International Journal of Innovative Scientific & Engineering Technologies Research 9(2):16-22, April-June, 2021

© SEAHI PUBLICATIONS, 2021 www.seahipaj.org ISSN: 2360-896X

Suitability of Sawdust as Partial Replacement for Fine Aggregate in Concrete Production

Agbi, G. G.

Department of Civil Engineering,
Delta State University, Oleh Campus, Nigeria
engr.agbi@gmail.com; https://orcid.org/0000-0002-3556-5699

ABSTRACT

Production of green concrete had become a major research area, due to the environmental hazards caused by synthetic materials. This research was carried out to determine the suitability of using sawdust in concrete production. The concrete was produced at the mix ratio of 1:2:4; and water to cement ratio of 0.6. But the sand volume was partially replaced with sawdust at the volume of 0%, 2.5%, 7.5%, 10% and 12.5%. Two sets of concrete were produced; one set was incorporated with cassava starch (1% of the cement weight), while the other set was produced without cassava starch. The concrete were produced and tested in accordance with ASTM International approved procedures. Results obtained from the compressive strength test revealed that, the compressive strength of the concrete decreased continuously, as the sawdust volume increases. However, it was observed that the cassava starch improved the compressive strength of the concrete. As curing day 28, the concrete produced without cassava starch decreased from 27.1 MPa to 9.4 MPa, as the sawdust volume increased from 0% to 12.5%; while the concrete produced with cassava starch decreased from 29.5 MPa to 13.6 MPa, as the sawdust volume increased from 0% to 12.5%. With respect to the concrete density, the results revealed that the concrete produced without cassava starch had lower density than the concrete produced with cassava starch. The study revealed that the density of the concrete produced without cassava starch decreased from 2393 kg/m^3 to 1321 kg/m^3, as the sawdust volume increased from 0% to 12.5%. While the density of the concrete produced with cassava starch decreased from 2485 kg/m^3 to 1532 kg/m^3, as the sawdust volume increased from 0% to 12.5%. These results depicted that the utilization of sawdust in lower volume (less than 8%) and 1% cassava starch can be used as partial replacement for sand during concrete production; hence contributing to the waste (sawdust) management in the society.

Keywords: Cassava starch, compressive strength, fine aggregate, green concrete, sawdust.

INTRODUCTION

Concrete is a composite material, which is produced from the mixture of water, fine aggregate, coarse aggregate and cement, that are mixed in a definite ratio. The cement acts as a binder that binds all the fine and coarse aggregates together, hence forming one solid mass (Ganiron, 2014; Akpokodje and Akpituren, 2020). Concrete is an essential construction material, due to its ease of workability and good compressive properties; although its tensile and flexural properties are very poor. According to Ravikumar *et al*. (2015), mechanical properties of concrete can be enhanced through the addition of reinforcement materials and admixtures. Agricultural (organic) materials are usually used to replace synthetic materials, during the production of green concrete. Within the past two decades there has been intensive campaign for green concrete, due to the climate change and environmental issues of synthetic materials. Applications of these green concretes are widely acceptable in several constructional works, due to their environmental friendliness, light weight, cost effectiveness, and their appreciable structural properties (Uguru and Uyeri, 2018).

Availability of agricultural materials is widespread in the rural areas where they are produced; and proper disposal of their waste products often become a problem. Several researches had incorporated natural materials in the production of hybridized green concretes. Agbi and Uguru (2021) reported that the compressive strength of sandcete blocks made from recycled paper was increased, by the addition of cassava starch solution as organic admixture. Similarly, Akpokodje *et al*. (2020) observed that concrete produced with fresh cassava effluent developed higher compressive strength (29.57 MPa), compared to the concrete produced with fresh water that developed compressive strength of 27.18 MPa at curing day 56. Furthermore, Akpokodje and Uguru (2019) produced sandcrete blocks from cassava wastewater, and reported that the cassava wastewater had positive significant ($p \leq 0.05$) effect on the compressive strength and water absorption rate of the solid sandcrete blocks produced. According to Akpokodje and Uguru (2019), sandcrete blocks made from the cassava wastewater developed a compressive strength of 3.38 MPa at curing day 28; whereas, the sandcrete blocks produced with fresh water developed compressive strength of 2.04 MPa at curing day 28.

