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The Effect of Strength and Characteristics of Concrete Using Crushed Waste Coconut Shell as Partial Replacement for Coarse Aggregate

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ABSTRACT
This study presents a description of evaluating the effects of strength characteristics of concrete produced using crushed waste Coconut shell as a substitute for conventional Coarse aggregate. The comparisons were made by replacing conventional coarse aggregates at 0%, 2.5%, 4.5%, 6.5%, 8.5% and 10% by weight of coconut shell. Mix design of 1:2:4 and water-cement ratio of 0.50 were used to produce concrete specimen of cubes size 150mm^3 and cylinder sizes 100mm x 200mm. A total of 48 concrete specimens were casted and wholly submerged in water to cure for the intervals of 7 and 28 days after which their average compressive strengths and split tensile strength were determined. The workability established was increasing with increase in the percentage replacement of crushed granite with coconut shell aggregates. Concrete mixtures were tested and compared in terms of compressive strength of the conventional concrete at 28days. Thus, 2.5%, 4.5% and 6.5% of Coconut shell content has upright performances at the replacement, making both technically, economically feasible and conformed with design mix grade M-15 of Concrete and the Split tensile strength results range at 2.10N/mm^2 to 1.32N/mm^2. On further replacement, decrease in the strength of Coconut Concrete has been observed. The study result shows that Coconut Concrete can be used as a substitute of aggregates and well as light weight concrete which will not only cost effective and eco-friendly but decreases the problem of discarding of waste materials and also help to resolve the problem of scarcity of conventional material such as Coarse aggregate.
Keywords: Strength, Physical properties, Workability, Coconut shell and Aggregates.

INTRODUCTION
Concrete is the chief civil engineering material that is used almost in all aspects of construction. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water and admixtures. Hence the relevance of coarse aggregate in concrete production in all areas of civil engineering practice and building construction cannot be flouted. Coarse

aggregate constitutes about 75% to 85% of the concrete matrix as reported via Gambhir, (2005). In a country like Nigeria being a developing country is challenged with inadequate provision of physical infrastructure and related amenities, which are typical factors of under development that need to be addressed through provision of alternative, cheap and affordable materials, many natural materials like palm nut, Pumice, scoria and volcanic debris and manmade materials like expanded blast-furnace slag, vermiculite and clinker are used in construction works as substitutes for natural stone aggregates. Therefore, a researcher has provided more data on the strength of concrete at different percentage of Coconut shell used, as an alternative solution to agricultural waste as best way to reduce the raw materials used in construction industry and thus helping to reduce pollution caused by disposal of agricultural waste, Shafigh et al., (2014). Consequently, in order to achieve a comfortable environment, this research will emphasize on utilizing coconut shell fillers to form composite materials in constructing a wall panel that is strong and can be used to replace conventional walls. Doing so will reduce the cost of construction and make the room cooler. It will also help to reduce agricultural waste and make the world more sustainable. The aim of this research is to study the waste coconut shell as partial replacement of coarse aggregate in concrete through determination of the physical properties and evaluating the strength characteristics of concrete produced using coconut shell as substitutes.

LIETRITURE APPRAISAL

Olanipekun *et al.,* (2006) examined the used crushed, granular Coconut and palm kernel shells as substitutes for conventional Coarse aggregate and the results of the tests showed that the compressive strength of the Concrete decreased as the percentage of the shells increased.

Vishwas P. Kulkarni *et al,* (2013) studied that aggregates provide volume at low cost, comprising 66 percent to 78 percent of the concrete. M20 Concrete is produced by 0%, 10%, 20%, 30% replacement of coarse aggregate by coconut shell. There is no need to treat the coconut shell before use as an aggregate except for water absorption. No bond failure was observed,

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confirming that there was adequate bonding between the coconut shell aggregate concrete and the steel bars.

Jerin M. George *et al.,* (2016) suggested that the properties of Concrete using crushed Coconut shell as coarse aggregate were investigated in an experimental study. Coarse aggregate was replaced by crushed coconut shells in three different percentages namely 25%, 50% and 100%. Workability, compressive strength, flexural strength and splitting tensile strength of the above said mixes were compared with normal concrete properties. The results from the study is expected promote the use of coconut shell as a substitute for conventional Coarse aggregates.

R. Robert Singh *et al.,* (2017) reported that Coconut shell concrete (CSC) could be used in rural areas and places where Coconut is abundant and may also be used where the conventional aggregates are costly. And also adding a steel fibre of certain amount for increasing the strength in concrete and by improve its crack resistance, ductility, energy absorption and impact resistance characteristics. An attempt has been made to examine the suitability of partial replacing 10%, 20% and 30% of coconut shell as for coarse aggregate in concrete of grade M20 and also adding a steel fiber at a certain amount in the Concrete. The results found were comparable with that of conventional mix.

Chanap., (2012) studied the Coconut shell is often used as a composite in Concrete because of the characteristics found in it better than material that commonly used in production of Concrete. Coconut shell has high strength and modulus properties along with the added advantage of high lignin content. The shells also absorb less moisture due to its low cellulose content suggested besides, the surface texture of the Coconut shell was fairly smooth on concave and rough on concave faces.

