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Strength Property of Laterite Blocks Made with Different Pozzolanic Materials

Okere, Chinenye E.*

Department of Civil Engineering, Federal University of Technology, Owerri, PMB 1526, Owerri, Nigeria

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Abstract

The need for alternative building materials to reduce cost and other environmental issues necessitated this work with locally available laterite, saw dust ash (SDA) and rice husk ash (RHA) obtained from agricultural and plant wastes. A total of 216 hollow blocks of size 450mm x 225mm × 150mm were produced using a mix ratio of 1:6 with water cement ratio of 1.0. SDA and RHA were used separately and in equal proportions to partially replace Ordinary Portland Cement (OPC) using percentage replacement levels of 0%, 5%, 10%, 15%, 20%, and 25%. The blocks were cured for 7, 14, 28 and 60 days and the compressive strength obtained at these ages. The results gave an optimum percentage replacement at 10% with equal proportions of SDA and RHA with compressive strength values of 2.29N/mm^2, 2.34N/mm^2, 2.39N/mm^2, 3.09N/mm^2 at curing ages of 7, 14, 28 and 60 days respectively. When considered separately, SDA with OPC gave a higher strength value of 2.31N/mm^2 at a curing age of 28 days than RHA with OPC which gave a strength of 1.93N/mm^2. The variation of the strength with age is linear, showing that the strength increases with curing age. The compressive strength values at these specified points are greater than the recommended value by Nigerian Building and Road Research Institute (NBRRI) and Nigerian Industrial Standard (NIS).

1. Introduction

With the increasing rise in the population of Nigeria, there is no commensurate increase in shelter to accommodate the people. This can partly be attributed to the rising cost of conventional building materials. Researchers have been seeking ways to handle this by delving into alternative building materials that are less expensive and readily obtainable. Laterite has been found to be in abundance in some parts of the country and its use in block production is highly recommended to reduce dependence on river sand which is quite expensive. The numerous advantages of laterite identified by some scholars make laterite desirable [1-6]. Cement which is another major material, has its own drawbacks in terms of cost, green house effects, etc. The introduction of supplementary cementitious materials will go a long way to addressing these issues. Moreover, cementing quality is enhanced if a good pozzolanic material is blended in suitable quantity with OPC [7]. These pozzolanic materials are disguised in form of our agricultural and industrial wastes. The environmental degradation caused by these wastes will be greatly reduced when they are channeled to more profiting outlets. Researchers have been making efforts to convert wastes to useful purposes [8-10]. Literatures abound on the use of these wastes in blended OPC production with its varied applications in concrete, sandcrete block production but not in laterite block production [11-15]. Hence this study. As a matter of fact, a group of researchers [16] worked on blended Ordinary Portland Cement, Afikpo Rice Husk Ash and Sawdust Ash in sandcrete production proving the pozzolanicity of these wastes cum ashes.

As a result of agricultural and plant processes going on in Nigeria, several tons of wastes such as rice husk and saw dust are generated. In this work, ashes from these wastes were adopted together with Ordinary Portland Cement in producing laterite blocks. In other words, OPC was replaced partially with the ashes using 5% to 25% replacement and the effect of this was considered on the compressive strength of the laterite blocks.

2. Methodology

2.1 Materials

The following materials were used for this research:

Laterite: The laterite sample was collected at a depth of 1.5 to 2.5m from an existing borrow pit at Otamiri Umuchima which is beside Federal University of Technology Owerri, using method of disturbed sampling. The grading and properties conformed to British Standards [17].

Cement: The cement used was an eagle brand of Ordinary Portland Cement (OPC) bought from cement depot at Ihiagwa Owerri Imo state, Nigeria with properties conforming to British standard [18].

Rice Husk Ash (RHA): Rice husk was collected from Amasiri Afikpo, Ebonyi State, Nigeria. The sample was carefully collected to avoid mixing the rice husk with sand. The collected sample was burnt into ashes by open burning in a metal container. The rice husk ash was collected when it was cool.