According to Akpokodje *et al.* (2019), although the incorporation of raffia palm fibre into concrete lower its flexural strength; its lower density and higher ductility made it good building materials, especially in areas that are not exposed to high moisture levels. Ali *et al*. (2012) reinforced concrete with coir fibre, and observed a declined in the reinforced concrete's static modulus of elasticity as the fibre volume increases. Aho and Ndububa (2015) investigated the impact of raffia palm fruit peel fibres on the mechanical properties of concrete; and observed that the concrete compressive strength decreased non-linearly, as the fibre volume increases. But in contrast, the flexural strength of the increases with increased in the raffia palm fruit peel fibre; although, the flexural strengths were lower than the unreinforced concrete.

Sawdust which is a wood fine particle is a by-product of wood. It is used as sourced of fuel (charcoal briquettes) due to its flammability. Investigations into the partial or total replacement of fine aggregate with sawdust, during sandcrete of concrete production are ongoing. Oyedepo *et al*. (2014) investigated the influence of sawdust on the compressive properties of concrete, and reported that the compressive strength of the concrete decreases as the sawdust volume increased from 25% to 100%. The concrete produced with 25%, 75% and 100% sawdust as partial replacement for sand developed compressive strength of 14.15 N/mm^2, 12.96 N/mm^2 and 11.93 N/mm^2, respectively. Likewise, Nurul *et al.* (2019) studied the effectiveness of using sawdust as partial replacement for riverbed sand in concrete production. They reported that the compressive strength of the concrete declined from 57.69 15 N/mm^2 to 34.7 15 N/mm^2, as the sawdust volume increased from 0% to 15%. Although several literatures have been reported on the utilization of sawdust as partial or total replacement for fine aggregate in concrete production; there is no recorded literature on the application of cassava starch as admixture, during the production of concrete from sawdust. Hence, this study used cassava starch as admixture to balance the knowledge gap with previous researches.

MATERIALS AND METHODS

Materials

Cement: Ordinary Portland cement, with grade 42.5 was used for the concrete production.

Water: Borehole water was used for the concrete production.

Fine aggregate: The riverbed sand (fine aggregate) used for the concrete production was obtained from Ase River in Delta State, Nigeria.

Coarse aggregate: 20 mm crushed granite was used for the concrete production

Sawdust: The sawdust was obtained from a local sawmill in Delta State, Nigeria.

Cassava starch: The cassava starch was procured from a local market in Delta State, Nigeria.

Method

Particle size grading: The sieves analysis of the fine aggregates was determined in compliance with ASTM International (ASTM C136 / C136M – 19) procedures.

Mix ratio: A volumetric concrete mix ratio of 1:2:4 (cement: fine aggregate: coarse aggregate) and water to cement ratio of 0.6 were adopted for the concrete production. During the course of the concrete production, the sand was replaced with 0%, 2.5%, 7.5%, 10% and 12.5% of sawdust.

Concrete Preparation: Two sets of concrete were produced during the course of this study; one set was incorporated with cassava starch (1% of the cement weight), while the other set was produced without cassava starch. The constituent materials (cassava starch, sand, gravel, cement and water) were thoroughly mixed by using the mechanical mixing method. The cassava starch was dissolved in appropriate amount water (water –to – cement ratio), to be used for the concrete production to form a starch solution. After obtaining a near homogenous material, the freshly mixed concrete was filled into a standard mould (150 mm x 150m x 150 mm), in three layers. Each layer was then rammed thirty five times. Then the cast concrete cubes were covered and left under a shady for 24 hours, before they were removed from the moulds. All the concrete cubes produced were cured by total immersion in water.

