IMPROVING THE ENGINEERING PROPERTIES OF REINFORCED CONCRETE MODIFIED WITH COCONUT SHELL AGGREGATES

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ABSTRACT: A common characteristic of sustainable buildings is that they significantly reduce emissions, material use and water use and with contribution of economic liveliness, environmental, health, and social impartiality in it. This has necessitated research into alternative materials of construction. The use of coconut by products has been a long time source of income for some people. Recycling of the disposed material is one method of treating the agricultural waste. The use of coconut shell could be a valuable substitute in the formation of composite material that can be used as a housing construction, such as concrete. In view to provide new knowledge to the contractors and developers on how to improve the construction industry methods and services by using coconut shells and to sustain good product performance and meet recycling goals, there is need to design a technical specification of concrete using coconut shell as aggregates that will meet the Indian standard requirements. In this study, coconut shell is used as coarse aggregate in concrete. The properties of coconut shell and coconut shell aggregate concrete is examined and the use of coconut shell aggregate in construction is tested. The project aims at analyzing engineering properties of samples. The characteristic properties of concrete are determined such as compressive strength and flexural strength using the mix made by replacing coarse aggregate with crushed coconut shell aggregate with partial replacement using M20 grade concrete. The project also aims to prepare and show that Coconut shell aggregate is a potential construction material for preparation of light weight concrete for construction of building components.
Keywords: Sustainable Building, Coconut Shell, Agricultural waste, Engineering properties, Light Weight Concrete.

I. INTRODUCTION

Now-a-days many engineers and scientists are in process to find various natural as well as modernized ways for the production of construction materials especially concrete. They are also keen in maintaining its quality and strength and therefore various other materials are used as a replacement of a particular material in the making of concrete. One such material is coconut shell which can be used in concrete making by partially replacing coarse aggregate which is a very important component in concrete.

Coconuts being naturally available in nature and since its shells are non-biodegradable in; they can be used readily in concrete which fulfils almost all the qualities of the original form of concrete. Natural sources are depleting by rapid rate; there should be some way to stop it somewhere. One way to overcome this problem is to replace the coarse aggregates used in the production of concrete by coconut shell which are readily available in nature. Use of this non-biodegradable material in concrete would not only make the construction cost less since coconut shells would require less costing as compared to the coarse aggregates but also re-use the waste material and help in environmental aspect.

A potential exists for the use of coconut shells as replacement of conventional aggregate in both conventional reinforced concrete and plain cement concrete construction. The use of coconut shells as partial replacement for conventional aggregates should be encouraged as an environmental protection and construction cost reduction measure. The increase in population also increases the industrial by- products, domestic wastes etc. It has been noticed in India that coconut shell (CS) as an agricultural waste, requires high dumping yards as well as an environmental polluting agent.

COCONUT

Coconuts are produced in 92 countries worldwide on about more than 10 million hectares. Indonesia, Philippines and India account for almost 75% of world coconut production with India being the world's second largest coconut producer. A coconut plantation is analogous to energy crop plantations; however coconut plantations are a source of wide variety of products, in addition to energy.

The current world production of coconuts has the potential to produce electricity, heat, fiberboards, organic fertilizer, animal feeds, fuel additives for cleaner emissions, health drinks, etc. The coconut fruit yields 40 % coconut husks containing 30 % fiber, with dust making up the rest. The chemical composition of coconut husks consists of cellulose, lignin, pyroligneous acid, gas, charcoal, tar, tannin, and potassium.

Coconut dust has high lignin and cellulose content. The materials contained in the casing of coco dusts and coconut fibers are resistant to bacteria and fungi. Coconut husk and shells are an attractive biomass fuel and are also a good source of charcoal. The major advantage of using coconut biomass as a fuel is that coconut is a permanent crop and available round the year so there is constant whole year supply. Activated carbon manufactured from coconut shell is considered extremely effective for the removal of impurities in wastewater treatment processes.

