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Experimental Study of Crushed Palmyra Palm Shells As Partial Repalcement For Coarse Aggregate In Concrete

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ABSTRACT : *In the study, effects of replacing crushed granite aggregate commonly used in concrete with crushed palmyra palm shells (CPPS) on the workability, strength and density of concrete were examined. Preliminary tests were carried out to determine some physical and mechanical properties of CPPS, so as to comparatively evaluate it with crushed granite. It was found that, CPPS had a relatively higher Water Absorption value compared to crushed granite. Conversely, crushed granite had a relatively higher aggregate impact value and specific gravity. Furthermore of the compressive strength, workability and density of concrete containing 10, 20, 30, 40 and 50% of CPPS as replacement to crushed granite in concrete mix of ratio 1:2:4 was studied. Concrete cubes of size 150 X 150 X 150 mm³ were casted, cured in water for 7, 14, and 28 days after which compressive strengths of casted cubes where determined. The result of the tests showed that the compressive strength of concrete as well as the density of the concrete decreases as the percentage of the CPPS increases in the concrete mix.*

Keywords*- Crushed palmyra palm shells,concrete, compressive strength, workability, density*

I. INTRODUCTION

Increase in the construction activities worldwide over time has made the demand for concrete to be on the increase. Concrete can be defined as a composite consisting of the dispersed phase of aggregates (ranging from its maximum size coarse aggregates down to the fine sand particles) embedded in the matrix of cement paste [1]. Aggregates essentially constitute over seventy percent of the volume of concrete [2] and [3]. With this large proportion of the concrete occupied by aggregates, it is expected that aggregates will have profound influence on the concrete properties and its general performance. Aggregates tend to give concrete its volumetric stability. It also has a remarkable influence on the reduction of moisture-related deformation like shrinkage of concrete. In developed countries, many construction industries have identified the use of waste natural materials as the potential alternatives to conventional aggregates. This has brought immense change in the development of high rise structures using Light Weight Concrete (LWC). At present, the most commonly used coarse aggregates for concrete production is the crushed granite rock due mainly to the presence of granite rocks deposits. With the high cost of constituent materials for the production of concrete especially coarse aggregates, coupled with the need for environmental sustainability, the need for the search for materials especially residual agricultural waste materials becomes imperative hence, the reason why many researchers are in search of replacing coarse aggregate to make concrete less expensive as well as enhancing sustainable development [3].

CPPS which is a residual agricultural waste material is obtainable in relatively large quantities especially in the northern parts of Nigeria where palmyra palms are mostly observed to thrive. CPPS is observed to be of little value in itself, being a residual agricultural waste, hence the need to integrate it as one of the components in concrete production thus opening a new horizon in agro-concrete research and at the same time offering alternatives to preserve natural coarse aggregate for the use of future generation. This paper investigates the performance of concrete mix in terms of workability and compressive strength upon addition of CPPS as partial replacement material for coarse aggregate. In previous research works, various types of waste materials have been investigated based on their potential to be used as partial coarse aggregate replacement material in concrete production such as palm kernel shell [4], crushed burnt bricks [2], crushed coconut shell [5], cockle shell [6], ceramic scrap [7] periwinkle shell [8], break tile [9], Date palm seed [10], Expanded polystyrene beads [11]. However, the use of CPPS is rare in literature, hence the need for the documentation of the potentials of its use as a partial replacement for coarse aggregate in concrete.

II. METHODS AND MATERIALS

2.1 MATERIALS

Basically, materials used for this research work include: River sand, crushed granite, CPPS samples and ordinary Portland cement.

2.2 METHODS

Tests carried out were done in accordance to the methods as prescribed in the BS code.

i. Specific gravity test was carried out in accordance with the procedure as outlined in [12].
ii. Particle size distribution analysis test was carried out in accordance with the procedure as outlined in [13].
iii. Aggregate water Absorption (AWA) test was conducted in accordance with the procedure as outlined in [14].
iv. Aggregated impact value (AIV) test conducted in accordance with the procedure as outlined in [15].
v. Slump test was carried out on the fresh concrete in accordance with the procedure as outlined in [16].