Compressive strength test: The concrete cube compressive strength was determined in accordance with ASTM C109 / C109M (2020) procedure, by using the concrete Compression Testing Machine (Model: STYE 2000), manufactured in China. Then the concrete compressive strength of each cube was calculated from the expression presented in Equation 1 (Akpokodje *et al*., 2021).

$$Compressive\ strength = \frac{Crushing\ force}{Effective\ surface\ area\ of\ cube} \quad (1)$$

Density determination: The concrete cube was weighed at curing day 28, by using an electronic weighing, having accuracy of 0.01. In addition, the three principal dimensions of the concrete cube were measured by using a digital vernier caliper, having accuracy of 0.01 mm. Then the density of concrete cube was calculated from the expression presented in Equation 2 (Esegbuyota *et al*., 2019).

RESULTS AND DISCUSSION

Particle size grading

Result obtained from the particle size distribution of the sand used for the concrete production is presented in Figure 1. The result revealed that the sand was well graded and met the NIS 87:2000 recommended. ASTM D2487-11 state that if sand had uniformity coefficient (Cu) greater than 6 (Cu >6), and fines particles less than 5% (fines < 5%), the soil is considered well Graded, and preferable for concrete production (USCS, 2015; Akpokodje *et al*., 2021).

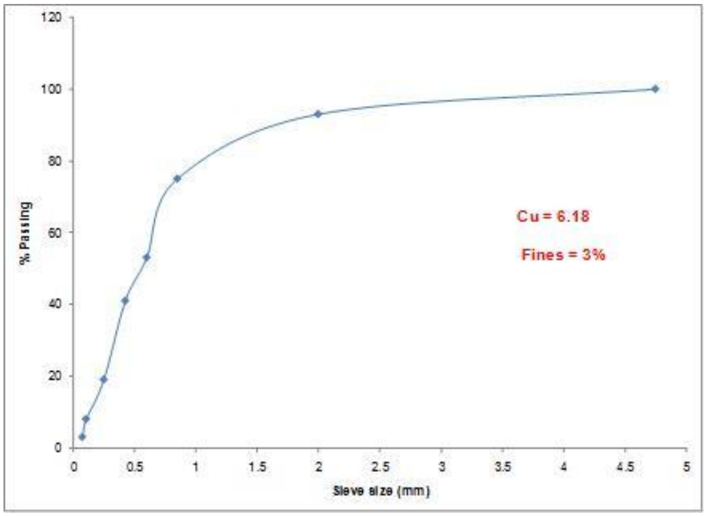

Figure 1: Particle size distribution curve and coefficient of uniformity value for fine aggregate used for the concrete production (Cu = 3; Fines = 6.18).

Compressive strength

The results of the compressive strength of the concrete cubes are presented in Figure 2. As shown in Figure 2, the starch solution influenced the compressive strength of the concrete. It was observed from the results that, the sawdust had a negative effect on the compressive strength of the concrete produced. At the 28th curing day, the compressive strength of the concrete declined non-linearly, as the sawdust volume increased from 0% to 12.5%. The results revealed that the compressive strength on the concrete decreased from 27.1 MPa to 9.4 MPa, as the sawdust volume increased from 0% to 12.5%. Similar results were obtained Ganiron (2014), when a declined in the compressive strength of concrete was observed, after the partial replacement of the fine aggregate with sawdust. Furthermore, the results revealed that the as the sawdust volume increased from 0% to 5%, the compressive strength declined by 38%; while as the sawdust volume increased from 0% to 5%, the compressive strength declined by 62%. The poor compressive strength witnessed as the sawdust volume increased from 5% to 12.5%, could be attributed to the poor bonding between the cement matrix and the sawdust filler; hence, creating maximum voids and weak interfacial adhesion in the process (Oghenerukewve and Uguru, 2018).

