Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 12, December - 2017

Effect of Sugarcane Bagasse Ash on the Engineering Properties of Blended Sandcrete Blocks

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***Abstract*-This research investigates the effect of Sugarcane Bagasse Ash (SBA) on the engineering properties of sandcrete blocks produced with optimal amount of blended lateritic and marine sand. Sandcrete hollow blocks (450mm x 225mm x 225mm) were made by blending varying contents of marine sand and lateritic sand using the nominal mix ratio of 1:6 (cement: sand). Marine and clean lateritic sand were blended at intervals of 10%. A total of 90 sandcrete blocks were casted and the compressive strengths of the blocks determined at 7, 14 and 28 days. The 28 day compressive strength of mixes containing 0, 10, 20, 30, 40, 50, 60, 80 and 100% marine sand were, 4 .47, 5.10, 5.25, 5.33, 5.20, 4.63, 4.58, 3.88 and 3.76 N/mm^2 respectively. The 28 days strength for both blends of sand exceeded the minimum strength value of 3.45N/mm^2 specified by BS 6073:2.Sandcrete blocks made with 30:70 marine-lateritic sand blending ratio produced the highest compressive strength. Using this ratio, 90 sandcrete blocks were casted by replacing cement with Sugar Bagasse Ash in the ratio of 0%, 5%, 10% 15% 20% and 25% by weight. The blocks were tested for compressive strength, density, water absorption and durability. The 28 day compressive strength were 5.33, 5.29, 5.18, 4.71, 3.42, 3.08 N/mm^2 for 0, 5, 10, 15, 20 and 25 % replacement respectively. Upto 15% replacement levels met the minimum compressive strength recommended in standards. The results for water absorption, density and durability of the blocks were within the acceptable limits.**

***Key Words--- Sugarcane Bagasse Ash, Sandcrete blocks, Lateritic Sand, Marine Sand, Blended Sand, Compressive Strength, water absorption, durability*.**

I. INTRODUCTION

Sandcrete blocks are masonry units manufactured from a mixture of cement, sand and water. They are predominantly used as walling materials in construction of residential houses and other infrastructures. The composition of a sandcrete block is usually (1:6) mix of cement and sand moistened with water and allowed to dry naturally [1]. Sandcrete has been in used throughout West Africa for over 5 decades as a popular building material for preparation of building blocks and bricks [2], Block molding or sandcrete technology is becoming the backbone of infrastructural development of every country [3].

Sandcrete blocks are either solid or hollow rectangular types. Hollow sandcrete blocks are the common types of sandcrete blocks. They are usually 450mm X 225mm X 225mm for load bearing walls and 450mm X 150mm X 225mm for non-load bearing walls. The hollow blocks have a void that is approximately a third of the volume of the blocks. In the contrary, solid sandcrete block does not have any void. Hollow sandcrete block is a good construction material for building. It is the main building material for walls of single-storey buildings (such as houses and schools) in countries such as Ghana and Nigeria [4]. The quality of sandcrete blocks is influenced by so many factors such as the quality of constituent materials, the process adopted in manufacture, duration of curing, forms and sizes of blocks [5].River sand and cement are the major constituent materials in sandcrete blocks. However continued extraction of river sand has resulted in a serious environmental degradation. These problems includes; loss of water retaining soil strata, deepening of the river beds and causing bank slides, loss of vegetation on the bank of rivers, disturbance of the aquatic life as well as agriculture. The environmental effects of cement production is also enormous. For this reason, coupled with the need of providing an affordable housing to all, there has been a need to explore the use of other alternative to this major constituent materials.

A number of studies across the world have investigated the use of alternative sources to fine aggregate in sandcrete blocks. In Pakistan and India studies on local sand showed good results. In West Africa, an extensive research on the use of lateritic sand in sandcrete blocks has been done. In Nigeria for example, [6] discovered that locally available laterite can replace sand upto 55% by dry-weight using upto to 9% cement content. [7] observed that laterite could be used as part of fine aggregate for making sandcrete blocks provided that the cement content used is at least 10%. Thus compressive strengths of the lateritic sandcrete cubes compares favorably with those of sandcrete blocks. Laterites have not been extensively used in constructing of medium to large-size building structures, probably because of lack of adequate data needed in the analysis and design of structures

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built of lateritic soils [8].Approximately 30% of the world's present population still lives in lateritic structures [9]. The restriction of laterite building to rural areas is due to lack of accepted standard design parameters for the effective structural applications of laterized concrete [10].

Marine sand properties make it suitable materials for use in sandcrete block. Existing studies on marine sand extensively relates to its performance in concrete. While the presence of chloride minerals provides a corrosive thatch to concrete studies have shown that up to 50% of marine sand is as good as river sand especially in its performance in under compressive strength. [11] found that the structural properties of off shore sand keeps improving after replacing the finer particles of marine sand with the river sand.

The environmental effects of cement production such as emissions of CO_2 has necessitated studies on use of agro waste as pozolanic materials. Agro wastes sources such as Rice Husk Ash, Millet Husk Ash, Bamboo Leaf Ash and Cement Corn Cob Ash (CCA) can be used up an optimum of 30% in replacing cement [12], [13], [5].Research on use of Sugarcane Bagasse ash (SBA) on sandcrete blocks have been limited. Sugarcane bagasse ash (SBA) increases compressive strength in concrete up to 10% cement replacement [14]. Sugar cane bagasse is a fibrous waste-product of the sugar refining industry, along with ethanol vapor. The product is already causing serious environmental pollution, which calls for urgent ways of handling the waste. Bagasse ash mainly contains aluminum ion and silica. In this research, Sugarcane Bagasse ash was used to partially replace ordinary Portland cement in the Production of sandcrete hollow blocks containing blended marine-lateritic sand.

II. MATERIALS AND METHODS

A. *Materials used*

1. *Ordinary Portland cement (OPC)*

The brand of cement used was PowerPlus Ordinary Portland Cement (OPC 42.5N) from the Bamburi Cement Company, Nairobi, Kenya with properties conforming to [15].

2. *Sugarcane Bagasse Ash (SBA)*

Sugarcane Bagasse Ash (SBA) was obtained from West Kenya Sugar Company, Kakamega. The company processes only one species of sugarcane which has a bearing on the uniformity in the chemical composition of SBA [16]. The SBA was prepared by drying and sieving through a 300µmm sieve and then packed into polythene bags so as to maintain its moisture**.**

3. *River sand*

River sand was locally available, clean, sharp, and free from clay and organic matter and was well graded conformity to [17].Was sourced from Meru, Kenya and sieved though 4.75 mm zone of British standard (BS) test sieves.

