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Strength Of Ternary Blended Cement Concrete Containing Rice Husk Ash And Saw Dust Ash

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----------ABSTRACT ----------
This paper summarizes the research work on the properties of ternary blended cement concrete containing Rice Husk Ash (RHA) and Saw Dust Ash (SDA). Eight mixes of ternary blended cement mixes with 70% Ordinary Portland Cement (OPC) and 30% of combined Rice Husk Ash (RHA) and Saw Dust Ash (SDA) was adopted. Compacting factor test was carried out on fresh concrete while Compressive Strength test was carried out on hardened 150mm concrete cubes after 7, 14 and 28 days curing in water. The results revealed that the Compacting factor increased as the RHA percentage increased relative to SDA percentage in the ternary blends. The results also revealed that the Compressive Strength of concrete cubes also increased as the RHA percentage increased relative to SDA percentage in the ternary blends. The Optimum Compressive Strength of all the ternary mixes considered was 70% OPC combined with 25% RHA and 5% SDA with a value of 15.08N/mm^2. The results showed that OPC-RHA-SDA ternary blended cement concrete could be used as lightweight concrete in Civil Engineering and Building works.

KEYWORDS: *ternary blended cement concrete, pozzolan, rice husk ash, saw dust ash.*

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I. INTRODUCTION

The need to reduce the high cost of Ordinary Portland Cement in order to provide accommodation for the populace has intensified research into the use of some locally available materials that could be used as partial replacement for Ordinary Portland Cement (OPC) in Civil Engineering and Building Works. Supplementary cementitous materials have been proven to be effective in meeting most of the requirements of durable concrete and blended cements are now used in many parts of the world (Bakar, Putrajaya, and Abdulaziz, 2010). Various research works have been carried out on the binary blends of Ordinary Portland Cement with different pozzolans in making cement composites (Adewuyi and Ola, 2005; De Sensale, 2006; Saraswathy and Song, 2007; Ettu et al. 2013).

Industrial waste pozzolans such as Fly ash (FA) and Silica Fume (SF) are already widely used in many countries and attempts have also been made to produce and use Pozzolanirice Husk Ash (RHA) commercially in some countries (Cisse and Laquerbe, 2000). Mehta and Pirth (2000) investigated the use of RHA to reduce temperature in high strength mass concrete and got result showing that RHA is very effective in reducing the temperature of mass concrete compared to OPC concrete. Malhotra and Mehta (2004) later reported that ground RHA with finer particle size than OPC improves concrete properties, including that higher substitution amounts results in lower water absorption values and the addition of RHA causes an increment in the compressive strength. Cordeiro, Filho and Fairbarn (2009) carried out elaborate studies of Brazilian RHA and Rice Straw Ash (RSA) and demonstrated that grinding increases the pozzolanicity of RHA and that high strength of RHA, RSA concrete makes production of blocks with good bearing strength in a rural setting possible. Their study showed that combination of RHA or RSA with lime produces a weak cementitous material which could however be used to stabilize laterite and improve the bearing strength of the material. Habeeb and Fayyadh (2009) investigated the influence of RHA average particle size on the properties of concrete and found out that at early ages the strength was comparable, while at the age of 28 days, finer RHA exhibited higher strength than the sample with coarser RHA. Rukzon, Chindaprasirt and Mahachai (2009) further studied the effect of grinding on the chemical and physical properties of rice husk ash and the effect of RHA fineness on properties of mortar and found that pozzolans with finer particles had greater pozzolanic reaction. A number of researchers have also worked on sawdust ash and found that it could be used in binary combination with OPC to improve the properties of cement composites (Elinwa, Ejeh and Mamuda, 2008; Elinwa and Abdulkadir, 2011; Raheem et al. 2012).