It was also observed from the results (Figure 2) that, the compressive strength of the concrete produced with cassava starch, was higher than the compressive strength of the concrete produced without cassava starch, regardless of the sawdust volume. This portrayed that cassava starch has the ability of enhancing the compressive strength of concrete. Similarly assertion was previously made by Akpokodje *et al.* (2020) and Akindahunsi and Uzoegbo (2015). According to Akindahunsi and Uzoegbo (2015), the compressive stregnt of concrete produced with 1% of cassava starch was 1.5% higher than the control concrete blocks. While Akpokodje *et al.* (2020) stated that cassava starch delayed the setting time of concrete produced from it; hence enhancing the concrete compressive strength as it ages. This study results had revealed that concrete produced with smaller sawdust volume (7.5%) and 1% cassava starch as admixture, met the minimum permissible of 17 MPa recommended for light weight concrete (Oyedepo *et al*., 2014); which are not exposed to harsh (e.g. high moisture levels) conditions.

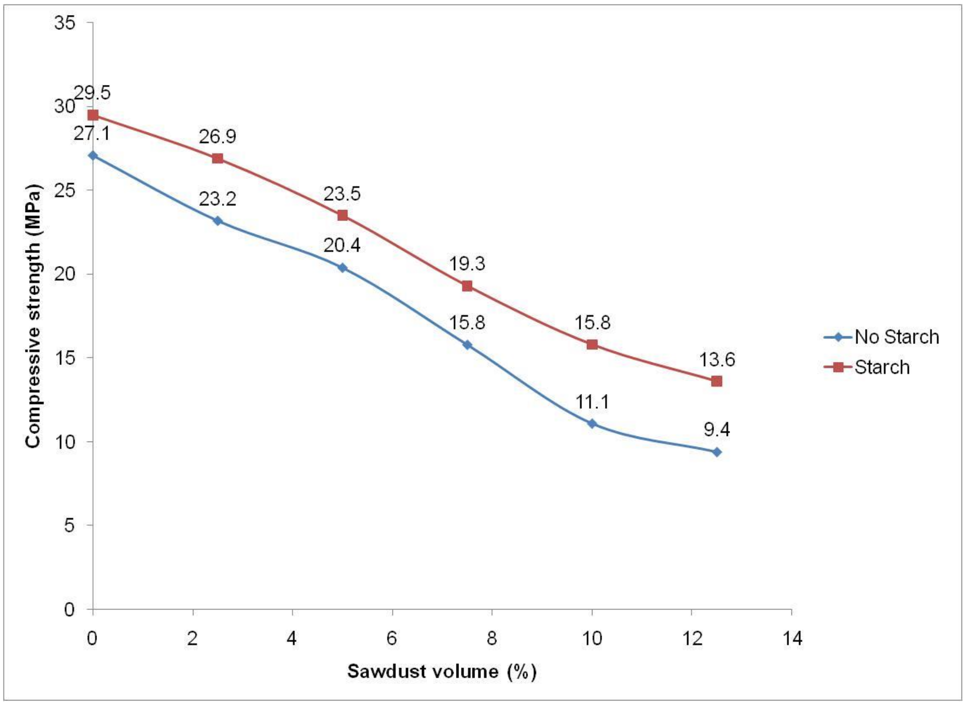

Figure 2: The compressive strength of the concrete at curing day 28

Density

The results of the concrete density are shown in Figure 3. As presented in Figure 3, the concrete density decreases with increased in the volume of the sawdust replacement, irrespective of the starch admixture added. The density of the concrete produced without cassava starch declined from 2393 kg/m^3 to 1321 kg/m^3, as the sawdust volume increased from 0% to 12.5%. Likewise, the density of the concrete produced with cassava starch declined from 2485 kg/m^3 to 1523 kg/m^3, as the sawdust volume increased from 0% to 12.5%. These results are similar to the previous results of Boob (2014), who reported that the density of sandcrete blocks produced with sawdust as partial replacement for sand, decreased from 2400 kg/m^3 to 1800 kg/m^3, as the sawdust volume increase from 0% to 20%.

