Coconut Shell as Course Aggregate in Conventional Concrete

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Abstract— **The rising cost of construction material is a matter of concern. The reason for increase in cost is high demand of concrete and scarcity of raw material. Hence the concrete technologists must search for some economical alternative to the coarse aggregate. Here we make use of coconut shell as a partial substitute to coarse aggregate.**

In this study, M20 grade of concrete was produced by partially replacing Coarse Aggregate by coconut shell. Cubes were cast and their compressive strength and Split tensile strength were evaluated at 7, 28 and 56 days by replacing coarse aggregate by coconut shell at 10%,20%, and 30%. The compressive strength of concrete reduced as the percentage replacement increased. It can be replaced up to 20%. With the increase in the replacement of coconut shell the slump value increases, which lead to increase in workability. Its utilization is cost effective and eco-friendly.

Index Terms—**Demand, economical alternative, coconut shell, compressive strength, replacement, eco-friendly**

I. INTRODUCTION

Concrete is world's most widely used construction material. The utilization of concrete is increasing at a higher rate due to development in infrastructure and construction activities all around the world.

However, there are some negative impacts of more production of concrete like continuous extensive extraction of aggregate from natural resources will lead to its depletion and ecological imbalance. Researchers are in search of replacing coarse aggregate to make concrete less expensive and to lead sustainable development.

The use of aggregates for construction is one of the most important parts of construction for it well added strength to the concrete. Finding a substitute for the aggregates used today is a task that is worth studying because the quarrying of aggregates from rivers and mountains harms the environment. If a substitute for aggregate can be obtained naturally and the source is abundant and can be regenerated, obtaining the aggregate would deplete its source. The use of coconut by products has been a long time source of income for some people in the country. 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 cubes, beams and cylinders. Coconut is famous as multi-function plant that all parts of its plant can be used for various activities.

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The use of this agricultural waste due to an assumption is that it can replace the existing material used in commercial product in order to reduce cost or improve mechanical properties of the composite material. Industrialists in most of the coconut producing countries hail the economic, environmental and technological benefits of utilizing coconut farm wastes. On the farmers' side, agricultural residues can be a source of extra income. Studies have shown that burning of agricultural wastes causes air pollution, soil erosion and even a decrease in soil biological activity that can eventually lead to decreased soil fertility. Using agricultural and forest residues for industrial purposes is a much more environment safe and friendly more than any other method of wastes disposal being commonly adopted nowadays. Considered the most useful tree in the world, the coconut palm provides food, drink, clothing, shelter and financial security. Hardly an inch of the coconut palm goes to waste in countries such as the Philip-pines where families rely on the coconut palm for survival and refer to it as the "tree of life".

Building materials from agricultural and forest wastes are ideal for socialized or low-cost housing since these are generally cheaper than conventional materials. The availability of suitable materials is intimately linked to the development of a new product, such as producing a concrete cubes using coconut shells. Generating this product using agricultural waste will introduce alternative construction materials with a low production cost and lessen the social and environmental problems. Modern construction technologies being developed, respond to ecological and social issues of excessive use of raw materials from nature.

Fig. 1: Coconut Shell

The main objective of this study gave partial replacement for the aggregates and determined the ability and benefits to the concrete cubes when substitutes. The Coconut shells are not commonly used in construction industry and are often dumped as agricultural waste. The aim of this research is to spread awareness of using coconut shell as partial replacement of coarse aggregate in concrete and determining its compressive strength, split tensile strength and density. Until now, industrial by-products and domestic wastes has been utilized in concrete, but the use of agricultural waste in

concrete is in its infancy stage. Coconut shell is an agricultural waste. The materials are proportioned by their weights. Tests conducted as per the specified procedure of Indian Standard Codes.