Some researchers have proceeded to investigate the possibility of ternary blended cement systems in order to further reduce the quantity of OPC in blended cements. Rukzon and Chindaprasirt (2006) investigated the strength development of mortars made with ternary blends of OPC, ground RHA and classified fly ash (FA). The results showed that the strength at the age of 28 and 90 days of the binary blended cement mortar containing 10 and 20% RHA were slightly higher than those of the control, but less than those of FA. Ternary blended cement mixes with 70% OPC and 30% of combined FA and RHA produced strengths similar to that of the control. The researchers concluded that 30% of OPC could be replaced with combined FA and RHA pozzolan without significantly lowering the strength of the mixes. Elinwa, Ejeh and Akpabio (2005) investigated the use of sawdust ash in combination with metakaolin as a ternary blend with 3% added to act as an admixture in concrete. Fadzil et al. (2008) also studied the properties of ternary blended cementitious (TBC) systems containing OPC, ground Malaysian RHA and FA. They found that the compressive strength of concrete containing TBC gave low strength at early ages, even lower than that of OPC but higher than binary blended cementitious (BBC) concrete containing FA. At long-term period, the compressive strength of TBC concrete was comparable to the control mixes even at OPC replacement of up to 40% with the pozzolanic materials. Their results generally showed that the TBC systems could potentially be used in the concrete construction industry and could be particularly useful in reducing the volume of OPC used. Ettu et al. (2013) investigated the compressive strength of ternary blended cement concrete containing corn cob ash (CCA) and pawpaw leaf ash (PPLA). Their results showed that OPC-CCA-PPLA ternary blended cement could be used in producing concrete with high strength values at 50 days of hydration and above. This research work investigated the compressive strength of ternary blended cement concrete containing Saw Dust Ash and Rice Husk Ash. The successful utilization of saw dust ash and rice husk ash in ternary combination with OPC for making concrete would further add value to these wastes and reduce the volume of OPC currently required for civil engineering and building works.

II. MATERIALS AND METHODS

Rice Husk Ash (RHA)

The Rice Husk used was obtained from Ile Ife, Nigeria. After collection, the Rice Husk was burnt under guided or enclosed place to limit the amount of ash that will be blown off. The ash was ground to the required level of fineness and sieved through 600 μm sieve in order to remove any impurity and larger size particles.

Saw Dust Ash (SDA)

The Saw Dust used was obtained from Iree, Nigeria. After collection, the sawdust was openly heated. The ash was ground to the required level of fineness and sieved through 600 μm sieve in order to remove any impurity and larger size particles.

Coarse Aggregate

The granite used for this research work was 12mm size. It was sourced from a quarry in Igbajo in Nigeria

Fine Aggregate

The sand used for this research work was sourced from Iree, Osun state, Nigeria. The impurities were removed and it conformed to the requirements of BS 882 (1992).

Cement

The cement used was Ordinary Portland Cement. It was sourced from Iree, Osun State, Nigeria and it conformed to the requirements of BS EN 197-1: 2000.

Water

The water used for the study was obtained from a free flowing stream. The water was clean and free from any visible impurities. It conformed to BS EN 1008:2002 requirements.

Batching and mixing of materials

Batching of materials was done by weight. Ternary blended cement mixes with 70% OPC and 30% of combined Rice Husk Ash (RHA) and Saw Dust Ash (SDA) was adopted. The percentage replacements of Ordinary Portland cement (OPC) by Rice Husk Ash (RHA) and Saw Dust Ash (SDA) are as shown in Table 1.

Table 1: Percentage replacement of OPC by RHA and SDA

Sample Number	RHA (%)	SDA (%)	OPC (%)
1	0	0	100
2	0	30	70
3	5	25	70
4	10	20	70
5	15	15	70
6	20	10	70
7	25	5	70
8	30	0	70

Concrete Mix Design

The concrete used in this research work was made using Binder, Sand and Gravel. The concrete mix proportion was 1:2:4 by weight respectively.

Casting of samples

Cubic specimens of concrete with size 150 x 150 x 150 mm were cast for determination of all measurements. Eight mixes were prepared using different percentages of RHA and SDA while the percentage OPC was kept at 70% of the binder in seven of all the mixes except the control where OPC only was used as the binder. The concrete was mixed, placed and compacted in three layers. The samples were demoulded after 24 hours and kept in a curing tank for 7, 14 and 28 days as required. The Compacting Factor apparatus was also used to determine the compacting factor values of the fresh concrete in accordance with BS 1881: Part 103 (1983).

Testing of samples

The Compressive Strength tests on the concrete cubes were carried out with the COMTEST Crushing Machine at The Sammya Nigeria Limited, Osogbo, Nigeria. This was done in accordance with BS 1881: Part 116 (1983). The sample was weighed before being put in the compressive test machine. The machine automatically stops when failure occurs and then displays the failure load.

III. RESULTS AND DISCUSSIONS

Results of Compacting Factor test on fresh concrete samples

The results obtained from the compacting factor test on fresh concrete samples are given in Table 2.