The cube moulds used where cleaned and oiled before each casting. 150 cubes of 150mm x 150mm x 150mm were produced with mix ratio of 1:2:4. Water/Cement ratio of 0.55, was used. De-moulding of the cubes was done between 18hours to 24hours after casting. The hardened cubes, where transferred into a curing tank at room temperature. The cubes where removed at the end of 7^{th}, 14^{th} and 28^{th} days from the curing tank and air dried for between 3 to 5 hours before testing. Partial replacement of crushed granite with CPPS was in of percentages 10%, 20%, 30%, 40%, and 50%.

III. RESULTS AND DISCUSSIONS

The specific gravity test result shows that the values for crushed granite and CPPS are 2.66 and 1.26 respectively as given in Table 1 below. This shows that crushed granite is denser than CPPS. Also, the Aggregate Impact Value (AIV) test for crushed granite and CPPS were found to be 18.85% and 14.25% respectively as shown. The average impact values calculated falls within the acceptable limits as stated in [17] which prescribes maximum value of 45% for aggregate to be used in concrete for non-wearing surfaces. Furthermore, it can be observed that the aggregate impact value (**AIV**) of CPPS aggregates are much lower compared to that of crushed granite aggregates, which indicates that these aggregates have good absorbance to shock. The Aggregate Water Absorption test result for crushed granite and CPPS were found to be 0.90% and 26.18% respectively hence, CPPS has higher water absorption and this is because of the porosity in its shell.

Table 1: Physical and Mechanical Properties of CPPS and Crushed Granite

S/No.	Physical and Mechanical Property	CPPS	Crushed Granite
1	Specific gravity	1.26	2.66
2	Aggregate Water Absorption (%)	26.18	0.90
3	Aggregate Impact Value (%)	14.25	18.85

Table 2: Varying Percentages of CPPS in concrete in relation to Slump Height.

CPPS in concrete (%)	**Crushed granite in concrete (%)**	**Water/Cement Ratio**	**Slump (mm)**
0	100	0.5	27
10	90	0.5	48
20	80	0.5	41
30	70	0.5	39
40	60	0.5	35
50	50	0.5	32

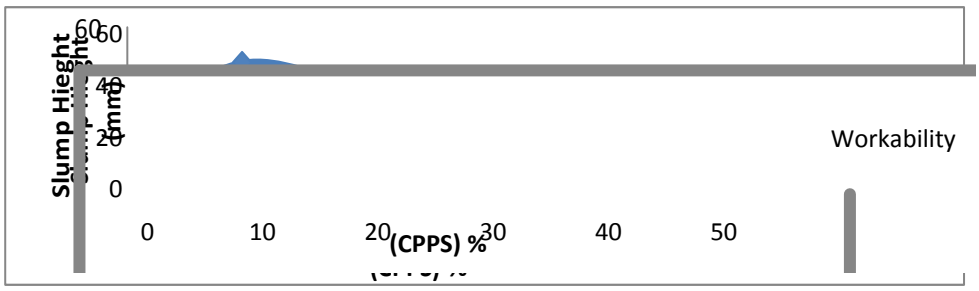

Figure 1: Plot of slump height against percentage of CPPS in concrete

The workability of concrete batches for different percentages of CPPS using slump test is shown in Table 2 and represented Fig.1. It can be observed that workability of concrete increased as the percentage of CPPS increased up to a maximum value of 48mm at 10% replacement of crushed granite with CPPS beyond which a decreasing trend in the workability of the concrete was observed as the percentage of CPPS increased. A w/c ratio of 0.55 was used for all the mixes. The hydrated cement paste produced enabled the penetration of cement into the CPPS aggregate. Results obtained by [19] using Oil Palm Shells (OPS) as the replacement of control aggregate shows similar trend the same as that of CPPS aggregate. This can be explained by the fact that, as the percentage CPPS increases, the workability of the concrete reduces, hence reducing the height of slump.

Table 3: Compressive Strength of concrete at varying percentages of CPPS in concrete (MPa).

Design Strength (MPa)	PPS content (%)	7 days (MPa)	14 day (MPa)	28 days (MPa)
	0	20	24	27.7
	10	14.36	16.52	18.45
25	20	12.15	14.81	17.04
	30	10.30	11.78	14.30
	40	8.89	10.30	12.00
	50	7.18	9.41	10.15

The compressive strengths of weight-batched concrete cubes at varying percentages of CPPS are shown in Table:3. The effect of replacement of crushed granite with CPPS on compressive strengths of the concrete cubes is as represented in Fig.2. It can be observed that the compressive strength decreased as the percentage of CPPS increased. The compressive strength is maximum at 0% replacement of crushed granite with CPPS and minimum at 50% replacement. The 28-day strength represented by 10and 20% replacement of crushed granite with CPPS satisfies the criteria for lightweight concrete [18].

