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Experimental Research of Saw Dust as Partial Replacement for Fine Aggregate in Production of Sandcrete Hollow Blocks in Nigeria

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Abstract
The research investigated the use of sawdust as partial replacement in fine aggregate for production of sandcrete hollow blocks in Nigeria. Due to high cost of conventional construction materials in the country, the research reduced the costof those conventional materials. Sawdust as an industrial waste is available at any time, numbers of sandcrete hollow blocks were produced by partial replaced in 0% to 20% by weighting of sawdust using a vibrating block moulding machine. Sandcrete hollow blocks without sawdust as aggregate were servedas a control. Compressive strength was determined, density was investigated and water absorption was determined. The ratio of the sandcrete hollow blocks was 1: 4. Total of forty (40) sandcrete hollow blocks were produced and mould used was 150x225x450mm. The crushing days were 7, 14, 21and28 days respectively to investigated the compressive strength of the sandcrete hollow blocks effectively. Sandcrete hollow blocks that were replaced with sawdust as partial replacement in fine aggregate can be used for non- load bearing walls and it can be used for internal partitioning as non-load bearing walls.

Keywords*: Absorption, Block, Compressive strength, Hollow and Sandcrete*

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I. INTRODUCTION

Sandcrete blocks are one the major parts of materials used in construction of building in Nigeria and in other parts of Africa and Asian countries. Sandcrete blocks serves as part of components of a building. Sandcrete blocks according to [8], in [6], are construction masonry units that have been generally accepted to the extent that when an average individual thinks of building, the default mind set is in the use of sandcrete blocks. Sandcrete blocks are majorly used for both load bearing and non-load bearing walls that form an enclosure in building. Sandcrete blocks make up to 70 – 80 percent of Conventional materials used in construction of buildings. [4], [2], states that over ninety percent of the physical infrastructures in Nigeria are constructed using sandcrete blocks. This makes sandcrete blocks a very important material in buildingconstruction. Sandcrete blocks are produced with cement, sand and water that are quality materials which cannot be neglected in construction of building in Nigeria and other parts of the world. [11]: Raheem, [12], indicates that the quality of sandcrete blocks is a function of the method employed in the production and the properties of the constituent materials.In this research, the use of saw dust as partial replacement for fine aggregate in sandcretehollow blocksproduction will be investigated. Many researchers have carried out researches onreplacing conventional materials with different local building materials to ensure reduction in cost of production of the concrete and sandcrete blocks in Nigeria without compromising qualities of the materials.Researchers have replaced conventional materials in sand for production of sandcrete hollow blocks, using the following local building materials lateritic soil, palm kernel shell and sludge. In Nigeria, sandcrete hollow blocks are part of the conventional material used in construction. The use of sawdust as partial replacement for fine aggregate is imperative because it will reduce the cost of production of sandcrete blocks, without loss of strength.The Sawdusts remain as waste in environment and should be used as materials for construction of building when used as fine aggregate. Research has gone into replacement of both fine and coarse aggregate in production of concrete and mortar, due to non-availability of the aggregate in some parts of the country in Nigeria. This research will focus in fine aggregate replacement. Mortar is one the most important conventional materials that builders and civil engineers depend on. Fine aggregates are from river that gives quality to the mortar and concrete in producing sandcrete hollow blocks and concrete. [3] states that river sand used as fine aggregate in mortar and concrete are gotten from the river banks. Fine aggregate (sand) used in Ilaro Ogun State for production of hollow sandcrete blocks is soft sand not sharp sand. The use of sawdust as partial replacement for fine aggregate will contribute more to the quality and strength of the sandcrete blocks. [15] States thatsawdust is one of the natural fiber that is used as filler. Sawdusts are collection of fine particle of hard and soft woods. These materials are produced from cutting of wood with saw. In United States, sawdusts have been used as an aggregate for more than 50 years for floor, wall and roof units but not widely. About 200 – 300 metric tonnes of sawdusts are usually generated per day, which serve has a waste and also cause environmental hazard while about 1.5million cubic metres are produced annually in a particular sawmill in Ilaro, Ogun State.Sawdust is usually disposed of by open burning thus producing harmful smokes that threaten human health. A more environmentally desirable way of disposing it is to use it as cement composites [13]. In our research the alternative way of reducing sawdust is to use it as replacement in fine aggregate.In considering sawdust as fine aggregate, the properties of the sawdust must be put into test to determine whether sawdust can perform same functions as other conventional materials.[14]: [7]: [13] states that sawdust damage and prolonged life of formwork due to lower exerted pressure easy handling, mixing and placing as compared with other concrete improved absorbent properties due to it high void ratio. [12] investigated sawdust ash as partial replacement for cement in the production of sandcrete hollow blocks and concluded that at 56 days, the compressive strength of block with 5% and 10% sawdusts replacement are 2.33N/mm^2 and 2.44N/mm^2 respectively. Both percentages surpassed the required standard of 2.0N/mm^2 that is specified by National Building code (2006) for non-bearing walls.