Saw Dust Ash (SDA): The saw dust used for this study was collected from saw mill points in Owerri, Imo State, Nigeria. The sample was carefully collected to avoid mixing the saw dust with sand. The collected sample was burnt into ashes by open burning in a metal container. The saw dust ash was collected when it was cool.

Water: Fresh, colourless, odourless and tasteless tap water free from contaminants either dissolved or in suspension conforming to the standard specifications [19] was used.

2.2 Preparation and Testing of Specimen

The laterite samples were air-dried for twenty days in a cool, dry place.The production process comprises the batching, mixing, casting, compaction and curing of the blocks. A total of 216 hollow blocks of size 450mm x 225mm × 150mm were produced using a mix ratio of 1:6 (binder:laterite) with a constant water cement ratio of 1.0. SDA and RHA were separately blended thoroughly with OPC using the required replacement percentages of 0%, 5%, 10%, 15%, 20%, 25% and the blended cement was mixed with laterite and water using the prescribed mix ratio and water cement ratio. SDA and RHA were also blended in equal proportions and subsequently blended with OPC using the required replacement percentages of 0%, 5%, 10%, 15%, 20%, and 25% and the blended cement was mixed with laterite and water using the prescribed mix ratio and water cement ratio. Note that the 0% replacement acts as the control because no ash was added. Three blocks were produced for each percentage replacement of OPC with ash and were tested for compressive strength using the universal testing machine.

3. Results and Discussion

Note that the SDA & RHA were sourced from Afikpo, Ebonyi State, the same location as in the work of Ettu and coworkers [16] and were prepared using the same method. According to Ettu et al, [16], the chemical analysis of the ashes showed they both satisfied the ASTM requirement that the sum of SiO_2, Al_2O_3, and Fe_2O_3 should be not less than 70% for pozzolans. The results of the compressive strength tests carried out on the laterite blocks are presented on Table 1.

Table 1: Compressive Strength of laterite blocks made with OPC, RHA and SDA at 7 - 60 days of curing

OPC Plus	COMPRESSIVE STRENGTH (N/mm^2) for					
	0% Poz	5% Poz.	10% Poz.	15% Poz	20% Poz.	25% Poz.
	Strength at 7 days					
SDA	1.86	1.36	1.00	1.19	0.97	1.43
RHA	1.86	0.95	1.16	1.06	0.87	0.58
SDA & RHA	1.86	1.94	2.29	1.77	1.31	0.74
	Strength at 14 days					
SDA	2.19	2.18	1.48	1.27	1.04	1.46
RHA	2.19	1.45	1.60	1.43	1.35	1.04
SDA & RHA	2.19	2.21	2.34	2.00	1.63	1.20
	Strength at 28 days					
SDA	3.05	2.58	2.31	1.64	2.01	2.03
RHA	3.05	2.28	1.93	1.72	1.75	1.05
SDA & RHA	3.05	2.28	2.39	2.41	1.90	1.51
	Strength at 60 days					
SDA	3.12	2.62	2.71	2.62	2.54	2.25
RHA	3.12	2.40	2.46	2.00	1.95	1.20
SDA & RHA	3.12	2.97	3.09	3.01	2.94	2.89

The results show that the combination of SDA and RHA with OPC gave better strength values than when the ashes were used separately with OPC in the block production with 10% as the optimum percentage replacement (See Figure 3). The strength values at this optimum percentage replacement are 2.29N/mm^2, 2.34N/mm^2, 2.39N/mm^2, 3.09N/mm^2 at curing ages of 7, 14, 28 and 60 days respectively. When considered separately, SDA with OPC gave a higher strength value of 2.31N/mm^2 at a curing age of 28 days than RHA with OPC which gave a strength of 1.93N/mm^2. These compressive strength values are greater than the recommended value by Nigerian Building and Road Research Institute (NBRRI). NBRRI proposed a compressive strength of 1.65N/mm^2 for laterite blocks [20]. Moreover, these obtained values can compete favourably with the recommended value of Nigerian Industrial Standard (NIS) [21] for hand-compacted sandcrete blocks which is

2.0N/mm^2 [6]. Considering the recommended values, the ashes can be used separately with OPC to obtain good quality blocks at higher curing ages. The strength values for the control (0% replacement) show relatively higher values than those with percentage replacement but for a few exceptions and as expected, the values increased with curing ages. The effect of the curing ages on the strength of these blocks could be seen from the results and charts in Figures 1-3. The variation of the strength with age shows that as the curing age increases, the strength increases with the highest strength value being 3.09N/mm^2, at 10% replacement with equal combinations of SDA and RHA at a curing age of 60 days.