II. LITERATURE REVIEW

Yashida Nadir, A. Sujatha (2018) have done experimental investigation to study the durability properties of Coconut Shell (CS) aggregate concrete. Effect of mineral admixtures such as fly ash and ground granulated blast furnace slag (GGBFS) as partial replacement of cement on durability properties of CS aggregate concrete was also verified. Specimens were cast and tested for durability characteristics such as water absorption, volume of pore voids, sorptivity, bulk diffusion, rapid chloride penetration, abrasion resistance and chemical attack tests. Four concrete mixes were considered for the study. Control mix, mix with18.5% coarse aggregate replaced by CS by weight, mix with 18.5% CS and 30% cement replaced by fly ash, and mix with 18.5% CS and 15% cement replaced by GGBFS. Test results showed that durability properties of all the mixes were comparable to normal concrete and some durability properties were enhanced by the addition of mineral admixtures.

B. Sandeep Reddy et al. (2017) carried out experimental investigation, using the coconut shell as a light weight aggregate in concrete, the properties of coconut shell concrete examined, Control concrete with normal aggregate and CS concrete with 10 -30% coarse aggregate replacement with CS were made, and Constant water to cementitious ratio of 0.5 was maintained for all the concretes. Properties like compressive strength, consistency, workability were investigated in the laboratory. The results showed that, density of the concretes decreases with increase in CS percent. Workability decreased with increase in CS replacement. Compressive strengths of CS concretes were lower than control concrete. The paper aims at analyzing flexural and compressive strength characteristics of with partial replacement using M20 grade concrete. The project also aims to show that Coconut shell aggregate is a potential construction material and simultaneously reduces the disposing the wastes. Cubes are casted, tested and their physical and mechanical properties are determined. The main objective is to encourage the use of these „seemingly" waste products as construction materials in low-cost constructions.

Parag S. Kambli & Sandhya R. Mathapati. (2014) prepared three different Mix Designs for M20, M35, M50 grades of concrete. Percentage replacement by coconut shell varied as 0%, 10%, 20%, 30%, 40% respectively. It is concluded in this study that for M20 grade concrete cubes with 30% replacement of CS aggregates had given strength of 23 MPa at 28 days. Concrete cubes with 30% replacement of CS aggregates had given strength of 42 MPa at 28 days for M35. For M50 grade concrete cubes with 30% replacement of CS aggregates had given strength of 51 MPa at 28 days.

Dewanshu Ahlawat et al. (2014) investigated the Coconut shell as partial replacement of coarse aggregate in concrete. The aim of this research is to spread awareness of using coconut shell partial replacement of coarse aggregate in concrete and determining its compressive strength and density. The conclusions for the research are the compressive strength of the concrete decreased as the percentage shell substitution increased. Also increased in percentage replacement by coconut shell increase workability of concrete. Coconut shell can be used as partial replacement of coarse aggregate in R.C.C. concrete.

B. Damodhara Reddy ET al. (2014) investigated the use of coconut shell as coarse aggregate. In this study, coconut shell is used as light weight aggregate in concrete. The project paper aims at analyzing flexural and compressive strength characteristics of with partial replacement using M30 grade concrete. The project also aims to show that coconut shell aggregate is a potential construction material and simultaneously reduces the environment problem of solid. The conclusions for the result are, CSC where 25% of the coarse aggregate is replaced, shows properties similar to the nominal mix and 50% replaced CSC shows properties similar to light weight concrete which can be used as filler materials in framed structures, flooring tiles, thermal insulating concrete etc.

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

Amarnath Yerramala et al. (2012) from structures and materials laboratory of Civil Engineeringr, Intell Engineering College, Anantpur, India were Properties of concrete with coconut shell (CS) as aggregate replacement were studied. Control concrete with normal aggregate and CS concrete with 10-20% coarse aggregate replacement with CS were made. Two mixes with CS and fly ash were also made to investigate fly ash effect on CS replaced concrete. Constant water to cementitious ratio of 0.6 was maintained for all the concrete. In this research properties like compressive strength, split tensile strength, water absorption and moisture migration were investigated in the laboratory. The aim of this work is to provide more data on the strengths of coconut shell concrete at different coconut shells replacement and study the transport properties of concrete with CS as coarse aggregate replacement. The result showed that, addition of CS decreases workability and addition of fly ash either as cement replacement or aggregate replacement increases workability of CS concrete and also compressive strength and split tensile tensile strength also decreased with increase in CS replacement. Furthermore, for 28 days of curing addition of fly ash as cement replacement reduced overall split tensile strength of CS concrete and fly ash addition as aggregate replacement showed no major difference with corresponding CS replaced concrete.

