NIPES

Journal of Energy Technology and Environment

Journal homepage: www.nipesjournals.org.ng

The Evaluation of Compressive Strength and Curing Duration of Binary Blend of Rice Husk Ash Concrete

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Article Info

***Keywords*:**
pozzolans, compressive strength, blended concrete, curing duration, replacement

Received 23 November 2020
Revised 09 December 2020
Accepted 19 December 2020
Available online 23 Dec. 2020

https://doi.org/10.37933/nipes.e/2.2020.6

https://nipesjournals.org.ng

Abstract

This paper examines the compressive strength of the binary blend of rice husk ash concrete and curing period. The purpose of the study was to source for local materials like agricultural waste that could replace some percentages of cement in order to make it more economical in concrete and to ascertain its usefulness in the construction industry. A quantitative method was used for the research design. The total concrete specimens of size 100mm x100mm produced in the laboratory were one hundred and twenty (120). The rice husk were completely burnt in an electric furnace to obtain the ash and 0 %, 5 %, 10 % and 15 % of the ashes were used to replace cement in grade 20 concrete. The curing duration were 7 days, 28 days, 30 days, 60 days, 90 days, 120 days, 150 days and 200 days respectively. The result revealed that compressive strength of the rice husk ash concrete increases as the curing period increases and there was decrease in the compressive strength of the pozzolanic concrete as the percentages of rice husk ash increases in the concrete. The binary blend of rice husk ash at 5% replacement had the maximum compressive strength of 40 N/mm^2 at 200 days of curing period, while the control concrete compressive strength was 22.0 N/mm^2. The 5% RHA had given more improved results in concrete when cured for a longer period of 200 days.

1. Introduction

Cement production is increasing globally at 3% annually [1] which amounts to 2.1 billion tons per year and is expected to grow to about 5.2 billion tons in 2019 [2]. In Nigeria the cement requirement has been put at 23.2 million tons as at 2015 [3] and local production stands at 15.8 million tons, while the shortfall of 7.4 million tons are imported [4]. These statistics have shown that cement demand is in excess of supply. Therefore, there is need to source for local materials that are cementitious in pulverized state, to complement the production of cement. The use of agricultural pozzolans like rice husk ash may improve the situation. The reaction of the pozzolan with cement, forms additional calcium silicate hydrates (C-S-H), which gives better strength and durability of concrete [5]. Research concerning mineral admixtures use to argument the properties of concrete has been going on for many years. Economics and environmental considerations also have a role in the growth of mineral admixture usage. The lower cement requirement leads to a reduction in the amount of carbon dioxide generated by the production of cement and hence its emission to atmosphere [6]. The addition of wide range of blending material also introduces significant diversity into the cementing system.

Rice husk ash (RHA) is obtained from the milling industry of rice. The ash is obtained by burning the husks of rice paddy. The controlled burning of rice husks takes place at temperatures ranging from 500°C and 800°C, which produce a non-crystalline amorphous RHA [7]; [8]. It is whitish or grey in color. The particles of RHA possess cellular structure with a very high surface area. RHA has 90–95% amorphous silica [9]. Rice plant is one of the plants that extract silica from the soil and assimilates it into its structure during its growth [10]. It produces relatively large proportions of ash which contains around 90% silica at the instance of burning the rice husk [11].

It possesses wonderful pozzolanic activity because of its high surface area and high silica content. After Mehta's findings in 1973 [9], the use of RHA in construction materials was accelerated. According to Givi et al. [12], RHA can be used in mortar and concrete with a good workability. Ismaila and Waliuddin [13] made high-strength concrete with RHA. Moreover, Zhang and Mohan [14] produced high performance concrete, using RHA as a supplementary cementing material. As a part of composite cement, normal-strength self consolidating concrete can be obtained from RHA [15]. It can also be used for producing self-consolidating high-performance concrete with improved hardened properties and durability [16]. The use of RHA decreases the porosity, and thus improves the compressive, tensile and flexural strengths of concrete. RHA also improves the freeze-thaw durability and corrosion resistance of concrete [17]. RHA can also be used successfully in other construction materials such as bricks and blocks without any degradation in the quality of products [17];[18];[19]. The compressive strength of bricks is increased in the presence of RHA and therefore recommended the use of RHA bricks in load-bearing walls [18]. He also showed that the absorption capacity of RHA bricks lies within the permissible limit [18]. RHA was used to develop innovative interlocking blocks for use in sustainable housing. They also obtained good compressive strength for the blocks incorporating RHA [17]. Curing is the process of controlling the rate and extent of moisture loss from concrete during cement hydration [20]. It may be either after it has been placed in position (or during the manufacture of concrete products), thereby providing time for the hydration of the cement to occur. Since the hydration of cement does take time, curing must be undertaken for a reasonable period of time if the concrete is to achieve its potential compressive strength and durability. Curing may also encompass the control of temperature since this affects the rate at which cement hydrate [20]. Curing is designed primarily to keep the concrete moist by preventing loss of moisture from it during the period in which it is gaining strength. Curing can be achieved by keeping the concrete element completely saturated or as much saturated as possible until the water-filled spaces are substantially reduced by hydration products [20]. Since it has been established from literatures that rice husk ash is useful in concrete, effects of the prolong curing of the rice husk ash concrete will be examined in relation to its compressive strength.

