SYNERGIC EFFECT OF MAIZE STRAW ASH AND RICE HUSK ASH ON STRENGTH PROPERTIES OF SANDCRETE

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ABSTRACT

The synergic effect of maize straw ash and rice husk ash on the strength properties of ash substituted sandcrete is investigated in this paper. Ash materials were obtained after burning the wastes from maize straw and rice husk. Since binding materials obtained from various sources, mostly as ashes when used as partial replacement for ordinary Portland cement in cement based application, play an important role not only towards sustainable strength development but in reducing the construction cost as well. In this paper, two binary blends of sandcrete substituting 15% ordinary Portland cement (OPC) with 15% maize straw ash (MSA) and 15% rice husk ash (RHA), also, three ternary blends of sandcrete substituting 15% ordinary Portland cement (OPC) with 10% maize straw ash (MSA) and 5% rice husk ash (RHA), also with, 5% maize straw ash (MSA), and 10% rice husk ash (RHA). 100% ordinary Portland cement (OPC) as a control specimen, which were subjected to destructive compressive strength test, after curing till 28days. It was clearly shown that neither the 15% substituted maize straw ash nor the 15% rice husk ash had a better combination for the synergic effect. Rice husk ash and maize straw ash can be used as substitution for ordinary Portland cement.

Keywords: Sandcrete, Maize straw ash, Rice husk ash, Cement, Strength properties.

INTRODUCTION

Engineering in developing countries, has always been and is still limited by three predominant factors; the availability of suitable power (electricity supply), the strength of the materials with which it is economically practical to work and the cost of procuring or producing the materials. Admitted in recent years, it would appear that progress in the development of highly efficient and enormous powerful sources has out stripped the development in materials that is required to cope fully with the handling of such power. The predominant factor holding back further development is still in all cases the limitation imposed by the mechanical and physical properties of currently available materials. It would also seem that the development of more sophisticated high strength materials is inextricably linked with increasing cost to a point at which the commercial use of such material is severely restricted. The cost of building materials nowadays is so high in Nigeria that only the government, industrial, business cooperation and few individual can afford it. This high and still rising cost can however be reduced to a minimum by use of alternative building materials that are cheap, locally available and bring about a reduction in the overall dead weight of the building. Some industrial and agricultural products that would otherwise litter the environment as waste or at best be put into only limited use could gainfully be employed as building material. This paper examines two of these materials namely; rice husk ash and maize straw ash which can be used as alternative materials to substitute cement in the building industry, so as to evaluate and confirm the feasibility of replacing cement with rice husk ash and maize straw ash in the production of sandcrete.

MATERIALS AND METHODS

Pozzolanic are materials which, when combined with calcium hydroxide, exhibits cementitious properties. Pozzolans are commonly used as an addition (the technical term is "cement extends") to Portland cement, sandcrete mixture to increase the long-time strength and other material properties of Portland cement sandcrete and in some cases reduce the material cost of mortar and other cement based materials for construction. Primarily pozzolans are vitreous siliceous materials which react with calcium hydroxide to form calcium silicates; other cementitious materials may also be formed depending on the constituents of the pozzolan.

The pozzolanic reaction may be slower than the rest of the reactions that occur during cement hydration, and thus the short-term strength of mortar made with pozzolans may not be as high as sandcrete made with purely cementitious materials, conversely, highly reactive pozzolans, such as silica fume and high reactivity metakaolin can produce 'high early strength' sandcrete that increase the rate at which it gains strength. The extent of strength development depends upon the chemical composition of alumina and silica along with the vitreous phase in the material, the better the pozzolanic reaction, and strength display.

Many pozzolans available for use in construction today were previously seen as waste products, often ending up in landfills. Use of pozzolans can permit a decrease in the use of ordinary Portland cement when producing sandcrete; this is more environmentally friendly than limiting cementitious materials to ordinary Portland cement. Due to knowledge gained since the 1990s, current practice may permit up to 40 percent reduction of ordinary Portland cement used in the sandcrete mix when replaced with a carefully designed combination of approved pozzolans (Basha & Agus, 2003; Frank R. et al, 2002; Malhotra & Mehta, 2009; Olutoge, 1999). When the mix is designed properly, sandcrete can utilize pozzolans without significantly reducing the final compressive strength or other performance characteristics.

