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STRENGTH AND WATER ABSORPTION PROPERTIES OF SAND-PALM KERNEL SHELL POLYMER BASED MASONRY BLOCKS

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Abstract: **The strength and water absorption properties of masonry blocks were investigated. This was done to know how variation in percentage replacement of sand with palm kernel shell affects the overall properties of masonry blocks when the binding agent is polymer. Sand was replaced with Palm Kernel Shell. Control samples were also produced. Mix ratio 1:6 was adopted because the mix was sticky and was not workable when the binder was higher. Masonry blocks were produced; air cured and subjected to compressive and flexural strength tests. The water absorption properties of the masonry blocks were tested. It was observed that sand could only be replaced up to 5% in the production of masonry blocks.**

Keywords: **Sand, Palm Kernel Shell, Masonry Blocks, Compressive Strength, Flexural Strength, Water Absorption.**

1. INTRODUCTION

Shelter is a necessity to man after food and water. Sandcrete blocks account for 60% of walling material used in most building in Nigeria and Africa in general. Other walling materials in use includes plywood, stones, glass, aluminium, bricks, steel, reinforced plastics, fibre etc.

Sandcrete blocks can be defined as materials made of coarse natural sand or crushed rock dust mixed with cement in certain proportion and water, and moderately compacted into shapes (Seeley, 1993). On moulding they set, harden and attain adequate shapes. NIS 87(2004) defines sandcrete blocks as composite materials made up of cement, sand and water and moulded into different shapes and sizes. Sandcrete blocks may be either lightweight or dense (Seeley, 1993). Light blocks are non-load bearing while dense are load bearing. They are made from a cement /sand mix usually 1 part of cement to 6 or 8 part of sand (1:6 or 1:8) with water/cement ratio of between 50 and 75% (B.S. 3921:1969).

Sandcrete blocks are used throughout Nigeria, in most African countries and Asia. Until perhaps a few years ago, these blocks were manufactured in many parts of Nigeria without reference to any specifications either to suit local building materials or for good quality work. The situation in Nigeria has since changed as the Standards Organization of Nigeria now has specifications for both the manufacture and use of these blocks in Nigeria (Oyekan, 2008).

They could be used as external walls or partition walls. The later (150mm thick blocks) is usually non-load bearing (Mohamed and Anwar, 2014).

The physical properties of sandcrete blocks include strength, durability, fire resistance and thermal insulation. The compressive strength of sandcrete blocks is a measure of its resistance to axial load. BS 2028(1968) recommends 3.45N/mm^2 for mean strength and 2.59N/mm^2 for the lowest individual strength. The federal Ministry of works recommends 2.1N/mm^2 for mean strength and 1.7N/mm^2 for the lowest individual strength.

B.S. 2028 (1968) gives specification for precast concrete blocks which describes solid, hollow and cellular blocks. It further stated that the total width of cavities measured at right angles to the face of the blocks as laid in a wall must not exceed 65 percent of the block thickness.

There has been a call by Nigerian government for sourcing and development of alternative non-conventional local construction materials in the construction industry to cut down the cost of construction. Alternatives to cement and/or sand are good for the social and economic development of the construction industry in general and building construction industry.

In order to reduce production cost and to also improve the Engineering properties of sandcrete blocks, there is the need to completely replace or to partially replace sand with Agricultural waste. Palm kernel shell, a by-product of agro-processing from oil palm is being increasingly used as substitutes for aggregate in concrete. The Palm kernel shell ash are also being used as partial replacement for cement in concrete. The availability of Palm Kernel Shell and the need for environmental sustainability and finding alternative use for waste and to reduce cost of blocks which will in turn satisfy the shelter needs of man is the main reason for this work using grinded Palm Kernel Shell as replacement for sand in block production.

The aim of this research is to analyse the compressive and flexural strength of Sand-Palm Kernel Shell Polymer based binder Masonry blocks and to determine the water absorption properties of the masonry.

2. MATERIALS AND METHODS

2.1 STUDY AREA

The south western part of Nigeria is known for production of palm oil. Palm kernel shell is an agricultural waste generated from oil production. The palm kernel shell used for this research was sourced from various market in Ogun state and grinded to fine aggregate form. Polystyrene was sourced from various electronic outlets in Ogun state.

