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Rheological Study on Strength Characteristics of Sandcrete Hollow Block Admixed with Oil Palm Stem Ash

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ABSTRACT: The study investigated the use of oil palm stem ash as partial replacement of OPC for sandcrete hollow block production which ranges from 0 to 25% (at 5% interval). Ninety six (96) sandcrete blocks were cast using 1:6 as mix ratio of cement: sand with 0.45 water cement ratio. The compressive strength, density, porosity and abrasion test were carried-out on sandcrete block were tested at curing age 7, 14, 21 and 28 days. The oil palm stem ash was analysed for chemical composition of (SiO_2, Al_2O_3 and Fe_2O_3) in which the summation is 75.3%. it was observed that compressive strength and bulk density decreases as the content of OPSA increases but 5% of OPSA has value of 4.66N/mm^2 and 2111.20Kg/m^3 as against the control 5.12N/mm^2 and 2162.01Kg/m^3 respectively. The porosity and abrasion test revealed the increase in value as the percentage content of OPSA increased. It was concluded that OPSA is a good pozzolan having satisfied the required standard. which can be used as 10% of OPSA content insandcrete hollow block production having attained a 28 day compressive strength of more than 3.5N/mm^2 as required by the Nigeria National Building Code (2007) for non load bearing wall.

KEYWORDS: Rheological Study, Compressive Strength, Sandcrete Hollow Block, Oil Palm Stem Ash, and Strength Characteristics

1.0 INTRODUCTION

Sandcrete hollow blocks containing a mixture of sand, cement and water are used extensively in many countries of the world especially in Africa. In many part of Nigeria, sandcrete block is the major cost component of the most common buildings. The high and increasing cost of constituent materials of sandcrete blocks has contributed to the nonrealization of adequate housing for both urban and rural dweller (Olaniyan, 2011). Hence, availability of alternatives to these materials for construction is very desirable in both short and long terms as a stimulant for socio-economic development. In particular, materials that can complement cement in short run, and especially if cheaper, will be of great interest.

Over the past decade, the presence of mineral admixtures in construction materials has been observed to impact significant improvement on the strength, durability, and workability of cementitious products Abdullahi, (2015). In areas prone to flood, hygrothermal properties of the buildings construction materials are of importance. Also, energy requirements for residential and commercial buildings are known to be influenced by building design and by the materials used in both temperate and tropical regions. The importance of the blocks as part of local building materials cannot be over emphasized in building and construction industry (Oyekan, 2014). This is necessary to provide a given level of thermal comfort within the building and over the annual climatic cycle. Substitution of any of the pozzolan is aimed at enhancing at least one of the properties of the block. Oil palm stem is an agricultural waste produced in significant quantity on a global basis. While it is utilized as fuel in some regions, it is regarded as a waste in others thereby causing pollution; due to problem with disposal.

Hence, its profitable use in an environmentally friendly manner, will be great solution to what would otherwise be a pollutant, when burnt under controlled conditions. The oil palm stem ash (OPSA) is highly pozzolanic and very suitable for use in lime-pozzolana mixes and for Portland cement replacement (Raheem, 2013). The effect of OPSA blended cement on the strength and permeability properties of concrete has been investigated by Ganesan et al. (2008). Olutoge (2009) observed that, the mechanical resistance of sandcrete blocks is obtained when ungrounded ash is added to increased the performance of mortar blocks. Their studies on Senegalese OPSA also revealed that use of unground OPSA enabled production of lighter sandcrete block with insulating properties at a reduced cost. The ash pozzolanic reactivity was responsible for the enhanced strength obtained. Okpala (2003) partially substituted cement with OPSA in the percentage range of 30-60% at intervals of 10% while considering the effect of some properties of the blocks. This results revealed that a sandcrete mix of 1:6 (cement/sand ratio) required up to 40% cement replacement and a mix 1:8 ratio required up to 30%, are adequate for sandcrete block production in Nigeria. In this study, a mix of 1:6 with the percentage range of 0 – 25 at 5% interval was adopted.

OPSA is an agricultural waste generated in palm oil industry. It is obtained from the combustion of oil palm stem residues of oil palm tree. Generally, the wastage of palm oil from palm oil industry was increasing eventually. It has become a major problem to palm oil power plants because this waste is not reused and recycled in any works. Therefore, OPSA whose chemical composition contains a large amount of Silica can be used in cement replacement.

