Strength Of Blended Cement Sandcrete &Soilcreteblocks Containing Coconut Husk Ash And Oil Palm Bunch Ash

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ABSTRACT

This work investigated the compressive strength of binary and ternary blended cementsandcrete and soilcreteblocks containing coconut huskash (CHA) and oil palm bunch ash (OPBA). 135 solid sandcrete blocks and 135 solid soilcrete blocks of 450mm x 225mm x 125mm were produced with OPC-CHAbinary blended cement, 135with OPC-OPBAbinary blended cement, and 135with OPC-CHA-OPBAternary blended cement, each at percentage OPC replacement with pozzolan of 5%, 10%, 15%, 20%, and 25%.Three sandcrete blocks and three soilcreteblocks for each OPC-pozzolan mix and the control were crushed to obtain their compressive strengths at 3, 7, 14, 21, 28, 50, 90, 120, and 150 days of curing. Binary and ternary blended cement sandcrete and soilcrete block strength values were found to be higher than the control values beyond 90 days of hydration at 5-25% OPC replacement with pozzolan. The 150-day strength values for OPC-CHA-OPBA ternary blended cement sandcreteand soilcrete blocks were respectively 6.00N/mm^{2}and 5.30N/mm^2 for 5% replacement, 5.90N/mm^{2}and 5.20N/mm^2 for 10% replacement, 5.75N/mm^{2}and 5.10N/mm^{2}for 15% replacement, 5.70N/mm^{2}and 5.00N/mm^{2}for 20% replacement, and 5.50N/mm^{2}and 4.90N/mm^{2}for 25% replacement; while the control values were 5.20N/mm^2 and 4.80N/mm^2. Thus, OPC-CHA and OPC-OPBA binary blended cements as well as OPC-CHA-OPBA ternary blended cement could be used in producing sandcrete and soilcreteblocks with sufficient strength for use in building and minor civil engineering works where the need for high early strength is not a critical factor.

Keywords: Binary blended cement, coconut husk ash, oil palm bunch ash, pozzolan, sandcrete block, soilcrete block, ternary blended cement.

INTRODUCTION

Sandcrete and soilcrete blocks are cement composites commonly used as walling units in buildings all over South Eastern Nigeria and many other parts of Africa. The major constituents of sandcrete are water, cement, and sand. Its essential difference with soilcrete is that natural soil, notably laterite, is used in soilcrete making rather than sand. Many researchers have investigated various aspects of these important construction materials. Joshua and Lawal (2011) successfully replaced sand with laterite in suitable optimal percentages to produce laterizedsandcrete blocks with adequate strength and more cost effectiveness than the traditional sandcrete blocks. Mama and Osadebe (2011) developed a mathematical model for optimizing the strength of laterizedsandcrete blocks.Baiden and Tuuli (2004) confirmed that mix ratio, materials quality, and mixing of the constituent materials affect the quality of sandcrete blocks.Wenapereand Ephraim (2009) found that the compressive strength of sandcrete blocks increased with age of curing for all mixes tested at the water-cement ratio of 0.5. Their findings showed that the strength at ages 7, 14, and 21 days were 43%, 75%, and 92% of the 28-day strength respectively. Much of the focus of researchers in this field within the past decade has been to find ways of reducing the cost of cement used in sandcrete and soilcreteblock production so as to provide low-cost buildings in the suburbs and villagesof South Eastern Nigeria and other places. For this reason agricultural by-products regarded as wastes in technologically underdeveloped societies are increasingly being investigated as partial replacement of Ordinary Portland Cement (OPC) in binary blended cement systems. Okpala (1993) partially substituted cement with RHA in the percentage range of 30–60% at intervals of 10% while considering the effect on some properties of sandcrete blocks. His results revealed that up to 40% cement replacement would still be suitable for a sandcrete mix of 1:6 (cement/sand ratio) while up to 30%replacement would be suitable for a mix of 1:8. Marthong (2012) used sawdust ash (SDA) as partial replacement of cement in sandcrete. Apata and Alhassan (2012) carried out an evaluation of locally available materials as partial replacement for cement and concluded that partial replacement of these local materials with 10% OPC can be adopted for low cost housing. Manasseh (2010)had earlier carried out an elaborate review of some of the commonest agro wastes that have been experimented as cement replacement in sandcrete making and found some of them such as rice husk ash (RHA)suitable. Aribisala and Bamisaye (2006) reported the successful use of bone powder as partial replacement for cement in concrete.Ganesan, Rajagopal, and Thangavel (2008) assessed the optimal level of replacement of OPC with RHA for strength and permeability properties of blended cement concrete.Nair, Jagadish, and Fraaij (2006) found that RHA could be a suitable alternative to OPC for rural housing.

