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EXPERIMENTAL STUDY ON STRENGTH CHARACTERISTICS OF M25 CONCRETE WITH PARTIAL REPLACEMENT OF COARSE AGGREGATE BY COCONUT SHELL

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Abstract: -With increasing exploitation of natural aggregates in developing countries, it becomes necessary to use synthetic lightweight aggregate produced from environmental waste. This paper presents a new method to produce structural lightweight aggregate concrete using an agricultural solid waste, namely coconut shell (CS), as a partial replacement to normal coarse aggregate. The lightweight concrete mix design is usually established by trial mixes. The proportion used in this study is 1:1.48:2.99 and water cement ratio is 0.44. In this study, M25 grade of concrete was produced by replacing 10%, 20%, and 30% of coconut shell as Coarse aggregate. Cubes, cylinders, and beams were casted and their compressive strength, split tensile strength, flexural strength, workability and density were evaluated at 7, 14 and 28 days and compared with the conventional mix. The strength of concrete decreased as the percentage of replacement of the conventional material increased .The result obtained encourage the use of CS as aggregate for the production of structural lightweight concrete.

Keywords: Crushed coconut shell, Lightweight aggregate concrete, Compressive strength. Split tensile strength, Flexural strength

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1. Introduction

The cost of construction materials is increasing day by day because of high demand, scarcity of raw materials, and high price of energy. From the standpoint of energy saving and conservation of natural resources, the use of alternative constituents in construction materials is now a global concern. Fast reduction of conventional aggregates, has challenge many engineers, and researchers to seek and develop new materials for construction, this include the use of by-product and industrial waste in building construction .Use of waste materials not only helps in their utilization in construction, but also solves their disposal problem. It also helps in reducing the cost of concrete manufacturing. One of the agricultural by-products that has been identified is coconut shell. India is the third largest producer of coconut products in the world. Coconut shell thus gets accumulated in the mainland without being degraded for around 100 to 120 yrs. In this juncture, the study on use of coconut shells as a substitute for coarse aggregate in concrete is gaining importance in terms of possible reduction of waste products in the environment and finding a sustainable alternative for non-renewable natural stone aggregate. The objectives of this project work are:

(a) To find economical solution for high cost construction material.

(b)To prepare lightweight concrete by using coconut shell as coarse aggregate as building material in construction.

2. Experimental investigation

2.1Material Used:

The discarded coconut shells were collected from the local oil mills and they were well seasoned. The seasoned CS is crushed manually. Coconut shell passing through 20mm and retained on 10mm sieves were collected. Due to higher water absorption capacity CS aggregates were used in saturated surface dry (SSD) condition. Portland Pozzolana Cement (PPC) conforming to Indian Standard IS 1489 (1991) was used as a binder. River sand conforming to grading zone III as per IS 383 (1970) was used throughout the investigation as the fine aggregate. The potable water from the College as per standards was used for mixing and curing. Compaction was achieved through the use of a table vibrator.

2.2Mix Proportions:

To investigate the properties of CS concrete, first of all conventional mix that is without CS was made. After that different concrete mixes were prepared by replacing 10%,20%. and 30% of coarse aggregate by coconut shells. Constant water cement ratio of 0.44 was maintained for all concretes. The proportion used in this study is 1:1.48:2.99.

2.3Test Methods:

Due to the high water absorption of coconut shell, they were pre-soaked for 24 hours in potable water prior to mixing and were in saturated surface dry (SSD) condition. Slump cone test was performed to know the workability of the mix. The obtained slump values were between 25 and 50mm . The specimens were cast in 150mm cubes for compressive strength test, 100 x 100 x 500mm beams for flexural strength test and 150mm diameter x300mm long cylinders for split tensile strength test. Compaction was done using a vibrating table to ensure adequate compaction. The specimens were demoulded after 24 ± 3hours in the laboratory and were cured in potable water till the tests were performed. The compressive strength, flexural strength and split tensile strength were determined in accordance to IS 516 (1959). The compressive strength of the specimen was determined on the 7th, 14th, 28th and 365th day in accordance to IS 516 (1959) to study the development of strength at later ages. The oven dry density was calculated as per ASTM C 567. Permeability Voids and Water Absorption were also evaluated.

3. Results

3.1 Density, Water Absorption and Permeable Voids:

When coconut shell is added to the concrete, it reduces the density of concrete. The 28 days air density of the mixes concrete specimen varied from 2384 to 2240 Kg/m^3. Permeable voids as well as Water Absorption increases as the percentage of coconut shell in concrete increases. With 10% CS replacement, the permeable voids were 30% higher than control concrete, and 88% higher for 20% CS replacement. The percentage increase of water absorption is more after 72 hrs.