III. OBJECTIVE OF THE WORK

The concrete as time goes on through a process of hydration of the cement paste, producing a required strength to withstand the load. The use of coconut shell as coarse aggregate in concrete has never been a usual practice among the average citizens, particularly in areas where light weight

concrete is required for non-load bearing walls, non-structural floors, and strip footings. Although coarse aggregate usually take about 30% of the overall self weight of concrete. 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 material is now a global concern. For this, the extensive research and development works towards exploring new ingredients are required for producing sustainable and environment friendly construction material. Coconut shell represents more than 60% of the domestic waste volume. Coconut shell, which presents serious disposal problems for local environment .this will have the double advantage of reduction in the cost of construction material and also as a means of disposal of wastes.

Main objective of the present research is to find out the effect of replacement of coarse aggregate by coconut shell on the properties of concrete. For this purpose coarse aggregate is replaced by coconut shell in different percentages such as 0%, 10%, 20%, 30%. In each replacement coarse aggregates are replaced in equal proportion of increments by coconut shell. Strength characteristics such as compressive strength, tensile strength and flexural strength are found when coarse aggregate is replaced by coconut shell in conventional concrete. Also workability and water absorption characteristics are studied for different replacements.

IV. MATERIALS AND METHODOLOGY

A. Materials

i. Cement

In this experimental work, Ordinary Portland Cement (OPC) 53 grade conforming to IS: 8112 - 1989 was used. The cement used was UltraTech cement from the local distributors. The most important use of cement is the production of mortar and concrete- the bonding of natural use of aggregates to from a strong building material which is the face of normal environmental effects. The specific gravity of the cement was 3.15.

ii. Fine aggregates

Locally available river bed sand belonging to zone II of IS: 383-1970 was used for the project work.

iii. Coarse aggregates

Locally available crushed aggregates confirming to IS 383-1970 are used in this experimentation.

iv. Coconut shell

Coconut shells which were already broken into two pieces were collected from hostels, hotels; air dried for five days approximately at the temperature of 25 to 100C; removed fibre and husk on dried shells; further broken the shells into small chips manually using hammer and sieved through 20mm sieve. The material passed through 20mm sieve and retained in 4.75mm sieve was used to replace coarse aggregate with Coconut Shell. The material retained on 20mm sieve was discarded.

v. Water

This is the least expensive but most important ingredient of concrete. Water, which is used for making concrete, should be clean and free from harmful impurities such as oil, alkali, acid, etc. In general, water which is fit for drinking should be used for making concrete and shall conform to the requirements of IS: 456-1978.

vi. Mix proportion for M20 Grade concrete

Grade of concrete	Cement	Fine aggregate	Coarse aggregate	W/C
M20	1	1.23	1.88	0.45

B. Methodology

The aim is to determine the characteristics of constituent materials and strength of concrete produced by replacing coarse aggregate by coconut shell. Several experimental works are carried out. Thus the work study is laboratory oriented.