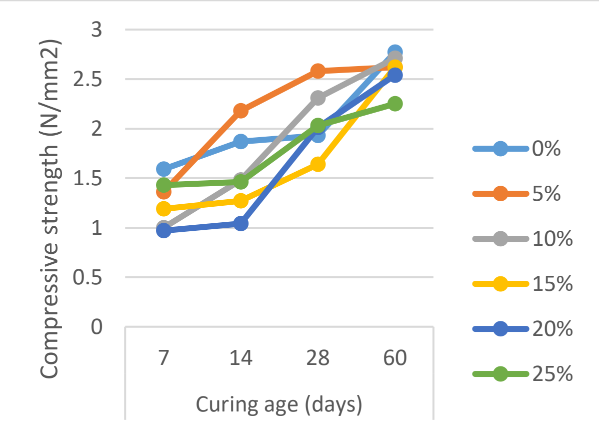

Figure 1: Graph of compressive strength against curing age for OPC and SDA only

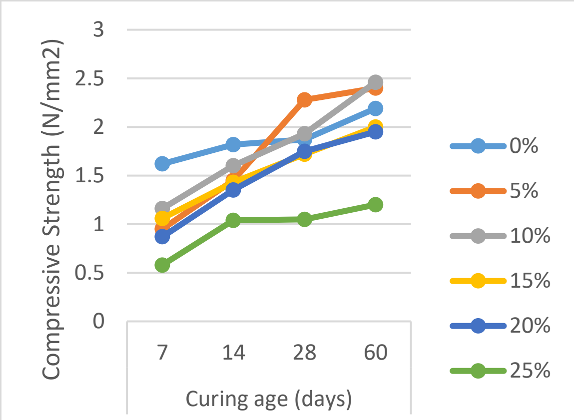

Figure 2: Graph of compressive strength against curing age for OPC and RHA only

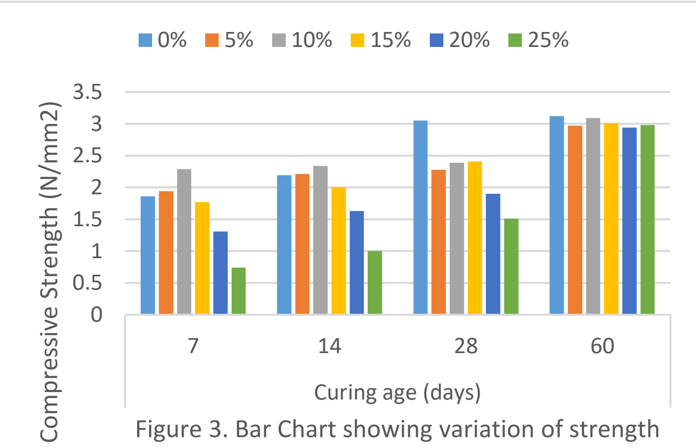

Figure 3. Bar Chart showing variation of strength with age for combination of OPC, SDA & RHA

4. Conclusion

Laterite blocks were made with OPC using 0% to 25 % replacement of the cement with pozzolanic materials (SDA and RHA) individually and in equal proportions adopting a mix ratio of 1:6 and constant water-cement ratio of 1.0. The compressive strength of the blocks was checked at 7, 14, 28 and 60 days of curing. The optimum percentage replacement is 10% with equal proportions of SDA and RHA. SDA with OPC gave a higher strength value at a curing age of 28 days than RHA with OPC. The variation of the strength with age is linear, showing that the strength increases with curing age.

The compressive strength values at these specified points are greater than the recommended value by Nigerian Building and Road Research Institute (NBRRI) and Nigerian Industrial Standard (NIS). Laterite blocks can be used for non-load bearing walls and in cases where early strength is not a critical factor.

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