Table 1: permeable voids, Density and water absorption of concrete cubes

S.No.	% replacement of coconut shell	% of Permeable voids	%Water Absorption in 0.5 hr	%water Absorption in 72 hr
1.	0%	7.7%	1.23	4.39
2.	10%	10.07%	1.80	5.4
3.	20%	13.8%	1.99	5.61
4.	30%	16.2%	2.1	5.72

Table 2: Density of coconut shell concrete (kgm-3)

Age(days)	% Replacement			
	0%	10%	20%	30%
7	2320	2290	2279	2223
28	2408	2384	2318	2240

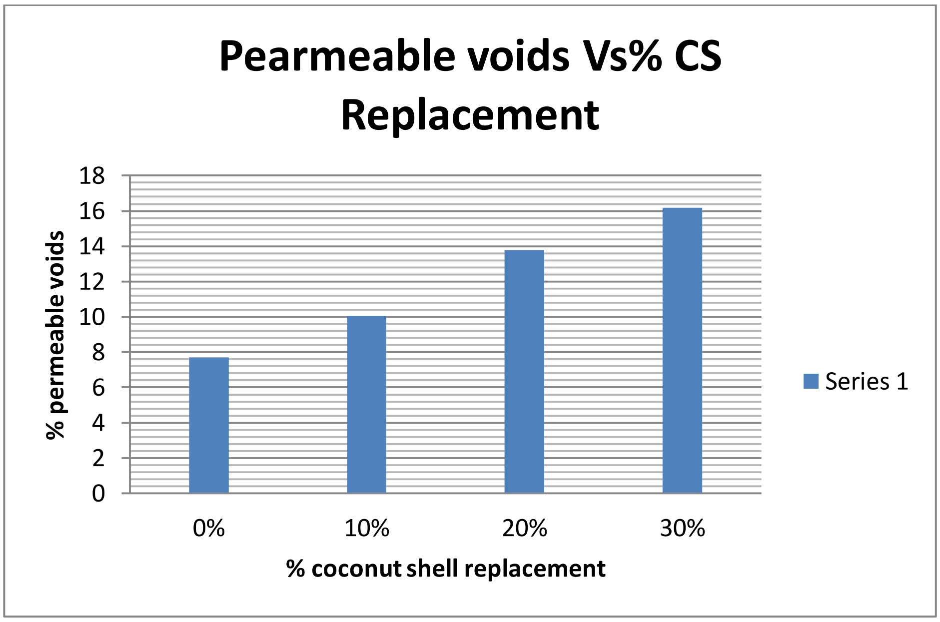

Fig 1: Permeable Voids Vs % CS Replacement

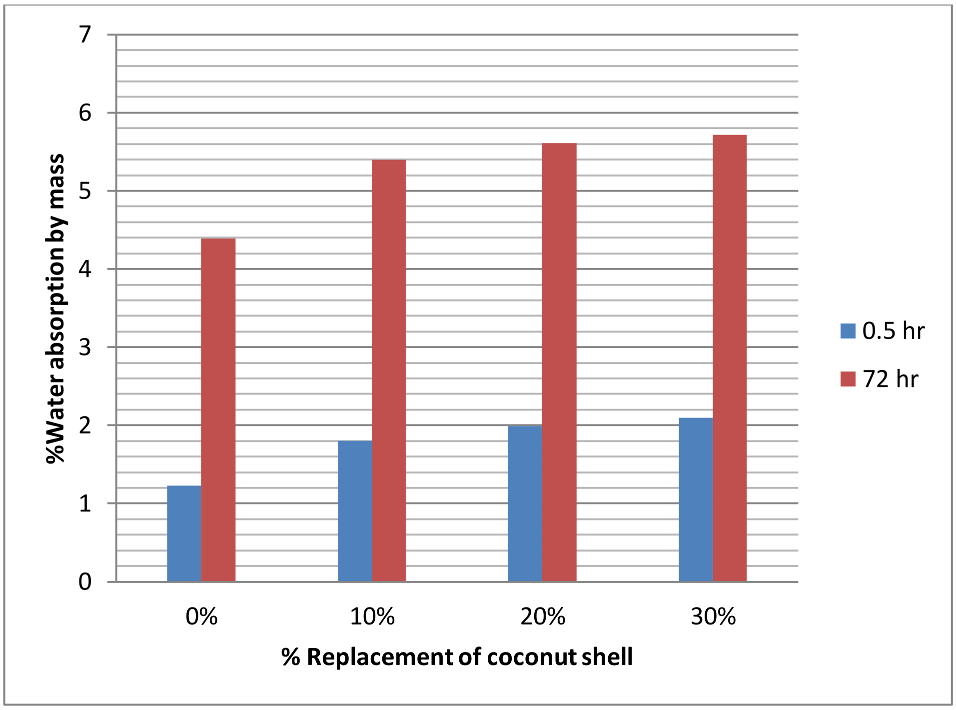

Fig 2: Water Absorption Vs % CS Replacement

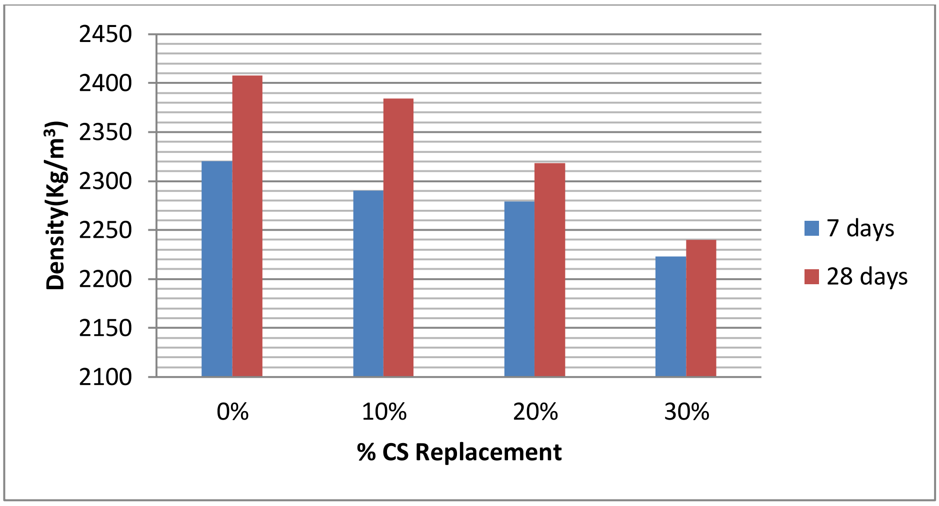

Fig 3: Density Vs % CS Replacement

