EXPERIMENTAL STUDY OF FIBER REINFORCED COCONUT SHELL AGGREGATE CONCRETE WITH FLY ASH

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Abstract—Solid wastes has increased many fold causing disposal problems and environmental pollution. It has become common sight to find large dumps of solid waste near every town and villages causing air, land and water pollution. A productive use of large scale wastes such as fly ash, coconut shell, rice husks, furnace slag etc., has become a matter of importance, as there is considerable scope for better management and disposal of the same. The waste materials considered in this work are fly ash, coconut shell. The disposal method proposed is by partially using them in building elements such as reinforced concrete elements and plain concrete elements.In this study, the compressive strength of concrete cubes of size 150 mm was carried out. The cement was replaced by 0% 10%, 20%, 30% of fly ash and add 0%, 0.1%, 0.3% and 0.5% of polypropylene fibre. The optimum percentage was found. The crushed coconut shells as substitutes for conventional coarse aggregate in gradation of 50% and 100%. For these optimum percentages three beams of 1700 x150 x100 mm were cast and tested. Extensive measurements such as material properties, deflection and ultimate load carrying capacity of the beams were done in the study for comparison.The experimental results shows that the ultimate load carrying capacity of coconut shell aggregate beam with fly ash and polypropylene fibre were higher than the control beam. The compressive test and split tensile test indicate that the gain in strength depends on curing time and strength increases gradually with the increase in fly ash and fibre content. It is concluded that a maximum of 50% of coarse aggregate can be replaced by coconut shell without any compromise on strength properties. The aim behind this is to use low cost material like coconut shell and thus taking close to the concept of low cost housing.

***Keywords*—construction materials; compressive strength; coconut shells; split tensile strength; environment; sustainability**.

I. INTRODUCTION

LWC generally has a density of less than 2000 kg/m3 and compressive strength of more than 20 N/mm2 it is known as structural LWC. The challenge in making LWC is in decreasing the density while maintaining strength and without adversely affecting cost. Introducing different types of lighter aggregates into the matrix is a common way to lower a concrete‘s density. The crushed stone and sand are the components that are usually replaced with lightweight aggregate (LWA) to produce LWC. LWC has been used as a building material for many decades throughout the world. It has gained its popularity due to its lower density and superior thermal insulation properties. Structural LWC offers design flexibility and substantial cost savings by providing less dead load, improved seismic structural response, lower foundation costs etc. LWC pre-cast elements offer reduced costs on both transportation and placement. The applications range from lightweight partitions, walls and secondary structural components to the primary structural components. The compressive strength ranges from 7 N/mm2 for light partition to about 40 N/mm2 for the primary structural components. Some of the LWC are foamed type concrete, no fines, and lightweight natural and artificial aggregates concrete.Natural LWA are normally obtained from the volcanic rocks such as pumice with density ranging from 500 to 900 kg/m3. Recent developments include the use of artificially manufactured LWA from various natural materials such as expanded clay, expanded shale, foamed slag, blast furnace slag, pulverized fuel ash and perlite to enable LWC and to achieve compressive strength up to 100 N/mm2. The main characteristic of LWA is its high porosity, which results in a low specific gravity. Porous LWA of low specific gravity can be used in LWC production instead of ordinary crushed stone aggregate. Though the commercially available LWA were used in many investigations in place of crushed stone aggregates to manufacture LWC, if waste materials are used as an aggregate in the production of LWC, more environmental and economic benefits may be derived. In view of the escalating environmental problems, the use of aggregates from by-products and/or solid waste materials from different industries is highly desirable. The high cost of conventional building materials is a major factor affecting construction delivery in India. In developing countries where abundant agricultural and industrial wastes are discharged, these wastes can be used as potential material or replacement material in the construction industry. This will have double the advantages viz., reduction in the cost of construction material and also as a means of disposal of wastes. Thus the above approach is logical, worthy and attributable. Therefore an attempt has been made in this study to utilize the coconut shell (CS) as coarse aggregate in the development of LWC.

