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# Comparative Study of the Properties of Sandcrete Blocks Produced with Sawdust as Partial Replacement of Sand

Donald Kwabena Dadzie[1], George Okyere Dokyi[2], Nicholas Niakoh[3]

**Abstract**—The study explores and compares the properties of sandcrete blocks produced with sawdust as partial replacement to the traditional sandcrete blocks in an attempt to establish the percentage replacement of sawdust that yield properties and characteristics that meets acceptable standards. After a review of relevant literatures, samples of materials (sawdust, sand, cement and appropriate water cement ratio) required were collected and batched by volume to a mix proportion of 1:6. The sawdust replacement varies from10%, 20%, 30%, and 40% with water cement ratio of 0.5. A total of 30 blocks was molded, cared for 28days, subjected to various tests, including water absorption, weight, density, and compressive strength. From the water absorption test conducted, it indicates that blocks produced from 10% to 40% sawdust replacement were found to be more porous than the traditional block since it exceeds the minimum standard of 130kg/m3 recommended by the ASTM. The weight and density of the sawdust block increases up to 10% sawdust replacement, and furthermore reduces when the sawdust exceeds 10%. With regard to strength test, it was revealed that, the compressive strength of the sawdust blocks exceeds the minimum requirement of 2.8N/mm$^2$ when the sawdust replacement do not exceed 10%. For blocks with sawdust as partial replacement to meet standard specification, the sawdust content should not exceed 10%. Further studies must focus on the factors that can affect the durability of the blocks produced with sawdust, people's willingness to adopt blocks produced with sawdust aggregates and to compare the cost per unit sawdust block to conventional sandcrete block.

**Index Terms**— Compressive strength, density, partial replacement, sand, sandcrete block, sawdust, water absorption, weight



## 1 INTRODUCTION

The construction industry in general contributes to the degradation of the environment through the deforestation of the natural resources, energy consumption, atmospheric pollution and waste generation. Research has shown that, resource depletion is noted to be one of the major challenges of the construction industry. This is because the industry relies heavily on conventional materials such as cement, granite and sand for construction (Dadzie and Yankah, 2015). The high and increasing cost of these materials has greatly hampered the development of shelter and other infrastructural facilities in developing countries that has made the search for alternative materials that meet the performance standards of the conventional materials essential imperative (Oyedepo et al., 2014).

The possibility of using sawdust as an alternative to the conventional sand sounds favourable. However, its use as a building material is not common in most of part of the world, including Ghana (Dadzie and Yankah, 2015). Attempt to produce affordable houses which will impose less environmental stresses and make construction, sustainable has induce research into the use of alternative materials.

Consequently, the search for alternative cheaper materials and utilization of industrial waste and by-product materials in infrastructure development is proven economically viable when environmental factors are considered and these materials meet appropriate performance specifications and standards (Dadzie and Yankah, 2015).

According to Mageswari and Vidivelli (2009), the choice of partial substitute or alternative materials for sand in block production depends on several factors such as availability of material, physical properties, chemical ingredients, etc. Saw-

- *Donald Kwabena Dadzie is a Lecturer in the Department of Building Technology at Cape Coast Polytechnic, Cape Coast, Ghana. E-mail: kwabenadadzie@yahoo.com*
- *George Okyere Dokyi is an Assistant Lecturer in the Department of Civil Engineering at Wa Polytechnic, Wa, Upper West Region, Ghana. E-mail: godokyi@yahoo.com*
- *Nicholas Niakoh is a Quantity Surveyor in Training Research and Networking for Development (TREND at Kumasi, Ghana. E-mail: nknjnr@gmail.com*

dust as fine aggregate is of particular interest, because their use can considerably reduce the disposal problem and hence helps the preservation of natural fine aggregate.

Studies have established that sand is the single most important commodity for building, aside cement and stones. The availability of sand for construction works is becoming rare due to the excessive mining as a result of increasing demand for shelter and other infrastructural facilities especially in the developing countries (Peprah, 2013). This has resulted in high cost of sand for construction works (Oyedepo et al., 2014).

According Oyedepo et al. (2014), sawdust is noted to be one of the major underutilized by-product which is accumulated from the countries all over the world which constitutes a nuisance and causes serious environmental problems and health hazards when managed improperly or left attended as they form refuse heaps in the areas where they are disposed.

