Quest Journals
Journal of Architecture and Civil Engineering
Volume 6 ~ Issue 1 (2021) pp: 19-24
www.questjournals.org

Research Paper

Characterization of Sandcrete Blocks Mixed With Burnt Tyre Residues (rubber ash)

[1]Okonkwo V. O., [2]Onodagu P. D
[12]*Department of Civil Engineering*
Nnamdi Azikiwe University, Awka Nigeria

ABSTRACT
The influx of used tyres into Nigeria is very high. It has left the country with a high quantity of waste or disposed tyres as these used tyres have a limited lifespan on arrival into the country. It was observed apparently that because of its vast availability many sandcrete block manufacturers use the residues of burnt tyres as a colour pigment in their blocks. In this work an investigation was carried out into the effect of using burnt tyre residues (BTRs) as a partial replacement for cement in sandcrete blocks. The results showed that the introduction of BTRs in sandcrete blocks is not only for esthetics, but also for a cost-saving measure.

Received 05 Jan, 2021; Revised: 18 Jan, 2021; Accepted 20 Jan, 2021 © The author(s) 2021. Published with open access at www.questjournals.org

I. INTRODUCTION

Over 90% of building infrastructures in Nigeria are constructed using sandcrete blocks [1, 2]. When producing sandcrete blocks, the following ingredients: cement, sand or fine aggregates and water are used. Cement plays an indispensible role in sandcrete block production as it is the material that binds the other constituents together to form a compact whole. It is also the most expensive component of sandcrete block [3]. Sand is inert filler and generally constitute at least three quarters of the volume of the sandcrete blocks. Fine aggregates are generally rock particles whose sizes are below 5mm. The recent British and European Standard (BS EN 12620, 2002) however, puts the dividing line between fine and coarse aggregate at 4mm. The water/cement ratio should be such that allows for proper hydration of the cement while allowing the block to stand unsupported after demoulding. Wenapere and Ephraim [4] gave a suitable water/cement ratio for block production as 0.5. Like in concrete, strength of block is known to decrease with increase in water/cement ratio. However, too much dry mix will also lead to fracture during demoulding.

Properties of sandcrete blocks

Strength and durability are two important properties of hardened sandcrete blocks. These properties are dependent, to a large extent, on the material constituents and mix proportions, presence of admixtures and manufacturing process [5]. The strength properties of sandcrete blocks are compressive strength, flexural strength, split tensile strength and shear strength and static modulus of elasticity. Durability is that property of sandcrete block that requires it to perform its intended functions, that is its strength and serviceability during the specified service life [6]. There are many other properties that are used as an indicator of durability of block. One of such properties is water absorption test. NIS 87: (2004) [7], recommends that sandcrete blocks should have water absorption not greater than 6%. According to NIS 87: (2004), the average minimum compressive strength of load bearing capacity of hollow sandcrete block for hand compaction is 2.0N/mm^2

But in present day, some materials are added during the production process which have effects on the sandcrete blocks [8]. Some of these materials include fly ash from coal combustion, rubber ash obtained from burning of waste rubber tyre, rice husk ash from burning of rice husk, metakaolin etc

Waste tyres

The accumulation of waste tyres is one of the major environmental problems worldwide [9, 10]. As scrap tyres are non degradable materials, they can cause serious problems to the environment and public health. For example, they can become breeding sites for mosquitoes and rodents as water become stagnant inside the tyres. They can also cause accidental fires and take up landfill space. Some people get rid of waste rubber tyres through open burning and by using them as source of fuel [11, 12].

Several investigations were carried out on the use of scrap tyre particles for production of concrete or block by partial replacement of fine aggregate with rubber tyre particles. The processed rubber tyres were used to replace fine or coarse aggregates depending on the fineness of particles [10]. Mechanical behavior of concrete containing rubber particles have been investigated by many researchers. Their result showed that the blocks exhibited lower mechanical strengths but showed a stronger resistance to impact [13, 14, 15].

