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Strength Characteristics of Sawdust Ash Modified Concrete

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Abstract: *The search for more durable and stronger concrete has led researchers to discover pozzolanas in many aggro-wastes .This research is on sawdust. In Nigeria enormous quantity sawdust are generated yearly in sawmills these sawdust are normally discarded or burnt as a means of disposal. Though this method of disposal to a great extent prevents sawdust from causing serious environmental problems, there is need to recycle the waste to make it economically useful. This work, therefore, studied the possibility of using the ash obtained from burning sawdust as partial substitute for cement content in concrete production. Sawdust ash was added to concrete of grade 20(M20) by substituting the cement with various percentage of sawdust ash of 0%, 10%, 20% and 30% by weight of the original cement content. The resulting compressive strengths were recorded. The oxide compositions of the ash was also obtained through x-ray fluorescence spectrometer test. It was observed that at the later ages of the hydration of the concrete (21 days and 28 days curing periods) the compressive strengths reduced significantly in direct proportion to the added ash. This reduction was worst at 30% ash content, showing near absence of pozzolanic reaction. The oxide compositions showed very low content of SiO2, Al2O3 and Fe2O3 . However, the 28-days strength for 10% and 20% ash contents do not differ widely from the control mix, so sawdust disposal by substituting part of the cement content of concrete with 10 to 20% was then recommended.*

***KEYWORDS*:** *Sawdust, cement, concrete, substitution, disposal method, agro-waste, pozzolana*

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1. INTRODUCTION

The rain forest belt of Nigeria, in West African sub region, is a home to rare hardwoods. These forest are made up of extensive mangroves and guinea savanna zones. Trees are felled daily and transported to the central sawmills, where the logs are converted to different marketable timber sizes. During these chains of processing, a lot of sawdust are produced. Enormous quantity of sawdust are generated yearly in sawmills dotted all over the rain forest zones. The processed timbers are used for furniture, buildings, roofs, bridges, etc., while the resulting sawdust is normally discarded as waste, and burnt as a means of disposal.

The ash produced from the burning is relatively small compared to the sawdust that is burnt to produce it. In the burning of rice husk 20kg of rice husk fills a basket burner. After burning at a temperature of about 500 - 6000C, 4kg of ash is produced, about 18 % of the weight of the original rice husk feed into the burner (Allen, 2003). Sawdust is lighter in weight than rice husk. Unlike rice husk composed of inorganic compound (silica) to the tune 95% of its weight; sawdust is composed of long chain hydrocarbons which can easily convert to carbon dioxide with burning, so comparable weight of sawdust should give much lesser volume of ash This relatively small volume of sawdust ash produced after burning is easily carried away by rain water and infiltrate into the soils.

Though this method of disposal by burning does not allow the sawdust to cause serious

Environmental problems, it is still not a proper way of disposing this waste that is generated in enormous volumes as recycling is better. Agro-wastes have always been successfully recycled by using them in one way or the other in concrete production, examples are rice husk and empty-oil-palm-fruit-bunch (Oyetola and Abdullahi 2006; Hanizan, and Mohammed 2018). If in addition to serving as an economic filler material in concrete, the recycled waste is found to be a pozzolana, its usefulness is enhanced as it becomes a special additive or admixture in concrete, and can improve the long term strength and durability of concrete (Shetty, 2009; Jackson, 1981).

Pozzolanas are siliceous–aluminous materials which naturally do not possess cementitious property, but when finely ground and with calcium hydroxide and water present, react with calcium hydroxide to produce compounds which have cementitious property (Neville, 2011). Pozzolanas are often added to fresh concretes to extend the duration of hydration and strength of the binder, hence they are sometimes called cement extenders (Ajjay, 2019; Engineering News, 2015).

Cement extender are additives used to increase the yield of concrete. Pozolanic extenders does this by reacting with NaOH produced during hydration of cement in concrete to produce more calcium silicate hydrate than normal. This action results in concretes with better strength and durability (Building and Décor,2015;Adinna et al., 2019).

The hydration of concrete with part of its cement content substituted with pozzolana is relatively slow at early ages compared with normal concrete ,but quickly picks-up at later ages and even supersedes the normal concrete in strength, or the two strengths become equal or nearly equal. This can happen at the ages of 28, 30 or 90 days of water curing (Adinna and Ezewamma, 2006; Obodo, 2011) depending on the reactivity of the pozzolana.

Works done in this area as reviewed include Obilado (2014) who replaced cement partially with sawdust ash by weight from 0 to 30% in steps of 5% and carried out compacting factor test on the fresh concrete and compressive strength test on the hardened concrete, and discovered that both compacting factor and compressive strength decreased with increase in sawdust ash content. He ,however, recommended 0-15% replacement of cement with sawdust ash without reports on the pozzolanic index and oxide composition of sawdust ash. Aliu and Daramola (2013) Studied the optimal quantity of sawdust ash and rice husk ash that can be used to replace cement in concrete. They recommended replacements of 10 and 15%, respectively, for sawdust ash and rice husk ash. They produced the ashes by open burning. Omoloye and Olugbenga(2022) studied the impact of palm fruit bunch ash on unconfined compressive strength of an already cement-stabilized soil for road construction. They obtained increases in the optimum unconfined compressive strength of the already stabilized soil to an optimum content of 4% palm bunch ash, after which it decreased. This shows pozzolanic action of the palm bunch ash on the cement already present in the soil. Tasiu et al(2022) studied the effect of sesame straw ash as a substitute for cement on the strength of concrete and obtained increase in the strength of grade 20 concrete as sesame straw ash was added to the concrete from 0% to 25% in steps of 5%. They recommended an optimum of 10% sesame straw ash in structural concrete. This suggests pozzolanic reaction in the sesame straw modified concrete.