Gunasekaran *et al.,* (2012) suggested that the Coconut shells are fairly enough to get workability same or better than normal material used in Concrete. Effort with the use of coconut shell as a replacement material in the construction industry, indirectly reduce the costs production of concrete and the disposal of waste. The project was carried out with various % replacement of Coconut shell in place of normal Coarse aggregates.

MATERIALS AND METHOD

Materials

a. Fine aggregate (river sand): The fine aggregate used in this project was river sand. Fractions below 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

b. Coarse aggregate: According to IS: 383-1970, Coarse aggregate may be described as crushed granite CGA or stone. The Coarse aggregate procured from quarry was sieved through the sieved of sizes 20mm and 10mm and the Coconut shells respectively.

c. Cement: In this study, the binder used was Ordinary Portland Cement (OPC), 3X brand manufactured by Dangote Cement Nigeria Plc. The cement was of grade 42.5 with a specific gravity of 3.15 as determined in accordance ordinary confirming to IS 12269-1987 was used.

d. Water: The water free from suspended particles and chemicals used for mixing and curing was portable borehole water from Civil Engineering Laboratory of the Federal Polytechnic Ado- Ekiti and satisfied ASTM C1602-12 specification of water for use in concrete mixtures.

Preparation of waste Coconut shell aggregate (CSA)

The freshly waste coconut shells were collected, washed and properly rinsed to removed residual and dirt i.e. fiber and husk which can doubtlessly affect the performance of the concrete produced. After rinsing, the Coconut shells were sun-dried for three days and sieved mechanically. The Coconut shells pass through the sieve size 5 - 12.5mm diameter was used to replace Coarse aggregate.

Concrete Mix Design

Mix design is the procedure of choosing suitable ingredients of concrete and determining their qualified amounts with the objective of producing a concrete of the required strength and workability as economical as possible. Table-1 presented the design mix for Material measures for M15 grade of concrete.

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Table-1: The Concrete material measures for the mix.

S/N	No. of cubes Cast	Mix of samples %	Water (Kg)	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	
						CGA	CSA
1	8	0% CSA	5.35	10.69	21.39	42.77	00.00
2	8	2.5% CSA	5.35	10.69	21.39	41.70	1.07
3	8	4.5% CSA	5.35	10.69	21.39	40.85	1.92
4	8	6.5% CSA	5.35	10.69	21.39	39.99	2.78
5	8	8.5% CSA	5.35	10.69	21.39	39.13	3.64
6	8	10% CSA	5.33	10.69	21.39	38.49	4.28

Experimental Method

The research was to study the effect of strength characteristics of concrete using waste coconut shell as a partial replacement of Crushed granites CGA in concrete production by weight of 0%, 2.5%, 4.5%, 6.5%, 8.5% and 10% of waste Coconut shell aggregates (CSA). All the raw materials used in this investigation were locally obtained. The waste coconut shells were collected and crushed using manual hammers to a size such that it passes through a 12.5mm sieve and retained on 4.75 sieve. The Concrete mix was prepared with nominal mix of 1:2:4 with w/c ratio of 0.50 were adopted and kept constant. The method batching was adopted by weight. 0%, 2.5%, 4.5%, 6.5%, 8.5% and 10% of Coconut shell aggregates respectively. Due to high water absorption of coconut shell, they were presoaked in water for 24 hours, prior to mixing. A total of (48 concrete specimens) were casted and a set of 24-each concrete specimens of sizes 150mm x 150mm x 150mm and cylinder sizes 100mm x 200mm were test for compressive strength and split tensile strength ofconcrete produced and cured in water for 7 and 28 days respectively. The harden Concrete specimens were demoulded after 24 hrs. and immersed in a curing tank at temperature of 26°C ± 2°C. The Concrete specimens were left in the tank until the prescribed age ranging from 7 and 28 days was reached. A set of 4 each of Concrete specimens were used to determine the average compressive strength and split tensile strength of

Concrete and the results obtained from the replacement are compared with data from a Conventional concrete.

RESULTS AND DISCUSSION

Physical properties test of coarse aggregates. (Coconut shell and crushed granite).

The experiment on physical properties of coarse aggregates are shown in Table 2. It was observed that 12.5mm size of crushed granite and the coconut shell was used as coarse aggregates. The Coconut shell has higher water absorption with a capacity of 22.50%. This high water absorption maybe due to the high porosity in the coconut shell and it shows that the shells need more water compared to the conventional aggregate to attain the same consistency. Since the shell has higher water absorption, the shells need to be pre-soaked in potable water for 24 hours to achieve saturated surface dry (SSD) condition before mixing. This is to prevent the absorption from occurring during the mixing. The abrasion and impact values are lower in percentage than the granite.

Table 2: Some properties of the coarse aggregates.