Burnt tyre residue (BTR)

Waste rubber tyres can be decomposed through a pyrolysis process to produce rubber ash. The process is operated at high temperatures above 430^0C (800^0F) and in the absence of oxygen. Rubber ash can be added to mortar to improve its compressive and flexural strengths [16]. Senin et al [17] while working on cement concrete with sand partially replaced with rubber ash discovered that a 3% percentage replacement of sand with rubber ash actually increased the flexural strength of concrete.

In Nigeria, however, controlled burning of tyre is very rare and the unhealthy open air burning is commonly practiced. The residue produced after burning for the sake of this work was termed 'Burnt tyre residue'.

II. MATERIALS AND METHODS

Soil classification was done using the results obtained from a dry sieve analysis test. The knowledge of the grain size analysis result is necessary for the determination of the relative proportion of the various grain sizes that make up the sand sample. The sandcrete blocks in this study were made of cement, sand, BTR and water. The cement used was Dangote brand Portland limestone cement. The sand used was collected from river Niger at Onitsha, Anambra State, Nigeria. The sand was sharp and free from dirt. The BTR used was obtained from the burning of automobile waste tyres. This was used to partially replace cement in the production of sandcrete blocks. The effect of 0% to 20% replacement of cement with BTR on dry density, workability, water absorption and compressive strength was measured.

III. RESULTS AND DISCUSSIONS

Particle size distribution analysis

The sand and burnt tyre residue were first classified using a particle size distribution analysis and a specific gravity test. The results obtained from the particle size distribution analysis on Onitsha river sand and BTRs were plotted in Figure 1.

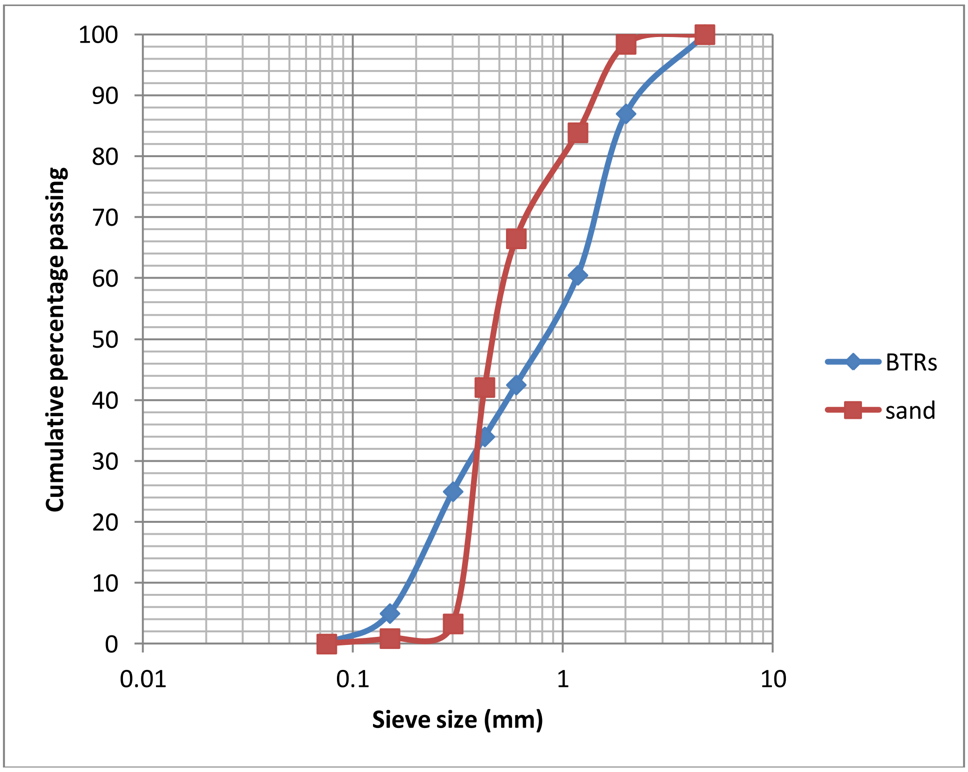

Figure 1: Grading curve for Sand and Burnt tyre residues (BTRs)