Table 2: Compacting Factor Values of Blended RHA-SDA-OPC Cement Concrete

Sample Number	Mix Proportion			Compacting Factor Value
	RHA % Binder	SDA % Binder	OPC % Binder	
1	0	0	100	0.92
2	0	30	70	0.87
3	5	25	70	0.89
4	10	20	70	0.89
5	15	15	70	0.89
6	20	10	70	0.90
7	25	5	70	0.90
8	30	0	70	0.88

The table indicates that the Compacting Factor Value for the control where no pozzolan was added was the highest at 0.92. However the Compacting Factor Values for Samples 3, 4 and 5 stood at 0.89 while the Compacting Factor Values 6 and 7 were slightly higher at 0.90. It can be observed in Samples 3 to 7 that as RHA content increased, the Compacting Factor Values also increased. It is also be observed that Sample 2 where only SDA was used as the pozzolan, the Compacting Factor was 0.87 which was lower than that of Sample 8 of 0.88 where only RHA was used as the pozzolan.

Bulk Densities of Blended RHA-SDA-OPC Cement Concrete

The Bulk Densities of the Concrete Cubes cast at various days of curing are shown in Table 3 and Figure 1.

Table 3: Results of Bulk Densities of Blended RHA-SDA-OPC Cement Concrete

Sample Number	Mix Proportion			Bulk Density (g/cm^3)		
	RHA % Binder	SDA % Binder	OPC % Binder	7 Days	14 Days	28 days
1	0	0	100	2.32	2.37	2.43
2	0	30	70	2.17	2.18	2.19
3	5	25	70	2.05	2.20	2.34
4	10	20	70	2.07	2.22	2.35
5	15	15	70	2.07	2.23	2.37
6	20	10	70	2.09	2.22	2.37
7	25	5	70	2.09	2.23	2.36
8	30	0	70	2.04	2.13	2.38

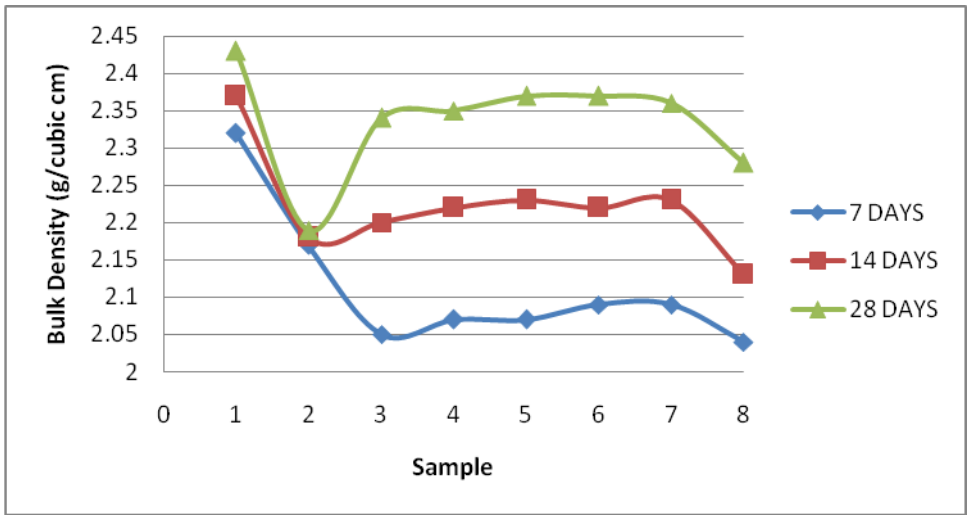

Figure 1: Bulk Densities of Blended RHA-SDA-OPC Cement Concrete

The table indicates that the Bulk Density for the control cube where no pozzolan was added after 28 days curing in water was the highest at 2.43 g/cm^3. However the Bulk Densities for Samples 3, 4, 5, 6 and 7 after 28 days curing in water ranged between 2.34 g/cm^3 and 2.37 g/cm^3. It can be observed that as RHA content increased compared to SDA the Bulk Densities increased. It is also be observed that Sample 2 where only SDA was used as the pozzolan, the Bulk Density after 28 days curing in water at 2.19 g/cm^3 was lower than that of Sample 8 of 2.38 g/cm^3 where only RHA was used as the pozzolan.

Results of Compressive Strengths of Blended RHA-SDA-OPC Cement Concrete

The results of the Compressive Strength tests on concrete cubes are shown in Table 4 and Figure 2

Table 4: Compressive Strengths of Blended RHA-SDA-OPC Cement Concrete

Sample Number	Mix Proportion			Compressive Strength (N/mm^2)		
	RHA % Binder	SDA % Binder	OPC % Binder	7 Days	14 Days	28 days
1	0	0	100	16.35	19.78	26.02
2	0	30	70	7.02	8.61	11.13
3	5	25	70	7.23	12.73	12.89
4	10	20	70	7.25	13.42	13.53
5	15	15	70	7.78	13.64	13.74
6	20	10	70	8.80	13.69	14.85
7	25	5	70	10.87	13.95	15.08
8	30	0	70	10.95	13.94	15.29

