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The Effects of Some Agricultural Wastes Ash on the Compressive Strength of Concrete

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Abstract

This research work examined the optimum compressive strength and density in sawdust ash and rice husk ash blended concrete. The reason for the research was due to the increase in green houses gas emission associated clinkers production for cement and also the ever-increasing cost of housing. The sawdust ash and rice husk ash concrete were prepared and replaced with cement at weighted percentages of 2 %, 4 %, 6 %, 8 %, 10 %, 12 %, 14 %, 16 %, 18 %, 20 % at 0.6 water/cement ratio. A total of one hundred and sixty-eight (168) concrete samples of 100 mm x 100 mm x 100 mm were produced and cured by immersion for 7 days, 14 days, 28 days, and 120 days respectively. The results show that at 120 days curing duration, the optimum density of the control concrete was reported as 2740Kg/m^3 which was less than that of the sawdust ash and rice husk ash blended concrete density recorded as 2852 kg/m^3 and 2919 Kg/m^3 and obtained at 2 % replacement of SDA and RHA respectively. Also, the optimum compressive strength for the control concrete of 35.5 N/mm^2 was similarly obtained for saw dust ash and rice husk ash concrete but at 2 % and 12 % replacements cured at 120 days. Regression coefficient of linear multiple regression model was determined. The R^2 was recorded as 0.985964 and 0.906269 for SDA and RHA respectively which shows the adequacy of the linear model.

1. Introduction

Concrete is rank third behind air and water as the most widely utilized construction material due to its application [1]. Cement is an expensive material, within the ingredients of concrete, and its demand is constantly increasing all over the globe. Hence, to control the cost of construction, it is important to utilize some waste materials to meet the increasing demand usage of concrete. Agricultural waste such as sawdust ash (SDA), rice husk ash (RHA) can be used as partial replacement in producing efficient concrete with improved concrete properties [2]. Utilizing these wastes as replacement materials in concrete is due to their huge pozzolanic behavioural quality [3]. The current practice is that sawdust wastes have been converted as fuel for domestic cooking and sand filling of ditches which invariably constituted environmental nuisance. Converting sawdust wastes into usefulness in concrete will create a safe environment free from some levels of pollution and jobs are created for our teeming unemployed youths who could become agents for supplying the sawdust wastes to concrete industries that needs it [4]. [5] reported on the highly reactive rice husk ash concrete. They found out that the compressive strength of mortar and concrete significantly increased by the RHA addition and became higher than those for the control concrete and mortar. Studies showing increased compressive strength are also reported by [6]. Rice husk wastes are

readily abundance in rice producing countries and the ashes obtained from it, are rich in silica which make it to be suitable for use as cement replacement materials [7; [8]; 9]. It also increases the concrete properties through the pozzolanic reaction of RHA with cement hydration and the filler effect, hydration heat reduction [10; 11].
Several studies [12; [13]; 14], have reported that the insertion of RHA as partial replacement for cement can enhance the compressive strength of concrete and mortar. These RHA materials are usually stockpiled in large quantities and mostly dump as residue thereby constituting a nuisance and environmental pollution especially in an area where they have been accumulated in large quantities. Thus, reason for the use of these materials in construction are considered as the most environmentally friendly method for their disposal [13]. The fineness of ash prepared depends on various heating temperature conditions like temperature rate of heating [15]. The high cost in the price of cement and other building materials across Nigeria has reawakened serious need to relate research to production, especially in the use of locally available materials as alternatives for construction of functional but low-cost dwellings in both rural and urban areas in the country. This work aimed at optimizing and predicting compressive strength of concrete when one of its conventional materials; cement is partially replaced by sawdust ash and rice husk ash in concrete production.

