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Exploring Sawdust as a Sustainable Alternative in Block Production: A Study on Compressive Strength and Environmental Impact

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***Abstract* - The utilisation of sawdust in block manufacture has effectively minimised the amount of waste material being disposed of in landfills. The study aimed to examine the utilisation of sawdust as a partial substitute for sand in the manufacture of blocks and assess the compressive strength of sandcrete and sawdust blocks. The experiment utilised cement grade 32.5R, pit sand as the fine aggregate, fine particles of sawdust, and a water-cement ratio of 0.65. Control specimen 0,utilised 10%, 15%, and 20% of fine sawdust particles as partial substitutes for sand. Subsequently, the materials were combined in a proportion of 1:3 to generate sawdust and sandcrete blocks. The block samples were cured by applying water at intervals of 7, 14, and 21 days, respectively. The results indicate a significant alteration in the water-cement ratio employed during the material batching and mixing procedure of the sawdust samples. Additional results revealed differences in the compressive strength and density tests between sandcrete and sawdust blocks in the control specimens. The compressive strength of sandcrete blocks was superior to that of sawdust blocks. Sandcrete blocks are suitable for load-bearing purposes in construction projects, whilst sawdust blocks are suitable for non-load-bearing walls.**
***Keywords:* Building Material, Compressive Strength, Eco-Friendly, Sustainable, Thermal Insulation Properties**

I. INTRODUCTION

Sandcrete blocks areutilised in their production and distribution by the majority of individuals on account of their accessibility, cost-effectiveness, and ecological sustainability [1]. In addition, enormous quantities of neither water nor energy are required in the production of sawdust blocks, which makes them an environmentally friendly building material. According to the study, sandcrete blocks are favoured for constructing walls, partitions, and other structural elements. Furthermore, their non-emission of detrimental gases or contaminants throughout the manufacturing or usage process renders them an optimal construction material for sustainable development. The average compressive strength of sawdust blocks was 0.81 to 1.08N/mm2 for 96 to 4% sawdust, according to the findings of [2]. Additionally, the research indicates that blocks manufactured incorporating sawdust may be viable for applications in construction where lightweight is critical, as this could effectively mitigate the load on the foundation. Moreover, according to [3], the compressive strength of sandcrete blocks varies between 0.23 N/mm2 and 0.58 N/mm2 in Nigeria. As the cement content and curing time of sandcrete blocks increases, so does their compressive strength. Sawdust composites are also desirable due to their low thermal conductivity, high sound absorption, and effective sound insulation properties, according to [4]. An increase in the use of sawdust composites in construction will mitigate potential sawdust environmental contamination, conserve energy, and reduce disposal costs, according to their findings.

In addition to being lightweight and simple to manipulate, sawdust blocks are an appealing option for construction workers. The Ghanaian construction industry has implemented sawdust blocks as a substitute for conventional building materials such as concrete blocks. The profusion of sawdust waste in the vicinity of Cape Coast Technical University and the Ayifua junction may pose a fire hazard. By comparing the compressive strengths of sandcrete and sawdust blocks, the study aimed to assess the viability of sawdust as a partial substitute for sand in the production of blocks.

A. Sandcrete Block in the Construction Industry

The environmental benefits of sawdust blocks were emphasised in the study by [1]. It was suggested that the utilisation of sawdust blocks derived from waste materials could contribute to the reduction of waste materials deposited in landfills. Sawdust blocks are an environmentally sustainable building material due to their minimal energy and water consumption during production. In contrast to the bricks specified in [7], blocks are defined as walling units in [5] and [6]. As opposed to providing a detailed description of the mode, the British standard primarily specifies block performance. [5], [6], and the Ghana industry all agree that the most popular recommended dimensions are 450mm x 225mm x 150mm, with a 150mm thickness. Blocks measuring 150mm x 450mm x 225mm are also permitted according to [5] and [6]. [8] specifies a minimum strength of 2.5 N/mm2 and a range of strength between 1.5 N/mm2 for sandcrete blocks.