II. Materials and Methods

Study Area: Ilaro is situated at Longitude 6^0 89N and betweenLatitude 3^{0}02E and 68 meters' elevation above the sea level. Ilaro is a small city in Ogun State, Nigeria, having about 46,999 inhabitants; while Federal Polytechnic Ilaro, is located in ilaro of Longitude 6.8^0 and Latitude 2.99^0.

Materials

The materials used for this research include the following: fine aggregates sharp sand from river Ogun which free clay loam, dirt and any organic and chemical matter, obtained from a local supplier. Sawdust was from timber saw mill in Ilaro Ogun State, Nigeria. Cement used for this research wasDangote cement which were obtained from one the major distributors of Dangote cement in Ilaro. Fresh, colourless, odourless and tasteless potable water freed from organic matter was used for mixing, weighing scale, vibrating block moulding machine.

Methods

This research was done in batching operation by volume, in mixes 1: 4 (cement; fine sand; and saw dust). A water cement ratio was obtained to meet the required water cement ratio for the actual mixes. Water cement ratio of 0.60 was adopted for 1:4 mixes. The mixes was properly prepared in a concrete mixing machine for a period of 8 to 10 minutes and the mortar was placed into 150 x 225 x 450mmsandcrete block mould. The sandcrete blocks were produced in percentage by weighting the fine aggregate and sawdust as partial replacement in fine aggregate for sandcrete blocks in 5%, 10%, 15%, and 20% respectively. Ranging from 0% to 20% replacement for fine aggregate and saw dust. The specimens were made in accordance with Nigeria Building codespecifications. A total of forty (40) sandcrete blocks specimens wasproduced and used the mix design for mortar mix ratio. The specimens that was produced were cured in an open air, sandcrete blocks were curedevery day from the second day of production and compressive strength test were done at 7, 14, 21,and 28days.The specimens were weighed before test and the density of the sandcrete blocks at different time of the test were measured a day before the test. Compressive strength of the sandcrete blocks were tested in accordance to BS 1881 (1996) with the used of universal compression testing machine. The water absorption was done on each of the specimen.

Plate 1: Moulded blocks at different replacement **Plate 2**: weighing of samples


Table 1: Replacement of Sand and Sawdust at different Percentages

Replacement level	Cement to Sand Ratio	Mix of Sand Sawdust Replacement	
		Sand (kg)	Sawdust (kg)
100% and 0%	1:4	100	0
95% and 5%	1:4	95	5
90% and 10%	1:4	90	10
85% and 15%	1:4	85	15
80% and 20%	1:4	80	20

Table 1 different five of levels, sand was replaced with sawdust 0%, 10%, 15%, and 20% by weight were done. The mix ratio was 1:4 at different intervals of replacement levels of sand and sawdust. A vibrating moulding machine of 150mm mould was used (150mm x 225mm x 450mm) design was used.

Water Absorption in hollow block replaced with sawdust

Percentage Water Absorption (Wa) = $\frac{Ww - Wd}{Wd} X \frac{100}{1}$

Where:
Wa = Water Absorption
Ww = Weight of wet block
Wd = Weight of dry block

Bulk Density

Hollow sandcrete blocks produced with different levels of replacement were dried to constant mass in the curing site. The weight of the hollow sandcrete blocks were determined at Federal Polytechnic Ilaro, Ogun State Nigeria Civil Engineering laboratory using a weighing balance. Dimensional volume was determined bysawdust replacement for sand respectively.The density of sandcrete hollow blocks produced are showed in tables 5, 6 and 7. The result showed that the sandcrete hollow block that was 0% replacement had the highest average density 1224,69kg/m^3 at 28days of curing follows by 5% 1086.42kg/m^3, 10% 896.79kg/m^{3,} 15% 892.84kg/m^3 and 20% 777.61kg/m^3.

Table 2: Percentage of water Absorption of Hollow Blocks (Control and Sawdust Replacement 7days).