At the basis of the pozzolanic reaction stands a simple acid-base reaction between calcium hydroxide, also known as portlandite, or ($Ca(OH)_2$), and silica acid (H_4Sio_4, or $Si(OH)_4$). At the density of calcium silicate hydrate, is lower than that of porlandite and pure silica, a consequence of this reaction is a swelling of the reaction products. This reaction may also occur with time in mortar between alkaline cement pore water and poorly crystalline silica aggregates. This delay process is also known as alkali silica reaction, or alkali-aggregate reaction, and may seriously damage mortar structures because the resulting volumetric expansion is also responsible for stalling and decrease of the sandcrete strength.

The strength of concrete is usually defined and determined by the crushing strength of $150mm^3$ at an age of 28days. Steel mould made of cast iron dimension 150mm x 150mm is always used for casting of concrete cubes. The mould and its base rigidly damped together so as to reduce leakages during casting. The sides of the mould and base plates are oiled before casting to prevent bonding between the mould and concrete. BS 1881: 1970 stipulates that the cube should be filled in three layers; each layer is computed and tamped 25 times of a 25mm steel power. The remaining is done efficiently to ensure full compaction. The cube is then stored for 24 hours undisturbed at temperature of l8°c to 22°c and a relative humidity of not less than 90%. The mould is stripped off after 24 hours and the cubes are to be stored in water for curing in a curing tank at 19° to 21° (BS 1881:1970).

At the end, the cubes were crushed with the cast faces in contact with the pattern of the testing machine. It also stated in BS 1881: 1970 that the load on the cube should be applied at the rate of

125N/mm^2; the rate of increase in storing is progressively increased as failure is approached. This is because of the non-linearity of the stress strain relationship for concrete at high stressed. The strength at failure is reported to the nearest 0.5Nmm2 (Jackson, 1984; Houston, 1972).

The mix design is to select the optimum proportion of cement, water and aggregates to produce a sandcrete that satisfies the requirements of strength, workability, durability and economy. The control cube been made of pure cement and the remaining having different percentage substitution of cement for rice chaff and maize straw ash, i.e. 5%, 10% 15% and 20% respectively. Mix ratio of 1:6 was used and the water-cement ratio was 0.5.

The sizes of sand used are mainly percentage passing 5.00mm with B.S sieve. The rice chaff used was obtained from "Ekimogun Mills" at Odo-Ado, Ado-Ekiti, Ekiti State. When the rice husk has been collected, a hollow container having holes all around it, holes of a small size that will not allow the passage of rice husk, the hollow container is placed on a slab, the rice husk is pre-burnt in order to remove the smokes from the rice husk, which latter formed a carbonized rice husk, then this carbonized rice husk with the fire still on it, is allowed in an air circulation for about 5 hours to burn completely which now form or become the rice husk ash. The ash is grinded again so as to increase its surface area, and sieved. The production of maize straw ash is achieved by packing the maize straw and sun drying them, and after ensuring a better or total dryness of the straws, they are been cut into sizes, and put in a hollow container and burnt. The straw is pre-burnt and finally burnt to ashes, the pre-burning reduces the smoke and produces a carbonized maize straw to a complete ashes. The ashes are grinded and sieved so as to remove the lumps and increase the surface area. The sandcrete were prepared in binary and ternary specimen, a controlling specimen were casted with pure ordinary Portland cement. Rice husk ash and maize straw ash were used in various percentages to partially replace the ordinary Portland cement in the mortar as a binder. Details of the mix and proportion of partial replacement for ordinary Portland cement by ashes from rice husk (RHA) and maize straw (MSA) are given below.