Bricks, blocks, and wall panels constructed from a mixture of sawdust, sand, and cement have been manufactured in some African nations for many years [9]. An increase in the use of sawdust composites in construction will mitigate potential sawdust environmental contamination, conserve energy, and reduce disposal costs, according to a study [3]. In addition to being lightweight and simple to manipulate, sawdust blocks are an appealing option for construction workers.

In a comparative analysis of the compressive strengths of sandcrete blocks and sawdust blocks, [10] discovered that the former possessed a strength of 4.01 N/mm2, whereas the latter exhibited a strength of 5.09 N/mm2. This indicates that sawdust blocks are weaker than sandcrete blocks. Additionally, [11] acquired blocks containing 10% SDA with compressive strengths ranging from 1.92N/mm2 to 2.19N/mm2 and mixtures from 1.65N/mm2 to 2.00N/mm2 after seven and twenty-eight days, respectively. In contrast, the norm advocated by [12] regarding the compressive strength of non-load-bearing walls is 2.0 N/mm2. According to the findings of [13], the compressive strength of sawdust blocks was 2.3 N/mm2, which was similar to that of sandcrete blocks.

Additionally, sawdust blocks had a lower density than sandcrete blocks, making them lighter and more manageable during construction, according to the study. Additionally, sawdust blocks exhibited superior thermal insulation characteristics in comparison to sandcrete blocks, a finding that may have practical implications for the reduction of energy usage in structures. [14] discovered that as the percentage of sawdust in concrete increases, both the weight and compressive strength of the concrete diminish, while the water-cement ratio increases. Further, he elaborated on the notion that sawdust concrete exhibits potential as a material for constructing buildings.

II. MATERIALS AND METHODS

A. Materials

1. *Cement:* The cement type used was ordinary Portland cement (Super Cool cement), conforming to [15]. The cement conforms to a strength of 32.5R as specified in [15].
2. *Sand (fine aggregate)*: The sandwas obtained from a pit, free from any impurities, at a block factory within the Cape Coast North Metropolis.
3. *Fine particles of sawdust*: The sawdust used for the experiment was obtained from the Abura sawmill factory and was cleaned from any unwanted materials with a very fine texture.
4. *Water:* Clean water was used in the mixing and curing process of the block samples at Elisand Block Factory, located off Cape Coast Technical University Road.

B. Methods

The experiment was carried out at the Construction Technology and Management Laboratory of the School of Built and Natural Environment and Civil Engineering Laboratory of the School of Engineering at Cape Coast Technical University.

1. Batching and Mix Proportion: Batching by gauge was the method used in the experiment. A head pan was used to measure the materials for the experiment and a plastic bucket to measure the volume of water needed, using the digital measuring scale.

Fig. 1 Batching of materials

Fig. 2 Mixing of sawdust sandcrete materials

Samples of 10% 15 % and 20% partial replacement of sand with sawdust were used during the experiment. The block samples were mixed using the (1:3) method (cement, fine aggregate, and fine particles of sawdust) using a water-cement ratio of 0.65. The blocks were moulded using a 5-inch steel block moulding machine, to achieve the required compaction of the blocks for the experiment. The dimensions of the mould used in the process were 150mm x

450mm x 225mm. The blocks were removed from the mould and allowed to dry for a day. The curing process was done by sprinkling water on the block. This process helped to prevent cracking and shrinkage which ensured that the finished product met the required specifications and standards.

Fig. 3 Block samples

Fig. 4 Mixing of sawdust sandcrete materials

The compressive strength of each sample was achieved in the following ages: 7, 14, 21, and a total of 42 days to determine the compressive strength and density of the percentages used in the experiment.

C. Procedures for Fine Aggregate (Sand)Test

1. Steps in the Silt Test

Step 1: A percentage of distilled water and a fine salt solution were filled in the measuring cylinder up to the 50-ml mark.