Fig 1: Waste Coconut Shells after use

BENEFITS OF COCONUT SHELL RECYCLING

The following points suggest the generalized benefits:

- Production of light weight reinforced concrete members
- Reuse and Conservation of non-renewable energy sources
- Preservation of the environment and reduction in land filling
- Energy conservation and reduction in depletion of natural resources
- Cost saving over traditional aggregate uses

II. BACKGROUND OF STUDY

Gambhir (2005) the suitability of a particular lightweight concrete is determined by the specified compressive strength and the density of concrete. the Coconut palm as one of nature‟s greatest gifts to man. Coconut palm “displays the whole range of human dependence on palm product”. Its uses are legion. Its greatest multiplicity of uses found on tropical Islands in the Pacific, where it provides the inhabitants with almost every requisite; human life would be intolerable, and sometimes impossible, without it. It provides food, drinks, oil, medicine, fiber timber, thatch, mats, fuel and domestic utensils. The oil is used for cooking, anointing the body, illumination, lubrication and making soap. It is not surprising that it has been called the “tree of life” and mankind‟s greatest provider in the tropics. Coconut tree or palm (coco nufera) is a member of the family Arecaceae (palm family) It is the only species in the genus coco, and is a large palm, growing to 30m tall, with pinnate leaves 4-6m long, pinnae 60-90cm long, old leaves break away cleanly leaving the trunk smooth.

Gambir (2005) stated that due to reduction in the weight of the concrete produced by using light weight aggregate this will enhance better thermal insulation and thereby improves the fire resistance of the structure.

Rossignolo and Agnesini (2001) Reported from their investigation that lightweight concrete production produces low unit weight concrete elements which are preferred as heat isolation materials. By this comfort temperature values can be provided with lower energy consumption. They concluded that because of the advantages of lightweight concrete in providing heat isolation, the production has increased from early 1980‟s until present day and an important industry has developed from it.

Adegoke et. al (2008) reported that numerous achievements have been made in researching in to the usage of local material which has attracted attention due to it‟s functional benefit of waste reusability and sustainable development. Reduction in construction costs and the ability to produce lightweight are added advantages. One of the disadvantages of conventional concrete is the high self weight of concrete. This heavy self weight will make it to some extent an uneconomical structural material. Attempts have been made in the past to reduce the self weight of concrete to increase the efficiency of concrete as a structural material. The density of normal concrete ranges from 2200kg/m3 to 2600kg/m3, while that of lightweight lies within 300 to 2000kg/m3. There are many advantages of having low density, this includes:

i. Reduction in dead load
ii. Increase the progress of building
iii. Lowers haulage and handling costs
iv. Low thermal conductivity, a property which improves with decreasing density

Teo et. al (2006) stated that by reducing the weight of the structure, catastrophic earthquake forces and inertia forces that influence the structures can also be ultimately reduced, as these forces are proportional to the weight of the structure

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Nor Azazi et al. (1999) lightweight concrete using oil palm shell, the replacement of aggregate by oil palm shell reduced compressive strength of concrete, the strength of 20 N/mm2 still can be achievable and meet the provision of BS 8110:1985. From the Reinforced Concrete beam and column tests, it is found that provision of BS 8110:1985 can be safely applied to this lightweight concrete.

J.P. RIES (2011) studied that Lightweight aggregate (LWA) plays important role in today's move towards sustainable concrete, Lightweight aggregates contributes to sustainable development by lowering transportation requirements, optimizing structural efficiency that results in a reduction in the amount of overall building material being used, conserving energy, Reducing labor demands and increasing the survive life of structural concrete.

AMARNATH YERRMALLA (2012) et al studied the strength of coconut shells(CS) replacement and different and study the transport properties of concrete with CS as coarse aggregate replacement. They concluded that:

a. Increase in CS percentage decreased densities of the concrete.
b. With CS percentage increased the 7 days strength gain also increased with corresponding 28 days curing strength.