2.0. Materials and Method

The sawdust and rice husk collected from local mills in Benin City was burnt in a furnace at a temperature of 650^{o} C in Civil Engineering Laboratory, University of Benin in order to obtained the ashes. After cooling, the ashes were sieved through sieve size No.200 to obtained fine particles of the ashes, while the ones retained on the sieves were ground and re-sieved again which were used for the preparation of blended concrete according to [16] standards. Portland limestone cement grade of 42.5 N was used in the course of this work.
Coarse aggregate used in this experimental work was crushed granite of maximum size 20 mm obtained from a local crushing plant. Also, fine aggregate used in the experiment was locally available river sand. Steel moulds of 100 mm X 100 mm X 100 mm were used. Replacement of sawdust ash and rice husk ash with cement was done at 0 %, 2 %, 4 %, 6 %, 8 %, 10 %, 12 %, 14 %, 16 %, 18 % and 20 % in weighted percentages in grade 20 concrete. The low levels of replacement percentages of the agricultural samples were chosen to ascertain its sensitivity on some mechanical properties of concrete.
Concrete cubes were cast, compacted and left in the moulds for 24 hours to solidify. It was then cured by immersion for 7 days, 14 days, 28 days and 120 days respectively. Again, the compressive strength was tested in accordance with standards of [17] and density of blended concrete was also determined in accordance with standards of [18]. Finally, the various compressive strength of the pozzolanic concrete were predicted using regression analysis. Data were also obtained from some laboratory test conducted which included particle size distribution test, slump test of SDA and RHA, density test and compressive strength test of blended concrete.

3.0. Results and discussion

3.1. Particle Size Distribution Test Results

The particle size distribution test was carried out for fine and coarse aggregate in accordance with [19] methodology and the fine aggregate was found to be a poorly graded material while the coarse aggregates was well graded as shown in Figure 1 and 2.

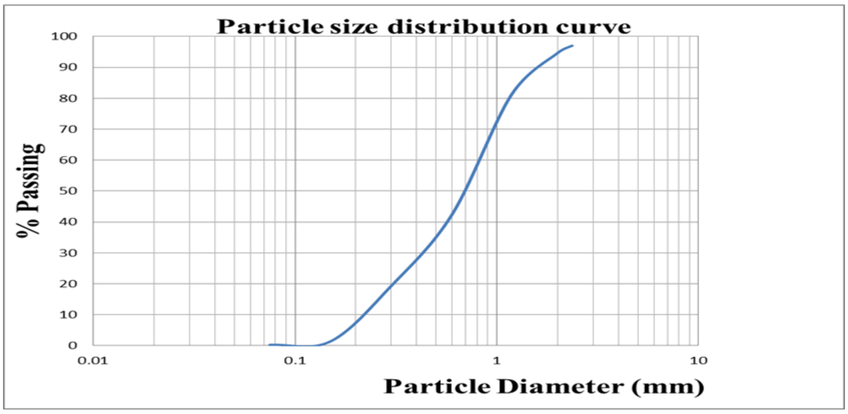

Figure 1: Particle size distribution of fine aggregate

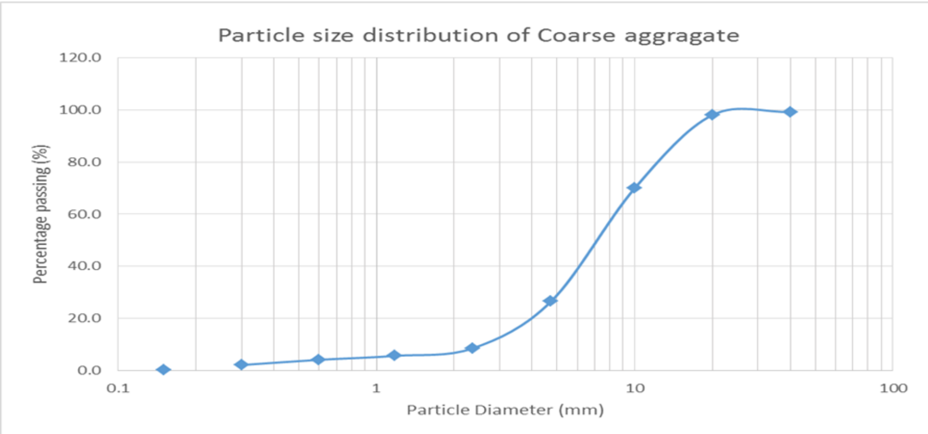

Figure 2: Particle size distribution of coarse aggregate

3.2. Slump test result

The slump test methodology was carried out in accordance with [20]. The results obtained in Figure 3 reported that the control concrete slump value was 40 mm and was higher, when compared to both sawdust ash and rice husk ash blended concrete's slump values at various percentage replacements. Thus, as the percentage replacement increased, concrete transit from plastic to stiff-plastic mix. This corroborates findings of earlier studies by [21].