The study of CS as an alternative for aggregates is another way of using the contributions a coconut tree will provide. The purpose of this research work is to develop a concrete with CS as coarse aggregate. The whole entity could be called coconut shell aggregate concrete (CSAC). After the coconut is scraped out, the shell is usually discarded as waste. The vast amount of this discarded CS resource is as yet unutilized commercially, its use as a building material, especially in concrete, on the lines of other LWA is an interesting topic for study. The study of CS will not only provide a new material for construction but will also help in the preservation of the environment in addition to improving the economy by providing new use for the CS. Therefore an attempt has been taken to utilize the CS as coarse aggregate and develop the new structural LWC in table 1.

TABLE1: COCONUT SHELL STATISTICS

Country	Production 2010	% of World Total	% Change from 2009
Indonesia	20,655,400 m/t	33.07%	- 3.691%
Philippines	15,540,000 m/t	24.88%	- 0.814%
India	10,894,000 m/t	17.33%	+ 6.65%
Brazil	2,705,860 m/t	4.33%	- 8.587%
Sri Lanka	2,238,800 m/t	3.58%	+ 6.66%

II. MATERIALS USED

A. CS as aggregate

The freshly discarded CS collected from a local oil mill was used in this study. Since the different species of CS are processed together, the shells are found to have varying thicknesses of 2–8 mm in fig 1. After crushing, the shells are flaky and irregularly shaped. For preparing CS aggregates were crushed by manually. Since CS is a flaky material, the sizes of CS lengthwise are restricted to a maximum of 12 mm (Fig. 1), to get enough workability with the concrete. The surface texture of the shell was fairly smooth on concave and rough on convex faces. The crushed edges were rough and spiky. CS aggregates have a relatively high water absorption value nearly, 24%, compared to the conventional aggregate (0.5%); hence, to prevent water absorption by the concrete mix, it is necessary to mix at Saturated Surface Dry condition (SSD) based on 24 h submersion in potable water.

Fig.1Sizes of coconut shell aggregate and normal aggregate

*B.*OTHER CONCRETE MIX CONSTITUENTS

Ordinary Portland Cement (OPC) 43 Grade conforming to Indian Standard IS 12269: 1987 is used as a binder. Well graded crushed quarry aggregate, with specific gravity 2.71, was used as coarse aggregate. A maximum aggregate size of 12.5 mm was used. River sand is used throughout the investigation as fine aggregate conforming to grading zone III as per IS 383-1970 with specific gravity 2.6 and maximum size 4.75 mm was used. The class F fly ash obtained from Mettur thermal power plant is used in this investigation. The specific gravity of fly ash found as 2.08. The potable water available in the University premises was used for mixing and curing.

III. MIX DESIGN

The mix design for lightweight concrete used for structural purposes depends on the physical and mechanical properties of lightweight aggregate. No specific methods are available for the design of lightweight concrete mixes. Lightweight concrete mix design is usually established by trial mixes. ACI and Indian Standard methods could not be applied to the mix design of concrete with agro-waste materials. For the production of coconut shell aggregate concrete (CSAC), enough trial mixes through weigh batches were already made and established for optimization of a mix ratio by considering cement content, wood–cement ratio, and water–cement ratio . The selected and established mix ratio for CSAC is 1:1.47:0.65:0.42 by weight of cement (Cement: Sand: CS: Water) in which cement content was set 510 kg/m3 and this mix also satisfies the criteria of structural LWC as per ASTM C 330. This established mix ratio was taken for this study. The physical and mechanical properties of CS were explained (Table 2).

TABLE 2: PROPERTIES OF COCONUT SHELL

Sl. No	Physical and mechanical properties	coconut shells
1	Maximum size (mm)	12.5
2	Moisture content (%)	5.13
3	Water absorption (24 h) (%)	6.17
4	Specific gravity	1.05–1.20
5	Impact value (%)	8.15
6	Crushing value (%)	2.58
7	Abrasion value (%)	1.63
8	Bulk density (kg/m3)	650
9	Fineness modulus	6.26
10	Shell thickness (mm)	2-8

IV. EXPERIMENTAL PROGRAMME

1. Compressive strength at 28 & 56 days
2. Split tensile strength at 28 & 56 days
3. Flexure test at 28 days

V. RESULTS AND DISCUSSION

A. Moisture content and water absorption capacity

The moisture content of the coconut shell was found to be 5.13%. These were allowed for in the calculation of batched quantities and of the total water requirement of the concrete mix. The water absorption capacity of the CS was found to be 6.17%. The absorption capacity is a measure of the porosity of an aggregate. Since the values obtained are low, it is reasonable to conclude that the shells absorb very little amount of mixing water during concrete production. These values are also within the range of absorption capacity of lightweight aggregates which have been put at 5–20% (Portland Cement Association).