Agbede and Obam (2008) investigated the strength properties of OPC-RHA blended sandcrete blocks. They replaced various percentages of OPC with RHA and found that up to 17.5% of OPC can be replaced with RHA to produce good quality sandcrete blocks. Cisse and Laquerbe (2000) reported that sandcrete blocks obtained with unground Senegalese RHA as partial replacement of OPC had greater mechanical resistance than 100% OPC sandcrete blocks. Their study also revealed that the use of unground RHA enabled production of lightweight sandcrete block with insulating properties at a reduced cost. Oyekan and Kamiyo (2011) reported thatsandcrete blocks made with RHA-blended cement had lower heat storage capacity and lower thermal mass than 100% OPC sandcrete blocks. They explained that the increased thermal effusivity of the sandcrete block with RHA content is an advantage over 100% OPC sandcrete block as it enhances human thermal comfort. Mehta and Pirtz (2000) investigated the use of rice husk ash to reduce temperature in high strength mass concrete and concluded that RHA is very effective in reducing the temperature of mass concrete compared to OPC concrete. Wada et al. (2000) demonstrated that RHA mortar and concrete exhibited higher compressive strength than the control mortar and concrete. Malhotra and Mehta (2004) reported that ground RHA with finer particle size than OPC improves concrete properties as higher substitution amounts result in lower water absorption values and the addition of RHA causes an increment in the compressive strength. Cordeiro, Filho, and Fairbairn (2009) investigated Brazilian RHA and rice straw ash (RSA) and demonstrated that grinding increased 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 cementitious material which could however be used to stabilize laterite and improve the bearing strength of the material.Sakr (2006) investigated the effects of silica fume and rice husk ash on the properties of heavy weight concrete and found that these pozzolans gave higher concrete strengths than OPC concrete at curing ages of 28 days and above. Rukzon, Chindaprasirt, and Mahachai (2009) studied the effect of grinding on the chemical and physical properties of rice husk ash and the effects of RHA fineness on properties of mortar and found that pozzolans with finer particles had greater pozzolanic reaction. Habeeb and Fayyadh (2009) also investigated the influence of RHA average particle size on the properties of concrete and found 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. Cordeiro, Filho, and Fairbairn (2009) further investigated the influence of different grinding times on the particle size distribution and pozzolanic activity of RHA obtained by uncontrolled combustion in order to improve the performance of the RHA. The study revealed the possibility of using ultrafine residual RHA containing high-carbon content in high-performance concrete.

The possibility of ternary blended cement systems whereby OPC is blended with two different pozzolans have also been investigated by some researchers. The ternary blended system has two additional economic and environmental advantages. First, it makes it possible for two pozzolans to be combined with OPC even if neither of them is available in very large quantity. Second, it enables a further reduction of the quantity of OPC in blended cements. 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. Frı´as et al. (2005)studied the influence of calcining temperature as well as clay content in the pozzolanic activity of sugar cane straw-clay ashes-lime systems. All calcined samples showed very high pozzolanic activity and the fixation rate of lime varied with calcining temperature and clay content.Tyagher, Utsev, and Adagba (2011) found that sawdust ash-lime mixture as partial replacement for OPC is suitable for the production of sandcrete hollow blocks. They reported that 10% replacement of OPC with SDA-lime gave the maximum strength at water-cement ratio of 0.55 for 1:8 mix ratio. 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 the combined FA and RHA pozzolans without significantly lowering the strength of the mixes. Fadzil et al. (2008) have also studied the properties of ternary blended cementitious (TBC) systems containing OPC, ground Malaysian RHA, and fly ash (FA). They found that 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. Their results suggested the possibility of using TBC systems in the concrete construction industry and that TBC systems could be particularly useful in reducing the volume of OPC used.