100%OPC	+	0%MSA	+	0%RHA
85%OPC	+	15%MSA	+	0%RHA
85%OPC	+	10%MSA	+	5%RHA
85%OPC	+	5%MSA	+	10%RHA
85%OPC	+	0%MSA	+	15%RHA

The hardened specimens were kept fully immersed in water at around (21±230C) temperature for the curing until the days of testing, for each of the replacement ratio, four sets were prepared for the destructive compressive strength test, after 7, 14, 21, and 28days. The freshly made sandcrete is placed in three successive layers in a slump cone (300mm high) with an open ended sheet metal mould shape like a truncated cone. Each layer is tamped 25 times with a tamping rod after the top of the mould layer has been loaded the surface is struck off level with the top of the mould with a trowel. Every spillage is cleaned away and the mould is then lifted vertically from the sandcrete slowly. The reduction in height of the sandcrete and the cone is also measured and noted.

The sandcrete was placed in (150 x 150 x 150) mm oiled mould and compaction is simultaneously done at each layer. Compaction is done in order to obtain a dense homogenous mass and to remove void and entrapped air but for the purpose of this work, the manual compaction mode is adopted. The mould used is made of steel so that it could resist any form of vibration. Each specimen was compacted in three layers and for each layer, 25 strokes of the tamping rod is given.

When the cubes had reached the required number of days needed, they were removed from the water and the water was allowed to drain off for some minutes. The cubes were then weighed before crushing the length and breadth and the height of cubes were also noted. The cubes were then placed on the machine with two cast faces in contact with the plate of testing machine. The machine dial is then adjusted to zero and the machine load being applied continuously until failure occur, that is the mortar cube is crushed. The pointer load will also stop at the maximum failure load which is then recorded.

RESULTS AND DISCUSSION

The values of the data gotten from the crushing compressive strength carried out on the sandcrete cubes at 7, 14, 21 and 28 days for all the cubes, the densities of the sandcrete cubes, and the percentage strength reduction on each of the sandcrete cubes are shown in tables 1, 2 and 3 respectively below.

Table 1: The Compressive Strength for the percentage of replacement of the mixture of Rice Husk Ash and Maize Straw Ash for Cement in Sandcrete

No of cubes	Curing Days	Percentage replacement			Applied load (kN)	Area of cube (m^2)	Compressive strength (kN/m^2)
		OPC	RHA	MSA			
1	7	100	0	0	120	0.0225	5.333
2	7	85	15	0	100	0.0225	4.444
3	7	85	10	5	100	0.0225	4.444
4	7	85	5	10	90	0.0225	4.000
5	7	85	0	15	100	0.0225	4.444
6	14	100	0	0	150	0.0225	6.666
7	14	85	15	0	125	0.0225	5.555
8	14	85	10	5	105	0.0225	4.667
9	14	85	5	10	105	0.0225	4.667
10	14	85	0	15	120	0.0225	5.333
11	21	100	0	0	150	0.0225	6.667
12	21	85	15	0	130	0.0225	5.778
13	21	85	10	5	115	0.0225	5.111
14	21	85	5	10	110	0.0225	4.889
15	21	85	0	15	130	0.0225	5.778
16	28	100	0	0	160	0.0225	7.111
17	28	85	15	0	135	0.0225	6.000
18	28	85	10	5	120	0.0225	5.333
19	28	85	5	10	120	0.0225	5.333
20	28	85	0	15	135	0.0225	6.000

Table 2: The densities of the sandcrete cubes

Cubes No	Curing Days	Percentage replacement			Weight on cube (Kg)	Volume (m^3)	Density (Kg/m^3)
		OPC	RHA	MSA			
1	7	100	0	0	7.386	0.0034	2172
2	7	85	15	0	7.110	0.0034	2091
3	7	85	10	5	7.476	0.0034	2198
4	7	85	5	10	7.035	0.0034	2069
5	7	85	0	15	7.131	0.0034	2097
6	14	100	0	0	7.430	0.0034	2185
7	14	85	15	0	7.323	0.0034	2153
8	14	85	10	5	7.576	0.0034	2228
9	14	85	5	10	7.215	0.0034	2122
10	14	85	0	15	7.273	0.0034	2139
11	21	100	0	0	7.310	0.0034	2150
12	21	85	15	0	7.191	0.0034	2115
13	21	85	10	5	7.781	0.0034	2288
14	21	85	5	10	7.368	0.0034	2167
15	21	85	0	15	7.284	0.0034	2142
16	28	100	0	0	7.223	0.0034	2154
17	28	85	15	0	7.320	0.0034	2153
18	28	85	10	5	7.450	0.0034	2191
19	28	85	5	10	7.310	0.0034	2150
20	28	85	0	15	7.287	0.0034	2143