B. Unit weight and specific gravity

The unit weight (density) and the specific gravity of the shells are 1738 kg/m3 and 1.74, respectively. These figures fall below the 2.5–3.0 range of specific gravity for normal weight aggregates. The CSs can therefore be classified as lightweight aggregates, the CSs having higher density and specific gravity. The clear differences in specific gravities of the shells (1.74) and cement (3.10) explained why it was necessary, as done in this investigation, for the material quantities to be computed by the method of absolute volume.

C. Compressive strength of concrete

As described in the above chapter specimens with the size of 150mmX150mmX150mm were tested for compressive strength. 28th days of water cured specimens were tested. The compressive load is applied to the specimen until failure occurs. The compressive strength are given in Table.

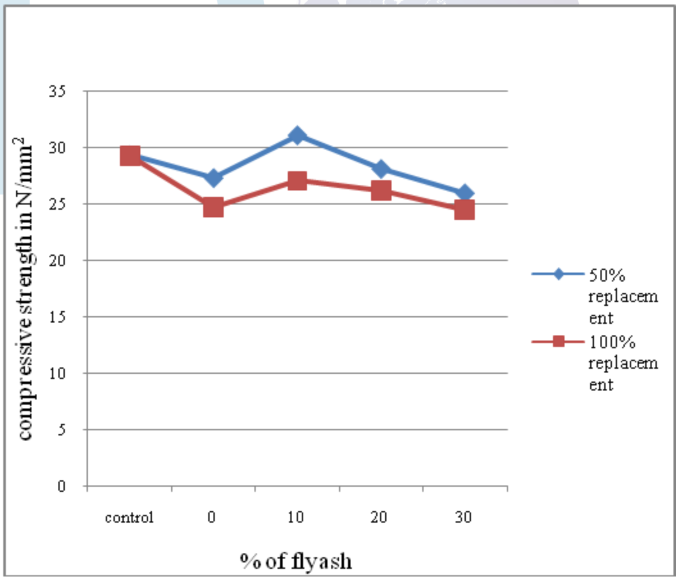
TABLE 2 DETAILS OF SPECIMEN TO BE CAST

Identification of Cubes	Cement(%)	Fiber(%)	Coconut Shell(%)	Fly ash(%)
C	100	-	-	-
C-1	100	-	50	-
C-2	100	0.3	50	0
C-3	90	0.3	50	10
C-4	80	0.3	50	20
C-5	70	0.3	50	30
C-6	100	-	-	-
C-7	100	-	100	-
C-8	100	0.3	100	0
C-9	90	0.3	100	10
C-10	80	0.3	100	20
C-11	70	0.3	100	30

TABLE 3 COMPRESSIVE STRENGTH OF THE CUBES

AT 56 DAYS

Identification of cubes	Weight of the specimen (Kg)	Density of the specimen (Kg/m^3)	Load (KN)	Stress (N/mm^2)
C	7.4	2192.5	659	29.28
C-1	6.32	1872.5	591	26.27
C-2	6.47	1917	614	27.28
C-3	6.63	1964.4	698	31.02
C-4	6.57	1946.6	632	28.08
C-5	6.62	1961.4	584	25.95
C-6	7.4	2192.5	659	29.28
C-7	5.86	1736.2	536	23.82
C-8	5.75	1703.7	556	24.71
C-9	5.84	1730.3	609	27.06
C-10	5.79	1715.5	589	26.17
C-11	5.73	1697.7	551	24.48