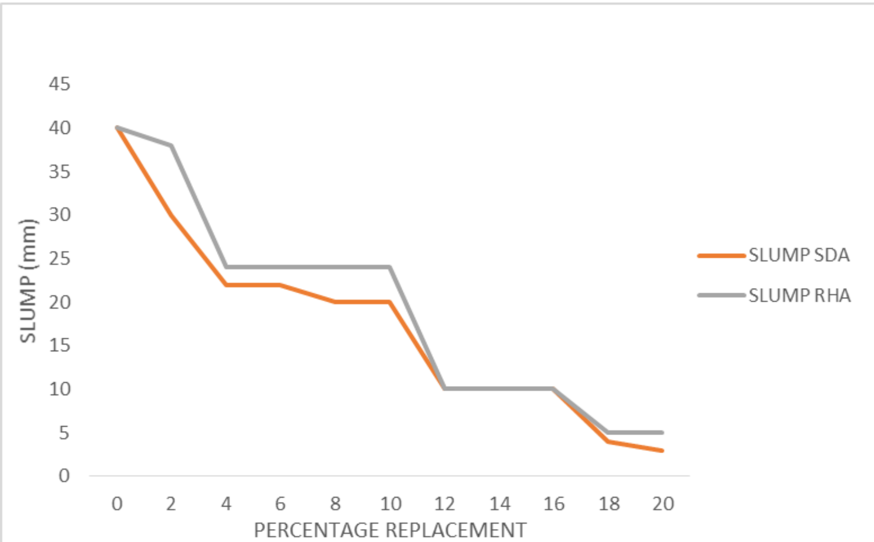

Figure 3: Relationship between slump and percentage replacement of SDA and RHA blended concrete

3.3. The effect of SDA and RHA on the density of blended concrete

The density results are shown in Figure 4 and 5. The density results of blended concrete indicates a rise and fall of values as the percentage replacement level increased and at different curing durations. However, the optimum density was obtained at 2 % replacement for SDA and RHA blended concrete at 120 days curing duration. This is as a result of pozzolan lime reactions which are usually slow due to their behaviour of delay in pozzolanic reaction which will gradually become denser than plain concrete with time. This finding was corroborated by the report of [21].

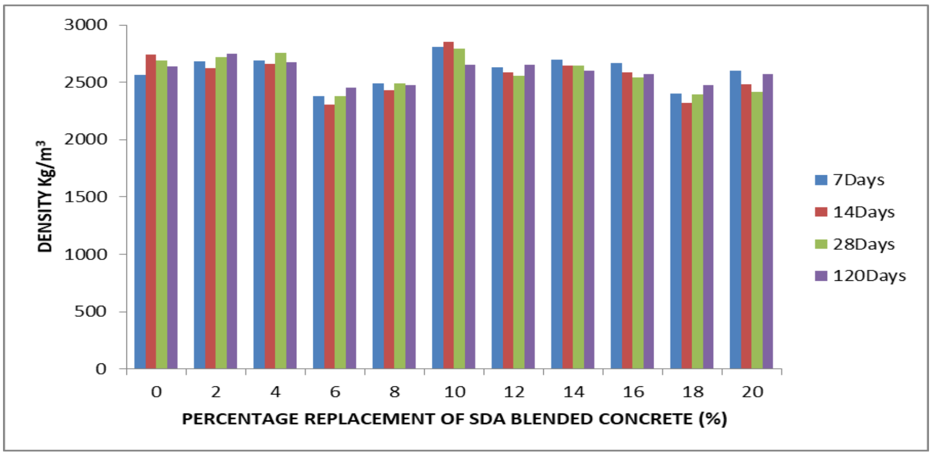

Figure 4: Relationship between density and percentage replacement of SDA Blended Concrete

