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Combined Effects of Sawdust and Rice Husk Ashes on Concrete Exposed To Sulphate Environment

ATA Olugbenga
Department of Building, Faculty of Environmental Design and Management,
Obafemi Awolowo University, NIGERIA
Corresponding Author: ATA Olugbenga

ABSTRACT: *This research investigated the compressive strength properties of concrete containing sawdust and rice husk ashes as partial replacement for cement in an aggressive environment. Compressive strength tests were conducted on 100mm concrete cube samples made by replacing ordinary Portland cement (OPC) with the combination of sawdust ash (SDA) and rice husk ash (RHA) up to 30^%. The cubes were exposed to magnesium sulphate solution of concentrations 3 and 5% for a period of 28 days. The results show that SDA and RHA did not only reduce the compressive strength of concrete but also did not mitigate magnesium sulphate attack on concrete within the curing age of 28 days.*

Keywords: *Rice husk ash, Sawdust ash, Compressive strength, Sulphate, Concrete*

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I. INTRODUCTION

In attempt to protect concrete in aggressive environments, efforts have been made in sourcing for local materials that could be used as partial replacement or supplement to ordinary Portland cement (OPC) in civil engineering and building works [1-3]. Calcium hydroxide [$Ca(OH)_2$] is obtained as one of the hydration products of OPC. When blended with Portland cement, a pozzolanic material reacts with the $Ca(OH)_2$ to produce additional calcium-silicate-hydrate (C-S-H), which is the main cementing component. Thus, the pozzolanic material serves to reduce the quantity of the deleterious $Ca(OH)_2$ and increase the quantity of the beneficial C-S-H. Therefore, the cementing quality is enhanced if a good pozzolanic material is blended in suitable quantity with OPC.

Attempts are being made to produce and use pozzolanic agricultural by-product and industrial waste pozzolans such as fly ash (FA) and silica fume (SF), sawdust ash (SDA), rice husk ash (RHA) to improve the quality of concrete[4-6]. Rice husk ash is very effective in reducing the temperature of mass concrete compared to OPC concrete. Ground rice husk ash with finer particle size than OPC improves concrete properties, such as low water absorption and increased compressive. Ten per cent replacement of OPC with RHA in concrete has been found to produce concrete that compared favourably (in terms of strength) with convectional concrete and improve concrete resistance to chemical attack [3]

Sawdust ash as a pozzolanic material for producing concrete either in binary combination with ordinary Portland cement or in ternary combination with one other industrial byproduct pozzolan such as rice husk ash increases the durability and strength of concrete[6] The strength of concrete depends on the amount of gel (the C-S-H which is the essential cementing compound) in the cement paste. The amount of gel produced at any given time also depends on the type of cement because different cements require a different length of time to produce the same quantity of gel. The knowledge of this variation would be of great importance to civil and structural engineers in determining the percentage of SDA and RHA to be blended with OPC for various categories of concrete works.

Sawdust ash is a solid residue of the combustion of sawdust or wood in air and is composed of carbonates and oxides of metals, e.g. calcium and potassium, originally compounded in the plant's woody tissues that are present in the residue. The major elements in sawdust ash are calcium, potassium and magnesium all in various proportions while sulphur, phosphorus and manganese are present at around 1% and iron, aluminium, copper, zinc, sodium, silicon and boron are present in relatively smaller amounts. The chemical compositions of sawdust ash are mainly carbonates and oxides of the alkali metals, namely $CaCO_3$, $K_2Ca(CO_3)_2$, $Ca(OH)_2$, MgO, $Ca_4Mn_3O_{10}$, K_2S0_4, SiO_2, AL_20_3, Fe_2O_3, CaO, TiO_2, K_2O, SO_3, organic matter (loss on ignition LOI=27%), moisture and available alkali, all with significant variations. The specific gravity is often between 1.6 and 2.8 and bulk density between 365 and 980kg m^{-3}[7]. Because of its being usually rich in calcium carbonate, which are a good binding agent and its other chemical components and sawdust ash acts as a pozzolana with good stabilizing with properties to improve the properties of cement composites.