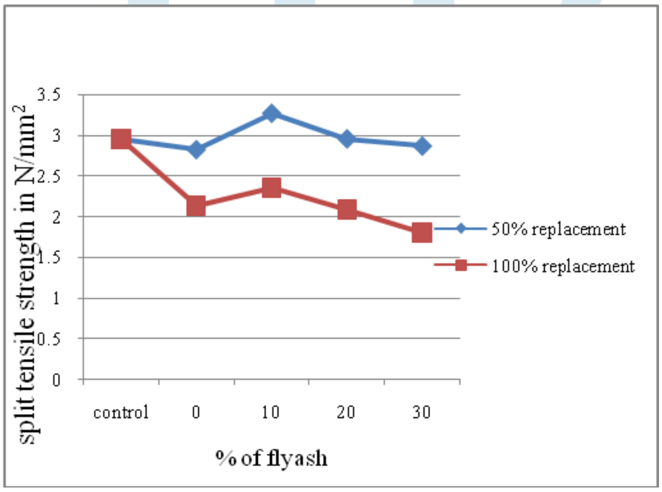
GRAPH-1 COMPRESSIVE STRENGTH OF THE CUBES AT 56 DAYS (COMPARISON OF COCONUT SHELL REPLACEMENT 50% AND 100%)

The graph shows that 56 days Compressive strength is maximum compare to 28 days compressive strength. Then the optimum percentage of fly ash never changed.

In the proportion of 10% fly ash content and 0.3% polypropylene fibre, the strength is maximum compared to the other proportions .The graph

Identification of cubes	Load (KN)	Stress (N/mm^2)
C	212	2.999
C-1	180	2.546
C-2	198	2.801
C-3	232	3.282
C-4	210	2.970
C-5	201	2.843
C-6	212	2.999
C-7	151	2.136
C-8	169	2.390
C-9	178	2.518
C-10	162	2.291
C-11	155	2.192

TABLE 4 SPLIT TENSILE STRENGTH OF THE CYLINDERS AT 56 DAYS

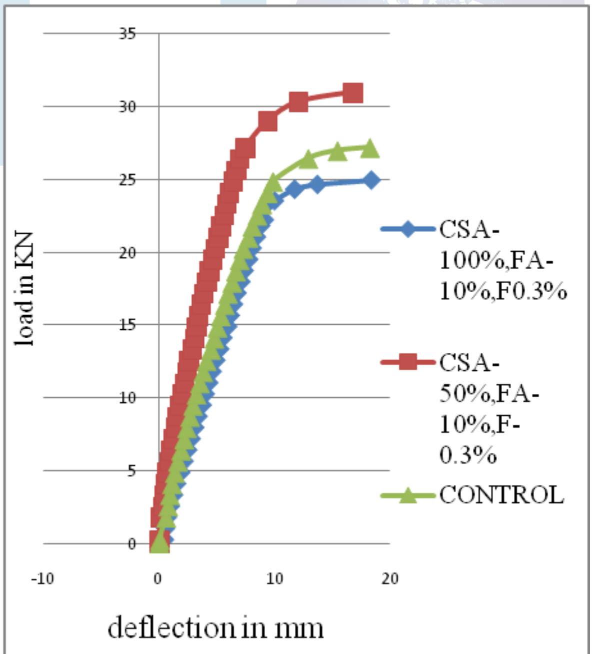


GRAPH-7 SPLIT TENSILE STRENGTH OF THE CYLINDERS AT 56 DAYS(COMPARISON OF COCONUT SHELL REPLACEMENT 50% AND 100%)

The graph shows that 56 days Split tensile strength is maximum compare to 28 days split tensile strength. Then theoptimum percentage of fly ash never changed.In the proportion of 10% fly ash content and 0.3% polypropylene fibre, the strength is maximum compared to the other proportions.The graph shows the maximum split tensile strength –3.282 N/mm^2 .

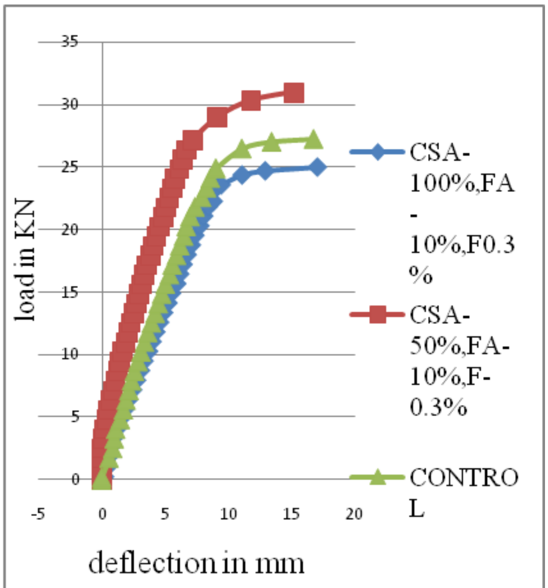
shows the maximum compressive strength 31.02 N/mm^2 .