Olutoge (2010), has defined sawdust as loose particles or wood chippings obtained as by-products from the sawing of timber into standard useable sizes. Sawdust is an industrial waste material in the timber industry, which constitute a nuisance to both the health and environment when managed improperly, which may cause serious environmental problems and health hazards. However, sawdust is one of the major underutilized by-products from the sawmill and its generation is an unavoidable hence a great effort is made with the utilization of such waste (Oyedepo et al., 2014).

Dadzie and Yankah (2015), established that there is need for engineering consideration of the use of cheaper and locally available materials to meet desired need to enhance efficacy and lead to an overall reduction in construction cost for sustainable development.

This study compared the properties of sandcrete blocks produced with sawdust as partial replacement of sand to that of the conventional sandcrete blocks.

## 2 MATERIALS AND METHODS

The ordinary Portland cement produced by Ghana Cement Limited (GHACEM) being Ghana's largest cement producer and as such readily available in almost every part of Ghana was used for all the mixes required for this study. This cement also conforms to the requirements of the British Standard Code (BS 12 of 1996) and requirements of GS 22 (2004). To prevent the cement from being exposed to moisture and hardened before usage, it was kept in air tight packages and stored inside the laboratory. Water produced by Ghana Water Company Limited was used in mixing materials. It conforms to BS 1348 (1980) and looked clean and also free from any visible impurities. The fine aggregates (sand) used was clean, sharp river sand obtained from Kakum River that is free from clay, loam, dirt and organic matter of any description. The sawdust used for this study is the industrial waste stockpiled by the local sawmilling operations. It was obtained from Abura a suburb of Cape Coast in the Central Region of Ghana. The sawing sawdust was first spread in an open space. The impurities and unwanted particles that could affect the block properties were further removed.

Fig 1: Batching of materials for block samples

Hand mixing was adopted to produce the samples. According to cement and concrete institute, it is possible to make blocks on a small scale without a concrete mixer. Measures were put in place to control deficiencies. Prior to mixing, all the components were weighted according to the mix proportions.

A block size of 100 x 100 x 100mm was produced under laboratory condition for the study. The mix ratio used is 1:6 (one part of cement to six parts of sand) at a constant water cement ratio of 0.5. The sand content was replaced with the sawdust from 0%, 10%, 20%, 30% and 40% is adopted from Dadzie and Yankah (2015). The 0% sawdust replacement served as the control sample for the study. To prevent shortage as a result of waste, compaction and bulking of aggregates, 40% were allowed on the materials. Six (6) sample cubes each were produced from per mix design. This comprises of three (3) number 100 x 100 x 100mm cube that were crushed at 28days for the strength test and three (3) number for the water absorption test. In all a sample size of thirty (30) cubes were moulded for the study in accordance with BS 1881 (1996).

In coming out with the properties of sandcrete block produced with sawdust as partial replacement of sand, an experimental investigation was conducted to study the following properties: weight, density, water absorption and compressive strength.

Fig 2: Crashing of Blocks samples

The arrangement of the experimental program can be summarized in the flow chart shown in figure 3.

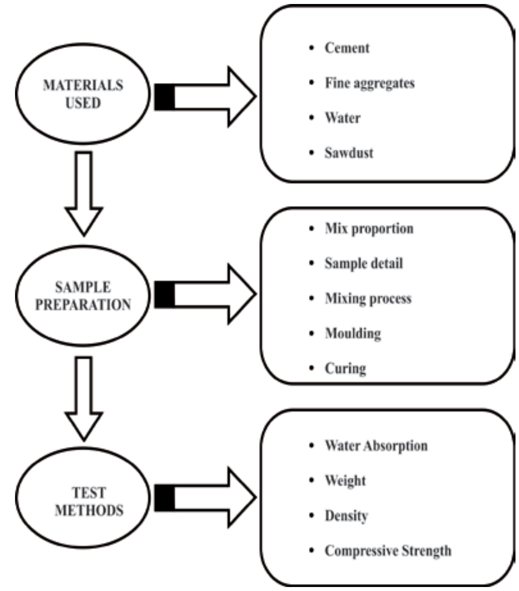



Fig. 3: Flow chart of experimental programme



## 3.0 RESULTS AND DISCUSSION

### 3.1 Water Absorption

Result of Water Absorption Test is presented in Table 1 as shown below.