2 Materials and Methods

The materials used consist of rice husk ash (RHA), Portland cement, crushed coarse aggregate of 20 mm size, fine aggregate and water. The tools used included steel mould of (100 mm x100 mm x 100 mm) size, shovel, head pans and concrete mixer. The ash was obtained by controlled burning of the rice husk with the help of a muffle furnace until the ash was produced at 500^{o}C for 5 hours. The burnt ash was sieved through British Standard sieve of 75 microns after grinding. The portion passing the sieve was adequate for the required degree of fineness that is 63 microns and below while the ash retained on the sieve were reground and sieved again. The pulverization of the rice husk ash (RHA) was carried out before it was added to grade 25 concrete at 5%, 10%, and 15% by weight respectively of the cement. The RHA concrete specimen produced was one hundred and twenty (120) moulds of dimensions 100 mm x 100 mm x 100 mm according to [21] methodology. After the curing duration of 7 days, 14 days, and 28 days on the concrete specimens, compressive tests were carried out. The compressive strengths tests were conducted using [22] methodology.

Several tests which included sieve analysis test for the sand and the rice husk ash (RHA), slump tests were also carried out on the materials.

3 Results and Discussion

RHA X-ray fluorescent

The X- ray fluorescent analysis carried out on the RHA reveals some chemical compounds found in rice husk ash (RHA). The percentage of silicon dioxide (SiO_2) found in the RHA was 87.22 % which was more than the minimum of 70 % specified for pozzolans by [23].

3.1 Sieve Analysis Test

The fine aggregate was subject to sieve analysis in accordance with [24] methodology. The result of the sieve analysis of the fine aggregate, are shown in Figure 1.

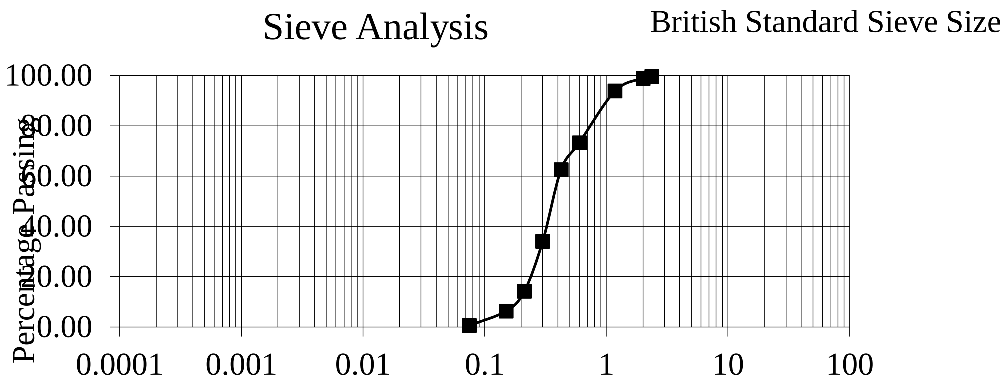

Figure 1: Sieve analysis of fine aggregate

3.2 Specific Gravity Test

The samples of the RHA, cement, fine and coarse aggregate were subjected to specific gravity test according to [25] methodology. The result of the specific gravity obtained show that the fine aggregate and coarse aggregate has 2.65 and 2.70 respectively. The RHA was 1.02 which was lighter than cement of value 3.15.

3.3 RHA and OPC concrete compressive Strengths

As the curing days increase, the compressive strength of concrete increases also for all the percentages of cement replacement with RHA pozzolan in concrete as shown in Table 1 and Figure 2. Its result has shown that binary replacement of cement with RHA pozzolan can be possible up to 15 %, for curing duration up 200 days.