Table 3: The percentage reduction in the compressive strength test of the sandcrete cubes

No of Cubes	Curing Days	Percentage replacement			Compressive strength (kN/m^2)	Percentage Reduction (%)
		OPC	RHA	MSA		
1	7	100	0	0	5.333	0
2	7	85	15	0	4.444	16.670
3	7	85	10	5	4.444	16.670
4	7	85	5	10	4.000	25.000
5	7	85	0	15	4.444	16.670
6	14	100	0	0	6.666	0
7	14	85	15	0	5.555	16.670
8	14	85	10	5	4.667	30.087
9	14	85	5	10	4.667	30.087
10	14	85	0	15	5.333	20.036
11	21	100	0	0	6.667	0
12	21	85	15	0	5.778	13.334
13	21	85	10	5	5.111	23.338
14	21	85	5	10	4.889	26.670
15	21	85	0	15	5.778	13.334
16	28	100	0	0	7.111	0

17	28	85	15	0	6.000	15.623
18	28	85	10	5	5.333	25.002
19	28	85	5	10	5.333	25.002
20	28	85	0	15	6.000	15.623

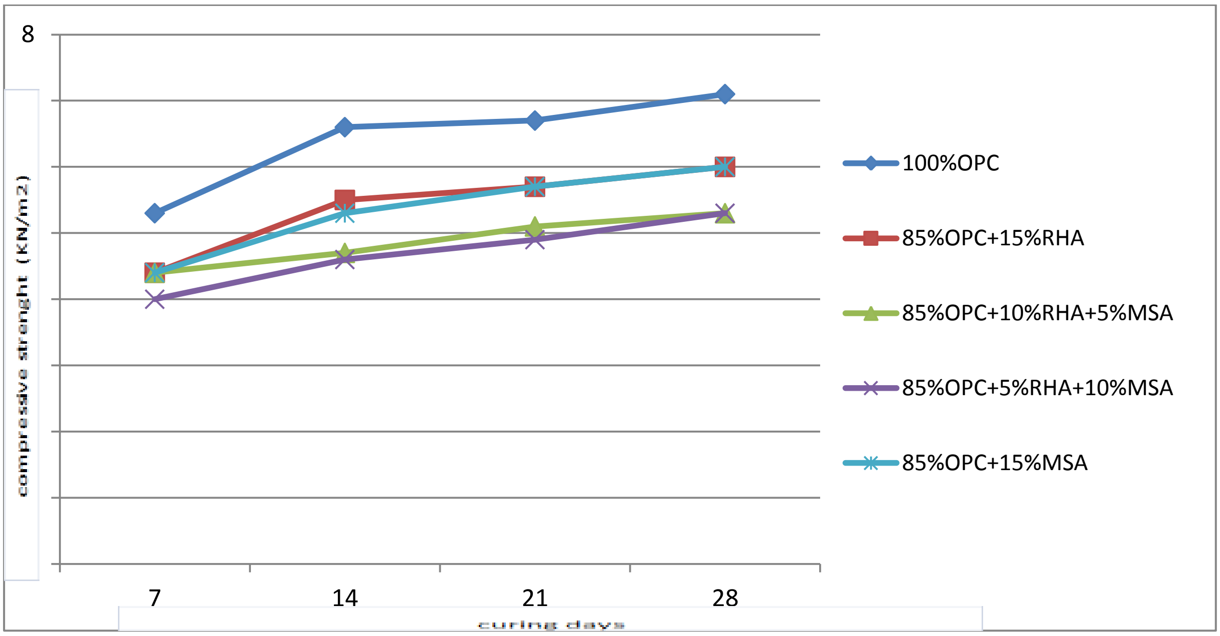

Fig 1: The compressive strength against curing days.