4. *The Lateritic sand*

Was sourced from Kakamega in Western Kenya between a depths of 1.5m to 2.0m using method of disturbed sampling .The lateritic sand was prepared by washing, drying and sieving so as to remove excess clay, silt, debris and organic content (Plate 1a). The clay particles in laterites are normally hygroscopic and would take up water and subsequently maintain a dynamic equilibrium of water content by absorbing water from the environment or desorb it. The behavior leads to a weaken bond between the aggregate particles and the cement paste resulting in a lower compressive strength ([18].

5. *Marine sand*

Marine sand was sourced from the offshore strip in Mombasa Kenya (plate 1b)

Both river sand, lateritic sand and marine sand used in this investigation passed thought 4.75mm British standard sieve and retained on sieve (150µm).

6. *Portable tap water*

The water was fit for drinking, free from contaminants either dissolved or in suspension and conformed in totality to the specifications in [19].

The main equipment used in this investigation were block making mold and a hydraulic compression machine (plate 2).

B. *Experimental program*

Lateritic sand, marine sand and river sand used in this study were physically characterized by conducting sieve analysis, fineness modulus, specific gravity test, water absorption and natural moisture content tests. The specific gravity and bulk density of sugarcane bagasse ash was determined. Chemical analysis of the sugarcane Bagasse Ash (SBA) was determined in order to ascertain the pozzollanic characteristic of the SBA. The standard mix ratio of 1:6 for sandcrete with a water cement ratio of 0.5 was used in casting hollow sandcretes 450 x 225 x 225 mm blocks with laterite content varying against marine sand. Batching was by weight. For each batch 9 blocks were casted. In total 81 blocks were casted in this study (plate 3 a,b). Using River sand 9 blocks were casted to be used as control. Experiences from the rule of thumb have revealed that different batches of the same mix will experience little or no significant variation in compressive strength [20].This practice is being used in commercial production blocks [9].Curing was done by sprinkling the blocks with water twice a day for the necessary days and crushing test were performed on the samples to determine their compressive strengths on the required number of days.

Using the lateritic sand and marine sand mix ratio that produces higher compressive strength in 28 days, SBA was used to partially replace cement in the ratio of 0%, 5%, and 10% 15%, 20% and 25% by weight of cement. 90 sandcrete blocks (plate 4) were casted and tested for compressive strength, bulk density, durability and water absorption, water was added in every case until reasonable workable mixes was obtained to simulate field conditions. 15 sandcrete blocks were casted in each batch to be tested in 7, 14 and 28 days. Durability test was conducted using abrasion test after 28 days.

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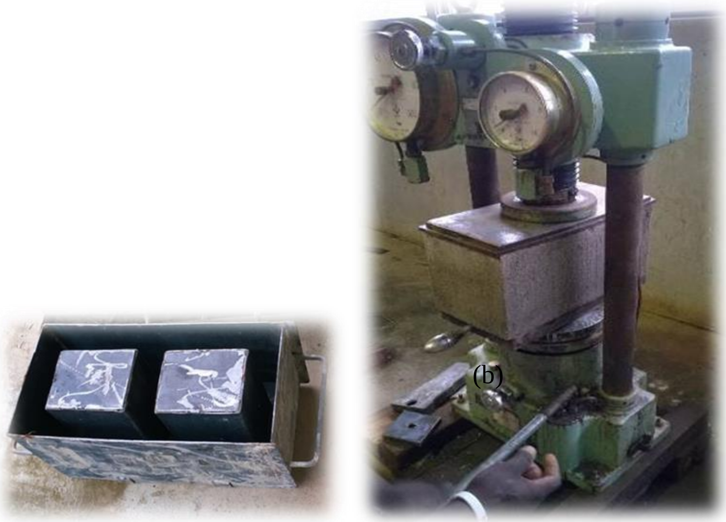
(a) (b) (c)

Plate 1:-Materials for sandcrete blocks (a) Sugarcane Bagasse Ash (b) Clean lateritic sand, (c) Marine sand



(a) (b)

Plate 2:-. (a) Block making mold (b) Compression machine

Plate 3:-Blended Sandcrete Blocks: (a) 80% marine sand (b) Various marine-lateritic sand blended blocks.

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Plate 4:-*Blended Sandcrete Blocks containing Sugarcane Bagasse Ash.*

C. Mix proportions

Table 1 summaries the mix proportioning of blending lateritic/Marine sand mix at saturated surface dry (SDD) condition

A nominal mix proportion of 1:6 (one volume of cement to six volume of sand) as specified in [21] is used. The proportioning was by weight. Trial test were conducted for all batches and it was found that a water-cement ratio of 0.5 was suitable for all the batches. This value is similar with the water –cement ratio adopted by [18] and [22]. Marine sand was blended with lateritic sand in the ratio of 0, 10,20,30,40,50,60,80 and 100%.The proportioning was by weight. Due to difference in water absorption values and the natural moisture content of marine sand and lateritic sand, adjustment on the proportioning was done appropriately to achieve the 0.5 free water to cement ratio.

The mix proportion for 0%, 5%, and 10% 15%, 20% and 25% cement replacement with SBA is summarized in Table 2.

In this study, the hand mixing was used. [23] opined that in hand mixing the materials are turned over a number of times until an even color and consistency are attained. For small scale production, the blocks are produced manually and compacted manually with the aid of a wooden rod. The binder/s and blended sand were mixed in a dry form and water was then added

TABLE 1:-Mix proportioning for cement and blended sand

Marine sand %	**Cement Kg/m^3**	**Lateritic sand Kg/m^3**	**Marine sand Kg/m^3**	**Water Kg/m3**
0	233.82	1222.86	0	116.91
10	234.79	1105.14	122.76	117.39
20	235.76	986.41	246.60	117.88
30	236.73	866.66	371.42	118.36
40	237.70	745.94	497.26	118.85
50	238.67	624.11	624.11	119.33
60	239.64	501.32	751.98	119.82
80	241.58	252.69	1010.76	120.39
100	243.52	0	1273.6	121.8
Control	**Cement Kg/m^3**	**River sand Kg/m^3**		**Water Kg/m^3**
100% river sand	227	1187.23		113.50

TABLE 2. Mix proportioning for SBA replacement

% SBA	**SBA Kg/m^3**	**Cement Kg/m^3**	**Lateritic sand Kg/m^3**	**Marine sand Kg/m^3**	**Water Kg/m3**
0	0	236.73	866.66	371.42	118.36
5	11.79	224.01	863.25	369.96	117.90
10	23.49	211.38	859.84	368.50	117.43
15	35.09	198.85	856.44	367.04	116.97
20	46.60	186.40	853.03	365.58	116.50
25	58.02	174.06	849.62	364.12	116.04

III. RESULTS AND DISCUSSION

A. Material properties

a) River sand

The physical properties of the river sand is as tabulated in table 3. Dry sieving analysis was done in accordance to [24].The river sand complied with C of [17].The particle size distribution curve of the sand used in this study is shown in Figure 1(a).