Table 1: Water Absorption of Block

| SD Replacement (%) | Dry Mass (kg) | | | Average Dry Mass (kg) | Wet Mass (kg) | | | Average Wet Mass (kg) | Wet of water absorbed (%) | Water absorption (kg/m$^3$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | SP 1 | SP 2 | SP3 | | SP 1 | SP 2 | SP3 | | | |
| 0 | 1.851 | 1.847 | 1.850 | 1.849 | 2.002 | 1.989 | 1.996 | 1.996 | 7.95 | 147 |
| 10 | 1.848 | 1.850 | 1.852 | 1.850 | 1.998 | 1.999 | 2.005 | 2.001 | 8.16 | 151 |
| 20 | 1.784 | 1.782 | 1.790 | 1.785 | 1.940 | 1.920 | 1.962 | 1.941 | 8.74 | 156 |
| 30 | 1.684 | 1.680 | 1.688 | 1.684 | 1.852 | 1.787 | 1.899 | 1.846 | 9.62 | 162 |
| 40 | 1.572 | 1.568 | 1.574 | 1.571 | 1.745 | 1.699 | 1.799 | 1.748 | 11.27 | 177 |

It was found from the study that, the amount of water absorption increases as the percentage replacement of the sawdust aggregates increases, but the compressive strength decreased with increasing percentage inclusion as shown in table 1. However, the 10% sawdust aggregate blocks could be used in most areas where the traditional sandcrete block is recommended to be used because its water absorption capacity and compressive strength both exceeds the standard recommended values.

The relationship between the sawdust aggregates content and the resulting densities of water absorption of the block produced are presented in figure 4. It could be deduced from the figure that, the amount of water absorbed by the block increases as the percentage replacement of sawdust increases. However, from 10% to 40% sawdust aggregate replacement, the resulting water absorptions densities are more than 130kg/m³ which is the minimum standard water absorption density of block made of lightweight aggregates (ASTM Standard C55, 2011). Water absorption is defined as the transport of liquids in porous solids caused by surface tension acting to the capillaries. The resulting decrease in water absorption of the samples as the sawdust aggregates which tend to make the block porous the more its content increases.

In terms of water absorption capacity, the study has revealed that the addition of sawdust to block increase its water absorption. The experiment results show that sandcrete blocks produced with a sawdust aggregate replacement for sand content from 0%, 10%, 20%, 30%, and 40% have water absorption densities of 147kg/m³, 151 kg/m³, 156 kg/m³, 162 kg/m³ and 177kg/m³, respectively which in all cases exceeded 130kg/m³ recommended by the ASTM Standard C55 (2011) as the minimum standard water absorption density of block made of lightweight aggregates.

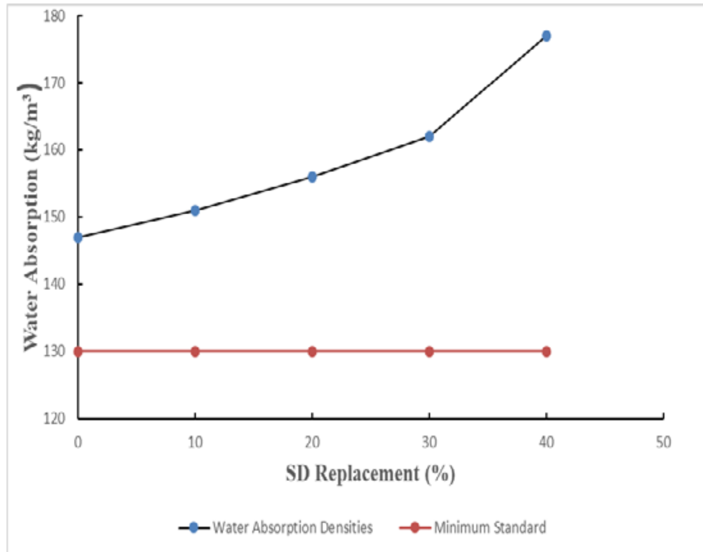



Fig 4: Relationship between percentage sawdust replacement and water absorption capacity

### 3.2 Weight and Density

Data obtained from the weight and density of the block samples are presented in Table 2 and Table 3 respectively.