Step 2: Sand was added to the solution, up to a mark of 150 ml.

Step 3: The mixture of sand and both distilled water with salt were kept, undisturbed for about 3 hours, after shaking.

Step 4: The silt, made of fine particles and sand, settled above the sand in the form of a layer.

Step 5: The thickness of the silt layer was measured, but the percentage of silt in the natural sand should not exceed 6%.

2. Sieve Analysis

Sieve analysis is a test used to determine the particle size distribution of aggregates.

Fig. 5 Initial weighing of fine aggregate

Fig. 6 Level of silt content, and sand, after 3hrs

Step 1: Sieves were arranged in a systematic order and shaken to ensure that most retained particles were grouped into fine aggregate to pass through the sieve.
Step 2: The retained materials on each sieve were weighed.

3. *Compressive Strength*

The compressive strength test was carried out at the ages of 7 days, 14 days, and 21 days of curing age, using a hydraulic compressive testing machine. Thirty-two (32) specimen samples were moulded for the experiment. Three (3) samples from each mix proportion, were control at 0%, 10%, 15%, and 20%, and crushed later.

A hydraulic crushing machine was used during the crushing (compressive strength test) of the samples at the Construction Technology and Management Laboratory. The compressive strength was then calculated for each block sample.

Fig. 7 Sandcrete blocks ready for crushing

4. Density

The density was determined after the sample was dry, indicating the density of the block samples after 7 days, 14 days, and 21 days of curing.

Step 1: Three (3) samples were taken from each specimen,

Step 2: The average density and the volume of the block sample were calculated.

Step 3: The masses of the block sample obtained from the weight test were used to calculate the densities (p) based on the formula:

Where M = mass (g) and V = volume (mm3) of cub's sample.

The mix ratio was (1:3), with a water-to-cement ratio of 0.65.

TABLE I DETAILS OF THE MIX PROPORTION FOR 0% AND 10% SAMPLES

Sample	Constituent	Proportion of Constituent in Kilogram
Control specimen (0 %)	Cement	18
	Sand	58.81
	Water	8.12
10 % of sawdust sample in sandcrete blocks	Cement	18
	Sand	41.51
	Sawdust as partial replacement of sand (10 %)	0.26
	Water	8.12

TABLE II DETAILS OF THE MIX PROPORTION FOR 15% AND 20% SAMPLES

Samples	Constituent	Proportion of Constituent in Kilograms
15 % of sawdust sample in sandcrete blocks	Cement	18
	Sand	29.41
	Sawdust as partial replacement of sand (0 %)	0.57
	Water	8.12
20 % of sawdust sample in sandcrete blocks	Cement	18
	Sand	18.45
	Sawdust as partial replacement of sand (20 %)	1.2
	Water	8.12

The preceding section presents the compressive and density results, as shown in Tables III to VI and Fig. 9 and 10.

III. FINDINGS OF THE STUDY

The water-cement ratio used for the experiment changed during the batching of materials and mixing process of the samples 0%, 10%, 15%, and 20 % of sawdust samples. This was a result of the high absorption rate of the sawdust in the mixture.

Table III shows the sieve analysis for the samples.

TABLE III SIEVE ANALYSIS

Sieve Size	Mass of Seive	Mass of Sieve + Sample	Mass of Sample	% Retained	% Passing
14	500	500	0	0.00	100.00
10	518	518	0	0.00	100.00
9.5	515	515	0	0.00	100.00
6.3	520	520	0	0.00	100.00
5	503	503	0	0.00	100.00
4.75	515	515	0	0.00	100.00
2.35	477	505	28	1.14	98.86
2	467	516	49	1.99	96.87
1.18	435	897	462	18.76	78.12
0.6	411	1212	801	32.52	45.59
0.425	366	910	544	22.09	23.51
0.3	377	364	-13	-0.53	24.04
0.15	345	751	406	16.48	7.55
0.063	340	495	155	6.29	1.26
PAN	337	368	31	1.26	0.00
Initial Mass= 2500					