Sample A (Sand)
The D_{60}, D_{30} and D_{10} were 0.51mm, 0.4mm and 0.31 respectively. Thus the values for coefficient of curvature Cc and coefficient of uniformity Cu were calculated as follows;

$$C_c = \frac{D_{30}^2}{D_{60} \times D_{10}} = 1.01 \quad (1)$$

$$C_u = \frac{D_{60}}{D_{10}} = 1.65 \quad (2)$$

The uniformity coefficient (Cu = 1.65) is less than 2, thus the soil is a uniformly graded coarse sand (2mm – 0.075mm grain sizes), with little percentage of fines 0.9% retained on sieve size 0.075mm.
Sample B (Burnt Tyre Residue)
For burnt tyre residue $D_{60} = 1.2$, $D_{30} = 0.38$, $D_{10} = 0.19$. From equations (1) and (2)
C_c and Cu were obtained as 0.63 and 6.32 respectively. With a coefficient of uniformity, Cu of 6.32, BTR can be said to be well graded fines. This property of rubber ash showed that it contains majority of fines and thus it can be used as mixture with sand which contains lesser percentages of fines.

Workability

The BTR was added to the sandcrete block mixture in 0%, 5%, 10%, 15% and 20% partial replacement of cement. Based on the works of Afolayan et al [18] the water cement ratio was maintained at 0.55. Each sample was tested for workability and the results are presented in Figure 2.

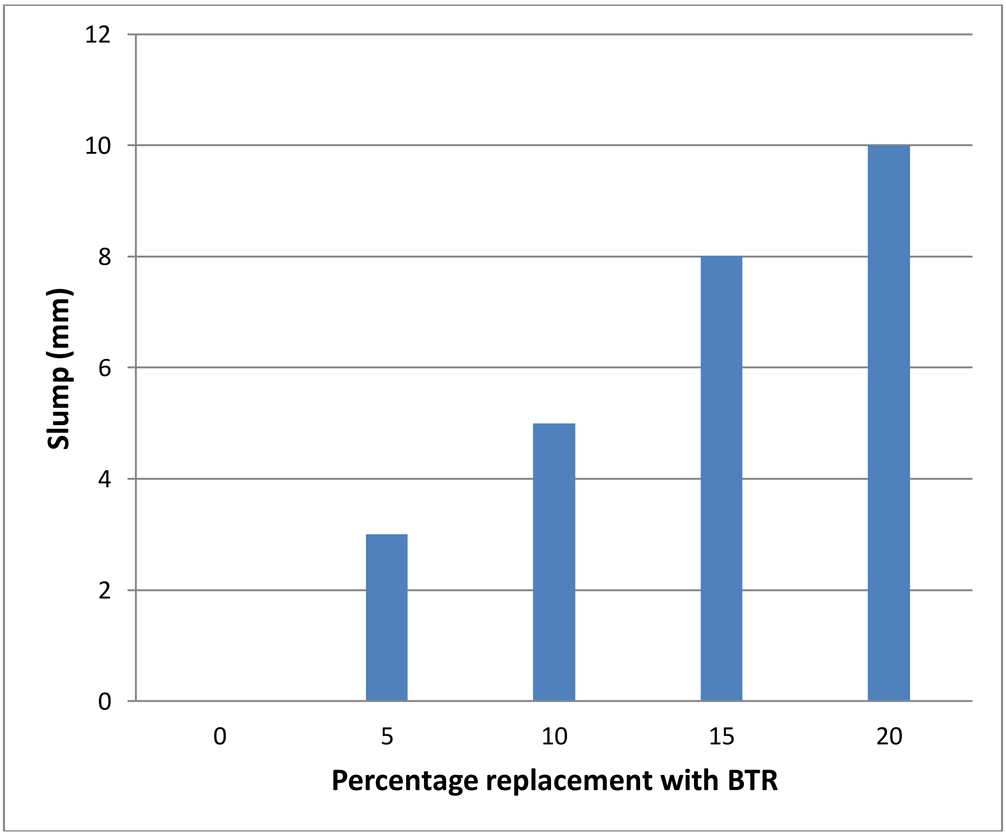

Figure 2: Result of workability test on Sandcrete block

From Figure 2 it can be seen that the workability of the sandcrete block increases with an increase in BTRs content, resulting from the increase in slump as BTRs content increases.