2.2 MATERIALS

2.2.1Palm Kernel Shell

Palm kernel shells (PKS) are the shell fractions left after the nut has been removed after crushing in the palm oil mill. The PKS used for this study were the industrial waste stockpiled by the local palm kernel oil producing firm in the community. Such palm kernel oil production sites served as the source from which the PKS used were obtained. The shells were put in a basket in batches and thoroughly flushed with water to remove impurities that could contaminant or affect the blocks properties and later spread in open space for it to dry thoroughly. It was then grinded to required sizes.

Plate 2.1: Washing of PKS with well water

Plate 2.2: Spreading and sun-drying of PKS

Plate 2.3: Grinding of PKS

2.2.2 Sharp Sand

Sand is a granular material composed of finely divided rock and mineral particles know as fine aggregate. It is finer than gravel and coarser than silt. The sand used for this research was sourced from the river. It was clean and free from organic matter.

Plate 2.4: Sharp sand from the river

Plate 2.5: Sieving of sand

2.2.3 POLYSTYRENE PASTE (Polystyrene plus Solvent)

Polystyrene paste is a sticky paste which hardens when expose to the air and it is produced when polystyrene is immersed in solvent e.g., PMS (petrol) in suitable quantity. The polystyrene melts immediately it is immersed in the solvent. The polystyrene paste is dissolved 3 days before use so as for it to dissolve completely.

Plate 2.6: Production of polystyrene paste (polystyrene plus petrol)

Plate 2.7: Weighing of polystyrene paste.

2.3 METHODS

A prescribe mix ratio of 1:6 was adopted in this project and it was batched by weight. The partial replacement of sand with palm kernel shell was done in proportion. The aggregate replacement was 100:0% and 95:5% (i.e., sand: PKS).

Hand mixing was adopted to produce the samples because the materials cannot mix properly using hand trowel or shovel due to the nature of the binder.

Twenty (20) blocks each was produced from the mix. The samples produced were tested for compressive strength and flexural strength test using a universal testing machine.

Plate 2.8: Demoulding samples

Plate 2.9: Block samples

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3. EXPERIMENTAL PROCEDURE

Aggregates were tested to determine their classification using sieve analysis results are presented below.

After curing the blocks for required number of days, the blocks were air dried, the blocks were then placed in the universal testing machine. After this, the compressive and flexural strength of the blocks was obtained.

Samples were selected from the blocks and was dried in a ventilated place for 28 days. The sample was then weighed and dry weights (M1) were recorded. After the recording, it was then fully immersed in water at room temperature for 24 hours. The sample was then removed and the water on it was wiped off with a cloth. Within three minutes of wiping off the block, it was then weighed again on the weighing balance and it wet weights (M2) was also recorded. Water absorption percentage by mass after 24 hours immersion in room temperature water is given by the following formula: Water absorption = [(M2-M1) / M1] X 100

The relationship between the PKS aggregates content and the resulting densities of water absorption of the block produced are presented in table 4.3. It could be deduced from the figure that, the amount of water absorbed by the block reduces as the percentage replacement of the PKS increases.

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 PKS content increases can therefore be as a result of the coarse nature of the PKS aggregates which tend to make the block porous the more its contents increase.

Plate 3.10: Block sample under flexural load

4. RESULTS AND DISCUSSION

Table 4.1 and 4.2 as well as Figure 4.1 and 4.2 shows the particle size distribution of the river sand and the PKS aggregate used for the study. The result from grading tests on both the river sand and the PKS indicated that both materials were all poorly graded.

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Table 4.1: Particle Size Distribution of Sand

Sieve size (mm)	Weight retained. (g)	Weight retained. (%)	Cumulative Weight retained (%)	Weight passing (g)	Weight passing (%)
4.75	0	0	0	500	100
3.15	6	1.2	1.2	494	98.8
1.18	54	10.8	12.0	440	88.0
0.600	148	29.6	41.6	292	58.4
0.425	110	22.0	63.6	182	36.4
0.212	134	26.8	90.4	48	9.6
0.125	36	7.2	97.6	12	2.4
Pan	12	2.4	100	0	0
Total	500	100	406.4		