VISHWAS P. KULKARNI (2013) studied that Aggregates provide volume at low cost, comprising 66 percent to 78 percent of the concrete. Conventional coarse aggregate namely gravel and fine aggregate is sand in concrete will be used as control. While natural material is coconut shell as course aggregate will be investigate to replace the aggregate in concrete.

III. EXPERIMENTAL PROGRAM & METHEDOLOGY

MATERIALS

The properties of material used for making concrete mix are determined in laboratory as per relevant codes of practice. Different materials used in present study were cement, coarse aggregates, fine aggregates, in addition to steel bars. The aim of studying of various properties of material is used to check the performance related to conventional methods. The description of various materials which were used in this study is given below:

PREPARATION OF MATERIALS FOR MIX

Materials used for this dissertation mix cement, coarse aggregates, fine aggregates, water, Coconut shell aggregate and Steel for reinforcement. The concrete mix uses a single group of cement supply to minimize variation of results. Aggregates are selected through gradation test which are free from impurities were checked and certain standards were complied in the course of this study.

COCONUT SHELL AGGREGATES

The coconut shell aggregate was obtained from the local hawkers of coconut in the market area and temples area, located within Bhopal (M.P). It was sun dried for two months before being crushed in the quarry. The crushed Coconut shell material was later transported to the laboratory where they were thoroughly cleaned and washed, then allowed to dry under ambient temperature. The coconut shells were available in various shapes, such as curved, flaky, elongated, roughly parabolic and other irregular shapes. The sizes shown below were obtained before crushing. In order to ascertain the properties of coconut shell aggregate the following tests was carried out which includes the specific gravity, particle size distribution and porosity/water absorption capacity. All these tests were performed in accordance to Indian Standards. The results are presented in tables

PROPERTIES OF COCONUT SHELL

Coconut shell has high strength and modulus properties.

It has added advantage of high lignin content. High lignin content makes the composites more weather resistant.

It has low cellulose content due to which it absorb less moisture as compare to other agriculture waste.

Coconuts being naturally available in nature and since its shells are non-biodegradable; they can be used readily in concrete which may fulfill almost all the qualities of the original form of concrete.

Table 1: Physical Property of Coconut Shell

S.NO	PHYSICAL PROPERTY	TEST RESULT
1	Maximum Size (mm)	20
2	Fineness modulus	6.48
3	Specific Gravity	1.56
4	Bulk Density(kg/m3)	510-600
5	Water Absorption (%)	23
6	Aggregate Crushing Value (%)	2.49
7	Aggregate Impact Value (%)	8.55
8	Moisture Content (%)	4.2
9	Shell Thickness(mm)	3-6

IV. DETAILS OF REINFORCEMENT FOR PREPARATION OF BEAM

For this experimental set up, No of beams were casted and tested which is of 1.2m long 0.1m wide and 0.2 m deep. One is conventional concrete beam; the other was coconut shell concrete beam. The beam was designed as under reinforced section to carry on a minimum ultimate load of 70 KN. The beam consists of two 12Ø bars at bottom & two 8Ø hanger bars at the top. 8Ø @135 stirrups are provided as stirrups to hold the reinforcements and to act as shear reinforcements. The beams were casted with the dimension of 230mm wide and 150mm deep with the cover of 15mm. The diameter of the bar used is 12mm as tensile bars and 10mm as compressive bars. 6mm stirrups are used to hold the bars in its position. There were four types of beams were casted.

Figure 2: Preparation of R.C Beam

PREPRATION OF CONCRETE MIX (M20)

The mix proportions obtained for the various mixes cast are tabulated in Table 3.7

Table 2:Proportions of Concrete Mixtures for Compressive strength Cubes Preparation

Mix	Mix Designation (M20)	Water (W), %	Cement (C) kg	Fine Aggregates (FA) kg	Coarse Aggregates (CA) kg	Coconut Shell Aggregates,kg
M1	1:1.5:3	0.45	1.47	2.20	4.41	00
M2	1:1.5:3	0.45	1.47	2.20	3.96	0.44
M3	1:1.5:3	0.45	1.47	2.20	3.52	0.89
M4	1:1.5:3	0.45	1.47	2.20	3.08	1.33

TEST ON FRESH CONCRETE

WORKABILITY TEST OF CONCRETE

Fig 3: Workability test of concrete by slump cone method

V. TESTS ON HARDENED CONCRETE

COMPRESSIVE STRENGTH

Compressive strength is calculate using the following formula:

Compressive strength (kg/cm2) = Wf / Ap

Where

Wf = Maximum applied load, (kg)

Ap = Plan area of cube mould, (mm2)

The results and graphs for compressive strength tests are tabulated in the next chapter.