Much of the previous works by researchers on ternary blended cements were based on the ternary blending of OPC with an industrial by-product pozzolan such as FA or silica fume (SF) and an agricultural by-product pozzolan, notably RHA. Tons of agricultural and plant wastes such as coconut huskand oil palm bunchare generated in the variouslocal communities in South Eastern Nigeria due to intensified food production and local economic ventures. Not much has been reported on the possibility of binary combination of these Nigerian agricultural by-products with OPC in developing blended cements and no literature exists on the possibility of ternary blending of two of them with OPC. This work is part of a pioneer investigation of the suitability of using two Nigerian agricultural by-products in ternary blend with OPC for sandcrete and soilcreteblock making. The compressive strength of binary and ternary blended cementsandcrete and soilcreteblocks containing coconut husk ash and oil palm bunch ash was specifically investigated. It is hoped that the successful utilization of coconut husk ash and oil palm bunch ash in binary and ternary combination with OPC for making sandcrete and soilcreteblocks would go a long way in reducing the cost of building and minor civil engineering projects that make much use of sandcrete and soilcrete blocks as well asadd economic value to these wastes.

METHODOLOGY

Coconut husk was obtainedfrom Orluand oil palm bunch from palm oil mill in Ohaji-Egbema, both in Imo State, South East Nigeria. These materials were air-dried, pulverized into smaller particles, and calcined into ashes in a locally fabricated furnace at temperatures generally below 650^{o}C. The coconut husk ash (CHA) and oil palm bunch ash (OPBA) were sieved and large particles retained on the 600µm sieve were discarded while those passing the sieve were used for this work. No grinding or any special treatment to improve the quality of the ashes and enhance their pozzolanicity was applied.The CHA had a bulk density of 800 Kg/m^3, specific gravity of 1.90, and fineness modulus of 2.02. The OPBA had a bulk density of 810 Kg/m^3, specific gravity of 2.05, and fineness modulus of 2.05. Other materials used for this work are Ibeto brand of Ordinary Portland Cement (OPC) with a bulk density of 1650 Kg/m^3 and specific gravity of 3.13; river sand free from debris and organic materials with a bulk density of 1590 Kg/m^3, specific gravity of 2.68, and fineness modulus of 2.82;laterite also free from debris and organic materials with a bulk density of 1450 Kg/m^3, specific gravity of 2.30, and fineness modulus of 3.30; and water free from organic impurities.

A simple form of pozzolanicity test was carried out for each of the ashes. It consists of mixing a given mass of the ash with a given volume of Calcium hydroxide solution [$Ca(OH)_2$] of known concentration and titrating samples of the mixture against H_2SO_4 solution of known concentration at time intervals of 30, 60, 90, and 120 minutes using Methyl Orange as indicator at normal temperature. For each of the ashes the titre value was observed to reduce with time, confirming the ash as a pozzolan that fixed more and more of the calcium hydroxide, thereby reducing the alkalinity of the mixture.

A standard mix ratio of 1:6 (blended cement: sand (or laterite)) was used for both the sandcrete and the soilcrete blocks. Batching was by weight and a constant water/cement ratio of 0.6 was used. Mixing was done manually on a smooth concrete pavement. For binary blending with OPC, each of the ashes was first thoroughly blended with OPC at the required proportion and the homogenous blend was then mixed with the sand in the case of sandcrete blocks and with laterite in the case of soilcrete blocks, also at the required proportions. For ternary blending, the two ashes were first blended in equal proportions and subsequently blended with OPC at the required proportions before mixing with the sand or laterite, also at the required proportions. Water was then added gradually and the entire sandcreteor soilcreteheap was mixed thoroughly to ensure homogeneity.

One hundred and thirty-five (135) solid sandcrete blocks and one hundred and thirty-five (135) solid soilcrete blocks of 450mm x 225mm x 125mm were produced with OPC-CHAbinary blended cement, one hundred and thirty-five (135) with OPC-OPBAbinary blended cement, and one hundred and thirty-five (135) with OPC-CHA-OPBAternary blended cement, each at percentage OPC replacement with pozzolan of 5%, 10%, 15%, 20%, and 25%. Twenty seven (27) sandcreteblocks and twenty seven (27) soilcrete blocks were also produced with 100% OPC or 0% replacement with pozzolan to serve as control. This gives a total of 432 sandcrete blocks and 432 soilcrete blocks.All the blocks were cured by water sprinkling twice a day in a shed. Three sandcrete blocks and three soilcreteblocks for each OPC-pozzolan mix and the control were tested for saturated surface dry bulk density and crushed to obtain their compressive strengths at 3, 7, 14, 21, 28, 50, 90, 120, and 150 days of curing.

