978-92-9230-258-0, The United Nations University World Institute for Development Economics Research (UNU-WIDER), Helsinki
7. Bugayan S. A. (2015). Disposal of Solid Waste: Foreign and Domestic Experience Science and Education: Agriculture and Economics: Entrepreneurship: Law and Governance, Rostovon-Don, 7 (62): 27-31.
8. Owamah, H.I., Izinyon, O.C. & Igbinewekan, P. (2015). Characterization and quantification of solid waste generation in Niger Delta Region of Nigeria: a Case Study of Ogbe – Ijoh community in Delta State, Journal of Material Cycles and Waste Management. 19(1): 1-11
9. Wallbaum, H. & Buerkin, C. (2003). Concepts and instruments for a sustainable construction sector. Indust. Environ., 26, 53-57.
10. Akpokodje, O.I. & Uguru, H. (2019). Effect of fermented cassava waste water as admixture on some physic-mechanical properties of solid sandcrete blocks. International Journal of Engineering Trends and Technology (IJETT), 67(10): 216 – 222
11. Agbi, G. G., Akpokodje, O. I. & Uguru, H. (2020). Compressive strength of commercially produced sandcrete blocks within Isoko Metropolis of Delta State, Nigeria. Turkish Journal of Agricultural Engineering Research (TURKAGER), 1(1): 91-103.
12. Akinwumi, I.I. (2014), Earth building construction processes in Benin City, Nigeria and engineering classification of materials used. Indi. J. Tradi. Kno., 13 (4): 23-31.
13. Atikpo, E., Ukala, D. C., Iwemah, E. R. & Agori, J. E. (2018), Construction feasibility of papercrete blocks produced from recycled abandoned papers. The Journal of the Nigerian Institute of Production Engineers. 322-330.
14. Akpokodje, O. I, Uguru, H. &Esegbuyota, D. (2019). Study of flexural strength and flexural modulus of reinforced concrete beams with raffia palm fibers. World J. Civ. Engin. Constr. Techn., 3(1): 057-064
15. Seyfang, G. (2010). Community action for sustainable housing: building a low-carbon future, Ener. Pol. 38: 7624-7633.
16. Subramani, T. & Shanmugam, G. (2015), Experimental investigation of using papercrete and recycled aggregate as a coarse aggregate. International J. Applica. Innova. Engi. Manag., 4 (5): 233-332.
17. Ali, A., Hashmi, H.N. & Baig, N. (2013), Treatment of the paper mill effluent – A review, Annals of Faculty Engineering Hunedoara, Intern. J. Engin., 11(3): 337-340.
18. Akpokodje, O. I. Agbi, G. G., Uguru, H. & Nyorere, O. (2021). Evaluation of the compressive strength of commercial sandcrete blocks produced in two metropolises of Delta State, Nigeria. Applied Journal of Physical Science Volume. 3(2): 61-71,
19. Akindahunsi, A.A. & Uzoegbo, H.C. (2015). Strength and durability properties of concrete with starch admixture. International Journal of Concrete Structures and Materials. 9(3): 323–335
20. NIS 2000. NIS 87:2000. Nigerian Industrial Standard: Standard for Sandcrete blocks. Standard Organisation of Nigeria, Lagos, Nigeria
21. Okafor, F.O. (2010). The performance of cassava flour as a water-reducing admixture for concrete. Nigerian Journal of Technology, 29 (2): 106-112.
22. Boob, T.N. (2014). Performance of saw-dust in low cost sandcrete blocks. American Journal of Engineering Research. 3(4):197-206.
23. British Standards Institute ~BSI (1975). ‘‘Precast concrete blocks.’’ BS 2028, London
24. Baiden, B.K. & Tuuli, M. M. (2004). Impact of quality control practices in sandcrete blocks production. Journal of Architectural Engineering 10(2): 53 – 600
25. Akpokodje, O.I., Uguru, H. & Esegbuyota, D. (2018). Remediation of cassava effluent contaminated soil using organic soap solution: Case study of soil physical properties and plant growth performance. Journal of Scientific Research & Reports. 21(3): 1-11.
26. Subramani, T. & Ravi, G. (2015). Experimental investigation of coarse aggregate with steel slag in concrete. IOSR Journal of Engineering, 5(5): 64-67.
27. Akpokodje, O.I., Agbi, G.G, and Uguru, H. (2020). Evaluation of cassava effluent as organic admixture in concrete production for farm structures. Turkish Journal of Agricultural Engineering Research (TURKAGER), 1(2):271-282. https://doi.org/10.46592/turkager.2020.v01i02.005.