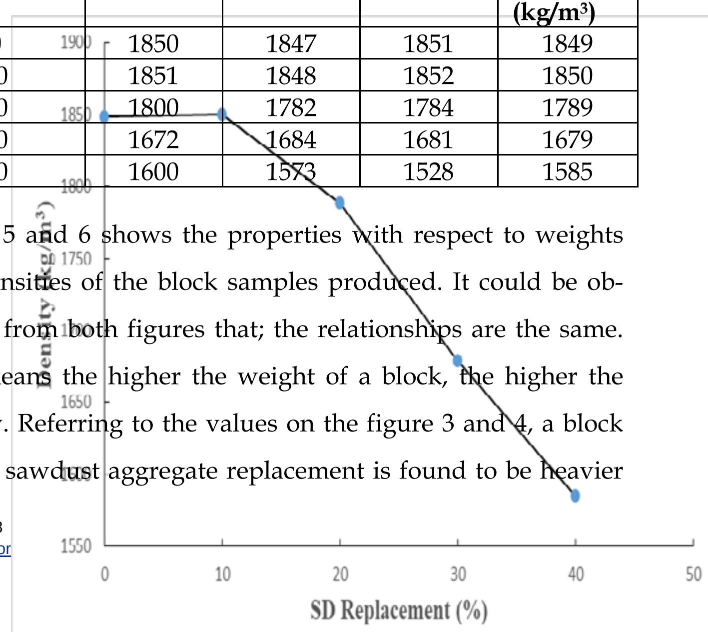
Table 2: Weight of Block Samples

| SD Replacement (%) | Weight (kg) | | | Average Weight (kg) |
|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | |
| 0 | 1.850 | 1.847 | 1.851 | 1.849 |
| 10 | 1.851 | 1.851 | 1.852 | 1.850 |
| 20 | 1.800 | 1.800 | 1.784 | 1.789 |
| 30 | 1.672 | 1.684 | 1.681 | 1.679 |
| 40 | 1.600 | 1.573 | 1.582 | 1.585 |

Table 3: Density of Block Samples

| SD Replacement (%) | Density (kg/m³) | | | Average Density (kg/m³) |
|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | |
| 0 | 1850 | 1847 | 1851 | 1849 |
| 10 | 1851 | 1848 | 1852 | 1850 |
| 20 | 1800 | 1782 | 1784 | 1789 |
| 30 | 1672 | 1684 | 1681 | 1679 |
| 40 | 1600 | 1573 | 1528 | 1585 |

Figure 5 and 6 shows the properties with respect to weights and densities of the block samples produced. It could be observed from both figures that; the relationships are the same. This means the higher the weight of a block, the higher the density. Referring to the values on the figure 3 and 4, a block of 10% sawdust aggregate replacement is found to be heavier



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and denser with a weight of 1.850kg and a density of 1850kg/m$^3$ as compared to the control sample of 0% sawdust aggregate replacement which has a weight of 1.849kg and a density 1849kg/m$^3$. However, from 20% to 40%, the weights and densities are 1.789kg, 1.679kg, 1.585kg and 1789kg/m$^3$, 1679kg/m$^3$, 1585kg/m$^3$ respectively, it could be noticed that, as percentage of sawdust increases both weights and densities decreases. This also indicates that, for a better partial replacement of sawdust percentage for sand in block production, 10% substitution is the ultimate if the emphasis is solely on the weight or density.

Figure 5: Relationship between percentage sawdust replacements and block weight

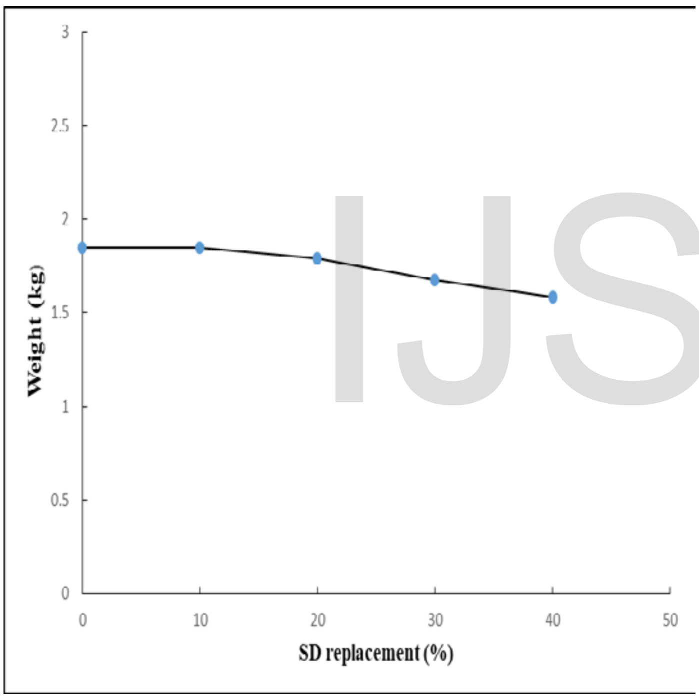


Figure 6: Relationship between percentage sawdust replacements and block density

### 3.3 Compressive Strength

Data obtained from Compressive Strength of block samples are presented in Table 4.