Physical Properties	Coconut shell	Crushed Granite
Specific gravity	1.13	2.73
Aggregate sizes (mm)	5 - 12.5	12.5
Abrasion value (%)	1.80	2.00
Aggregate impact value (%)	7 .86	14.20
24-hr Water absorption (%)	21.30	1.36
Crushing value (%)	2.65	8.78
Bulk density (Kg/m^3)	630	1650
Average shell thickness (mm)	3 - 8	-

Workability Test

Workability, (American Concrete Institute ACI), defines the workability of concrete as 'the property of freshly mixed concrete or mortar which determines the ease and homogeneity with which it can be mixed, placed,

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consolidated and finished without segregation of concrete. Slump cone test was employed to find the workability of the different mixes in which consistency of each mix was measured as presented in Table-3. It was observed that the workability established was increasing with increase in the replacement percentage of crushed granite aggregate CGA with coconut shell aggregate CSA. Coconut concrete probably has better workability due to the smooth surface on one side of the shell, relatively high water absorption and also due to the smaller size of Coconut shells compared to conventional aggregates.

Table-3: Slump Cone value test results.

% Replacement of Coarse Aggregate		Slump Cone Value (mm)
CGA	CSA	
100	0.0	15
97.5	2.5	20
95.5	4.5	30
93.5	6.5	50
91.5	8.5	63
90	10	75

Compressive Strength Behaviour

The compression strength is the capacity of a material or structure to withstand loads tending to reduce size. In Table 4, the comparison of compressive strength of Concrete Grade M15 with 0%, 2.5%, 4.5%, 6.5%, 8.5% and 10% replacement of granite aggregates with Coconut shells to determine the compressive strength are recorded at 28days of curing age according to BS 1881 Part 116 (1983). It was observed that tested Concrete specimens in compression testing machine of four (4) readings gives the average compressive strength of hardened Concrete at curing age of 7days and 28days. The results were found as 25.15N/mm^2 for control Concrete compare to the maximum value range from 2.5% - 6.5% replacement of Coconut shells recorded as 21.68N/mm^2 - 16.67 N/mm^2 at curing age of 28dasys respectively. Thus, the performance of Concrete strength decreases

in compressive strength with a corresponding increase in Coconut shell content at 28days of curing.

Table-4: The average Compressive strength of coconut shell Concrete. N/mm²

S/No	Cube Size (m³)	% Mix	W/c ratio	7 days.	28 days.
1	0.15	0.0	0.50	17.51	25.15
2	0.15	2.5	0.50	16.71	21.68
3	0.15	4.5	0.50	14.83	18.71
4	0.15	6.5	0.50	12.30	16.67
5	0.15	8.5	0.50	10.49	14.25
6	0.15	10	0.50	8.36	12.68

Split Tensile Strength Test

The comparison of split tensile strength of Concrete produced with partially replacement of 0%, 2.5%, 4.5%, 6.5%, 8.5% and 10% of Coconut shell as coarse aggregates for fresh Concrete as presented in Table 5. It was observed that 4 set of cylinder Concrete specimens were tested in compression testing machine and the average readings of hardened Concrete at curing age of 7days and 28day was recorded. The Strength decrease with increase in Coconut shell content at 28days of curing. The maximum split tensile strength for addition of percentage weight of Coconut shell as Coarse aggregates in Concrete is 2.10N/mm² compare to control experiments at 0% recorded as 3.27N/mm². The performance of Concrete decreases in strength with a corresponding increase in Coconut shell content at 28days of curing.

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Table-5: The average Split tensile strength of coconut shell Concrete. N/mm²

S/No	Cylinder Size (m)	% Mix	W/c ratio	7 days.	28 days.
1	0.1x 0.2	0.0	0.50	1.30	3.27
2	0.1x 0.2	2.5	0.50	1.11	2.10
3	0.1x 0.2	4.5	0.50	1.05	1.83
4	0.1x 0.2	6.5	0.50	0.85	1.68
5	0.1x 0.2	8.5	0.50	0.55	1.32
6	0.1x 0.2	8.5	0.50	0.25	1.05

CONCLUSION AND RECOMMENDATIONS

The study of coconut shell as a substitute for Coarse aggregates for M-15 grade of Concrete has been carried out, therefore, the following conclusions and recommendations are drawn:

- Conventional Concrete demonstration better performance compared to Coconut Concrete with respect to cracking from the observations of the compression testing machine.
- The compressive strength of Concrete cubes at 2.5%, 4.5% and 6.5% replacement of Coconut shell content has upright performances and on further replacement, decrease in the strength of Coconut Concrete has been observed at 28days curing. Thus, making the replacement both sustainable and conformed with design mix grade M-15 of Concrete and the Split tensile strength results range at 2.10N/mm² to 1.32N/mm² respectively.
- Use of coconut shell waste as aggregate will reduce depletion of natural sources of conventional aggregate and will also be helpful to make eco-friendly environment.

All the aggregates utilized in this research work demonstrated their suitability in Concrete production by their properties observations and the results presented. Thus, the study is projected to encourage the uses of Coconut shell as a substitute for conventional Coarse aggregate.

Furthermore, studies should be conduct with other water-cement ratios and mix designs to further evaluate their influences on Concrete strength.

Subsequent studies on Coconut Concrete should allow a curing age of up to 90 days and above.

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