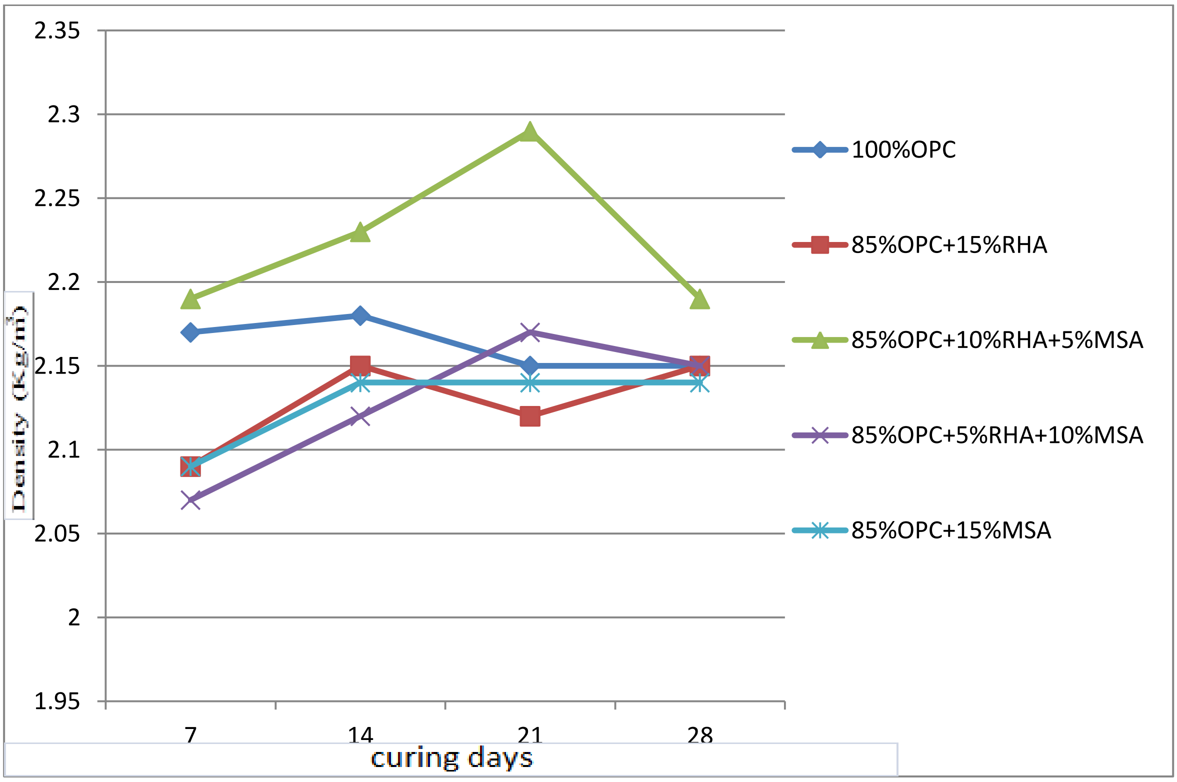

Fig 2: The density against the curing days.