RESULTS AND DISCUSSION

The pozzolanicity test confirmed both the CHA and the OPBA as pozzolans since they fixed some quantities of lime over time. The particle size analysis showed that both ashes were much coarser than OPC, the reason being that they were not ground to finer particles. This implies that the compressive strength values obtained using them could still be improved upon if the ashes are ground to finer particles. The compressive strengths of the OPC-CHA and OPC-OPBA binary blended cement sandcrete and soilcrete blocks as well as the OPC-CHA-OPBA ternary blended cement sandcrete and soilcreteblocks are shown in tables 1, 2, and 3 for 3-14 days, 21-50 days, and 90-150 days of curing respectively.

The results in tables 1 to 3 show that the values of soilcreteblock strength are consistently less than the corresponding values of sandcrete block strength for all percentages of OPC replacement with pozzolans and at all curing ages. This confirms that sand is better than laterite as fine aggregate material in making cement composites. However, a close examination of the results shows that the values of the soilcrete block strengths are not much different from those of sandcrete block strengths. For example, the 50-day strengths are 4.70N/mm^2 for sandcrete block and 4.30N/mm^2 for soilcrete block at 100% OPC and 4.55N/mm^2 for sandcrete block and 4.10N/mm^2 for soilcrete block at 10% replacement of OPC with CHA-OPBA in ternary blending. This also confirms that laterite could be used as sole fine aggregate in making cement composites for low-cost houses in communities where sharp sand is difficult to obtain at affordable prices.

Table 1. Compressive strength of blended OPC-CHA-OPBA cement sandcrete and soilcreteblocks at 3-14 days of curing

OPC Plus	Compressive Strength of sandcrete blocks (N/mm^2)						Compressive Strength of soilcrete blocks (N/mm^2)					
	0% Poz.	5% Poz.	10% Poz.	15% Poz.	20% Poz.	25% Poz.	0% Poz.	5% Poz.	10% Poz.	15% Poz.	20% Poz.	25% Poz.
	Strength at 3 days						Strength at 3 days					
CHA	0.90	0.65	0.55	0.50	0.45	0.40	0.80	0.55	0.50	0.45	0.35	0.30
OPBA	0.90	0.65	0.60	0.55	0.50	0.45	0.80	0.60	0.55	0.50	0.40	0.35
CHA & OPBA	0.90	0.65	0.60	0.50	0.45	0.40	0.80	0.60	0.55	0.45	0.35	0.30
	Strength at 7 days						Strength at 7 days					
CHA	1.50	1.30	1.20	1.15	1.00	0.90	1.30	1.05	1.00	0.90	0.70	0.60
OPBA	1.50	1.35	1.30	1.10	1.05	0.95	1.30	1.10	1.05	0.95	0.80	0.65
CHA & OPBA	1.50	1.30	1.25	1.10	1.00	0.90	1.30	1.05	1.00	0.90	0.70	0.60
	Strength at 14 days						Strength at 14 days					
CHA	2.70	2.35	2.30	2.20	2.00	1.90	2.30	1.90	1.85	1.75	1.60	1.50
OPBA	2.70	2.40	2.35	2.25	2.10	2.00	2.30	2.00	1.90	1.80	1.70	1.60
CHA & OPBA	2.70	2.35	2.30	2.20	2.00	1.95	2.30	1.95	1.90	1.75	1.60	1.50

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Table 2. Compressive strength of blended OPC-CHA-OPBA cement sandcrete and soilcreteblocks at 21-50 days of curing