Table 3: Description of cube specimen prepared

S.No	Coconut shell aggregate, %	W/C, %	Fck N/mm2	Size of the cube, mm
C.1	0	0.45	26.6	150*150*150
C.2	10	0.45	26.6	150*150*150
C.3	20	0.45	26.6	150*150*150
C.4	30	0.45	26.6	150*150*150

Figure4: Placing of concrete cube specimen in Compression testing machine.

BEAM FLEXURAL STRENGTH (BENDING)

DESCRIPTION OF SPECIMENS

The Reinforced concrete beams are casted of M20 grade concrete (1:1.5:3) in this experimental work, were the dimensions of beams was 100 mm wide x 200 mm deep x 1200 mm long are casted with 2- 12Ø bars at bottom and 2- 8Ø hanger bars, 8Ø @135 stirrups are provided. The beams are casted with the variable percentage of coconut shell aggregate as a replacement of coarse aggregate to determine its bending strength.

Table 4: Description of beam specimen prepared

S.No	Coconut shell aggregate, %	W/C	Fck N/mm2	Fy N/mm2	Ast (mm2)	Size of the beam	Design load kn
B.1	0	0.45	26.6	415	226.2	1200*200*100	70.4
B.2	10	0.45	26.6	415	226.2	1200*200*100	70.4
B.3	20	0.45	26.6	415	226.2	1200*200*100	70.4
B.4	30	0.45	26.6	415	226.2	1200*200*100	70.4

Before conducting the experiments some assumptions are made as following:

The planes of the cross section of the beam considered will be remains plane before bending and after bending.

The bonding between the concrete and steel will be prefect and homogenous.

The stress-strain behavior of concrete and steel are mostly similar.

The tensile strength of concrete is ignored. All the tensile

stress is taken only by the reinforcement.
The stress-strain relationship for the compressive zone in concrete is assumed to be parabolic that results in obtaining the strength.

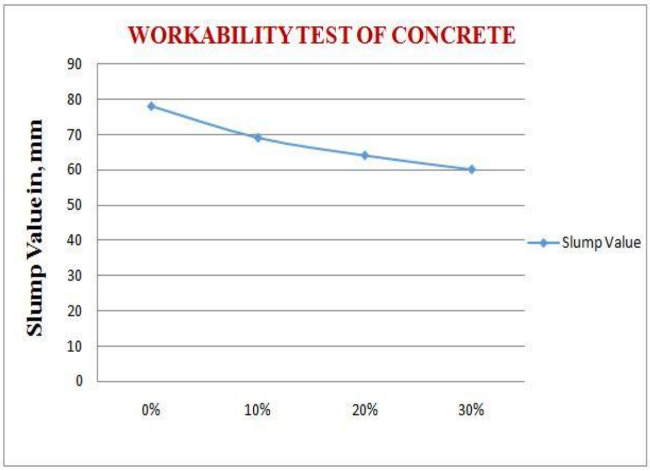
Figure 5: Flexural strength test of Beam specimen on centre point loading apparatus.

TEST RESULTS:
WORKABILITY (SLUMP CONE TEST)
Slump cone test was conducted on all samples. Concrete mix with 30% coconut shell aggregate gave the lowest slump with 60 mm while control mix showed a slump measurement of 78 mm. Graph shows the reduction in slump measurement when coconut shell aggregate was added.

Table 5: Workability Test results of cement replaced with CSA.