Replacement level	Block No	Dry weight (kg)	Wet weight (kg)	water absorbed (kg)	Water Absorption (%)
0%	1	17.80	19.30	1.50	8.43
	2	17.46	19.01	1.55	8.88
	Mean	17.63	19.16	1.53	8.68
5%	1	16.71	18.36	1.65	9.87
	2	16.70	18.40	1.70	10.18
	Mean	16.71	18.38	1.67	9.99
10%	1	14.64	16.35	1.71	11.68
	2	14.56	16.25	1.69	11.61
	Mean	14.60	16.30	1.71	11.71
15%	1	13.20	14.45	1.25	9.24
	2	13.50	15.35	1.85	13.70
	Mean	13.35	14.90	1.55	11.61
20%	1	11.86	13.56	1.70	14.33
	2	12.22	13.42	1.22	9.98
	Mean	12.04	13.49	1.45	12.04

Table 3: Percentage of water Absorption of Hollow Blocks (Control and Sawdust Replacement 14days).

Replacement level	Block No	Dry weight (kg)	Wet weight (kg)	water absorbed (kg)	Water Absorption (%)
0%	1	17.90	18.60	0.70	3.76
	2	18.00	19.50	1.50	7.69
	Mean	17.55	19.05	1.45	5.73
5%	1	16.00	17.50	1.50	8.57
	2	16.10	17.40	1.30	7.47
	Mean	16.05	17.45	1.40	8.02
10%	1	13.60	14.60	1.00	6.85
	2	13.70	14.60	0.90	6.16
	Mean	13.65	14.60	0.95	6.51
15%	1	13.24	14.50	1.26	8.62
	2	13.40	14.50	1.10	7.59
	Mean	13.32	14.50	1.18	8.11
20%	1	11.50	12.60	1.10	8.73
	2	11.60	12.60	1.00	7.94
	Mean	11.55	12.60	1.05	8.34

Table 4: Percentage of water Absorption of Hollow Blocks (Control and Sawdust Replacement 28 days).

Replacement level	Block No	Dry weight (kg)	Volume(m^3)	Bulk density(kg/m^3)
0%	1	17.90	0.0151875	1178.60
	2	18.00	0.0151875	1185.19
	Mean	17.55	0.0151875	1155.56
5%	1	16.00	0.0151875	1053.50
	2	16.10	0.0151875	1060.08
	Mean	16.05	0.0151875	1056.79
10%	1	13.60	0.0151875	895.47
	2	13.70	0.0151875	902.06
	Mean	13.65	0.0151875	898.77
15%	1	13.24	0.0151875	871.77
	2	13.40	0.0151875	882.31
	Mean	13.32	0.0151875	877.04
20%	1	11.50	0.0151875	757.20
	2	11.60	0.0151875	763.79
	Mean	11.55	0.0151875	760.49

Table 5: Bulk Density Hollow Blocks (Control and Sawdust Replacement 7 days)

Replacement level	Block No	Dry weight (kg)	Wet weight (kg)	water absorbed (kg)	Water Absorption (%)
0%	1	18.40	20.10	1.70	9.24
	2	18.60	20.20	1.60	8.60
	Mean	18.50	20.15	1.65	8.92
5%	1	16.30	18.40	2.10	12.88
	2	16.50	18.30	1.80	14.07
	Mean	16.40	18.35	1.89	11.89
10%	1	13.62	15.50	1.88	13.80
	2	13.50	15.40	1.90	14.07
	Mean	13.56	15.45	1.89	13.94
15%	1	13.72	15.80	2.08	15.16
	2	13.40	15.40	1.90	14.18
	Mean	13.56	15.55	1.99	14.68
20%	1	11.34	13.90	2.06	17.40
	2	11.78	13.80	2.02	17.15
	Mean	11.81	13.85	2.04	17.27

Table 6: Bulk Density Hollow Blocks (Control and Sawdust Replacement 14 days).

Replacement level	Block No	Dry weight (kg)	Volume(m^3)	Bulk density(kg/m^3)
0%	1 2 Mean	17.80 17.46 17.63	0.0151875 0.0151875 0.0151875	1172.02 1149.63 1160.82
5%	1 2 Mean	16.71 16.70 16.71	0.0151875 0.0151875 0.0151875	1100.25 1099.59 1100.25
10%	1 2 Mean	14.64 14.56 14.60	0.0151875 0.0151875 0.0151875	963.95 958.68 961.32
15%	1 2 Mean	13.20 13.50 13.35	0.0151875 0.0151875 0.0151875	869.14 888.89 879.01
20%	1 2 Mean	11.86 12.22 12.04	0.0151875 0.0151875 0.0151875	780.91 804.61 792.75

Table 7: Bulk Density Hollow Blocks (Control and Sawdust Replacement 28 days)