b) The Lateritic sand

The physical properties of the lateritic sand is tabulated in table 3.The specific gravity of 2.88 for the lateritic sand is slightly higher than that obtained by [25] and 2.78 obtained by [26].The loose and bulk densities are close to 1490Kg/m^3 and 1660Kg/m^3 respectively obtained by [26].This clearly shows that the inherent physical properties of lateritic sand is location dependent. The silt content is less than 6% maximum limit recommended in [27].The particle size distribution curve complies with curve C in table 4 of [17] as shown in Figure 1 (b).

c) Marine sand

The physical properties of the marine sand is tabulated in table 3.The specific gravity of the marine sand used in this study is 2.3 this value is slightly lower than 2.66 obtained by [28].A fineness modulus of 0.97 is an indication than the marine sand is finer than river sand with majority of the

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particles being retained on sieve number 1.The marine sand is uniformly graded and does not comply with C, M and F of [17].The grading is however close to curve F. When the marine sand was blended with the lateritic sand used in this study, it was discovered that the 0%, 10%, 20% and 30% replacement of the marine sand replacements in lateritic sand conformed to the requirements of grading C. The 50 and 60% replacement conformed to M while 70 and 80% replacement conform to F. Figures 1(c) to 1(e) shows a typical grading curve for 30, 40 and 60% marine sand in lateritic sand.

d) Ordinary Portland cement

The properties of the OPC is summarized in table 3 .The specific gravity of the OPC is close to 3.1 that was obtained by [29].and specific gravity of 3.12 obtained by [26].

Cement blended with SBA at 5%, 10%, 15%, 20% and 25% level of replacement has a standard consistency of 36, 40, 44, 50 and 54 percentages respectively.

e) Sugarcane Bagasse Ash (SBA)

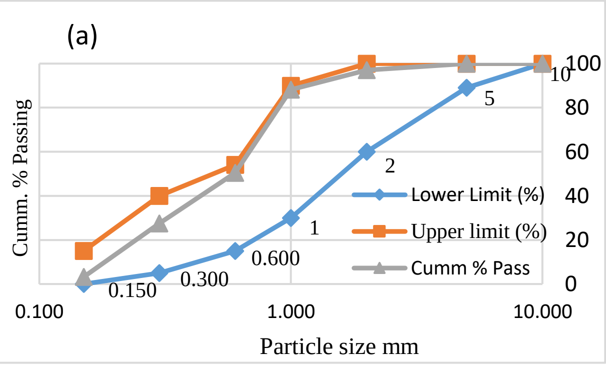
Table 4 shows the result of the chemical analysis of the SBA and the Ordinary Portland Cement. The results have been compared with fly ash stated in [30].In this chemical analysis of SBA, the sum of SiO_2, Al_2O_3 and Fe_2O_3 is more than 70% thus satisfies the minimum percentage requirement for pozzolana, class F, according to [30].The sum of SiO_2, Al_2O_3 and Fe_2O_3 is slightly lower than values obtained by [31].The specific gravity of the SBA is 1.94 and its compacted bulk density is 555Kg/m^3. Low specific gravity (1.8–2.1) of the bagasse ash may be due to large amount of lightweight unburnt particles [32].

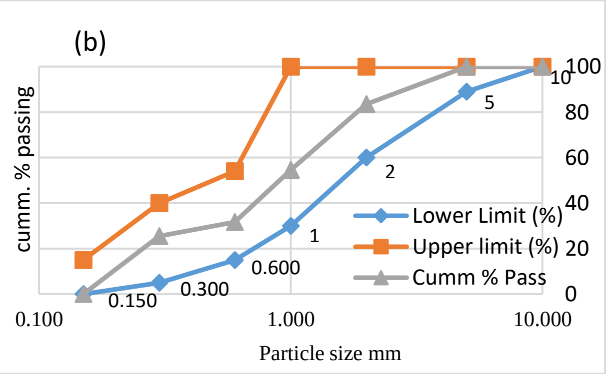
TABLE 3.Properties of the materials used

MATERIAL	PROPERTIES							
	Specific gravity (SSD)	**Fineness modulus**	**Bulk density Loose (compacted)**	**Moisture content %**	**Absorption %**	**Silt content %**	**Grading (chemical analysis)**	**Setting time Initial (Final)**
River sand	2.5	2.3	1402.08Kg/m^3 (1602.8Kg/m^3)	3.6	6.1	4.7	Grading C OF [17]	-
Lateritic sand	2.8	3.5	1519Kg/m^3 (1662Kg/m^3)	2.3	5.3	4.0	Grading C OF [17]	-
Marine sand	2.3	0.97	1573Kg/m^3 (1746kg/m^3)	3.2	13.8	2.8	Grading C,M,F after blending -see fig. 1c,d &e	-
Bagasse Ash	1.94	-	445.8Kg/m^3 (555.05Kg/m^3)	-	-	-	(See Table 4)	-
Cement	3.11	-	1162Kg/m^3 (1398Kg/m^3)	-	-	-	(See Table 4)	160 min 252 min

TABLE 4.Chemical analysis of the SBA and cement.

Parameter	**Bagasse Ash %**	**Fly Ash class F ASTM C618 %**	**BAGASH ASH from Nzoia sugar** [31]	**Cement (%)**
Silica (SiO_2)	62.3	40-63	66.23	22.0
Aluminium Oxide (Al_2O_3)	4.25	17-28	1.90	4.80
Ferrous Oxide (Fe_2O_3)	3.69	3-12	3.09	2.44
Calcium Oxide (CaO)	1.02	2-8	2.81	59.0
Magnesium Oxide (MgO)	0.43	0.6-2	1.54	0.75
Sodium Oxide Na_2O	0.38	-	0.26	0.28
Potassium Oxide K_2O	2.7	-	6.44	0.60
Titanium Oxide (TiO_2)	0.32	-	0.07	0.20
Manganese Oxide (MnO)	0.23	-	1.54	0.04
LOI	15.28	0-5	16.36	6.30





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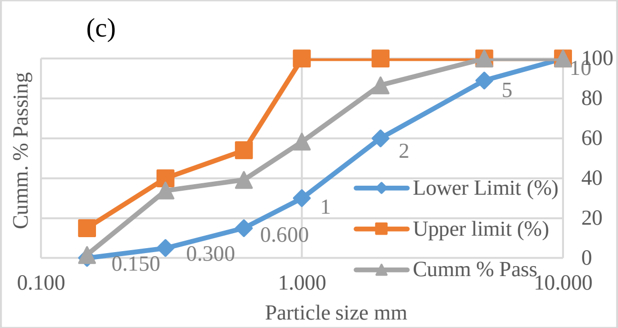