S.No	CSA, %	Weight of CSA in Mix (Kg)	Slump Value, mm
M1	0	00	78
M2	10	0.44	69
M3	20	0.89	64
M4	30	1.33	60

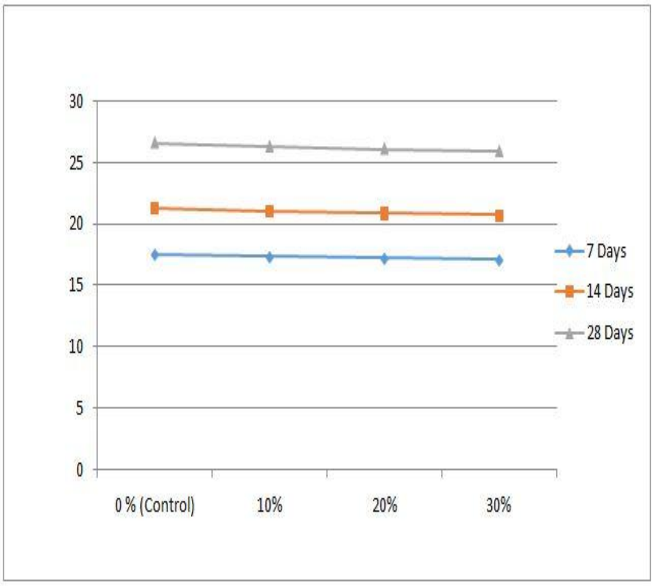
Graph 1: Workability testing of concrete Mix with CSA.



COMPRESSIVE STRENGTH
Table 5: Details of Compressive Strength test with various % of CSA.

S.No	CSA, %	Average Compressive Strength (N/mm^2)		
		7 days	14 days	28 days
C1	0	17.55	21.28	26.60
C2	10	17.35	21.04	26.30
C3	20	17.22	20.88	26.10
C4	30	17.09	20.72	25.90

Graph 2: Compressive Strength testing of concrete cubes with various % CSA.



FLEXURAL STRENGTH

Table 6: Load and corresponding deflection for under reinforced beams for 0% CSA

Name of Specimen	Percentage of Coconut Shell Aggregate, %	Load, Kn	Deflection, mm
B.1	0 (Control)	20	1.15
		40	2.35
		60	3.56
		70	4.65
		73.3	5.20

Table 7: Load and corresponding deflection for under reinforced beams for 10% CSA

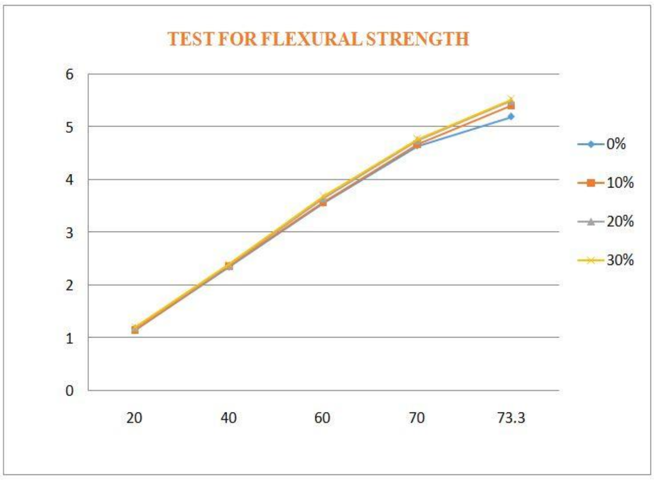
Name of Specimen	Percentage of Coconut Shell Aggregate, %	Load, Kn	Deflection, mm
B.2	10	20	1.16
		40	2.37
		60	3.58
		70	4.68
		73.3	5.41

Table 8: Load and corresponding deflection for under reinforced beams for 20% CSA

Name of Specimen	Percentage of Coconut Shell Aggregate, %	Load, Kn	Deflection, mm
B.2	20	20	1.19
		40	2.38
		60	3.65
		70	4.75
		73.3	5.50

Table 9: Load and corresponding deflection for under reinforced beams for 30% CSA

Name of Specimen	Percentage of Coconut Shell Aggregate, %	Load, Kn	Deflection, mm
B.2	30	20	1.21
		40	2.40
		60	3.69
		70	4.78
		73.3	5.53



Graph 3: Flexural Strength testing of concrete Beam with variable CSA%.