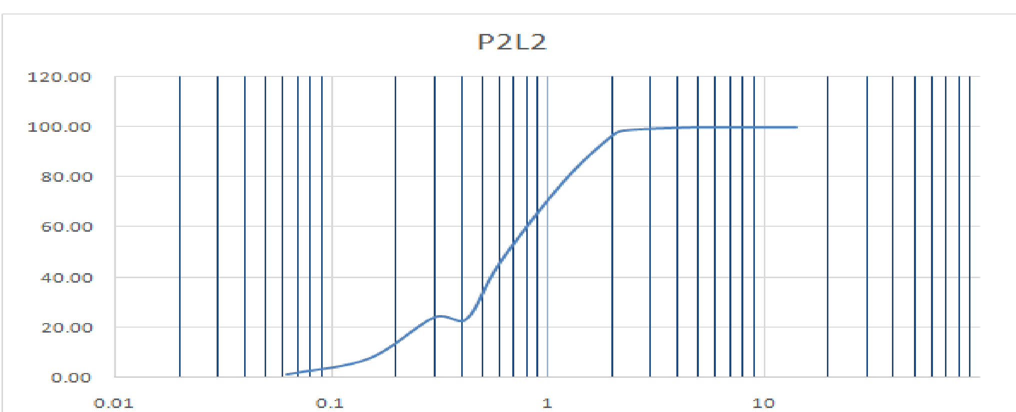

Fig. 8 Sieve Analysis Result

Table IV shows that the silt test conducted on the pit sand was below 6%, which means that the fine aggregate was suitable for the experiment.

TABLE IV SILT TEST RESULTS

Samples	Initial Volume of Sand (Vol)	Final Volume of Sand V_1(Vol)	Volume of Silt V_2(Vol)	Silt Content (%) $\frac{V1}{V2} X\ 100$
1	100	82	6	7.32
2	100	82	4	4.88
3	100	84	4	4.76
Average				**5.65**

$$\frac{7.32 + 4.88 + 4.76}{3} = 5.65$$

Table V shows that the control specimens (0%) had an average strength of 1.48 N/mm^2 for 7 days, 2.20N/mm^2 for 14 days,1.73N/mm^2 for days with the average density of 1.47kg/m^3 for 7 days, 1.48 kg/m^3 for 14daysand 1.42 kg/m^3 for 21days.

TABLE V COMPRESSIVE STRENGTH AND DENSITY OF BLOCKS FOR 0% SPECIMEN

Samples	Force (Failure) KN			Massin kg		
Control Specimen (0%)	**7 days**	**14 days**	**21 days**	**7 days**	**14 days**	**21 days**
1	110.00	150.00	110.00	22.69	22.10	21.35
2	90.00	180.00	140.00	21.59	22.60	21.57
3	100.00	135.00	100.00	22.58	22.51	21.92
Average compressive strength and density	1.48 N/mm^2	2.20 N/mm^2	1.73 N/mm^2	1.47 kg/m^3	1.48 kg/m^3	1.42 kg/m^3

Table VI shows that average compressive strength (10%) was 0.22N/mm^{2}for7 days, 0.074 N/mm^{2}for 14days, and 0.12 N/mm^2 for 21days. The density for 7days 1.18 kg/m^3, 14 days 1.20 kg/m^3, 21days 1.06 kg/m^3.