Replacement level	Block No	Dry weight (kg)	Volume(m^3)	Bulk density(kg/m^3)
0%	1 2 Mean	18.40 18.60 18.50	0.0151875 0.0151875 0.0151875	1211.52 1224.69 1218.11
5%	1 2 Mean	16.30 16.50 16.40	0.0151875 0.0151875 0.0151875	1073.25 1086.42 1079.84
10%	1 2 Mean	13.62 13.50 13.56	0.0151875 0.0151875 0.0151875	896.79 888.89 892.84
15%	1 2 Mean	13.72 13.40 13.56	0.0151875 0.0151875 0.0151875	803.38 882.31 892.84
20%	1 2 Mean	11.34 11.78 11.81	0.0151875 0.0151875 0.0151875	746.67 775.64 777.61

Table 8: Compressive Strength of Sandcrete Hollow Block (7, 14 and 28 days)

Replacement level (%)	Block No	Net Area (mm^2)	Crushing Load (KN)	Compressive Strength (N/mm^2)
0	1	30,000	115	3.83
	2	30,000	114	3.80
	3	30,000	112	3.73
	4	30,000	111	3.70
	5	30,000	110	3.67
	6	30,000	109	3.63
	Mean		111.83	3.73
5	1	30,000	34	1.13
	2	30,000	33	1.10
	3	30,000	32	1.07
	4	30,000	31	1.03
	5	30,000	30	1.00
	6	30,000	29	0.97
	Mean		31.5	1.05
10	1	30,000	26	0.87
	2	30,000	25	0.83
	3	30,000	24	0.80
	4	30,000	22	0.73
	5	30,000	21	0.70
	6	30,000	20	0.67
	Mean		23	0.76
15	1	30,000	20	0.67
	2	30,000	21	0.70
	3	30,000	19	0.63
	4	30,000	18	0.60
	5	30,000	17	0.57

	6	30,000	16	0.53
	Mean		18.5	0.61
20	1	30,000	16	0.53
	2	30,000	15	0.50
	3	30,000	14	0.47
	4	30,000	13	0.43
	5	30,000	12	0.40
	6	30,000	11	0.36
	Mean		13.5	0.45

III. DISCUSSION

Water absorption

Water absorption was investigated to increase as the sand is been replaced with sawdust increases. Sandcrete hollow block produced from 80% sand 20% sawdust replacement at 28days of curing showed highest water absorption. The sandcrete hollow blocks produced from 0%, 5%, 10%, 15% and 20% sawdust replacement levels had water absorption, values higher than the maximum water absorption value of 7% specified for blocks by British Standard Institute (BSI). Water absorption values determined from this study was 11.61% at 7days on 15% replacement of sawdust, which is less than the acceptable value of 12% according to BS5628: part 1. Finally, the sandcrete hollow blocks produced from 0%, 5%, 10%, 15% and

20% sawdust replacement levels were not porous. It can be due to the lower percentage weight of sawdust.

Density

Density of hollow blocks as determined in this study decrease with increase in sawdust. The result obtained from this study was 1056.79kg/m^{3}in 5% replacement at 7days. The hollow sandcrete blocks densities obtained in this study for all levels of sawdust replacement for sand are also below the minimum densities specified for light concrete and minimum value of 1500kg/m^3 recommended for first grade sandcrete block by Nigerian Industry Standard (NIS) 087: 2000. The density obtained from this study can be used for non – load bearing walls.

Compressive strength

From table 8 compressive strength of sandcrete hollow blocks replaced with sawdust in 5% at 28days ranges between 1.13 to 1.10 N/mm^{2}which are lower to minimum required standard of 2.0N/mm^2 specified by the Nigeria National Building code for non – load bearing walls. The 5% from of the study can be used for non – load bearing. Compressive strength results of 10%, 15% and 20% sawdust replacement which ranged between 0.97 – 0.45N/mm^2.These values are lower to the required minimum standard of 2.0N/mm^2 as specified by Nigerian National Building for no- load bearing walls. The compressive strength is said to be influence by the level of quality of control employed in selection of materials adequate curing is a factor to put in place when producing sandcrete block (Afolayan *et al* 2008: Ekhuemelo *et al*2017).

IV. CONCLUSION

This study shown that an increase in the replacement level of sawdust, increased the rate of water absorption was determined the percentage water absorption increase as the replacement of sawdust percentage increase of sawdust for sand increase. It was investigated that the density of sandcrete hollow blocks decrease as the replacement levels of sand with sawdust increased. Compressive strength of sandcrete blocks also decreased as the sawdust increased. Sawdust replacement level in this study was 5%. The 5% sawdust replacement level as obtained in the study is recommended for non- load bearing wall

V. RECOMMENDATIONS

Form the results of this study, the following are the recommendations of the study:

1. Block producing companies in Ilaro Ogun State should adopt 5% sawdust level for hollow block production for non – load bearing walls.
2. The high percentage of water absorption of sandcrete blocks replaced with partial sawdust, should not be used in water flooded and water logged area.

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