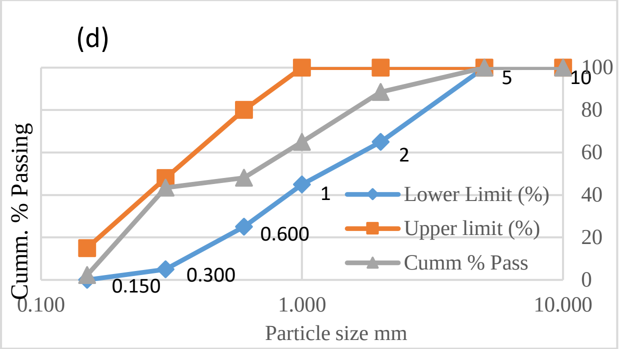

B. Properties of sandcrete blocks made by blending marine and lateritic sand

1) Density

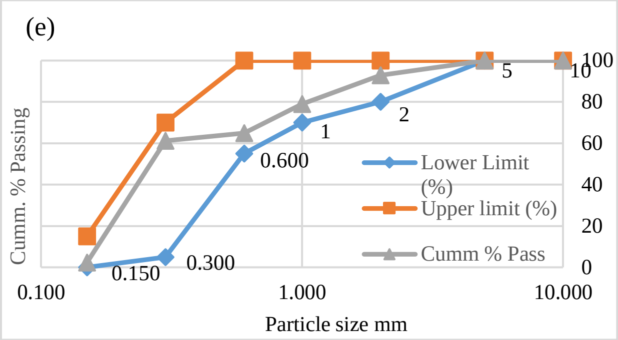

FIGURE 1.Grading curves: (a) River sand, (b) Lateritic sand, (c) 30% marine sand (d) 40% Marine sand (e) 60% Marine sand

The table 5 illustrates the variation of the density of sandcrete blocks with different percentage of marine sand and laterite sand for 7, 14 and 28 days curing respectively The average density for three blocks varies from 1986.93Kg/m^3 to 1835.88 Kg/m^3, 1989.25 Kg/m^3 to 1780.90 Kg/m^3 and 1970.66 Kg/m^3 to 1749.89 Kg/m^3 for 7, 14 and 28 days respectively. All the values exceed the 1500kg/m^3 [21] recommendation for an average of three (3) blocks and all the blocks had densities more than the minimum of 1600kg/m^3 recommended by [33] for a masonry unit. The values of dry density in this study were lower than those obtained by [34] which ranged from 2002.21kg/m3 to 2203.03kg/m3 .The lower bulk density is attributed to the manual production and compaction as opposed to the use of block molding machine employed in [34].This decline can be attributed to the lower density of marine sand compared to lateritic sand. Subsequently the density of the blocks decrease as the percentage of marine sand in the mix increases. A similar trend was observed by [35] when sawdust was used to replace sand in hollow sandcrete blocks.

TABLE 5. Dry density for sandcrete blocks at various percentages of marine and lateritic sand

		7 DAYS			14 DAYS			28 DAYS		
Marine sand %	Sample No	Weight Kg	Dry density Kg/m^3	Average Kg/m^3	Weight Kg	Dry Density Kg/m^3	Average Kg/m^3	Weight Kg	Dry Density Kg/m^3	Average Kg/m^3
0	1	28.50	1986.93	1986.93	28.50	1986.93	1989.25	28.40	1979.96	1970.66
	2	28.50	1986.93		28.50	1986.93		28.30	1972.98	
	3	28.50	1986.93		28.60	1993.90		28.10	1959.04	
10	1	28.50	1986.93	1986.93	28.50	1986.93	1986.93	28.00	1952.07	1961.37
	2	28.30	1972.98		28.50	1986.93		28.20	1966.01	
	3	28.70	2000.87		28.50	1986.93		28.20	1966.01	
20	1	28.30	1972.98	1977.63	28.10	1959.04	1959.04	28.40	1979.96	1956.72
	2	28.50	1986.93		28.80	2007.84		27.80	1938.13	
	3	28.30	1972.98		27.40	1910.24		28.00	1952.07	
30	1	28.30	1972.98	1959.04	28.10	1959.04	1956.72	27.70	1931.15	1954.39
	2	28.00	1952.07		28.00	1952.07		28.20	1966.01	
	3	28.00	1952.07		28.10	1959.04		28.20	1966.01	
40	1	28.10	1959.04	1956.72	28.30	1972.98	1949.75	27.60	1924.18	1935.80
	2	28.00	1952.07		27.80	1938.13		28.00	1952.07	
	3	28.10	1959.04		27.80	1938.13		27.70	1931.15	
50	1	27.50	1917.21	1924.18	27.40	1910.24	1903.27	27.60	1924.18	1896.30

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	2	27.80	1938.13		27.40	1910.24		27.00	1882.35	
	3	27.50	1917.21		27.10	1889.32		27.00	1882.35	
60	1	27.40	1910.24	1910.24	27.30	1903.27	1907.92	26.30	1833.55	1828.90
	2	27.40	1910.24		27.30	1903.27		26.30	1833.55	
	3	27.40	1910.24		27.50	1917.21		26.10	1819.61	
80	1	27.10	1889.32	1887.00	26.50	1847.49	1847.49	26.10	1819.61	1812.64
	2	26.70	1861.44		26.50	1847.49		25.80	1798.69	
	3	27.40	1910.24		26.50	1847.49		26.10	1819.61	
100	1	26.50	1847.49	1835.88	25.50	1777.78	1780.10	24.80	1728.98	1749.89
	2	26.50	1847.49		25.50	1777.78		24.80	1728.98	
	3	26.00	1812.64		25.60	1784.75		25.70	1791.72	
100% River sand	1	28.10	1959.04	1961.37	28.00	1952.07	1954.39	28.00	1952.07	1952.07
	2	28.20	1966.01		28.00	1952.07		27.90	1945.10	
	3	28.1	1959.04		28.10	1959.04		28.10	1959.04	

2) Compressive strength

The Compressive strength tests for all mixes at 7, 14 and 28 curing days are presented in figure 2.

The compressive strength ranges from 1.96 to 4.78 N/mm^2, 2.67 to 5.07 N/mm^2, and 3.76 to 5.33 N/mm^2 at 7, 14 and 28 curing age respectively. The compressive strength for the control block made from 100% river sand is 4.08, 4.24 and 4.67 N/mm^2 for 7, 14 and 28 curing days respectively. The 28 days strength obtained for both the percentages blends of sands exceeds the minimum strength value of 3.45N/mm^2 specified by [21] as well as [33] for load bearing walls

These results obtained in this study are higher than those obtained by [34] where the result indicated that the compressive strength of 225mm sandcrete hollow blocks varies from 1.59 N/mm^2 at 7 days to 4.25 N/mm^2 at 28 days. The higher compressive strength recorded in this study are due to the stronger mix ratio of 1:6 (cement: sand). The high early strength in this study can be attributed to the brand of cement used.