Therefore, this paper investigated the use of OPSA as partial replacement for ordinary Portland Cement in the production of sandcrete Hollow Blocks. It is believed the results obtained from the study could be useful where compressive strength is desirable.

2.0 MATERIALS AND METHODS

2.1 Materials

The materials used in this study are cement, aggregate water, and oil palm stem ash. The sand was graded in conformity to BS 882 (1983). The cement (OPC with grade 42.5) was purchase from a retailed shop in Esa-Oke, Osun State of Nigeria with The water cement ratio 0.45 used conformed to specification by BS 3148 (1980). The oil palm stem ash (OPSA) used in this study was obtained from burning the oil palm stem into ashes by closed burning in limited supply of air at measured temperature of 600^{0}c using piezometer. The ash was sieved using 75 microns sieve after cooling to obtain ash that is fine enough to react perfectly with ordinary Portland cement. The oil palm stem ash used is presented in Plate 1 to 3.

Plate 1: Before Burning Oil Palm Stem

Plate 2: During Burning Oil Palm Stem

Plate 3: Oil Palm Stem Ash

2.2 Batching Proportion of Sandcrete Hollow Block Admixed with Oil Palm Stem Ash (OPSA)

The sieve analysis was carried out in accordance with the provision Section 103 of BS 812 (1985). The ordinary Portland cement was replaced with OPSA at 5 – 25% (at 5% intervals) by weight of cement, with sandcrete blocks without OPSA serving as control experiment. The specimen were cured and crushed after 7, 14, 21, and 28 days. The batching proportion is presented in Table 1.

Table 1: Batching of materials for the Sandcrete Block Samples

Percentage Replacement of OPSA	Mixed Ratio	Weight of Cement (kg)	Weight of OPSA (kg)	Weight of Sand (kg)
0	1:6	25	0	150
5	1:6	23.75	1.25	150
10	1:6	22.50	2.50	150
15	1:6	21.25	3.75	150
20	1:6	20.00	5.00	150
25	1:6	18.75	6.25	150

2.3 Preparation of Sandcrete Hollow Block and Casting of Samples

The mix ratio used was 1:6 with water cement ratio of 0.45 to achieve the desirable block strength. Block samples with size 450 x 225 x 225 mm^3 were cast for the determination of compressive strength, abrasion, density, and porosity. For each batch of sandcrete hollow lock, a total of twelve blocks were cast giving a total of 96 blocks for all batches. The sandcrete hollow block was mixed, placed and compacted.

2.4 Compressive Strength Test and Density

The test was carried out on the sandcrete hollow block at different curing ages 7, 14, 21 and 28 days. The surface of the sample was placed on the bearing surface, another plate was placed on the block to ensure equal distribution of the applied load. The gauge of the machine was adjusted to be zero reading. While the machine was on, the applied load was gradual and gauge reading increased as the load increased until failure was noticed. This reading was carried out to compute the compressive strength of the specimen.

The density was computed as mass of sandcrete hollow block divided by its volume (mm^3).

2.5 Porosity Test on Sandcrete Hollow Block

This was done by sun-drying sandcrete hollow block (specimen) at the curing age of 28 days in water. The specimens were then removed from the curing tank and allowed to drain the specimen that much water, consequently become weakened and eventually fail. The volume of liquid absorbed by a porous medium is an indication of its pore volume and it is a good approximate measure of its porosity.

Hence, porosity Ʊ is obtained with the relation:

$$Ʊ = \frac{V_f}{V} \times 100\%$$

The presence of admixtures may increase, decrease, or maintain the porosity with Oil Palm Stem Ash (OPSA) depending on the aggregate sizes when exposed to persistent flooding, a highly porous block could absorb.

2.6 Abrasion Test on Sandcrete Hollow Block

The abrasion test were performed on three samples each by first sun drying the sample for seven days after 28 days curing and later immersed in water for 24 hours. The samples were then removed from the curing tank and allow to drain for about three hours. This was followed by direct scratching of the sides of the specimen with ten (10) backward and forward strokes of iron brush. The resulted scratched particle difference sandcrete hollow block was weighted to give the amount of abrasive resistance of each sample.