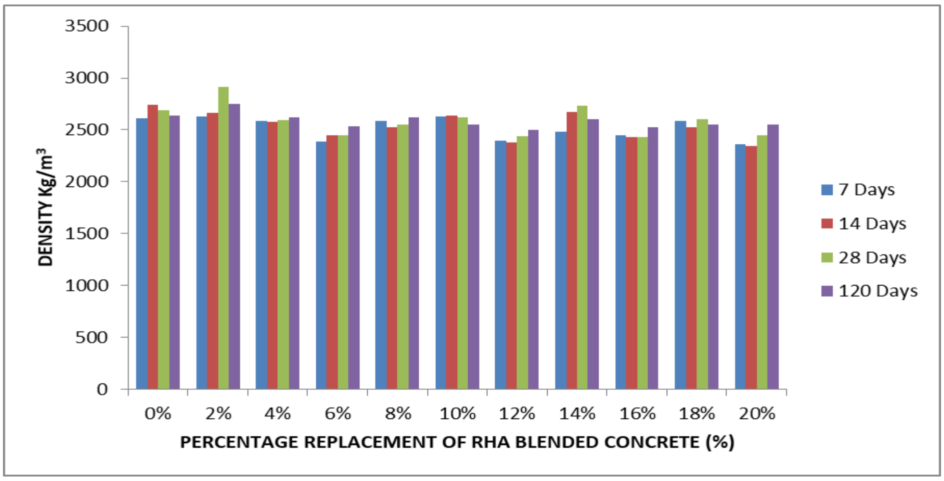

Figure 5: Relationship between density and percentage replacement of RHA blended concrete

3.3. The effect of SDA and RHA on the compressive strength of the blended concrete

The compressive strengths of blended concrete samples are shown in Figure 6 and 7. The optimum compressive strength recorded was obtained at 35.5N/mm^2 for the control at 120 days curing duration. Furthermore, SDA blended concrete optimum compressive strength was obtained at 2 % replacement and at 120 days curing duration while for RHA blended concrete it was recorded at 12 % replacement and at 120 days curing period. The results indicate that the strength of the SDA and RHA blended concrete cubes increases with age of curing and decreases with the addition of the RHA content. This corroborates earlier findings by [6].