It was observed that as the percentage of marine sand is increased and lateritic sand reduces, the compressive strength of sandcrete blocks at 7 days, 14 days and 28 days increased up to 30% replacement level. At 40% replacement level compressive strength was less than the strength at 30% replacement level but greater than the strength of control sandcrete block. At replacement level greater than 40% the strength reduces to values less than the referral sandcrete block. This trend conforms to an earlier studies [35] conducted on fine sand-local sand blend for Masonry Concrete Unit MCU where the strength of the blocks increased up to 40% replacement of fine sand with local sand, and dropped at replacement level above 40%. A similar trend was also obtained by [36] where the strength of concrete increased with replacement level of fine aggregate with Stone Dust up to 60%.

At replacement levels less than 30%, the increase of marine sand increases the smaller sized particles which fills the spaces between the bigger ones, thus creating a more compact sandcrete block and increasing the strength. Beyond 30% marine sand replacement the strength reduces as finer materials induced increases the overall surface area of the sandcrete increasing the water demand.

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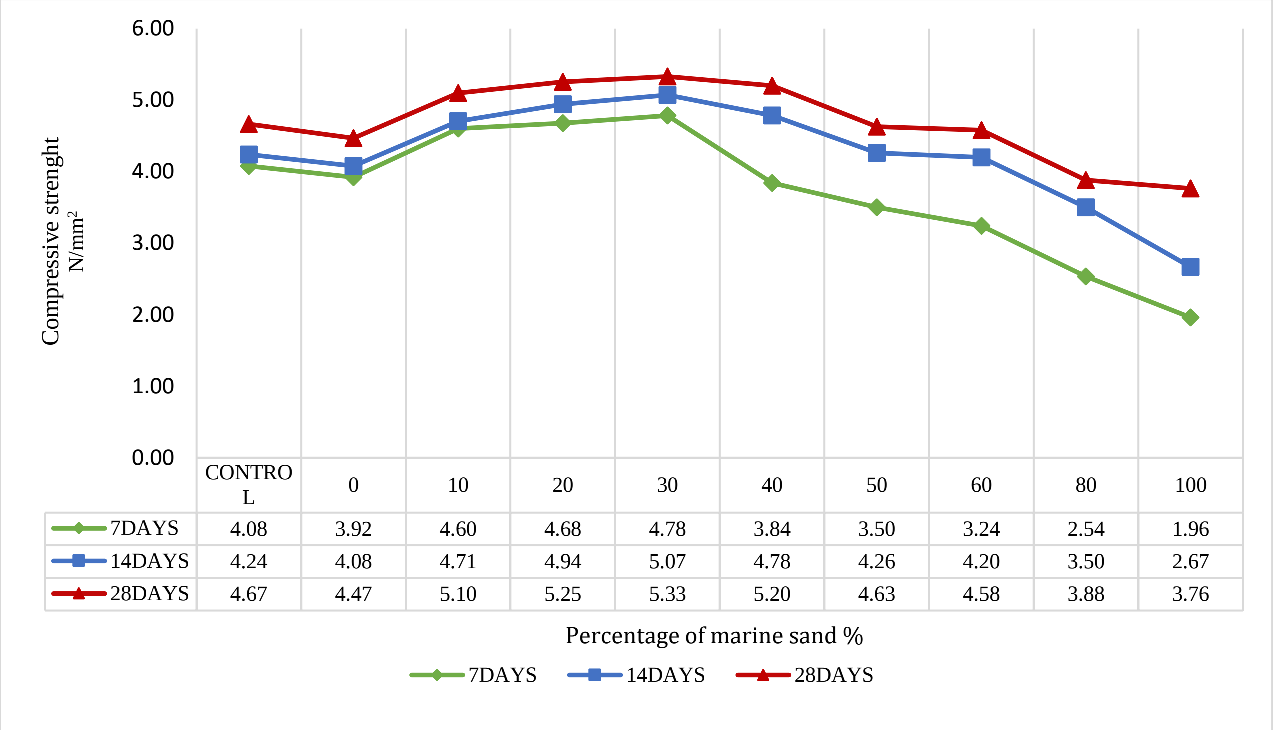


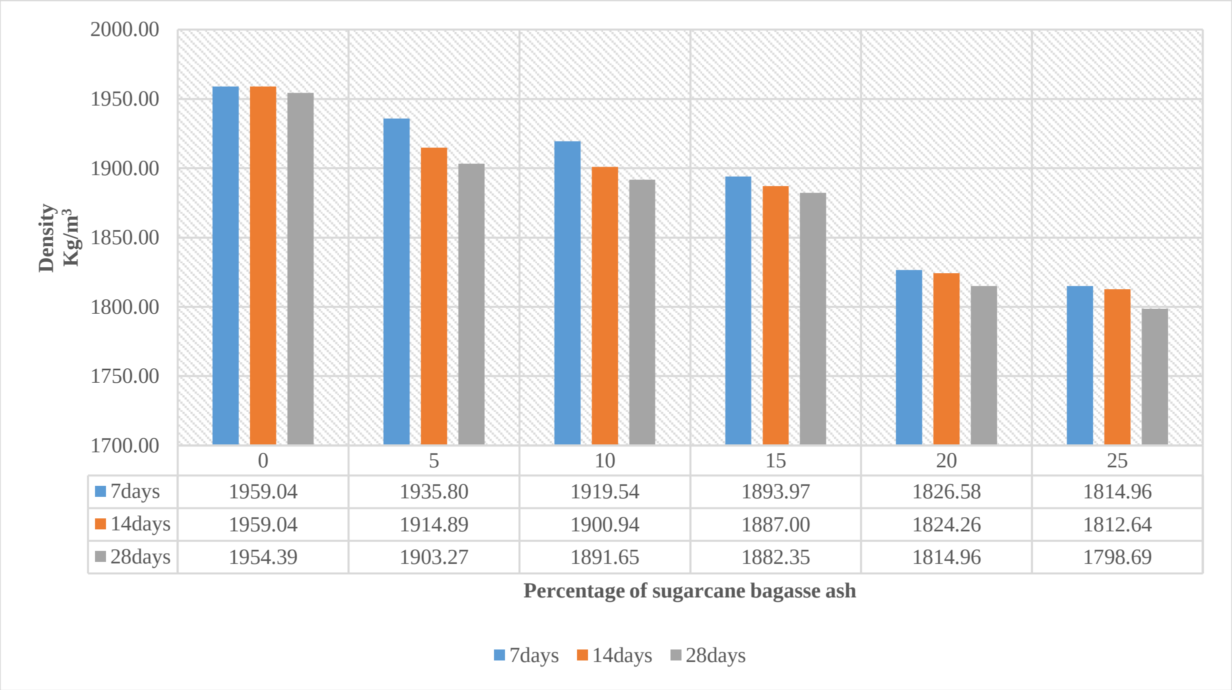
	CONTROL	0	10	20	30	40	50	60	80	100
7DAYS	4.08	3.92	4.60	4.68	4.78	3.84	3.50	3.24	2.54	1.96
14DAYS	4.24	4.08	4.71	4.94	5.07	4.78	4.26	4.20	3.50	2.67
28DAYS	4.67	4.47	5.10	5.25	5.33	5.20	4.63	4.58	3.88	3.76

FIGURE 2:-Compressive strength result for blended sandcrete blocks

C. Effect of Sugarcane Bagasse Ash on blended sandcrete blocks

1. Effect on density

The figure 3 shows how densities of sandcrete blocks varies as replacement levels of Sugarcane Bagasse Ash is increased.