3.0 RESULTS AND DISCUSSION

3.1 Physical and Chemical Constituents of OPSA

The results of the chemical and physical composition of oil palm stem ash (OPSA) is presented in Table 2. It was observed that the elemental oxide composition of oil palm stem ash showed that the OPSA has combined percentage of (SiO_2, Al_2O_3 and Fe_2O_3) of 75.31 which more than 70% indicating that OPSA is a class F pozzolan and a good pozzolanic material which is in accordance with the requirements in ASTM (1991). The mean percentage of LOI for OPSA was 4.26% and this does not exceed 6% specified by ASTM for class F, pozzolans. High value of LOI in OPSA is an indication of the presence of carbon content in the ash. The specific gravity (SR) was 3.05 compared to cement which has specific gravity of 3.15 due to its degree of fineness, this indicate that OPSA was porous in nature (Olaniyan, 2011)

Table 2: Physical and Chemical constituent of OPSA

Chemical and Physical Constituents	**Percentage Composition (%)**			
	Sample 1	**Sample 2**	**Sample 3**	**Average**
SiO_2	62.45	66.32	65.11	64.30
Al_2O_3	8.16	5.99	6.01	6.72
Fe_2O_3	3.81	4.09	3.91	3.94
CaO	11.01	10.96	11.66	11.20
MgO	1.67	2.14	2.01	1.94
SO_3	1.11	1.31	1.06	1.16
Na_2O	0.41	0.52	0.31	0.41

K_2O	2.34	2.51	2.12	2.32
$CaCO_3$	7.64	8.06	7.62	7.77
LOI	4.09	4.70	3.99	4.26
LSF	2.01	1.13	2.08	1.74
SR	11.06	10.46	10.97	10.83
AR	13.01	11.53	12.71	12.42
$Al_2O_3 + SiO_3 + Fe_2O_3$	74.42	76.40	75.11	75.31

3.2 Compressive Strength of OPSA in Sandcrete Hollow Block

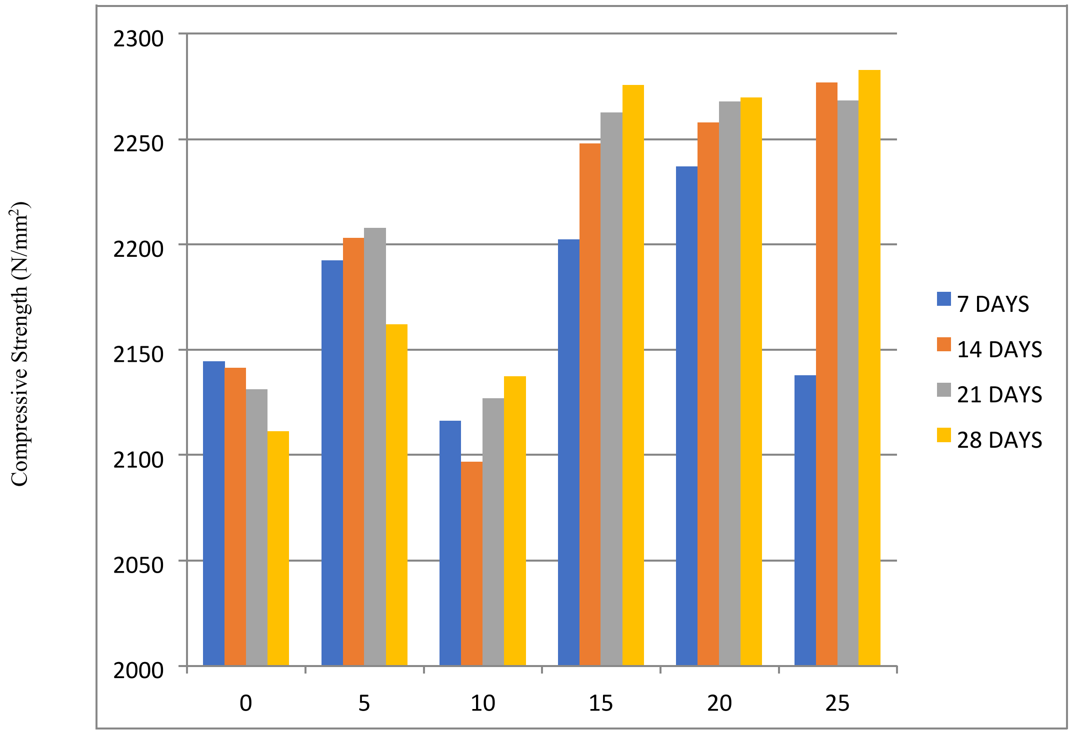
The compressive strengths for both the reference and blended samples are presented in Figures (1a and 1b) in which the oil palm stem ash was replaced partially at 0 to 25% (at 5% interval) with ordinary Portland cement in the production of sandcrete hollow block. Figure 1a shows that the compressive strength generally increase with curing period but decreased with increasing amount of oil palm stem ash.