OPC Plus	Compressive Strength of sandcrete blocks (N/mm^2)						Compressive Strength of soilcrete blocks (N/mm^2)					
	0% Poz.	5% Poz.	10% Poz.	15% Poz.	20% Poz.	25% Poz.	0% Poz.	5% Poz.	10% Poz.	15% Poz.	20% Poz.	25% Poz.
	Strength at 21 days						Strength at 21 days					
CHA	3.50	3.10	3.00	2.90	2.80	2.70	3.10	2.70	2.60	2.50	2.45	2.30
OPBA	3.50	3.20	3.10	3.00	2.95	2.80	3.10	2.80	2.65	2.55	2.50	2.40
CHA & OPBA	3.50	3.15	3.00	2.95	2.90	2.75	3.10	2.70	2.60	2.55	2.50	2.40
	Strength at 28 days						Strength at 28 days					
CHA	4.40	4.00	3.95	3.90	3.70	3.60	3.90	3.50	3.40	3.30	3.20	3.15
OPBA	4.40	4.10	4.00	3.95	3.80	3.65	3.90	3.55	3.50	3.40	3.25	3.20
CHA & OPBA	4.40	4.00	4.00	3.90	3.70	3.60	3.90	3.50	3.55	3.35	3.20	3.15
	Strength at 50 days						Strength at 50 days					
CHA	4.70	4.60	4.50	4.45	4.40	4.25	4.35	4.30	4.20	4.15	4.00	3.90
OPBA	4.70	4.55	4.40	4.35	4.25	4.20	4.30	4.25	4.10	4.00	3.90	3.80
CHA & OPBA	4.70	4.55	4.55	4.40	4.30	4.20	4.30	4.25	4.10	4.10	3.90	3.80

Table 3. Compressive strength of blended OPC-CHA-OPBA cement sandcrete and soilcreteblocks at 90-150 days of curing

OPC Plus	Compressive Strength of sandcrete blocks (N/mm^2)						Compressive Strength of soilcrete blocks (N/mm^2)					
	0% Poz.	5% Poz.	10% Poz.	15% Poz.	20% Poz.	25% Poz.	0% Poz.	5% Poz.	10% Poz.	15% Poz.	20% Poz.	25% Poz.
	Strength at 90 days						Strength at 90 days					
CHA	4.90	5.00	5.00	4.85	4.75	4.60	4.50	4.85	4.77	4.60	4.50	4.30
OPBA	4.90	5.05	4.95	4.70	4.60	4.55	4.50	4.80	4.70	4.55	4.45	4.20
CHA & OPBA	4.90	5.00	5.00	4.80	4.70	4.60	4.50	4.80	4.70	4.60	4.50	4.20
	Strength at 120 days						Strength at 120 days					
CHA	5.10	5.65	5.55	5.40	5.30	5.20	4.70	5.10	5.05	4.90	4.85	4.70
OPBA	5.10	5.50	5.45	5.30	5.25	5.15	4.70	5.00	4.90	4.80	4.75	4.70
CHA & OPBA	5.10	5.60	5.50	5.30	5.25	5.20	4.70	5.10	5.00	4.90	4.80	4.70
	Strength at 150 days						Strength at 150 days					
CHA	5.20	6.05	5.95	5.80	5.75	5.60	4.80	5.30	5.20	5.15	5.05	4.95
OPBA	5.20	6.00	5.90	5.75	5.70	5.50	4.80	5.25	5.10	5.00	4.95	4.85
CHA & OPBA	5.20	6.00	5.90	5.75	5.70	5.50	4.80	5.30	5.20	5.10	5.00	4.90

As can be seen in tables 1, 2, and 3, the strength values for OPC-CHA and OPC-OPBA binary blended cement sandcrete and soilcrete blocks as well as those of OPC-CHA-OPBA ternary blended cement sandcrete and soilcrete blocks were all less than the equivalent control values at 3-50 days of hydration for all percentage replacements of OPC with pozzolans. The strength values of the binary and ternary blended cement sandcrete and soilcrete blocks were the same with the equivalent control values at about 90 days of hydration and greater than the control values at curing ages beyond 90 days. The 150-day strength values for OPC-CHA-OPBA ternary blended cement sandcreteand soilcrete blocks were respectively 6.00N/mm^{2}and 5.30N/mm^2 for 5% replacement, 5.90N/mm^{2}and 5.20N/mm^2 for 10% replacement, 5.75N/mm^{2}and 5.10N/mm^{2}for 15% replacement, 5.70N/mm^{2}and 5.00N/mm^{2}for 20%

replacement, and 5.50N/mm^{2}and 4.90N/mm^{2}for 25% replacement; while the control values were 5.20N/mm^2 and 4.80N/mm^2. The lower strength values of blended cement sandcrete and soilcrete blocks at earlier days of hydration shows that pozzolanic reaction was not yet much at those earlier periods; the pozzolanic reaction became higher at later ages and this accounts for the much increase in strength of blended cement sandcrete and soilcrete blocks compared to the control specimens.