The compressive strength of ternary blended cementitious (TBC) systems containing ground sawdust ash and rice husk ash at long-term period compare to the control mixes even at OPC replacement of up to 40% is high[8]. The combination of rice husk ash with lime produces a weak cementitious material which could however be used to stabilize laterite and improve the bearing strength of the material.

In developing countries like Nigeria, proper utilization of agricultural waste has not been given due attention. The sawdust and rice husk thereby constitutes an environmental nuisance as they form refuse heaps in the areas where they are disposed. The use of burnt sawdust and rice husk ash with varying percentages in concrete wasinvestigated in this project work with a view to facilitating an economic use of the by-products and enhancing concrete durability.

II SAMPLE COLLECTION

The rice husk, sawdust, sharp sand, granite chipping used in this research work were sourced from Ile-Ife. Ordinary Portland cement was used and were procured from the open market and ascertained to be in conformity with the requirements of [9]. The magnesium sulphate ($MgSO_4$) salt was obtained from the Department of Chemistry, Obafemi Awolowo University, Ile-Ife. The portable water free from organic impurities was sourced from the tap in the Building Materials and Construction Laboratory, Department of Building, Obafemi Awolowo University, Ile Ife.

III PREPARATION OF MATERIALS

Rice husk and sawdust were sun-dried to remove all intrinsic water. They were burnt separately for about 36 hours in an open air and uncontrolled burning process. The ashes were allowed to cool after which it was pulverised to the required level of fineness and sieved through BS standard sieve size 212µm in order to remove any impurity and large particles.Preliminary tests were done to ensure compliance with the established standards.

IV PREPARATION OF SPECIMENS

The test specimen was 100mm cube meeting the requirements of [10]-1&3. The wooden modes were fabricated in compliance with [10]-1 specifications. Batching was by weight and mixing was done manually on a smooth concrete platform. A mix proportion of 1:2:4 was adopted. The total weight of each of the constituent materials that was needed to fill 100mm cubic mould was estimated. The quantities of each component depended on the mix proportion involved. The ashes were first thoroughly blended with OPC at the required proportion and the homogenous blend was then mixed with the fine aggregate-coarse aggregate mix. Water was then measured and added gradually and the entire concrete heap was mixed thoroughly to ensure homogeneity. The percentage replacements of ordinary Portland cement (OPC) with rice husk and sawdust ashes combined were 0%, 10%, 20% and 30% as shown in Table 1. The inner parts of all the 100mm cubic moulds were coated with mould oil so as to ensure easy demoulding and to provide smooth surface finish. Immediately after mixing, the wet mixture was cast into the moulds using hand trowel. Manual compaction was done in three layers of 25 strokes each using a 16mm tamping rod. After the top layer had been compacted, the surface of the concrete was finished level with the top of the mould by means of a trowel. Then all the samples were then marked by permanent marker for easy identification. Three replicates were cast using various percentages replacement of up to 30% of rice husk and sawdust ashes.

Table 1: Proportion of Cement, Sawdust and Rice Husk ashes for testing

S/No	% of Cement	% of SDA	% of RHA
1	100	0	0
2	90	5	5
3	80	10	10
4	70	15	15

V CURING OF TEST SPECIMENS

The curing method that was adopted in this research was wholly water-submerged. The samples were demoulded after 24 hours, divided into three portions and kept in three curing tanks for up to 28 days as required in different curing conditions. The first portion (control specimens) were cured in accordance with BS EN 12390-2. The two remaining portions (main specimens) were in a similar manner exposed to 3% and 5% solutions of magnesium sulphate.These concentrations represent severe and very severe sulphate exposure conditions according to[11] cited in [12] and [13]which recognizes four classes of exposure. The solution used in the tests has two different purposes, the first is the simulation of field conditions in laboratory experiments and the second is to cause an acceleration of the reaction processes. The investigation of durability problems in a reasonable period in the laboratory requires the use of highly concentrated solutions since the stronger a solution the more aggressive but the less like the real situation [16].