This work is aimed at investigating the possibility of using the ash obtained from burning saw dust as a partial substitute for cement in concrete production as a way of providing a better disposal method for the waste. In the process, the pozzolanic property of the sawdust was investigate through studying the hydration history of the concrete and oxide compositions of the ash ,and also by comparing the observation with those of some known pozzolanas. To achieve this aim, the main objectives of the study were to add sawdust ash to concrete of known mix proportion by substituting the cement content with sawdust ash at varying percentages of 0, 10, 20 and 30% and study the resulting concrete strength and the history of the hydration through tables as well as analyzing the oxide compositions of the ash.

This study is relevant in that the outcome of the study can provide an economically more viable solution to the disposal problem of sawdust. It will also result in production of more durable concrete, if saw dust ash is found to be pozzolanic.

II. MATERIALS AND METHODS

(i) Materials

The materials used include sawdust (collected from local sawmills), clean rivers sand of 3mm maximum size, granite course aggregate (12mm size), Portland limestone cement of designation CEM 42.5N, by the Nigerian Industrial Standard Organization (NIS, 2003) These were all purchased from local dealers

The sawdust was processed by burning it totally into white ash in a locally made incinerator at an approximate temperature range of 300-400^{0}C. The ash was further passed through a B.S sieve size of 45µm, to obtain fine particles for better exhibition of pozzolanic action.

(ii) Experiments

The equipment used were 150 x 150 x 150mm cube moulds, universal testing machine, curing tank, weighing balance and slump test equipment.

The cement, sand and gravels were weighed out in the ratio of 1:2:4, and thoroughly mixed on a nonabsorbent surface, before water was added (Water/cement ration of 0.55 was used) and final mixing was done. Slump test was conducted on the fresh concrete and 12 concrete cubes were cast to B.S 1881 standard (B.S 1881, 1970). The concretes were allowed to harden for 24 hours and was demoulded and cured under water for 28 days. Following this procedure 12 concrete cubes were cast as normal concrete (i.e. 0% sawdust ash content) and fresh concretes were variously prepared with cement contents substituted with 10, 20 and 30% sawdust ash, and 12 cubes prepared, respectively, making a total of 48 cubes to be tested for compressive strength. Three cubes from each of the four groups of sawdust ash contents (0,10,20, and 30%) were crushed variously at 7 days, 14 days, 21 days and 28 days water curing ages with the use of the universal testing machine and the average value of the strength results tabulated for analysis.

A sample of the sawdust ash was also tested in a separate laboratory (Research and Development Center, Defense Industries Corporation, Kaduna state Nigeria) for oxide compositions using X-ray Fluorescence Spectrometer (XRF).

III. RESULT AND DISCUSSION

(i) Results

The result of concrete strength tests for each of the group of 12 concrete cube specimens of the various sawdust ash contents are presented in Table 1.0.

Table 1.0: slump values and compressive of concrete of various sawdust ash contents

Sample and Designation	Sawdust Ash Content (%)	Slump Value (mm)	Average Compressive Strength N/mm^2			
			7 days	14 days	21 days	28 days
1 (control)	0	80	20.05	22.77	24.71	26.28
2	10	65	19.30	21.02	23.94	24.80
3	20	60	17.87	19.37	20.62	22.60
4	30	55	19.78	13.34	16.40	17.59

Table2.0: Oxide Composition (mole %) of Sawdust Ash (From XRF test)

SiO_2	SO_3	P_2O_5	Fe_2O_3	Al_2O_3	Ti_2O	Mn_2O_3	CaO	MgO	Na_2O	K_2O
8.03	3.32	0.80	1.19	2.12	0.30	0.48	57.10	7.91	8.11	15.9

(ii) **Discussion**

From table 1.0 , it can be observed that the strength of the concretes for the 0%, 10% and 20% ash contents at the age of 28days do not differ so much from the control, but the 30% ash content has a strength that is quite low compared to the reference concrete. It is also seen that the drop in strength at all ages increases more than the previous one for every 10% increase in sawdust ash. At 28 days curing age there is a uniform drop in strength of 2.0N/mm^2 from 0% to 20% sawdust ash content, but as it gets to 30% sawdust the drop changed to 5.0N/mm^2. Following this narrative, one can assume the graph of strength versus age, if drawn, to be parallel between 21 and 28 days. This means they are never going to intersect at any future age. This mean there is little or no pozzolanic action taking place in the concrete. In Table2.0 the composition of relevant oxides such as SiO_2 , Al_2O_3 and Fe_2O_3 are only 8.035 , 2.122 and 1.191,respectively; but comparable values for rice husk ash and fly ash(known pozzolenas)range from 50 to 70 , 20 to 30 and 3 to 30, respectively(Abul et al,2019; Adinna et al,2018, Shetty, 2009). American society for testing and material, ASTM, specifies a minimum of 70% by mass of sum of Sio_2, Fe_2O_3 and Al_2O_3 for any substance to be called a pozzolana, also minimum of 35% for Sio_2. In the case of sawdust ash the above mentioned sum is 11.34% and Sio_2, 8.035. These are far below standard. One can only infer from these observations that the only hydrating substance in the concrete is the cement, and that differences in strength are caused only by the difference in cement content; pozzolanic reaction being virtually absent.

IV. CONCLUSION AND RECOMMENDATION

From the discussions presented, one can conclude that sawdust disposal by addition of its ash to concrete at 10-20% replacement of the cement content is recommendable. This recommendation is based on the assumption that sawdust only serves as a means of improving the volume of the concrete product with some reduction in strength as pozzolanic action may be very insignificant.

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