VI. CONCLUSIONS

This study was undertaken to investigate the compressive strength and flexure strength of concrete cube and R/F Beam with substitute of natural coarse aggregate with coconut shell aggregate in concrete mix. Coarse aggregate was fairly replaced by coconut shell aggregate in concrete mix at different percentage i.e. 0%, 10%, 20%, and 30%. On the origin of this experimental work done in the laboratory, following conclusion can be drawn.

OBSERVATION ON FRESH CONCRETE

Visual observations during mixing and compaction of the concretes suggested that the concrete were homogeneous; there was no segregation and bleeding, the mixes were compactable. By replacing the normal aggregate with coconut shell aggregate, the concrete made from it falls under the category of light weight concrete. Addition of coconut shell aggregate in replacement with natural aggregate into the concrete significantly decreases the workability due to its lightweight. Coconut shell concrete has average workability because of the smooth surface on one side of the shell. So we could possibly use coconut shell concrete in concretes where high workability is desirable. The CSA mix concrete has fewer slumps, the slump values of the concretes were between 70-80mm. The slump decreased with increase in CSA percentage.

OBSERVATIONS ON HARDENED CONCRETE

Construction of Sustainable Light-weight concrete is attained by replacement of CSA with natural coarse aggregates. Increase in percentage replacements by coconut shells reduced the strength and density of concrete. The dry density of mix was less than 2000 kg/m3. Minute Compressive Strength and Flexural strength reduction is observed variably depending on the percentage use of Aggregates and Coconut shells. It lacks in strength as compared to conventional concrete but it can be neglected and adopted for the light weight structures. Since minute non-uniform variations are observed in the strength of Coconut Shell Concrete, it can be effectively used for Low Strength Concrete Mixes. Coconut shells can be used as partial replacement of crushed granite or other conventional aggregates in reinforced concrete construction. Up to 20 to 30% of aggregate replaced by

coconut shell is good according to strength and cost wise.
Trying to replace aggregate by coconut shell partially to make concrete structure more economic along with good strength criteria. Overall cost reduction of the construction is observed. From the experimental results and discussions of above researches on coconut shell, the coconut shell has potential as lightweight aggregate in concrete. Also, using the coconut shell as aggregate in concrete can reduce the material cost in construction because of the low cost and its availability is abundance. Coconut Shell Concrete can be used in rural areas and places where coconut is abundant and may also be used where the conventional aggregates are costly.

RECOMMENDATION

The study found that addition of coconut shell as partial aggregate replacement reduces the concrete workability owing to its shape and rougher texture. To increase the speed of construction, enhance green construction environment we can use lightweight concrete. The possibility exists for the partial replacement of coarse aggregate with coconut shell to produce lightweight concrete. Coconut shell exhibits more resistance against crushing, impact and abrasion, compared to crushed granite aggregate. Coconut shell can be grouped under lightweight aggregate. There is no need to treat the coconut shell before use as an aggregate except for water absorption. Coconut shell is compatible with the cement.
The 28-day air-dry densities of coconut shell aggregate concrete are less than 2000 kg/m3. However, it is interesting to note that replacement of natural coarse aggregate by coconut shell resulted in the minute decrease of compressive strength and flexural strength compared to conventional concrete mixture. It can be understood by the results that integration of too much of coconut shell will produces harsher mix which cause difficulties to produce dense concrete. Our study had many limitations, of which the time was a major concern. The durability properties of coconut shell concrete are to be rested before practically applying our project. Durability tests on CSA which may take around a year to complete can be conducted as a future work. The strength properties of CSA depend on the aggregate properties of coconut shells and its individual strength characteristic.

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