	0	5	10	15	20	25
7days	1959.04	1935.80	1919.54	1893.97	1826.58	1814.96
14days	1959.04	1914.89	1900.94	1887.00	1824.26	1812.64
28days	1954.39	1903.27	1891.65	1882.35	1814.96	1798.69

FIGURE 3.Chart showing the variation of density with increase in SBA

The result shows that the bulk density of the individual sandcrete block ranges between 1798.69Kg/m^3 to 1972.98Kg/m^3 for 7 curing days, 1798.69 Kg/m^3 to 1959.04Kg/m^3 in 14 curing days and 1784.75Kg/m^3 to 1966.01Kg/m^3 in 28 days. The average values for bulk density for 3 blocks varies from 1798.69Kg/m^3 to

1954.39Kg/m^3 for 7 days,1812.64Kg/m^3 to 1959.04Kg/m^3 in 14days and 1798.69 to1954.39 Kg/m^3 in 28 days . Both the lowest and highest values of density are higher than 1500kg/m^3 which are the minimum values of density required for load bearing blocks as recommended in the standards [21] [33].The density decrease with percentage increase in SBA substitution. This can be attributed to the lower density of SBA compared to that one of cement consequently partially substituting cement with SBA produces lighter sandcrete blocks. A similar trend was also obtained by [5] where the density of sandcrete decreased with replacement level of cement with Bamboo leaf Ash (BLA).The data also indicate a decreases in density with increased curing age, a trend which conforms to [12].

2. Effect on Compressive strength

The compressive strengths of the SBA sandcrete blocks with varying replacement levels are shown in figure 4 below for 7 days, 14 days, and 28 days of curing. The compressive strength were determined as an average of 3 blocks. The compressive strength of sandcrete blocks made with increasing SBA percentages varies from 4.78N/mm^2 to 1.83N/mm^2, 5.07N/mm^2 to 2.30N/mm^2 and 5.33N/mm^2 to 3.08N/mm^2 for 7 days, 14days and 28days curing age respectively. The compressive strength obtained at 14 days is higher than those obtained by [37] of sandcrete blocks produced with Partial replacement of cement with SawDust Ash which are ,2.16, 1.94, 1.64, 1.59, 1.39 and 1.25N/mm^2 for 0, 5, 10, 15, 20 and 25% SDA contents respectively. At 7 days curing age up to 10% replacement level produces sandcrete blocks meeting the requirement of 3.45N/mm^2 specified in [21] and [33]. At 14 and 28 days, up to the 15% replacement levels satisfy the recommended standards.

The compressive strength of the blocks decrease as the SBA percentage content in the mix increases. This can be attributed to the decrease of cement content as the percentage of SBA was increased. The main constituent of SBA is silica (SiO_2) while that of cement is calcium (CaO). When cement is replaced by Sugarcane Bagasse Ash, the proportion of cement reduces and subsequently the quantity of cement in the mix available for the hydration process. Also, increase of SBA increases the quantity of silica, at lower percentage replacement, silica contributes to the pozollanic reaction. At higher SBA replacement, the excess silica contributes nothing to hydration of cement and consequently resulting to reduction in compressive strength [2].A similar pattern was observed by an earlier studies by [13] which showed that compressive strength decreases with increase in Millet Husk Ash (MHA) content for all ages of curing. At 28 days, the compressive strength of mixes with 0, 10, 20, 30 and 40% replacements of cement with MHA were 4.50, 4.00, 3.15, 2.00, and 1.15N/mm^2 respectively. On using Coconut Husk Ash to replace cement, [38] also observed that the compressive strength of the Ordinary Portland Cement /Coconut Husk Ash sandcrete blocks generally decreases as the percentage of Coconut Husk Ash content increases.

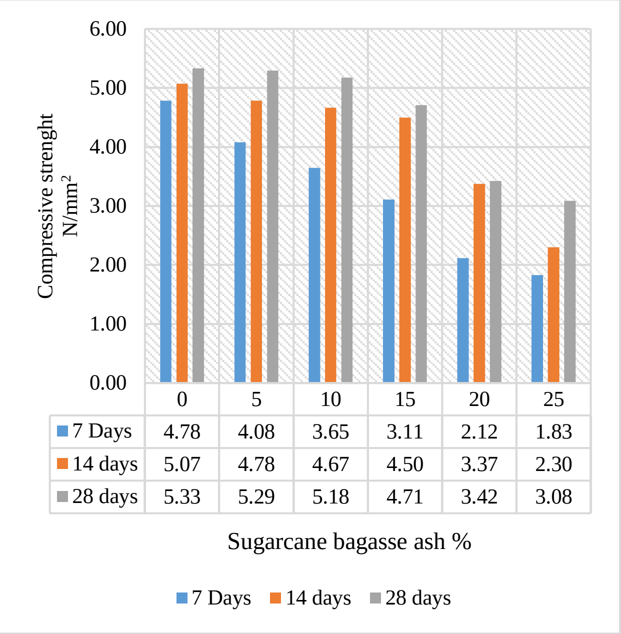


Figure 4.Compressive strength for SBA sandcrete block

3. Effect on water absorption

Table 6 illustrates how the water absorption of the blocks is affected with percentage increase of sugarcane bagasse ash. The water absorption of the blocks for SBA replacement at 0, 5, 10, 15, 20 and 25% are 5.01, 5.39, 6.02, 6.52, 7.01 and 7.23 % respectively. It was observed that the water absorption increases as the percentage replacement of SBA increases. This may be attributed to increase in pores spaces in the blocks as SBA percentage increases. This values are close to those obtained by [13] which were 5.25, 5.00, 5.85, 6.75 and 8.25 % for 0, 10, 20, 30 and 40% MHA replacement respectively. In thus study water absorption at all replacement levels does not exceed the maximum allowed water absorption of 12% as specified by [41].