At 7 days curing, the results showed a high compressive strength between OPSA sandcrete block and that of control. The strength of the OPSA sandcrete block decreased from 1.72 N/mm^2 for the control to 1.36N/mm^2 for 15% replacement. Highest compressive strength was observed for 5% replacement of cement with OPSA.

At 28 days curing, the strength of the OPSA sandcrete block were significantly lower than that of the control. However, the strength decreased with increasing amount of OPSA, with highest and lowest values observed for 5 and 25% replacements respectively. This increased in strength of OPSA sandcrete Hollow Block can be attributed to the pozzolanic activity of OPSA.

These results showed clearly that OPSA had significant impacts on the strength of sandcrete Hollow Block, with its effective optimal performance observed at 5% replacement.

This is in consonance with previous finding of (Oyekan, 2014).



% Replacement of OPSA

Figure 1a: Plot of compressive strength against % content of OPSA

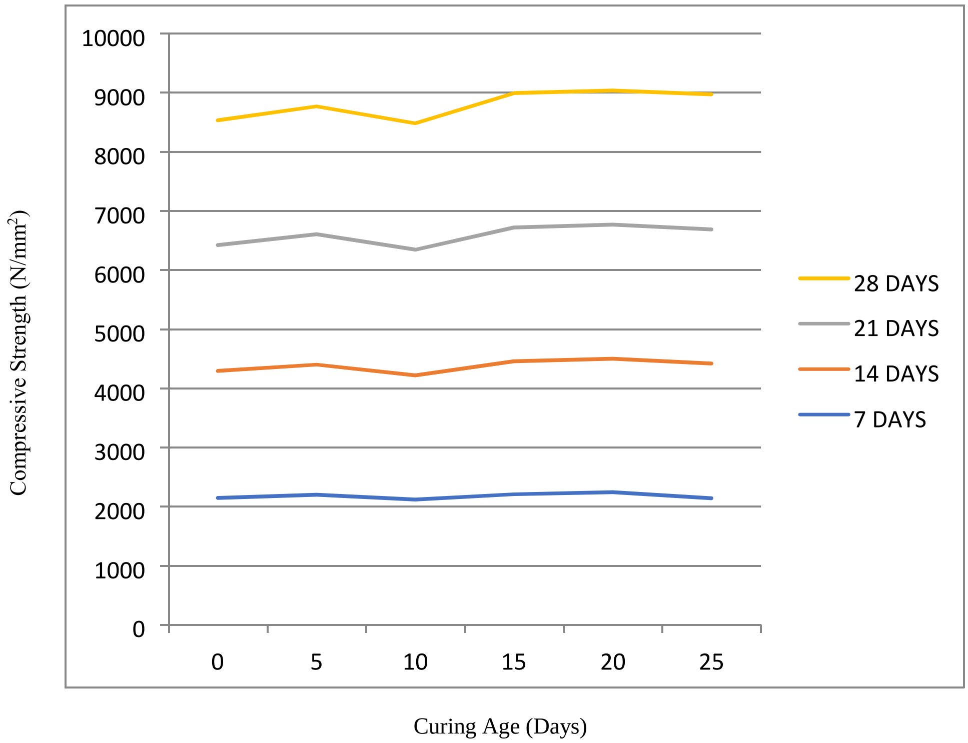


Figure 1b: Plot of compressive strength against curing age

3.3 Density Test on OPSA content on Sandcrete Hollow Block

The results of the bulk density performance of the OPSA blended cement are hereby presented in Figure 2.