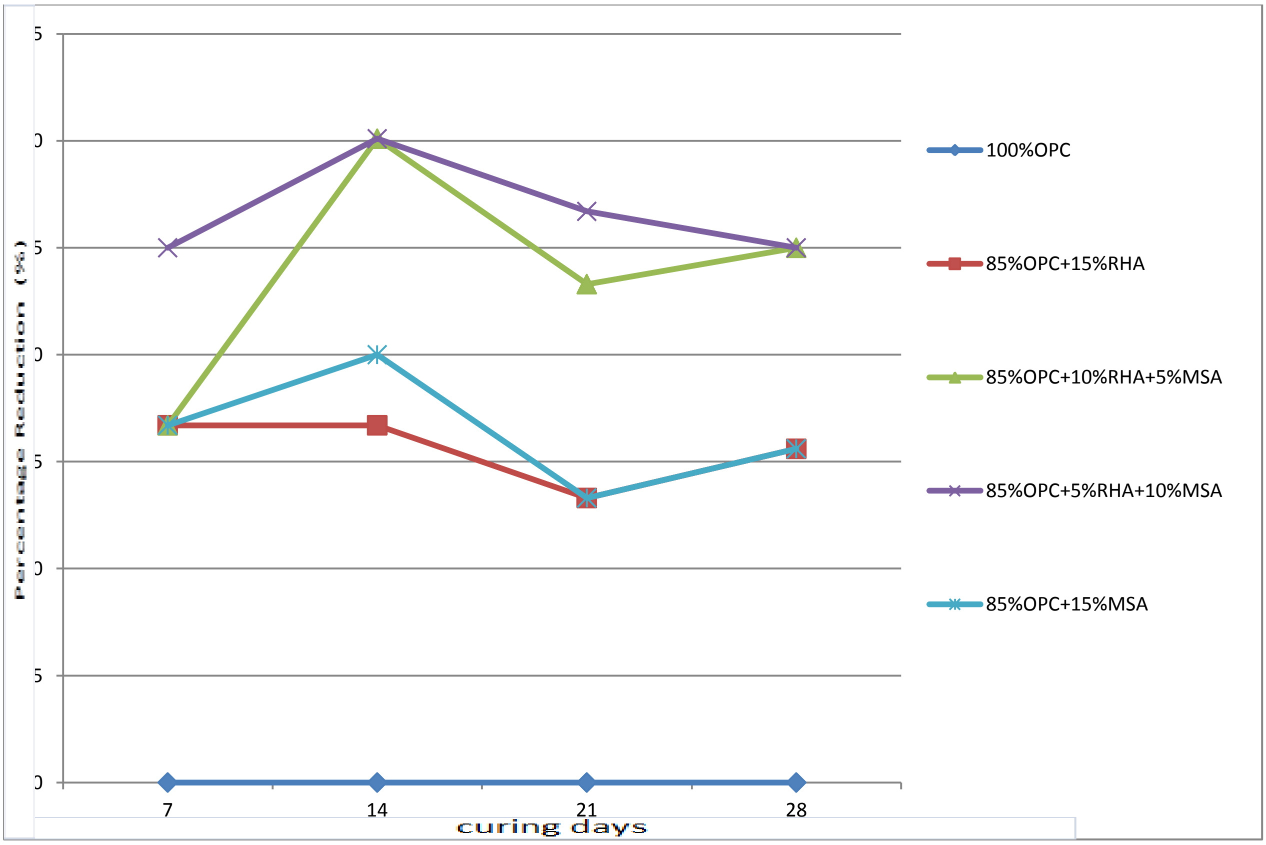

Fig 3: The percentage reduction against the curing days.

The higher ultimate strength in 85%OPC+15%RHA, and 85%OPC+15%MSA was due to the synergic effect; also, 85%OPC+10%RHA+5%MSA has higher compressive strength than 85%OPC+5%RHA+10%MSA as shown in Fig. 1. The ternary blended sandcrete specimen 85%OPC+10%RHA+5%MSA showed higher density value, while, the highest percentage reduction was in the ternary blended mortal of 85%OPC+5%RHA+10%MSA as shown respectively in Fig. 2 and 3.

CONCLUSION

Preparation of sandcrete with very different characteristics for different ends is a possibility that should be supported by further tests of physical characteristics. Decrease of compressive strength seems to be gradual; thereby making its variation in sandcrete with Pozzolanic additives becomes evident. However, this decrease does not jeopardize the use of sandcrete with adequate strength for application in conservation practice. Thus, Rice husk ash and maize straw ash could be used as substitution for ordinary Portland cement.

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