TABLE 6.Water Absorption Test Result

SBA %	S. N	Weight of oven dried block (Kg)	Weight of soaked block (Kg	Weight of water absorbed (kg)	Water Absorption %	Average water absorption %
0	1	27.80	29.2	1.40	5.04	5.01
	2	28.00	29.4	1.40	5.00	
	3	28.00	29.4	1.40	5.00	
5	1	27.90	29.4	1.50	5.38	5.39
	2	27.80	29.1	1.30	4.68	
	3	27.80	29.5	1.70	6.12	
10	1	27.70	29.4	1.70	6.14	6.02
	2	27.70	29.2	1.50	5.42	
	3	27.70	29.5	1.80	6.50	
15	1	27.60	29.4	1.80	6.52	6.52
	2	27.70	29.5	1.80	6.50	
	3	27.50	29.3	1.80	6.55	
20	1	26.30	28	1.70	6.46	

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	2	26.10	28	1.90	7.28	7.01
	3	26.10	28	1.90	7.28	
25	1	25.70	27.6	1.90	7.39	7.23
	2	25.70	27.5	1.80	7.00	
	3	26.00	27.9	1.90	7.31	

4. Abrasion test:

Figure 5 shows the results of the abrasion tests. The loss of weight due to abrasion for 28 days blocks increases as the percentage of SBA is increased. This implies that the block becomes weaker as the cement content in the mix reduces. The percentage of the materials abraded away from the blocks is 0.004, 0.010, 0.018, 0.036, 0.056 and 0.066 % for 0, 5, 10, 15, 20 and 25% SBA replacements respectively. A similar trend was obtained by [5], however, the materials abraded away in his study were slightly higher. The lower values obtained in this study ascertained the suitability of the mix to produce a more durable sandrete blocks.

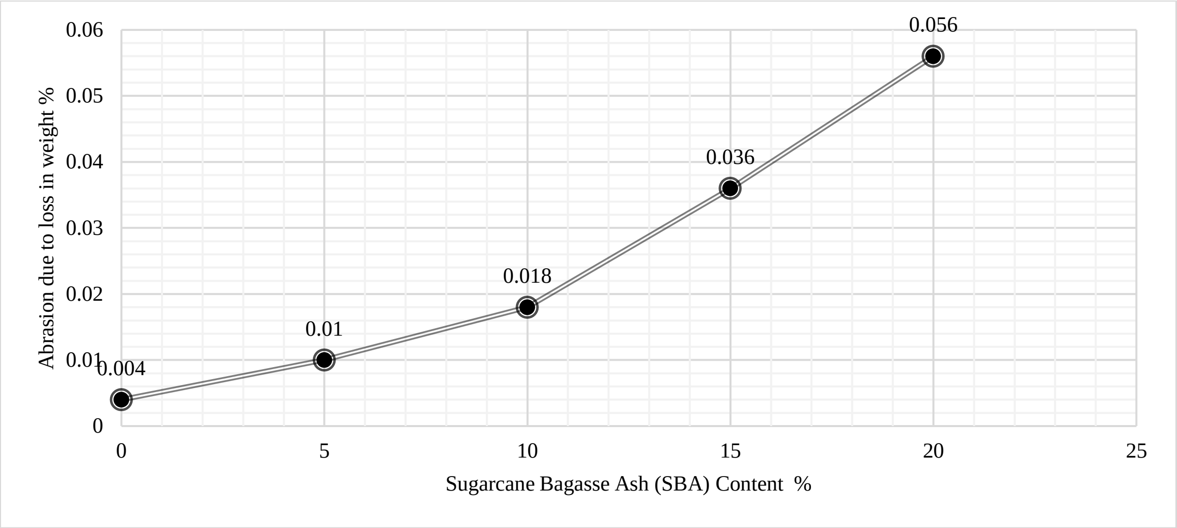

FIGURE 5: Abrasion due to loss of weight

IV. CONCLUSIONS

Based on the findings of this research, the following main conclusions were drawn:

- The 28 days strength of sandcrete blocks made by blending fine marine sand and clean lateritic sand meets the strength value of 3.45N/mm^2 recommended by [21] and [33].The highest 28 days strength of sandcrete blocks is achieved when 30% of marine sand is blended with 70% of clean lateritic sand.
- Sugarcane Bagasse Ash from West Kenya Sugar Company meets the minimum percentage requirement for pozollana class F, provided in [30].
- Increase of SBA into the cement-blended sand matrix produces sandcrete blocks of lower density. The high density being recorded at 0% while the lowest being at 25% SBA replacement.
- As the percentage SBA content in the cement-blended sand matrix increases, the compressive strength of the sandcrete block decreases. At 14 and 28 days, upto 15% SBA replacement levels satisfy the 3.45 N/mm^2 recommended standards for load bearing walls.
- Water absorption increases as the percentage replacement of SBA increases in the Cement-blended sand matrix with the highest value of absorption of 7.23% recorded at 25% SBA replacement. Water absorption for all SBA % content does not exceed the maximum allowed water absorption of 12% as specified by [39].
- The loss of weight due to abrasion for 28 days sandcrete blocks increases as the percentage of the percentage of SBA is increased. The lower values obtained in this study ascertained the suitability of the mix to produce a more durable sandrete block.

ACKNOWLEDGEMENT

We are grateful to the Pan African University, Institute for Basic Sciences, Technology and Innovation (PAUISTI) and Jomo Kenyatta University of Science and technology (JKUAT) for providing relevant resources and a conducive environment to undertake this research.

REFERENCES

[1] M. Anosike and A. Oyebande, “Sandcrete blocks and quality management in Nigeria building industry,” *Journal of engineering project and production management,* vol. 2, no. 1, pp. 37-46, 2012.

[2] E. B. Oyetola and M. Abdullahi, “The Use of Rice Husk Ash in Low-Cost Sandcrete Block Production.,” *Leonardo Electronic Journal of Practices and Technologies,* vol. 8, pp. 58- 70, 2006.

[3] D. Onwuka, N. Osadebe and C. Okere, “Structural Characteristics of Sandcrete Blocks Produced in South-East Nigeria,” *Journal of Innovative Research in Engineering and Sciences,* vol. 4, no. 3, pp. 483- 490, 2013.

[4] M. Abdullahi, “Compressive Strength of Sandcrete Blocks in Bosso and Shiroro Areas of Minna, Nigeria,” *AU J.T.,* vol. 9, no. 2, pp. 126-131 , 2005.

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[5] T. O. Adewuyi, K. O. Olusola and M. G. Oladokun, “Engineering properties of sandcrete blocks made with blended bamboo leaf ash (BLA) and ordinary Portland cement,” *A multidesplinary journal of graduate school,University of Uyo,Uyo Nigeria,* vol. 1, no. 3, pp. 48-59, 2013.

[6] I. O. Agbede and J. MAanasseh, “Use of cement: Sand admixture in laterite brick production for low cost housing.,” *Leonardo Electronic Journal of Practices and Technologies,* pp. 163-174, 2008.

[7] O. M. Ibearugbulem, E. N. Okonkwo, A. N. Nwachukwu and L. O. Obi, “Determination of compressive strenght of lateritic sandcrete cubes,” *International Journal of Scientific & Engineering Research,* vol. 6, no. 5, pp. 1190-1194, 2015.

[8] J. O. Ukpata, M. E. Ephraim and G. A. Akeke, “Compressive strength of concrete using lateritic sand and quarry dust as fine aggregate,” *ARPN Journal of Engineering and Applied Sciences,* vol. 7, no. 1, 2012.