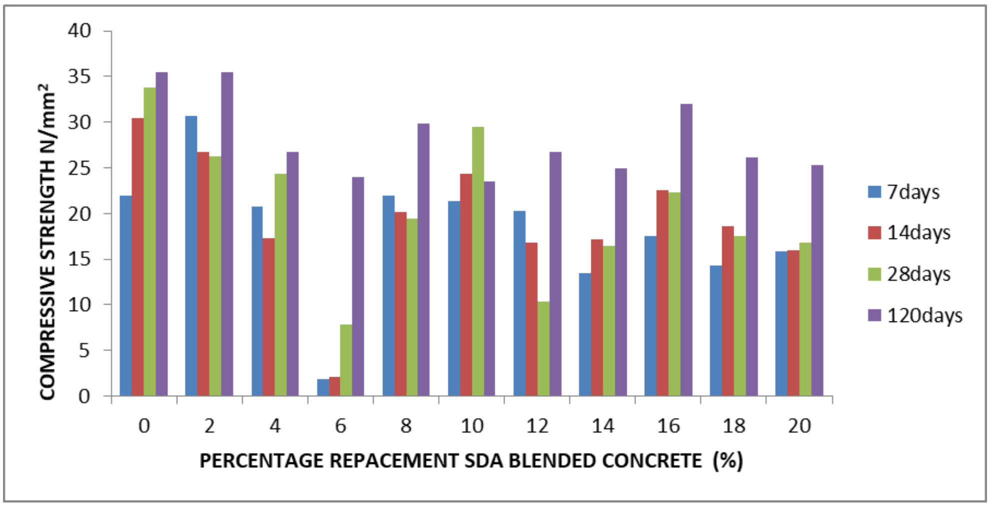

Figure 6: Compressive strength of SDA concrete

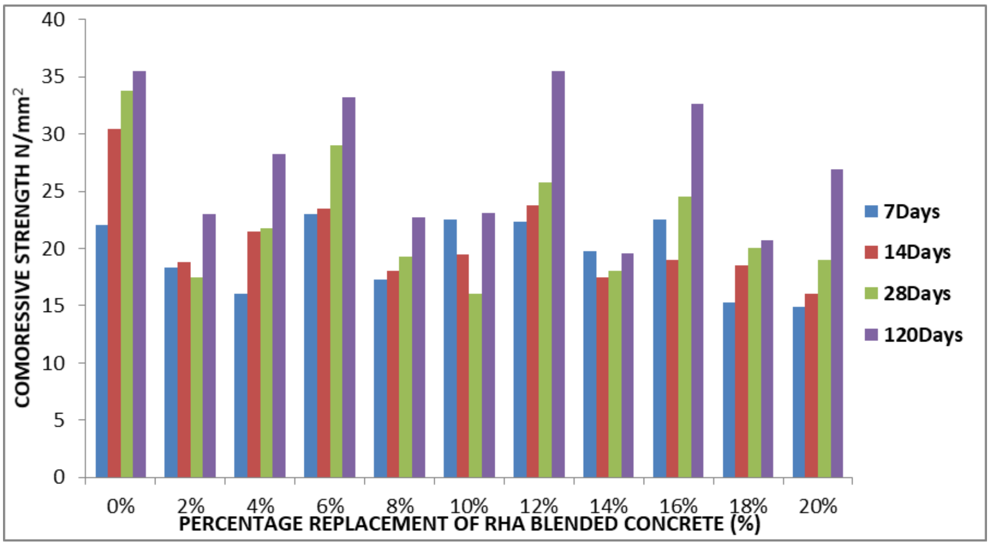

Figure 7: Compressive strength of RHA concrete

3.4. Regression analysis results

Regression equation relating compressive strength of the blended concrete (dependent variable), percentage replacement (independent variable) and curing age (independent variable) was developed as given in equation 1. Also, regression coefficient of linear multiple regression model was determine using the excel data analysis tool pack for the evaluation of the compressive strength of the various blended concrete and results obtained are as shown in Table 1.

$$Y = b_0 + b_1x_1 + b_2x_2 \quad (1)$$

where;

Y = Predicted compressive strength
b_0 = Intercept
b_1 = Slope of x_1
x_1 = percentage replacement
b_2 = Slope of x_2
x_2 = curing age

Table 1: Regression analysis data for SDA and RHA concrete cured at 120 days duration

Regression Statistics	**SDA Concrete**	**RHA Concrete**
Murtiple R	0.992957	0.951982
R Square	0.985964	0.906269
Adjusted R Square	0.957891	0.718808
p- value	0.0126	0.03312
F- value	35.122	4.83444
Standard error	1.01451	2.155021
Observation	4	4

$$Y = 35.352 + 0.151x_1 - 0.095x_2 \quad (2)$$

Equation 2 gives the linear model of the blended concrete at 120 days curing duration. The R^2 was recorded as 0.985964 and 0.906269 for SDA and RHA blended concrete respectively and this shows the adequacy of the model while adjusted R^2 was recorded as 0.957891 and 0.7718808 which shows how the variations in the compressive strengths are accounted for by independent variables (curing age and percentage replacement). Finally, F- values of 35.12 and 4.83 are statistically significant from the SDA and RHA concrete model which indicate that the linear model can help to predict the compressive strength of the concrete. Again, the p –values of the SDA and RHA model results were less than 0.05 hence, the better the chances of the model.

4.0. Conclusion

According to the findings in this work, as the percentages of the SDA and RHA contents increased in the concrete, the slump of the blended concrete transit from plastic to stiff plastic concrete. The density of the SDA and RHA concrete increased and decreased at intervals of curing duration and percentages replacement of the agricultural wastes in concrete. However, the density of the blended concrete was peaked at 2 % replacement by weight of both the SDA and RHA concrete cured at 120 days duration. This work has shown that the optimum compressive strength of SDA concrete can be obtained at 2 % replacement by weight while that of the RHA concrete can be obtained at 12 % replacement by weight. These occurrences were also observed in the density of the blended concrete which shows that there may be a correlation between the density and compressive strength of the blended concrete.

The work also shows that the linear regression model was able to predict the compressive strength of the blended concrete at 120 days curing duration with an adjusted coefficient of determination (R^2) of 0.957891 and 0.7718808 for SDA and RHA concrete with a p value of less than 0.05 respectively which makes the linear model significant. The data obtained from this study may be useful for practitioners in the construction industries who may be keen in the production of SDA and RHA blended concrete.

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