Table 1: Compressive strength and curing age of RHA concrete

Age of Curing (Days)	Compressive Strength (N/mm^2)			
	5% RHA	10% RHA	15% RHA	Control (OPC)
7	8.5	7.2	1.2	9.4
28	13.8	12.5	1.7	14.1
30	15.5	21.0	2.0	16.0
60	18.5	21.5	3.0	16.5
90	29.0	25.2	5.5	18.5
120	31.0	25.5	9.0	18.5
150	35.0	25.5	14.8	19.5
200	40.0	27.2	24.2	22.0

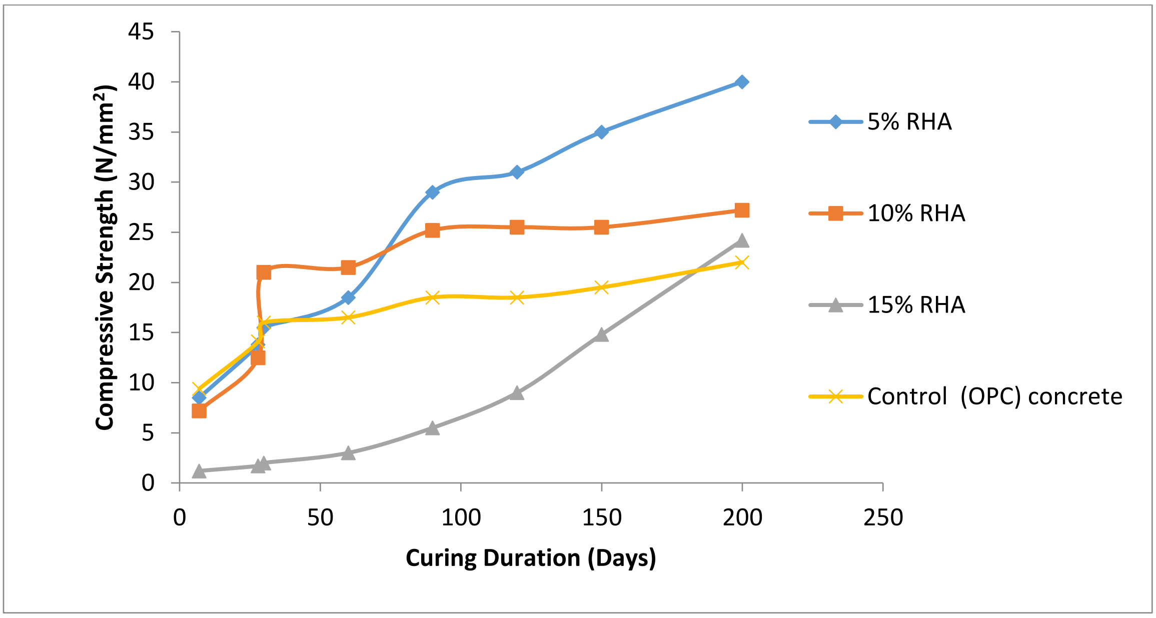

Figure 2: Compressive strength and curing period at 0%-15% RHA concrete

Compressive strength of 0 %, 5 %, 10 % and 15 % pozzolans RHA blended concrete at several curing periods using 0.6 water/cement ratios are shown in Figure 1. The 5 % RHA blended concrete had compressive strength of 40 N/mm^2 at 200 days curing period while the OPC concrete gave a compressive strength of 22.0 N/mm^2 at 200 days of curing. The 5 % RHA blended concrete strength increase started from 90 days of curing with a compressive strength of 29.0 N/mm^2 while 10 % RHA blended concrete started its strength increase at 30 days with a compressive strength of 21.0 N/mm^2. The increase of compressive strength may be due to silica content in the RHA, bonding with the cement to produce more calcium silicate hydrate paste (C-S-H) which is the strength component of the concrete. This was collaborated by [26].

The 15 % RHA blended concrete started its strength increase from 200 days with compressive strength of 24.2 N/mm^2. However, the binary blend of rice husk ash at 5 % replacement had the maximum compressive strength of 40.0 N/mm^2 at 200 days while the control concrete compressive strength was 22.0N/mm^2. This represents about 81.8 % increase of the RHA concrete over the OPC concrete. This shows that prolonging the curing duration for RHA concrete, the better compressive strength result obtained and this was collaborated by [27].

4. Conclusions

This study has shown that rice husk ash is pozzolanic because it satisfies the minimum requirement of 70 % composition requirements according **to** [23]. More so, the rice husk ash (RHA) concrete's compressive strength consistently increased as the curing period increases. The 5 % RHA concrete gave an optimum value of 40 N/mm^2 which was 81.8% higher in compressive strength to the OPC concrete, when cured for 200 days duration. The 15 % by weight of RHA concrete can be used for structural applications when cured up to 200 days. This work has provided a database of the reaction of RHA pozzolan on the compressive strength of concrete subjected to prolong duration of curing.

5. Conflict of Interest

There are no conflicts of interest associated with this article.

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