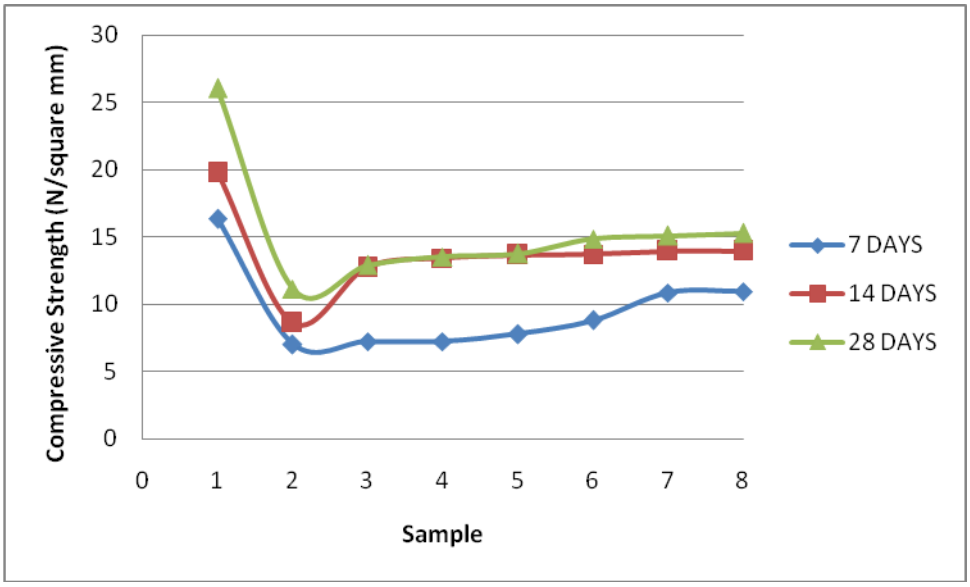

Figure 2: Compressive Strengths of Blended RHA-SDA-OPC Cement Concrete

The table indicates that the Compressive Strength for the control cube where no pozzolan was added after 28 days curing in water was the highest at 26.02 N/mm^2. However the Compressive Strengths for Samples 3, 4, 5, 6 and 7 after 28 days curing in water ranged between 12.89 N/mm^2 and 15.08 N/mm^2. It can be observed that as RHA content increased compared to SDA the Compressive Strength increased. The 28 day strength for Samples 2, 3, 4, 5 and 6 were above the specified value of 10N/mm^2 for Grade 10 Plain Concrete (BS 8110, 1997) as shown in Table 5. It is also be observed that Sample 2 where only SDA was used as the pozzolan, the Compressive Strength after 28 days curing in water at 11.13 N/mm^2 was lower than that of Sample 8 of 15.29 N/mm^2 where only RHA was used as the pozzolan. The 28 day strength for Samples 7 and 8 were above the specified value of 15N/mm^2 for Grade 15 light weight concrete (BS 8110, 1997) as shown in Table 5. Generally, these results indicated that pozzolan blended cement concrete gain strength slowly at early curing age.

Table 4: Recommended grade of concrete (BS 8110, 1997)

Grade	Characteristic strength	Concrete class
7 10	7.0 10.0	Plain concrete
15	15.0	Reinforced concrete with lightweight aggregate
20 25	20.0 25.0	Reinforced concrete with dense aggregate
30	30.0	Concrete with post tensioned tendons
40 50 60	40.0 50.0 60.0	Concrete with pre tensioned tendons

IV. CONCLUSIONS

From the investigations carried out, the following conclusions can be made:

The Compacting Factor Values increased as the RHA percentage increased relative to SDA percentage in the ternary blends.

It can be observed that as RHA content increased compared to SDA in the ternary blends, the Bulk Densities increased.

The Compressive Strengths of concrete cubes for ternary blended cement mixes with 70% Ordinary Portland Cement (OPC) and 30% of combined Rice Husk Ash (RHA) and Saw Dust Ash (SDA) after 28 days curing in water ranged between 12.89 N/mm^2 and 15.08 N/mm^2

The Optimum Compressive Strength of all the ternary mixes considered was 70% OPC combined with 25% RHA and 5% SDA with a value of 15.08 N/mm^2.

V. RECOMMENDATIONS

The following are recommended from this study:

The utilization of Rice Husk Ash (RHA) and Saw Dust Ash (SDA) in ternary combination with Ordinary Portland Cement (OPC) should be encouraged.

Further studies are recommended for performance of the ternary blends at 56 days of hydration and above.

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