Regardless of the sawdust volume, it was observed from the result that the concrete produced with starch solution had higher density than the concrete produced without cassava starch solution. This portrayed that the cassava starch increases the density of the concrete cubes. This trend is similar to results obtained by previous researchers (Okafor, 2010; Abd *et al.*, 2016), who observed that the density of concrete generally increases with the addition of cassava starch into the concrete. This is because the cassava starch aids better compaction of the concrete; hence, increasing the concrete bulk density.

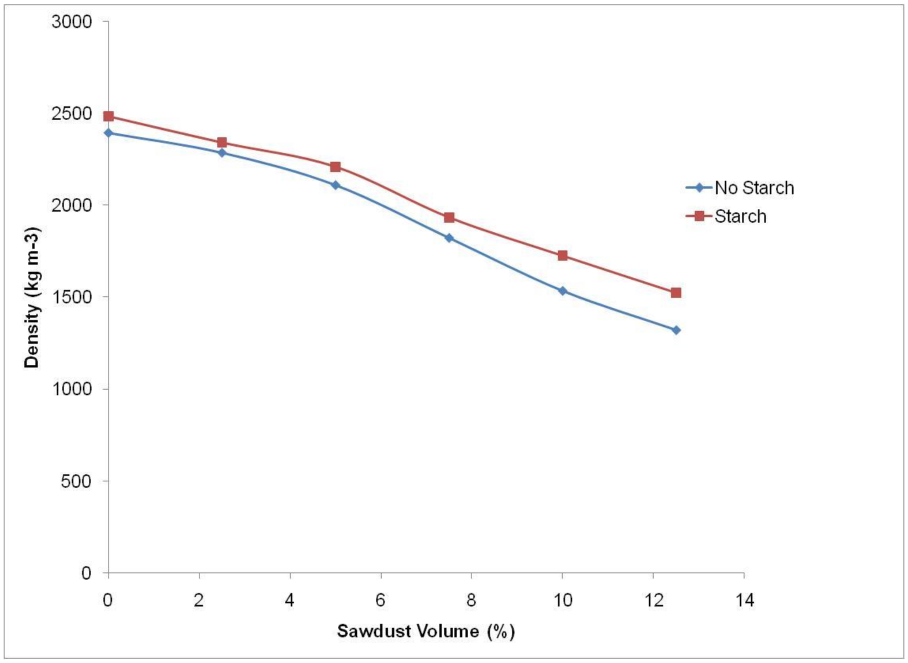

Figure 3: The concrete density at curing day 28

CONCLUSION

This research was carried out to evaluate the possibility of using sawdust as partial replacement of sand, in concrete production. Concrete cubes were produced with the partial replacement of sand, with sawdust at the rate of with 0%, 2.5%, 7.5%, 10% and 12.5% of sawdust. Regardless of the sawdust volume, two sets of the concrete were produced: one set was produced with cassava starch (1% of the cement weight); while the other set was produced without cassava starch. Both concrete sets were subjected to compressive strength tests, after 28 curing days. Results obtained from the compressive strength test revealed that, the sawdust decreased the compressive strength of the concrete. The compressive strength of the concrete decreased by 65%, as the sawdust volume increased from 0% to 12.5%. However, the addition of the cassava starch to the concrete enhances its compressive strength, as it does not only increase the concrete compressive strength, but prevent strength lost in the concrete as the sawdust volume increased from 0% to 12.5%. The results revealed that only 54% compressive strength of the concrete was lost, as the sawdust volume increased from 0% to 12.5%. In terms of the concrete density, the results depicted that the concrete density declined continuously, as the sawdust volume increased from 0% to 12.5%. However, it was observed that the concrete produced with cassava starch developed higher density, than the concrete produced without cassava starch. This study had revealed that smaller volume of sawdust (less than 8%) can be used as partial replacement for sand during concrete production, provided 1% of cassava starch can be added as admixture.