3.2: Workability

Table 3: Slump Value

S.No	Slump Value(mm)	
1.	Conventional	40
2.	10% CS Replacement	30
3.	20% CS Replacement	34
4.	30% CS Replacement	42

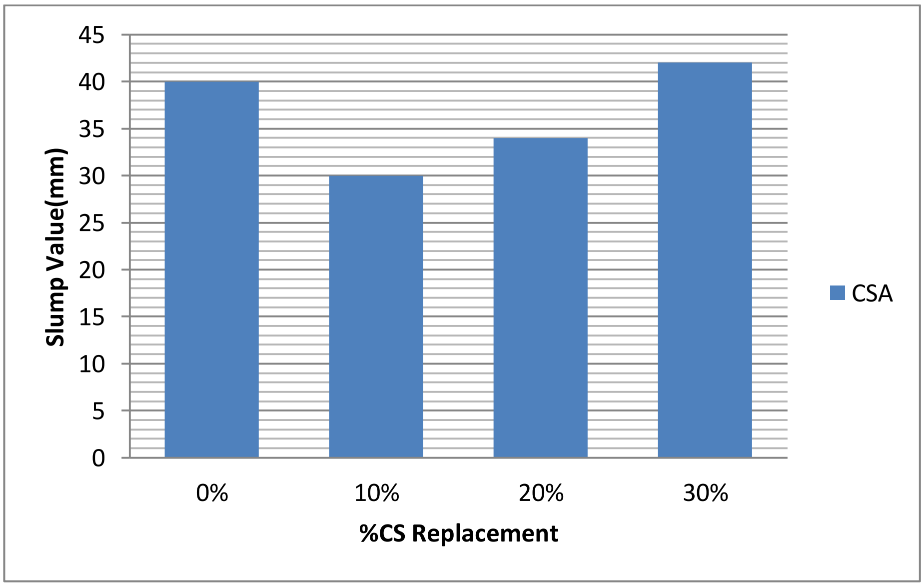

Fig 4: Slump Value Vs % CS Replacement

From Table and graph, it is clear that the slump of the concrete increased when the percentage of coconut shell increases and decrease as comparison with the conventional concrete .The workability was found to be increasing with increase in the replacement percentage of aggregate with coconut shell. Coconut shell concrete probably has better workability due to the smooth surface on one side of the shells.