TABLE VI COMPRESSIVE STRENGTH AND DENSITY OF BLOCKS FOR 10% SAMPLE

Sample	Force (Failure) KN			Mass in kg		
(10%) of Sawdust Sample	**7 days**	**14 days**	**21 days**	**7 days**	**14 days**	**21 days**
1	10.00	5.00	10.00	17.94	18.60	16.54
2	25.00	5.00	5.00	17.96	17.82	16.81
3	10.00	5.00	10.00	17.98	18.33	16.22
Average Compressive Strength And Density	0.22 N/mm^2	0.074 N/mm^2	0.12 N/mm^2	1.18 kg	1.20 kg/m^3	1.06 kg/m^3

Table VII shows the average compressive strength (15%) 0.074 N/mm^2 for 7 days, 0.01 N/mm^2 for 14 days, 0.12 N/mm^2 for 21 days. The Density for 7days 1.14 kg/m^3, 14 days 1.17 kg/m^3, 21days 1.20 kg/m^3

TABLE VII COMPRESSIVE STRENGTH AND DENSITY OF BLOCKS FOR 15% SAMPLE

15% of Sawdust Sample	7 days	14 days	21 days	7 days	14 days	21 days
1	5.0 0	5.00	5.00	17.18	16.86	17.95
2	5.00	10.00	10.00	17.56	16.22	18.49
3	5.00	5.00	10.00	17.14	16.81	18.28
Average Compressive Strength and Density	0.074 N/mm^2	0.01 N/mm^2	0.12 N/mm^2	1.14 kg/m^3	1.17 kg/m^3	1.20 kg/m^3

Table VIII shows the average compressive strength (20%) 0.074 N/mm^2 for 7 days, 0.074 N/mm^2 for 14 days 0.074 N/mm^{2}for 21days. The density for 7days 3.98 kg/m^3, 14 days 9.42 kg/m^3, 21days 8.70 kg/m^3

TABLE VIII COMPRESSIVE STRENGTH AND DENSITY OF BLOCKS FOR 20% SAMPLE

Sample	**Force (failure)** KN			**Mass in Kg**		
(20%) of sawdust sample	**7 days**	**14 days**	**21 days**	**7 days**	**14 days**	**21 days**
1	5.0 0	5.0 0	5.00	15.08	14.33	13.40
2	5.00	5.00	5.00	15.31	14.29	13.95
3	5.00	5.00	5.00	15.26	14.35	12.75
AVERAGE Compressive Strength and Density	0.074 N/mm^2	0.074 N/mm^2	0.07 N/mm^2	3.98 kg/m^3	9.42 kg/m^3	8.70 kg/m^3

Figs. 9 and 10 show the compressive strength test and average compressive strength test of samples 10%, 15% and 20% for ages 7, 14 and 21.