The effects of OPSA replacements on the density of the sandcrete Hollow Block at different curing periods showed that the density generally decreased with curing age and the decrease became insignificant after 21 days curing period. At 7 and 14 days curing, density increased with OPSA substitution from 0 to 5% but further addition of OPSA led to a decrease in density, with the lowest density observed for 10% OPSA substitution. Results at 21 and 28 days curing are similar and showed a increased in density from 0 to 5% OPSA replacement. It decreased from 5 to 15% but further amount to OPSA gave rise to a decrease in density. The result is in line with previous finding of (Raheem, 2013)

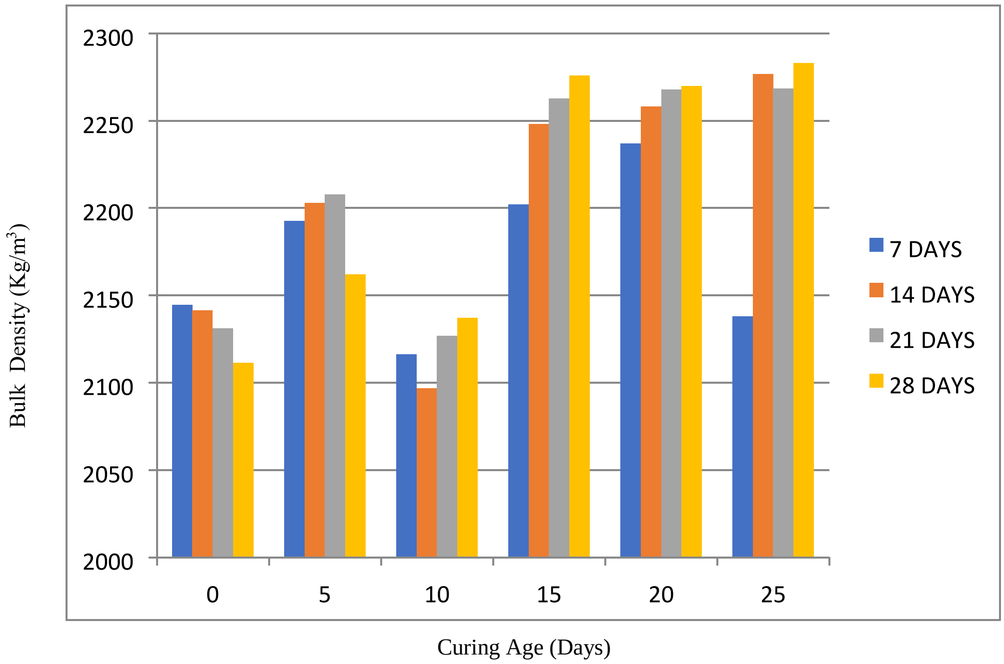


Figure 2: Graph of bulk density against % content of OPSA

3.4 Porosity Test of Sandcrete Hollow Block with Percentage Content of OPSA

The results of porosity test conducted on sandcrete hollow block ternary replaced with cement and OPSA at 28 days curing period of hydration.