3.3. Compressive strength

Table 4: compressive strength test Results

Days	CONVENTIONAL	10% CS Replacement	20% CS Replacement	30% CS Replacement
7	25.77	19.29	15.86	12.22
14	28.46	22.55	18.72	16.32
28	34.10	28.53	22.32	20.12

The maximum compressive strength of 34.10 N/mm^2 was attained at 0 % replacement (no coconut shells) while the minimum strength of 20.12 N/mm^2 was attained at 30% replacement. At 10% and20%replacement, concrete attained strength of 28.53 N/mm^2 and 22.32 N/mm^2 respectively. It can be seen that at all replacement levels, the strength of concrete increased as it aged. On each day of testing, the strength decreased as the percentage replacement of crushed granite increased.

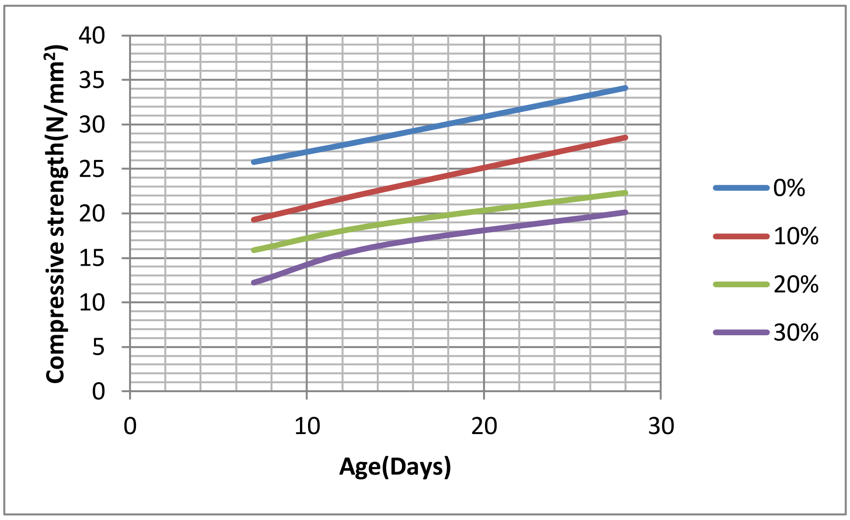

Fig 5: Compressive Strength Vs Curing Age

3.4 Split Tensile Strength

Table 5: Split tensile Strength test Result

Days	7		14		28	
	Load(KN)	Strength(N/mm^2)	Load(KN)	Strength(N/mm^2)	Load(KN)	Strength(N/mm^2)
Conventional	165	2.33	190	2.68	242	3.42
10% CS	146	2.066	164	2.32	215	3.04
20% CS	105	1.48	152	2.15	198	2.80
30% CS	96	1.35	140	1.98	165	2.33

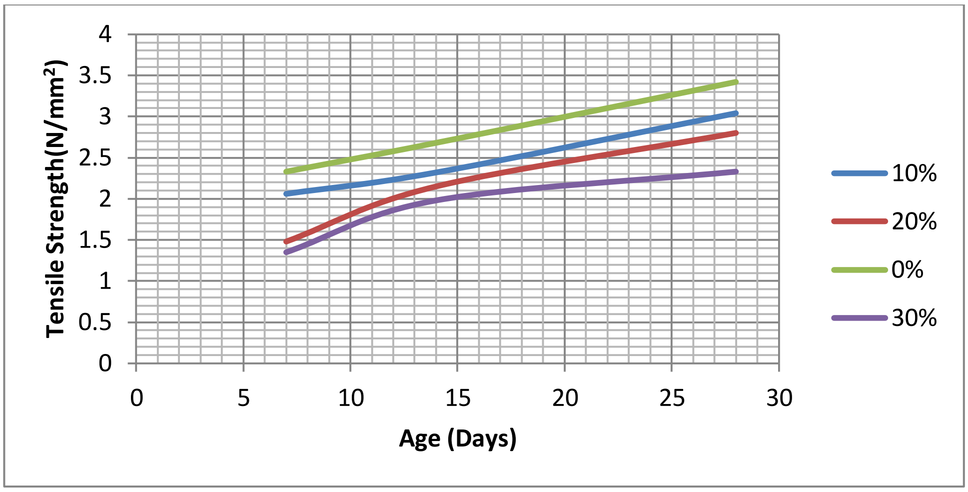

Fig6: Tensile strength Vs Curing Days

From table and figure, it is clear that, Similar to compressive strength, the split tensile strength also decreased with increase in %CS replacement. The results demonstrated that, irrespective of CS percentage replacement there was good relationship between compressive strength and split tensile strength.