[9] O. Ata, K. Olusola, O. Omojola and A. Olanipekun, “A study of compressive strenght characteristic of laterite/sandcrete hollow blocks,” *Civil Engineering Dimension,* vol. 9, no. 1, p. 15–18, 2007.

[10] J. Ayangade, O. Alake and A. A Waha, “The effects of different curing methods on the compressive trength of Terracrete.,” *Civil Engineering Dimension.,* vol. 11, no. 1, pp. 15–18,, 2007.

[11] C. G. Girish, D. Tensing and K. Priya, “Dredged offshore sand as a replacement for fine aggregate in concrete,” *International Journal of Engineering Sciences & Emerging Technologies,* vol. Volume 8, no. Issue 3, pp. 88-95, 2015.

[12] G. Oyekan and O. M. Kamiyo, “A study on the engineering properties of sandcrete blocks produced with rice husk ash blended cement,” *Journal of Engineering and Technology Research,* vol. 3, no. 3, pp. 88-98, 2011.

[13] S. I. AnowaI and J. E. Afunanya, “Millet husk ash as partial replacement of cement in sandcrete block,” *international Research Journal of Engineering and Technology,* vol. 4, no. 7, pp. 670-680, 2017.

[14] K. Sathiya and S. R., “Experimental Study on Bagasse Ash in Concrete,” *International Journal for Service Learning in Engineering,* vol. 5, no. 2, pp. pp. 60-66,, 2010.

[15] BS 12, Specification for Portland cement, 389, Cheswick High Road, London,: British standard Institute, 1996.

[16] R. Onchiri, J. Kiprotich, B. Sabuni and C. Busieney, “Use of sugarcane bagasse ash as a partial replacement for cement in stabilization of self-interlocking earth blocks,” *International journal of civil engineering and technology (ijciet),* vol. 5, no. 10, pp. 124-130, 2014.

[17] BS 882, Specification for aggregates from natural sources for concrete., BSI, 1992.

[18] E. Asiedu and A. Agbenyega, “Suitability of Laterite Fines as a Partial Replacement for Sand,” *International Journal of Emerging Technology and Advanced Engineering,* vol. 4, no. 10, 2014.

[19] BS 3148, Methods of test for water for making concrete, BSI, 1980.

[20] J. Osunade, “Granite Fines on the Compressive and Tensile Strengths of Laterized Concrete, Building and Environment,,” vol. 37, no. 5, pp. 491-496., 2002.

[21] BS 6073¬1, Precast concrete masonry units. Specification for precast concrete masonry units., BSI, 1981.

[22] T. Nwofor, "Durability of block work: the effect of varying water/cement ratio of mortar joint," *Advances in Applied Science Research,* vol. 3, no. 3, pp. 1848-1853, 2012.

[23] M. Goncalves and C. Bergmann, “Thermal insulators made with rice husk ashes: Production and correlation between properties and microstructure.,” *Constr. Build. Mater.,* no. 21, pp. 2059-2065., 2007..

[24] BS 1377-2, Methods of test for soils for civil engineering purposes. Classification tests, 1991.

[25] J. Santhiyaa and S. Ramasundaram, “Strength and Durability Characteristics of Laterite Sand Mixed Concrete,” *International Journal of ChemTech Research,* vol. 8, no. 3, pp. 1253-1259, 2015.

[26] A. R. Dongapure and S. S. Mangalgi, “Study on Strength of Concrete using Lateritic Sand and Quarry Dust as Fine Aggregates.,” *nternational Journal of Engineering Research & Technology,* vol. 3, no. 12, pp. 126-130, 2014.

[27] BS 812: Part 101., Testing aggregates: Part: Guide to Sampling and Testing Aggregates., 389, London,Cheswick High Road: Institution British Standard:, 1984.

[28] V. Ravindra and A. K. Buraka, “Mechanical Properties of Concrete with Marine Sand as Partial Replacement of Fine Aggregate,” *Dr. V.Ravindra Int. Journal of Engineering Research and Applications,* vol. 6, no. 2, pp. 8-11, 2016.

[29] J. J. Santhiyaa and S. Ramasundaram, “Strength and Durability Characteristics of Laterite Sand Mixed concrete,” *International Journal of ChemTech Research,* vol. 8, no. 3, pp. 1253-1259,, 2015.

[30] ASTM C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete, ASTM International, West Conshohocken: PA, 2017.

[31] P. K. Barasa, K. J. Too and Mulei, “Stabilization of Expansive Clay Using Lime and Sugarcane Bagasse Ash,” *Mathematical Theory and Modeling,* vol. 5, no. 4, 2015.

[32] G. Cordeiro, R. Filho, L. Tavares and E. Fairbairn, “Effect of calcination temperature on the pozzolanic activity of sugar cane bagasse ash,” *Construction and Building Materials,* vol. 23, no. 10, pp. 3301-3303, 2009.

[33] NIS 87, Specification for Standard Sandcrete Blocks.Nigeria Industrial Standard, Lagos: Standard Organization of Nigeria (SON), 2000.

[34] A. Raheem, O. Falola and K. Adeyeye, “Production and Testing of Lateritic Interlocking Blocks.,” *Journal of Construction in Developing Countries,,* vol. 17, no. 1, pp. 33-48, 2012.

[35] B. A. Memon and G. S. Channa, “Compressive strength of concrete masonry unit made by partial replacement of fine sand with local sand,” *International Journal Of Engineering Sciences & Research,* vol. 4, no. 3, pp. 123-131, 2015.

[36] A. K. Singh, V. Srivastava and V. Agarwal, “Stone Dust in Concrete: Effect on Compressive Strength,” *International Journal of Engineering and Technical Research,* vol. 3, no. 8, 2015.

[37] A. A. Raheem and O. K. Sulaiman, "Saw Dust Ash as Partial Replacement for Cement in the Production of Sandcrete Hollow Blocks," *International Journal of Engineering Research and Applications,* vol. 3, no. 4, pp. 713-721, 2013.

[38] O. A. Oyelade, “Coconut Husk Ash as a Partial Replacement of Cement in Sandcrete Block Production,” in *Proceedings of the 11th International Conference and 32nd Annual General Meeting of the Nigerian Institution of Agricultural Engineers,* Ilorin, Nigeria., 2011.

[39] BS 5628-1, Code of practice for the use of masonry.Structural use of unreinforced masonry, BSI, 2005.

[40] S. Duggal, Building materials, Daryaganji, New Delhi, India.: New Age International Publisher., 2009.

[41] I. H. Adebakin, A. A. Adeyemi, J. Adu, F. A. .Ajayi, A. A. Lawal and O. B. Ogunrinola, “Uses of sawdust as admixture in production of lowcost and light-weight hollow sandcrete blocks,” *American Journal Of Scientific And Industrial Research,* vol. 3, no. 6, pp. 458-463, 2012.

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