Fineness Modulus = Cumulative Weight retained /100 = 406.4/100=4.064

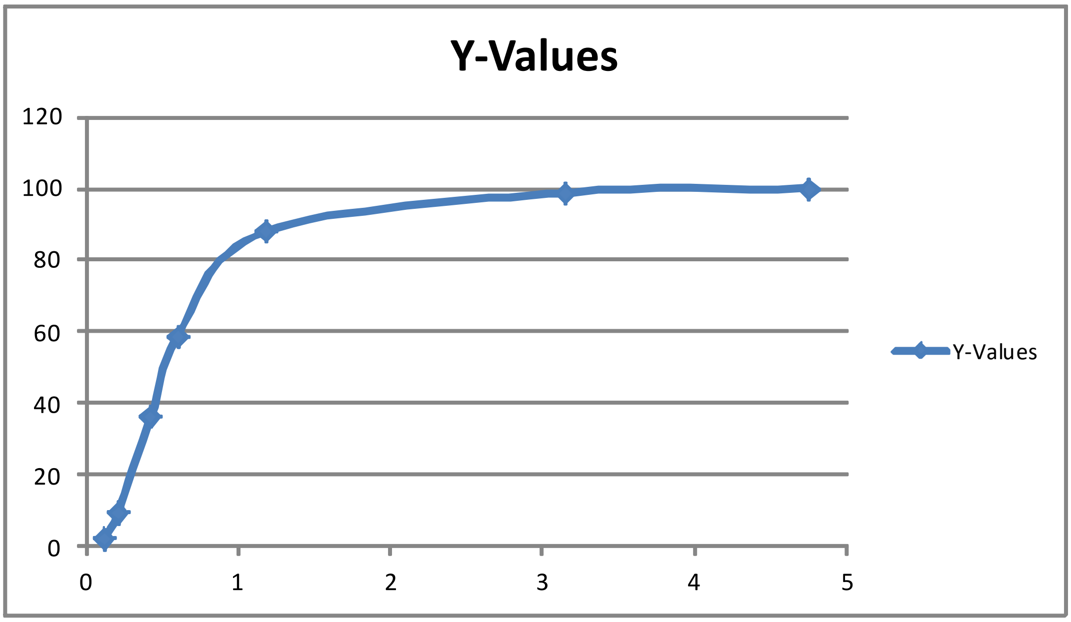

Figure 4.1: Graph of particle distribution of sand

Table 4.2: Particle Size Distribution of PKS

Sieve size (mm)	Weight retained. (g)	Weight retained. (%)	Cumulative Weight retained (%)	Weight passing (g)	Weight passing (%)
4.75	0	0	0	500	100
3.15	2	0.4	0.4	498	99.6
1.18	236	47.2	47.6	262	52.4
0.600	136	27.2	74.8	126	25.2
0.425	35	7.0	81.8	91	18.2
0.212	48	9.6	91.4	43	8.6
0.125	18	3.6	95.0	25	5.0
Pan	25	5.0	100	0	0.0
Total	500	100	491		