3.5. Flexural Strength

Table 6: Flexural Strength test Results

Days	7		28	
	Load(KN)	Strength(N/mm^2)	Load(KN)	Strength(N/mm^2)
Conventional	13.8	6.9	15.9	7.95
10% CS	12.0	6.0	13.7	6.85
20% CS	11.2	5.6	12.8	6.4
30% CS	10.2	5.1	11.8	5.9

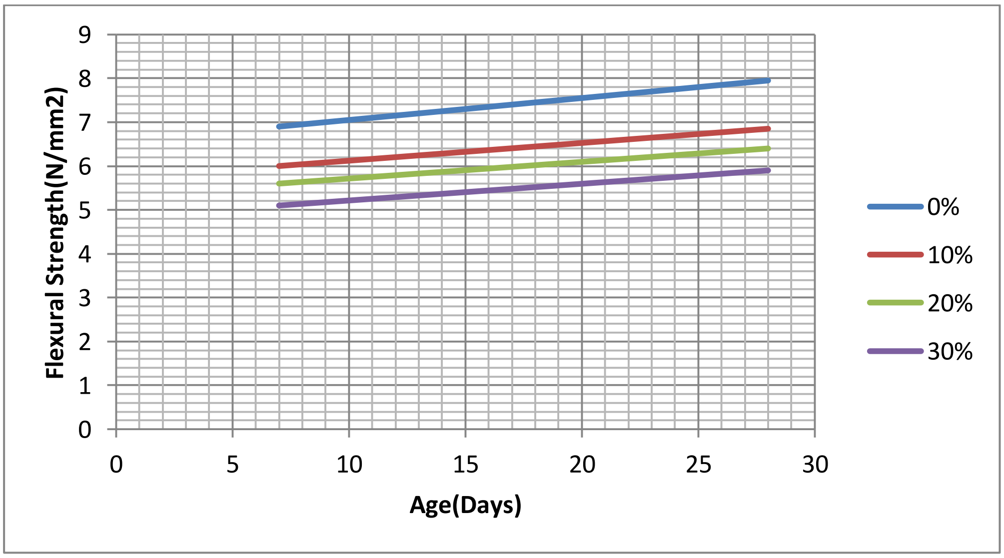

Fig7: Flexural strength Vs time in days

From Table and Fig ,it is clear that Flexural Strength decreases with increase in percentage replacement of coconut shell. Flexural strengths of concrete specimens with CA only, with 10% CSA, 20%CSA, and with 30% CSA were found to be 7.95 MPa, 6.85 MPa, 6.4 MPa, and 5.9 MPa respectively. The flexural strength is very much dependent on the physical compressive strength of coarse aggregate. flexural strength is equal to 0.7√fck where fck is the characteristic compressive strength of conventional concrete .So, similar to compressive strength, flexural strength also decreases with increase in CS replacement.

4. Conclusion

- Coconut shell exhibits more resistance against crushing, impact and abrasion, compared to crushed granite aggregate. So, the impact resistance of coconut shell aggregate concrete is high when compared with conventional concrete.
- Coconut shell can be grouped under lightweight aggregate as the 28-day air-dry densities of coconut shell aggregate concrete are less than 2000 kg/m^3 and these are within the range of structural lightweight concrete.
- Using coconut shell as aggregate in concrete can reduce the material cost in construction because of the low cost and abundant agricultural waste.
- The slump of the concrete increased when the percentage of coconut shell increases and decrease as comparison with the conventional concrete .The workability was found to be increasing with increase in the replacement percentage of aggregate with coconut shell. Coconut shell concrete probably has better workability due to the smooth surface on one side of the shells. Addition of fly ash as cement Replacement increases workability in CS concrete.
- Density of concrete decreases as the percentage of coconut shell in concrete increases.
- Compressive strength of concrete decreases as the percentage of coconut shell in concrete increases. . Biological decay was not evident as the cubes gained strength even after 365 days. At all replacement levels the strength of concrete increased as it aged. However, the overall strength decreased with CS replacement when compared to control concrete. Furthermore, fly ash as cement replacement had negative influence when compared to corresponding CS concrete.
- Similar to compressive strength, the split tensile strength and flexural strength also decreased with increase in CS replacement.
- With Increase in CS replacement, permeable voids, and Water Absorption also increased.

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