C. Flexure test



LOAD DEFLECTION CURVE AT L/2 DISTANCE

When comparing the load carrying capacity, the beam CSA-50%,FA-10%,F-0.3% gives higher ultimate load carrying capacity than the other beams. CSA-100%,FA-10%,F-0.3% having the maximum deflection.



LOAD DEFLECTION CURVE AT L/3 DISTANCE

The graph shows that CSA-100%,FA-10%,F-0.3% having the maximum deflection.

TABLE-5 FLEXURE TEST RESULTS

Beam designation	Load		Deflection		Max crack width in (mm)
	1st crack load in (KN)	Ultimate load in (KN)	Mid span deflection at 1st crack in (mm)	Mid span deflection at Ultimate load in (mm)	
CONTROL	8.7	27.21	2.66	18.23	4
CSA-50%,FA-10%,F-0.3%	15.63	30.98	3.44	16.87	3
CSA-100%,FA-10%,F-0.3%	6.43	24.96	2.47	18.41	4

TABLE -6 DUCTILITY INDEX

Beam designation	First crack mid span deflection (mm)	Ultimate mid span deflection (mm)	Ductility Index
Control	2.66	18.23	6.85
CS-50%:FA-10%;F-0.3%	3.44	16.87	4.90
CS-100%,FA-10%:F-0.3%	2.47	18.41	7.45

TABLE-7 STIFFNESS VALUES AT INITIAL CRACK LOAD

Beam designation	Initial Crack Load (KN)	Initial Crack mid span deflection (mm)	Stiffness (KN/mm)
Control	8.7	2.66	3.27
CS-50%:FA-10%;F-0.3%	15.63	3.44	4.54
CS-100%,FA-10%:F-0.3%	7.93	2.47	3.21

TABLE-8 STIFFNESS VALUES AT ULTIMATE LOAD

Beam designation	Ultimate Load (KN)	Ultimate mid span deflection (mm)	Stiffness (KN/mm)
Control	27.21	18.23	1.49
CS-50%:FA-10%;F-0.3%	30.98	16.87	1.83
CS-100%,FA-10%:F-0.3%	24.96	18.41	1.35

From the above table it is clear that the specimen CS-50%, FA-10%, Fibre- 0.3% beam has higher stiffness values at ultimate load than other beams. Same specimen cannot have ductility and stiffness

CRACK PATTERN

Crack pattern were observed during the test. Figure shows the crack pattern. once the cracks are formed in beams, their propagation is more parallel to each other and normal to the axis of the beam .They have reached the ultimate moments with no sign of lateral moment of the cross section or any other instability.

MODES OF FAILURE

- All specimens failed in the flexure zone.
- After the first crack load,major cracks have formed in the flexure region and extended towards the point loads.
- At the ultimate load, the failure of beams occurred with crushing of concrete of concrete in compression zone.

VI. SUMMARY AND CONCLUSION

SUMMARY

In this project coconut shell is used as coarse aggregate with the constant proportions such as 50% & 100% with various proportions of fly ash such as 0%, 10%, 20%, and 30%,and polypropylene fibre add to concrete with various proportion such as 0%, 0.1%, 0.3% 0.5%. The optimum percentage of fly ash and fibre was found. From the result shows that increase the compressive strength for increasing the Polypropylene fibre.

CONCLUSION

1. The compressive strength increased while increasing the curing period of Specimen, because adding fly ash.

2. In the proportion of 10% fly ash content and 0.3% polypropylene fibre, the strength is maximum compared to the other proportions.

3. compressive strength increases 9% compare to control specimen.

4. Optimum percentage of fly ash is 10%

5. Optimum percentage of polypropylene fibre is 0.3%.

6.When comparing the load carrying capacity, the beam CSA-50%,FA-10%,F-0.3% gives 14% higher ultimate load carrying capacity than the control beam.

7. The specimen CSA-100%, FA-10%,F-0.3% has higher ductility index than other beams.

8. The specimen CS-50%, FA-10%,F-0.3% has higher stiffness values at ultimate load than other beams.

9. The density of light weight concrete 11.7% less than conventional concrete. The reduction of density will play important factor in the economy of the project because the total dead loads of the building were reduced and it helps in economic design of foundation.

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