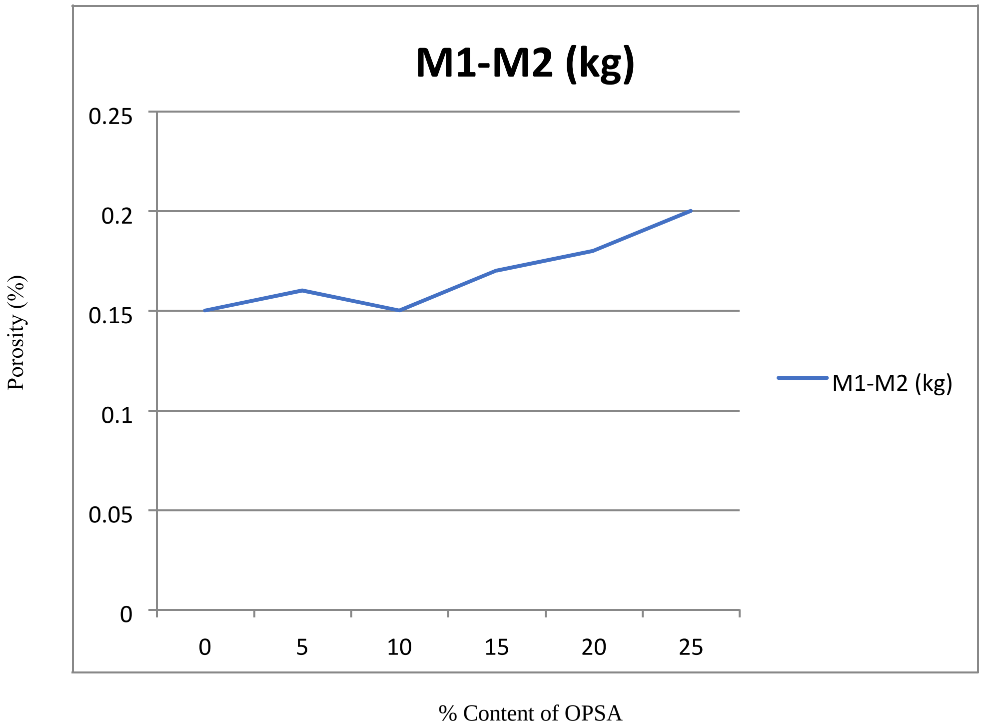


Figure 3: Plot of porosity against OPSA substitution

It was observed from Figure 3 that the degree of porosity increased as the percentage content of OPSA increased from 0 to 25%. This could be as a result of oxide composition present in the OPSA which react readily with OPC when subjected to water. This is in line with previous findings of (Abdullahi, 2015).

3.5 Abrasion Test on Sandcrete Hollow Block with OPSA Content

The variation of abrasion with percentage substitution of the OPSA is presented in Figure 4.

From the Figure, it could be depict that OPSA substitution on the abrasion resistance of the sandcrete Hollow decreased from 0 to 5% of OPSA content when replaced partially with ordinary Portland Cement. It was observed that the sandcrete block made with 10 and 25% of OPSA substitution gave highest abrasion value and thus undergone the highest shrinkage. However, the sample with 0 to 5% of OPSA content showed the lowest shrinkage values, indicating the highest resistance to abrasion. This suggest that 5% substitution of OPC with OPSA can perform favourably with the control sample. This is in line with previous findings of (Adebambi, 2017).

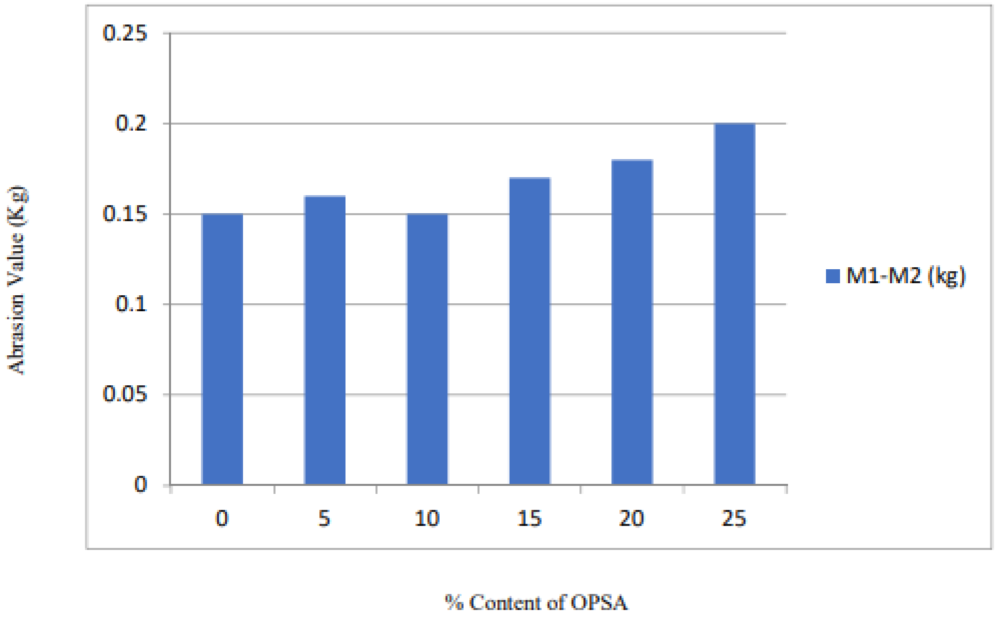


Figure 4: Graphical illustration of abrasion against percentage content of OPSA

4.0 CONCLUSIONS

Based on the findings in this study, the following conclusions can be drawn:

i. OPSA is a suitable material for use as a pozzolan, since it satisfied the requirement of ASTM in which the sum of (SiO_2 + Al_2O_3 and Fe_2O_3) greater than 70%

ii. The maximum compressive strength of 4.66N/mm^2 was obtained for the sandcrete block specimens at 5% percentage of OPSA iii. The density of the blocks increases as the content of OPSA increases.

iv. The compressive strength achieved at 5% of OPSA content satisfied ASTM requirement

v. Sandcrete block with OPSA blended with cement is more porous than that of the control.

vi. The sandcrete hollow block with OPSA is therefore recommended for external wall up to 5% content of OPSA

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