Table 4: Compressive Strength of Block Samples

| SD Replacement (%) | Compressive Stress (N/mm$^2$) | | | Average Compressive Strength (N/mm$^2$) |
|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | |
| 0 | 3.115 | 2.701 | 3.199 | 3.005 |
| 10 | 3.117 | 2.755 | 3.237 | 3.036 |
| 20 | 2.641 | 2.415 | 2.567 | 2.541 |
| 30 | 1.897 | 2.019 | 1.999 | 1.972 |
| 40 | 1.101 | 0.852 | 0.999 | 0.984 |

The relationship between the compressive strength and the sawdust aggregates content is shown in figure 7. It can be observed that 20% to 40% sawdust aggregates replacements which has its compressive strength (2.54N/ mm$^2$, 1.97N/ mm$^2$ and 0.98N/mm$^2$) respectively, are lower than the compressive strength (3.01N/ mm$^2$) of the control sample (0% sawdust aggregates replacement), the compressive strength of 10% sawdust aggregate replacements (3.04N/ mm$^2$) equivalent to the control sample. Furthermore, the compressive strength result of the 20% to 40% of the sawdust aggregates replacements does exceeds the minimum compressive strength (2.8N/ mm$^2$) requirement by the BS 6073. It could be observed from figure 5 that the compressive strength increases from 0% to 10% sawdust aggregates replacement, and decreases from 10% upwards of replacement of sawdust aggregates. Comparing the results of the compressive strength test to the density test results, the relationship seems the same; hence from 0% to 10% sawdust aggregate replacement in block production, the particles are more closely packed. This confirms the statement by Baiden and Asante (2004), that the more closely the particles in a material are packed, the higher the density. In further, development through this study, it can be observed that from 0% to 10% sawdust aggregate replacement, the particles are closely packed. Hence the resultant effect of both higher densities

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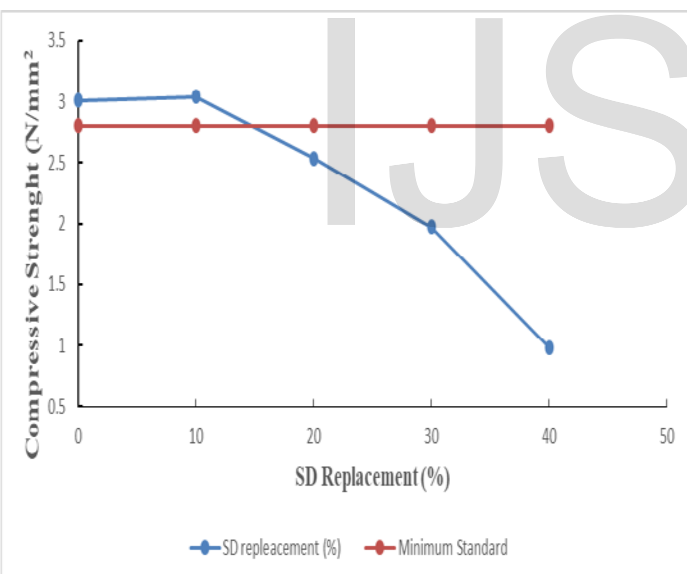
and higher compressive strength.

Figure 7: Relationship between percentage sawdust replacement and compressive strength of block.

## 4 Conclusion

Based on the results of the various tests performed, it was concluded that, blocks of 10 to 40 % sawdust aggregate replacement absorb water more than the traditional sandcrete block. However, blocks produced with up to 10% sawdust replacement, has higher compressive strength than minimum standard of 2.8N/mm². Since up to 10% sawdust replacement, the weight and density are equivalent to the traditional blocks, hence it could be classified as medium weight concrete blocks, whereas above 10% sawdust replacement, the blocks are classified as light weight concrete blocks according to ASTM standard C55 (2011).




## 5 RECOMMENDATIONS

Based on the results obtained, the following recommendations were made:

1. Sawdust blocks produced are found to be porous than the traditional sandcrete block, hence recommend for areas where sound insulation is required for example studio, auditorium, etc.

2. Recommending that the percentage of sawdust aggregate replacement for blocks should not exceed 10%. Since up to 10% replacement, the properties in terms of strength, weight and density are equivalent to the traditional sandcrete block, hence it can be use as load bearing walls.

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