VI COMPRESSIVE STRENGTH TEST

Compressive strength gain or loss with time under different curing conditions were determined for all samples by using a compression testing machine, ELE2000, conforming to BS EN 12390-4 in accordance with BS EN 12390-3. The test specimen was 100mm cube meeting the requirements of BS EN 12350-1, EN 12390-3 and EN 12390-2. Specimens were loaded to failure; the maximum load sustained by the specimen was recorded and the compressive strength of the sample was calculated. The reduction in compressive strength was calculated as follows:

$$Change\ in\ compressive\ strength(\%) = \frac{A - B}{A} \times 100$$

where A = average compressive strength of three specimens cured in water (MPa) and B = average compressive strength of three specimens exposed to the test solution (MPa)

Plate 1: Compressive test of 100mm cube

VI EXPERIMENTAL RESULTS AND DISCUSSION

Table 2: Compressive strength of concrete specimens exposed to 0%, 3% and 5% sulphate concentration

	Exposure period (days)	**Compressive strength (N/mm^2)**		
		Water	3% SO_4	5% SO_4
	7	9.00	10.65	9.45
0	14	12.50	14.70	9.10
	28	18.05	22.75	8.85
	7	7.40	8.85	6.65
10	14	7.55	9.35	5.40
	28	10.15	11.55	4.55
	7	4.40	4.90	5.25
20	14	5.45	6.55	5.00
	28	7.60	9.60	3.90
	7	3.45	3.75	3.20
30	14	4.30	4.30	2.70
	28	5.10	5.90	1.75

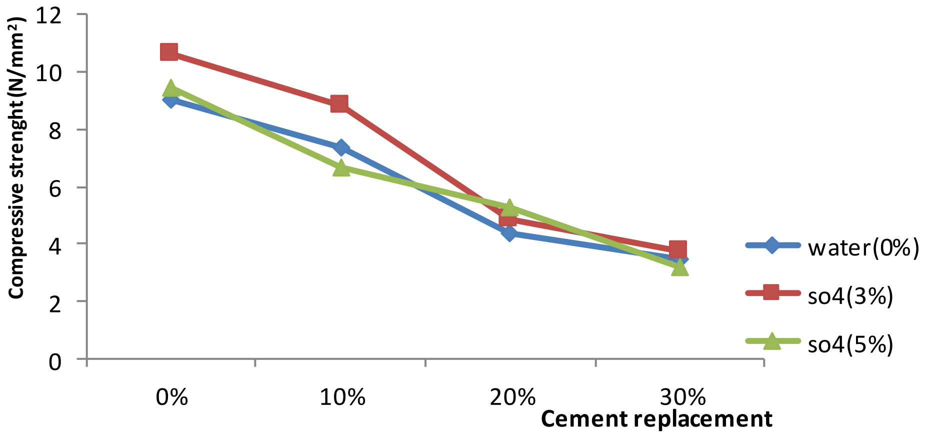

Fig. 1: Effects of SDA and RHA on compressive strength of concrete exposed to magnesium sulphate solution for 7days