Water Absorption Test

As minimizing fluid transport properties of concrete is very important for prolonged durability of concrete structures, we decided to carry out water absorption tests on the sandcrete block samples [19]. The test results are as presented in Table 1.

Table 1: Result of Water absorption test on Sandcrete blocks

% Replacement of BTR	**Samples**	**Mass of the samples**		Water absorption (kg)	Water Absorption (%)
		Dry weight of the block (kg)	Weight of the block after soaking for 24Hrs in water		
0	A	18.064	19.18	1.12	6.20
5	B	17.822	18.90	1.08	6.05
10	C	17.314	18.31	1.00	5.78
15	D	16.895	17.82	0.92	5.45
20	E	16.644	17.38	0.74	4.45

Table 1 shows the results of water absorption test carried out on sandcrete block moulded with percentage replacement of cement with burnt tyre residue (BTR) ranging from 0% to 20%. The results indicated that the rate of water absorption of the sandcrete block decreased with an increase in the percentage of BTR content. The results obtained in the water absorption tests are all below the maximum (11%) set by the Nigerian Industrial standard [6]. This makes BTR a useful admixture for reducing water absorption in sandcrete blocks.

Compressive Strength Test

The hardened sandcrete blocks were finally tested for compressive strength by a destructive method.

The compressive strength test was performed on sandcrete block with percentage replacement of cement with BTR of 0%, 5%, 10%, 15%, 20%. They gave compressive strength values of 3.55N/mm^2, 3.19N/mm^2, 2.96N/mm^2, 2.67N/mm^2 and 2.38N/mm^2 respectively after 7 days and 4.44N/mm^2, 3.78N/mm^2, 3.41N/mm^2, 2.96N/mm^2 and 2.74N/mm^2 respectively after 28 days of water bath curing.

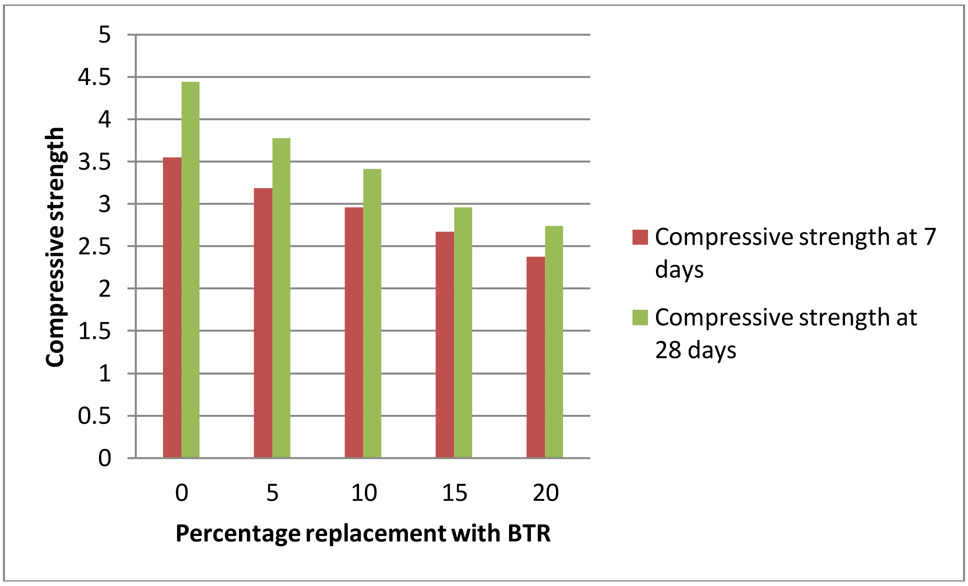

Figure 3: Combined Bar Charts showing the effect of BTR on the Compressive Strength of Sandcrete blocks after seven and twenty eight days.

The results as presented in Figure 3 show that increase in percentage of BTR in sandcrete block would lead to a steady decrease in its compressive strength.

But according to Nigeria Industrial Standard (NIS 87(2004), the minimum strength requirement for load bearing and non load bearing sandcrete blocks are 3.45N/mm^2 and 2.5N/mm^2 respectively. Therefore, sandcrete block produced with BTR at a percentage replacement of 20% still passed the strength value for non load bearing wall. But for load bearing walls only a 5% replacement of cement with BTR gave a compressive strength above the recommended minimum.