It can also be seen from tables 1-3 that the strength values of OPC-CHA binary blended cement sandcrete and soilcreteblocks were consistently marginally less than those of OPC-OPBA binary blended cementsandcrete and soilcreteblocks for all percentage replacements of OPC with pozzolans at 3-28 days of hydration. The strength values for the two binary blended cement composites became approximately equal at about 50 days of hydration, after which the strength values of OPC-CHA binary blended cement sandcrete and soilcreteblocks became slightly greater than those of OPC-OPBA binary blended cementsandcrete and soilcreteblocks. This suggests that the pozzolanic reaction set in more slowly for the OPC-CHA binary blended cement composites than for the OPC-OPBA binary blended cement specimens, but continued more pronouncedly at later ages of hydration. The strength values for the OPC-CHA-OPBA ternary blended cement sandcrete and soilcreteblocks wereconsistently in-between the values for the OPC-CHA and OPC-OPBA binary blended cement sandcrete and soilcrete blocks. Therefore, more OPBA than CHA should be utilized if the two pozzolans are to be used in unequal proportions to optimize the early strength of the OPC-CHA-OPBA ternary blended cement sandcrete and soilcrete blocks. However, the closeness in strength values of OPC-CHA and OPC-OPBA binary blended cement sandcrete and soilcrete blocks and the fact that the strength of the OPC-CHA-OPBA ternary blended cement sandcrete and soilcreteblocks was in-between these values suggests that the two agricultural by-product pozzolans could be combined in any available proportions individually in binary blending or together in ternary blending with OPC in making blended cement sandcrete and soilcrete blocks.

CONCLUSIONS

OPC-CHA and OPC-OPBA binary blended cement sandcrete and soilcreteblocks as well as OPC-CHA-OPBA ternary blended cementsandcrete andsoilcreteblocks have compressive strength values less than those of 100% OPC sandcrete and soilcreteblocks for 5-25% replacement of OPC with pozzolans at 3-50 days of hydration. The blended cement sandcrete and soilcreteblock strength values become equal to the control values at about 90 days of curing and greater than the control values beyond 90 days of hydration. Thus, OPC-CHA and OPC-OPBA binary blended cements as well as OPC-CHA-OPBA ternary blended cement could be used in producing sandcrete and soilcreteblocks with sufficient strength for use in building and minor civil engineering works where the need for high early strength is not a critical factor.

The strength values of soilcrete blocks were found to be less than those of sandcrete blocks for all percentages of OPC replacement with pozzolans and at all curing ages. Therefore, sand should be used in preference to laterite for making cement blocks. However, since the soilcrete block strengths were not much less than the equivalent sandcrete block strengths, good quality laterite could still be used for block making in the various communities where sand is scarce and unaffordable to the rural populace.

The strength of OPC-CHA binary blended cement sandcrete and soilcreteblocks was consistently less than that of OPC-OPBA binary blended cement specimens for all percentage replacement of OPC with pozzolans at 3-28 days of hydration. The strength of both binary blended cement composites were equal at about 50 days of curing, after which the strength of OPC-CHA binary blended cement sandcrete and soilcreteblocks became slightly greater than that of OPC-OPBA binary blended cement specimens. The strength values of OPC-CHA-OPBA ternary blended cement sandcrete and soilcreteblocks were consistently in-between the values of OPC-CHA and OPC-OPBA binary blended cement sandcrete and soilcrete blocks. This suggests that more OPBA should be used than CHA if the two pozzolans were to be used in unequal proportions to optimize the early strength of the OPC-CHA-OPBA ternary blended cementsandcrete and soilcrete blocks.

Moreover, the closeness in strength values of OPC-CHA and OPC-OPBA binary blended cement sandcrete blocks (this closeness was also observed for soilcrete blocks) and the fact that the strength of the OPC-CHA-OPBA ternary blended cement sandcrete blocks was in-between these values suggests that the two agricultural by-product pozzolans could be combined in any available proportions individually in binary blending or together in ternary blending with OPC in making blended cement sandcrete and soilcrete blocks for use in various Nigerian communities.

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