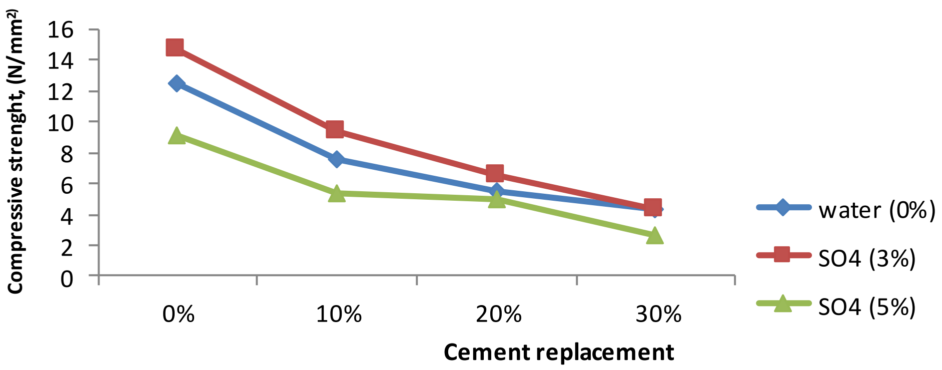

Fig. 2: Effects of SDA and RHA on compressive strength of concrete exposed to magnesium sulphate solution for 14days

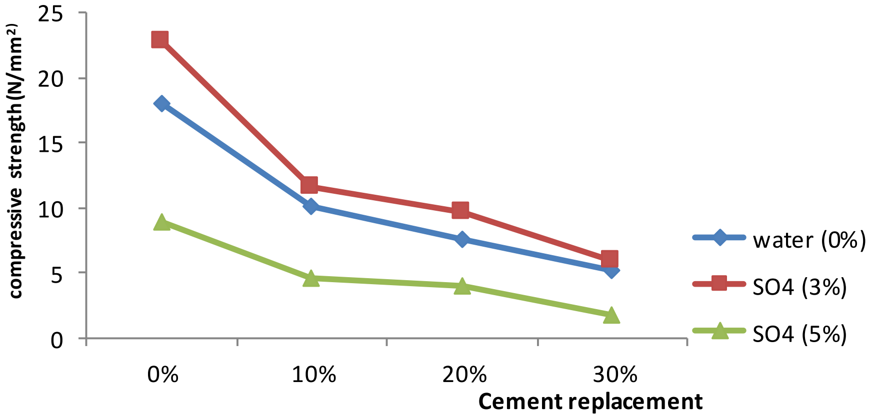

Fig. 3: Effects of SDA and RHA on compressive strength of concrete exposed to magnesium sulphate solution for 28days

The results of the compressive strength of SDA and RHA blended concrete cubes subjected to 3 and 5 per cent concentrations of magnesium sulphate solution are presented in Table 2 and compared in Figures 1 to 3.

The immersion of these cubes in magnesium sulphate solution initially (in a severe exposure) results in a slightly increase in compressive strength which according to [14, 15] occurs as a result of the action of alkali sulphates on concrete made with Portland cement which is brought about by filling of the existing pores with ettringite. However, as the formation of this phase continues and the available pore space loses its capacity to accommodate additional amounts of ettringite, potential damaging expansion forces start to be generated within the material. This explains the reason for subsequent reduction in strength i.e. in a very severe exposure. It can also be seen that there is a general reduction in the compressive strength of the specimens with increment in the amount of sawdust and rice husk ashes cement replacement. This corroborates the submission of[3,4] that compressive strength decreases with increase in amount of SDA and RHA replacement of cement content in concrete. The compressive strengths of the specimens exposed to magnesium sulphate solutions reduced vis-à-vis the control specimen. This can either imply that the pozzolanic action of SDA and RHA was not effectual at 28 days or that it does not enhance resistance of concrete to magnesium sulphate attack.

VII CONCLUSIONS

On the basis of the result obtained, the following conclusion can be drawn:

1. There is a general reduction in the compressive strength of the specimens with increment in the amount of sawdust and rice husk ashes replacement of cement.
2. The compressive strength of SDA and RHA blended concrete decreased with increasing $MgSO_4$ concentration visa-a-vis the control specimens. The strength loss at later age by SDA and RHA blended concrete indicates thepozzolanic activity of the SDA and RHA was not effective.
3. Compressive strength of SDA and RHA blended concrete increased with increase in curing age. However, exposure to magnesium sulphate solution lowered the compressive strength after 14 days.

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