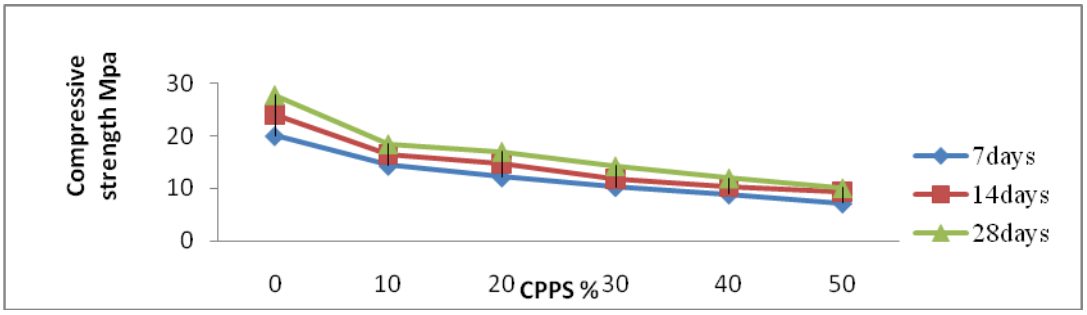

Figure 2: Plot of compressive strength against percentage of CPPS in concrete

DENSITY:

Densities of the concrete cubes at varying percentage replacement of crushed granite with CPPS are as given in table 4 and represented in fig.3.

Table 4: Density of the Concrete of all Percentage of CPPS

CPPS content (%)	7 days (Kg/m^3)	14 days (Kg/m^3)	28 days (Kg/m^3)
0	2586	2622	2623
10	2202	2338	2426
20	2115	2240	2328
30	2053	2181	2319
40	1940	2128	2187
50	1884	2058	2133

It can be observed from figure 3 that density of concrete reduces as percentage of CPPS increases and vice versa. The range of densities for CPPS (at 10-50% replacement of crushed granite with CPPS) in concrete for 28days was between 2426 – 2133 Kg/m^3 while at, 0% CPPS in concrete (100% crushed granite used as coarse aggregates) the density was 2623 kg/m^3. The least density was at 50% replacement of CPPS with a value of 2133 kg/m^3.

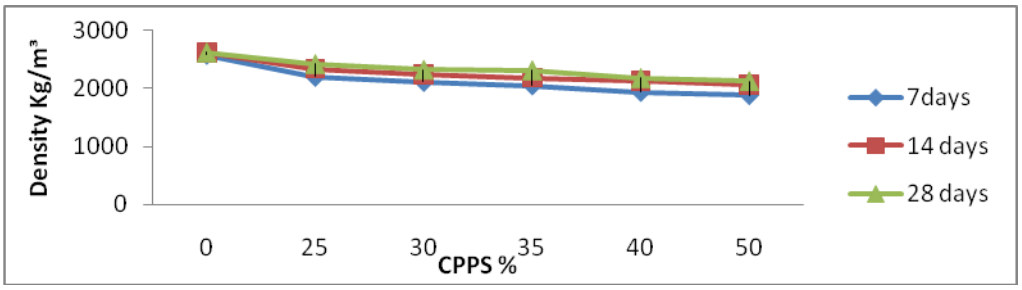

Figure 3: Plot of Density of concrete at varying percentage of CPPS in Concrete

The densities of all the concrete cubes casted within the range of 0-50% replacement of crushed granite with CPPS in concrete was found to be above 2000 kg/m^3 making it suitable for use as lightweight concrete[18].

IV. CONCLUSIONS

From the study, it can be observed that, the 28-day compressive strength of the concrete made using CPPS as coarse aggregate (at 10 and 20% replacement of granite with CPPS) produced concrete with a compressive strength above the minimum value required for structural lightweight concrete [18]. This is similar to findings of [20]. Hence, CPPS can be recommended for use as partial replacement of aggregate for light weight concrete for non structural members. Furthermore, the CPPS indicates that CPPS has good absorbance to shock. However, it is recommended that durability studies on concrete made using CPPS as aggregates should be carried out to assess its behavior in aggressive environments.

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