REFERENCES

Abd SM, Hamood QY, Khamees AS, Ali ZH (2016). Effect of using corn starch as concrete admixture. *International Journal of Engineering Research and Science and Technology.* 5(3): 35-44

Agbi GG, Uguru H. (2021). Assessing the impact of cassava starch on the structural properties of sandcete blocks produced from recycled paper. *Saudi J Eng Technol,* 6(5): 99-103.

Aho IO, Ndububa EE. (2015). Compressive and flexural strength of cement mortar stabilized with raffia palm fruit peel (RPEP). *Global Journal of Engineering Research,* 4: 1-7

Akindahunsi AA, Uzoegbo H, (2015). Strength and durability properties of concrete with starch admixture. *International Journal of Concrete Structures and Materials*. 9(3): 323–335

Akpokodje OI, 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

Akpokodje OI, 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.

Akpokodje OI, Agbi GG, 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

Akpokodje OI, Akpituren MB. (2020). Mechanical performance of cement composites reinforced with raffia palm fabric. *American Journal of Construction and Building Materials*. 4(1):1-7.

Akpokodje OI, Agbi GG, 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.* 3(2): 61-71

Ali M, Liu A, Sou H, Chouw N. (2012) Mechanical and dynamic properties of coconut fibre reinforced concrete. *Constr and Build Mater* 30: 814-825

ASTM C136 / C136M-19 (2019). Standard test method for sieve analysis of fine and coarse aggregates, ASTM International, West Conshohocken, PA. Available online at: https://www.astm.org/Standards/C136. Retrieved April, 2021.

ASTM C109 / C109M (2020). Standard test method for compressive strength of hydraulic cement mortars, ASTM International, West Conshohocken, PA. Available online at: https://www.astm.org/Standards/C109.htm. Retrieved April, 2021.

Esegbuyota D, Akpokodje OI, Uguru H. (2019). Physical characteristics and compressive strength of raffia fibre reinforced sandcrete blocks. *Direct Research Journal of Engineering and Information Technology*, 6(1):1-8

Ganiron TU. (2014). Effect of sawdust as fine aggregate in concrete mixture for building construction. *International Journal of Advanced Science and Technology*, 73-82.

Nurul HS, Amir AAR, Hazrina M, Anizahyati A, Norliyati MA (2019). Concrete using sawdust as partial replacement of sand: Is it strong and does not endanger health ? *MATEC Web of Conferences*, 258: 1-6

Oghenerukewve PO, Uguru H. (2018). Effect of fillers loading on the mechanical properties of hardwood sawdust/oil bean shell reinforced epoxy hybrid composites. *International Journal of Scientific Research in Science, Engineering and Technology*. 4(8): 620-626.

Okafor FO (2010). The performance of cassava flour as a water-reducing admixture for concrete. *Nigerian Journal of Technology*, 29 (2): 106-112.

Oyedepo OJ, Oluwajana SD, Akande SP. (2014). Investigation of properties of concrete using sawdust as partial replacement for sand. *Civil and Environmental Research*. 6(2):35-42

Ravikumar CS, Ramasamy V, Thandavamoorthy T S. (2015). Effect of fibers in concrete composites. *International Journal of Applied Engineering Research*, 10 (1): 419-429.

USCS (2015). Soil classification basics. http://faculty.uml.edu/ehajduk/Teaching/14.330/documents/14.330SoilClassification.pdf (February, 2020).

Uguru H, Uyeri C. (2018). Effect of vine section on the tensile properties of fluted pumpkin vine. *Direct Research Journal of Engineering and Information Technology*. 5(5): 10-16