Fineness Modulus = Cumulative Weight retained /100 = 491/100=4.91

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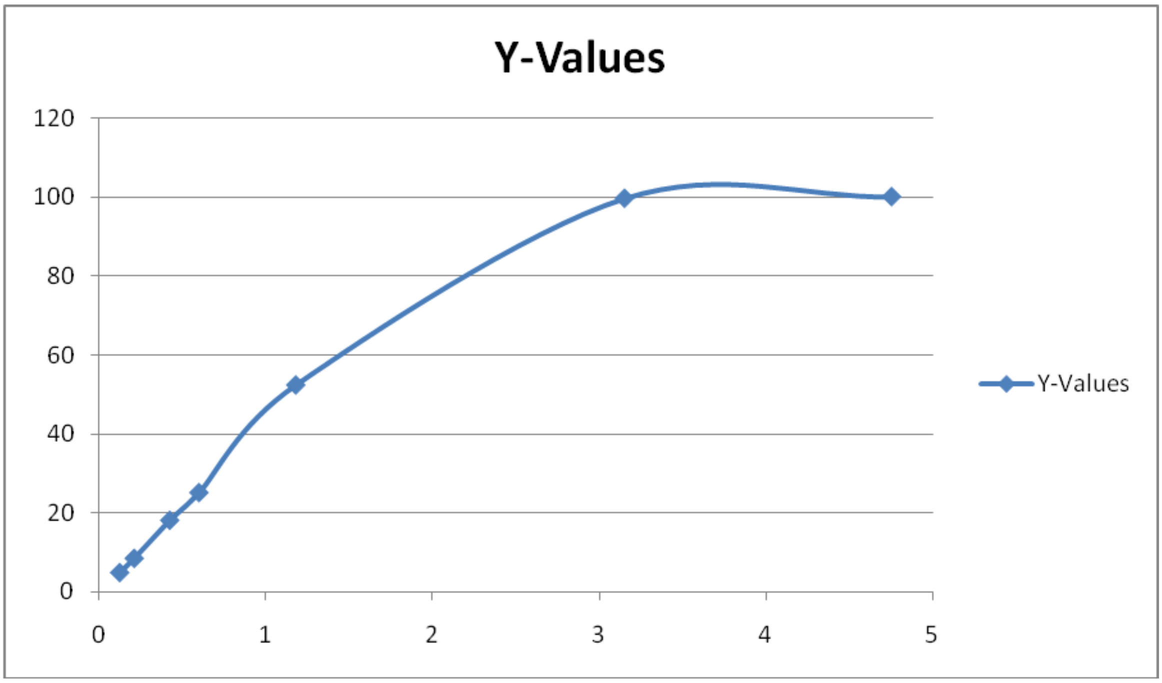

Figure 4.2: Graph of particle distribution of PKS

Table 4.3: Water Absorption test of the blocks

S/n	Determination No.	100% sand :0%PKS	95% sand :5%PKS
1	Weight of saturated sample in g(A)	2650	2585
2	Weight of dried sample in g(B)	2655	2590
3	Water absorption	×100 = 0.19	×100 = 0.19

TABLE 4.4: Compressive Strength Test Analyses

PKS (%)	Sand (%)	Curing age (Days)	Mix Proportion	Max. Load (N)	Average Load (N)	Area (mm^2)	Compressive strength (N/mm^2)
0	100	28	1:6	116480 118790 121350	118873	25950	4.58
5	95	28	1:6	117780 107680 106910	110790	25950	4.27

From the results that was gotten from this analysis shows that the PKS replacement had an adverse effect on the compressive strength of the masonry blocks. In the analysis of results in table 4.4 shows that the control (i.e., 0%PKS) has the highest compressive strength effect. However, the table also shows the compressive strength effect of the PKS. The result gotten of 5%PKS masonry blocks replacement was different from the 0% PKS (control) masonry blocks. From the result, there was an increase in the compressive strength 0% PKS masonry blocks compare to the 5% PKS masonry blocks.

TABLE 4.5: Flexural Strength Test Analyses

PKS (%)	Sand (%)	Curing age (Days)	Mix Proportion	Max. Flexural Strength (N/mm^2)	Average Flexural Strength (N/mm^2)
0	100	28	1:6	17.22 17.72 17.84	17.59
5	95	28	1:6	15.09 15.65 14.88	15.21

5. CONCLUSION AND RECOMMENDATION

5.1Conclusion

PKS blocks were found to be more porous than the river sand blocks, however, up to 5% PKS aggregates replacement, the resulting porosity do not exceed the minimum acceptable standard. Blocks produced from river sand aggregates are heavier, denser and stronger than the PKS blocks when the PKS aggregates content do not exceeds 5%. At such percentage replacement, the blocks could be classified as medium weight concrete blocks.

5.2 Recommendation

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

- In terms of water absorption, it is recommended that the use of PKS aggregate in place of sand should not be more than 5% for block production.
- The PKS blocks are strongly recommended not to be used in areas where high moisture penetration is anticipated.
- The blocks with percentage PKS aggregate replacement not exceeding 5% (medium weight blocks) are recommended for load bearing walls such as gravity retaining walls, whereas those produced from 5% PKS is recommended for areas where light weight concrete blocks are suitable.
- Blocks produced with PKS content was found to be light, porous and of low compressive strength, hence recommended for non-load bearing partition walls.
- It is recommended that PKS replacement should not be used in masonry blocks where high strength is required because the compressive and flexural strength reduces as the percentage replacement of the PKS increases.

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