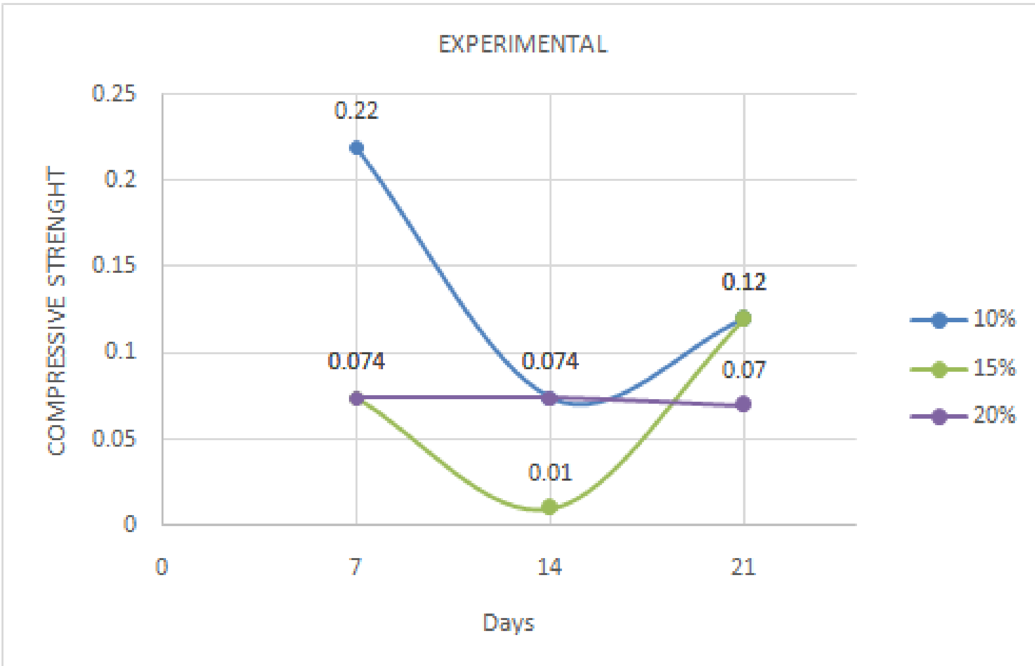

Fig. 9 Compressive Strength Test

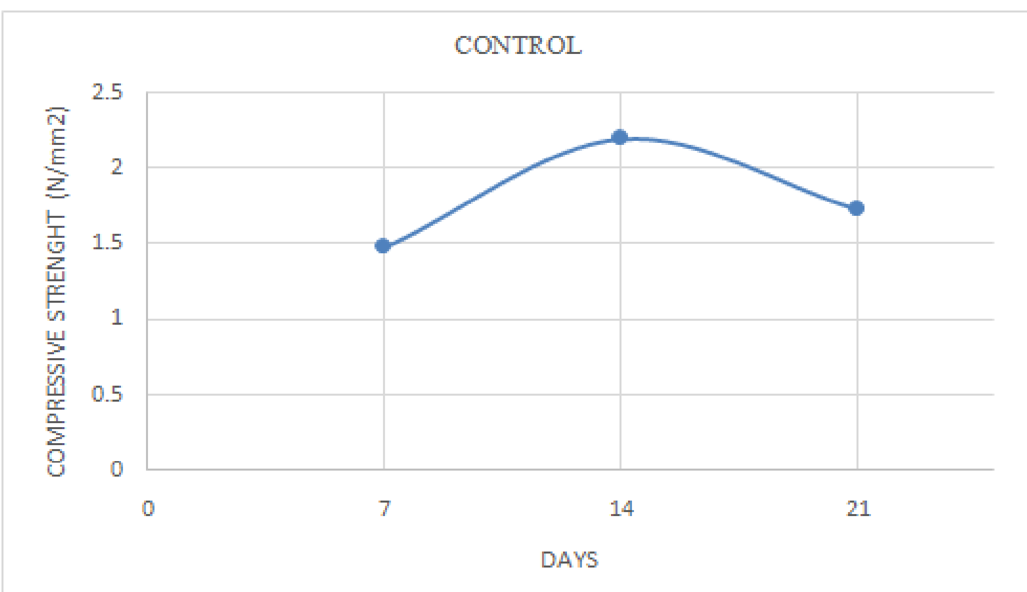

Fig. 10 Average Compressive Strength Test

IV. CONCLUSION AND RECOMMENDATIONS

The study sought to investigate the use of sawdust as a partial replacement for sand in block production and determine the compressive strength of sandcrete and sawdust blocksThe water-cement ratio used for the batching of materials and mixing process of the samples 0%, 10%, 15%, and 20 % of sawdust samples changed drastically due to the high absorption rate of the sawdust in the mixture. There was variation in the strength and density test in the compressive strength between sandcrete and sawdust blocks on the control specimens. Sandcrete blocks exhibited higher compressive strength compared to sawdust blocks. It is recommended that further research should be considered to include water absorption test and others to reduce the percentage of sawdust used in the experiment to 3% 5% 10%. Sandcrete blocks are recommended for load-bearing applications in construction projects where structural strength is crucial. They should be used in areas requiring high durability and resistance to external forces. Sawdust blocks are recommended for applications where weight reduction and insulation properties are important, such as non-load-bearing walls (partition walls or as filler material). They are also suitable for eco-conscious building projects.

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