Density Test

The density of sandcrete blocks can be obtained by dividing its dry weight with its volume. The hollow sandcrete block measures 225mm wide, 450mm long, 225 high and 50mm thick. This gives a volume of

0.01434 cubic metre per block. The dry densities of the sandcrete block at different percentage replacement of cement with BTR were obtained from Table 1. The results of the density tests are presented in Figure 4.

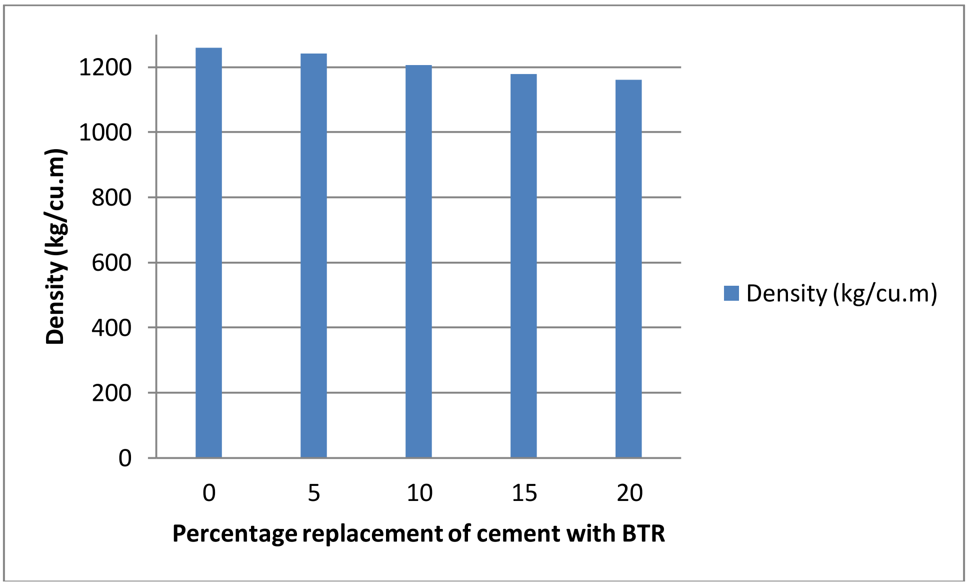

Figure 4: Combined graphs showing the effect of BTR on the density of sandcrete blocks

From the results of Figure 4, it can be seen that increase in rubber ash content decreases the density of sandcrete blocks. This is because rubber ash is less dense than cement and the higher its content in the block, the lesser the density of the block. The effect is however very small as at a 20% replacement of cement with BTR with the density only dropped by about 8%.

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IV. CONCLUSION

Workability values of sandcrete blocks increase with increase in content of rubber ash. Furthermore, the results obtained from water absorption tests of the sandcrete block indicated that the rate of water absorption of the block decreases with an increase in percentage of BTR content. Also 5% replacement of cement with BTR has been found to have satisfied the strength requirements for load bearing sandcrete blocks. Therefore, 5% partial replacement of cement with rubber ash presents satisfactory and more economical choice and should be encourage in production of sandcrete blocks.

Moreover, sandcrete blocks produced with 5% partial replacement of cement with rubber ash are lighter than blocks without replacement. This could lead to easy and less work done on lifting such blocks for construction in the construction sites.

V. RECOMMENDATION

The following recommendations are made:

1. The inclusion of rubber ash in sandcrete block production at 5% partial replacement of cement should be encouraged in Nigeria as this has been shown to be satisfactory according to Nigerian Industrial Standard requirement and this practice will lead to reduction in the cost of sandcrete block production and also reduce accumulated waste rubber tyres within our environment which serve as breeding sites for mosquitoes, rodents that causes diseases and health problems to human.
2. Production of sandcrete blocks with partial replacement of cement with rubber ash ranging from 5% to 20% satisfied the Nigerian Industrial Standard (NIS) 2004, requirements for non load bearing sandcrete blocks and therefore should be encouraged for sandcrete block production for use in similar conditions.

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