1. The materials such as cement, coconut shell, fine aggregate, coarse aggregate, M20 grade concrete and required slump are chosen.
2. The materials have been collected from a specific location and properties have been studied.
3. Using these properties, mix design is carried out with suitable w/c ratio for M20 grade of concrete.
4. Required slump is obtained experimentally by slump cone test.
5. Concrete cubes, using coconut shells as a partially replacement of coarse aggregate will be cast to study the compressive strength of concrete. Then the cubes will be tested in compression testing machine.
6. The compressive strength of the concrete will be determined by using 150 mm concrete cube specimens. The specimens will be tested at 7, 28 and 56 days age, in 200 tons capacity hydraulic type compression-testing machine. The cube compressive strength will be obtained by considering the average of three specimens at each age.
7. Using 150mm by 300mm Cylinders, using coconut shells as a partially replacement of coarse aggregate will be cast to study the split tensile strength of concrete. The specimens will be tested 7, 28 and 56 days age, in 200 tons capacity hydraulic type compression-testing machine. The tensile strength will be obtained by considering the average of three specimens at each age.
8. Beam members (100mmX100mmX500mm), using coconut shells as a partially replacement of coarse aggregate will be cast to study the flexural strength of concrete. The specimens will be tested 7, 28 and 56 days age, in 200 tons capacity hydraulic type flexure-testing machine.
9. Then the beams will be tested in single point loading, and deflections under the load points will be recorded. The flexure strength will be obtained by considering the average of three specimens at each age.
10. The test specimens are stored in place free from vibration, in moist air of at least 90% relative humidity and at a temperature of 27^{o}+2^{o}C for 24 hours from the time of addition of water to the dry ingredients. After this period, the specimens are marked and removed from the moulds and immediately submerged in clean fresh water and kept there until taken out just prior to test. The water in which the specimens are submerged, are renewed every seven days and maintained at a temperature of 27^{o}+2^{o}C. The specimens are

not allowed to become dry at any time until they have been tested.

11. Using 150mm concrete cube specimen, durability property-water absorption will be determined after 28days age.

12. The density of concrete coarse aggregate replaced with coconut shell will be observed and compared.

13. All test results are tabulated systematically.

14. Conclusions are drawn based on test results.

V. EXPERIMENTAL TEST RESULTS

Experimental program is carried out as per the methodology. The specimens casted were designated as follows to get the results of various combinations.

Table 1: Designation of the specimens casted

Name	Replacement of Coconut shell
M0	0% Conventional Concrete
M1	10%
M2	20%
M3	30%

Table 2: Workability of concrete

Name	Slump(mm)
M0	83
M1	79
M2	82
M3	85

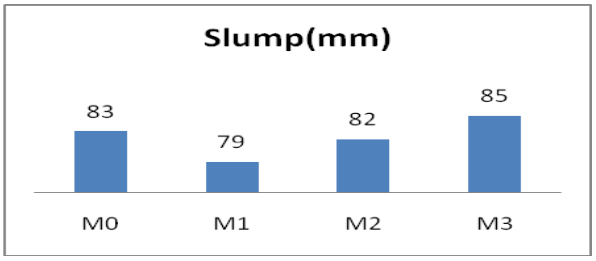

Fig. 2: Slump values for samples

Table 3: Water absorption

Name	Percentage water absorbed
M0	0.87
M1	0.90
M2	0.94
M3	0.97

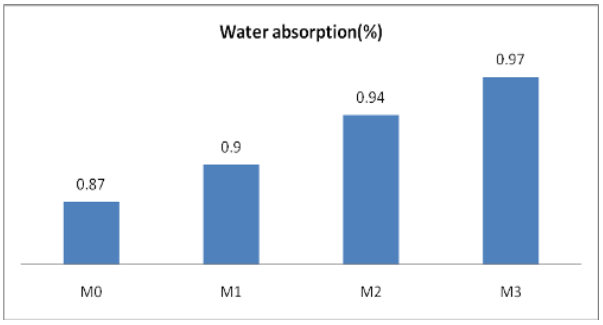

Fig. 3: Water absorption

Table 4: Compression test results

Name	Age of concrete	Compressive strength (N/mm^2)
M0	7 days	15.00
	28 days	18.25
	56 days	26.60
M1	7 days	11.10
	28 days	14.81
	56 days	18.22
M2	7 days	12.15
	28 days	13.77
	56 days	17.03
M3	7 days	11.58
	28 days	12.50
	56 days	15.55

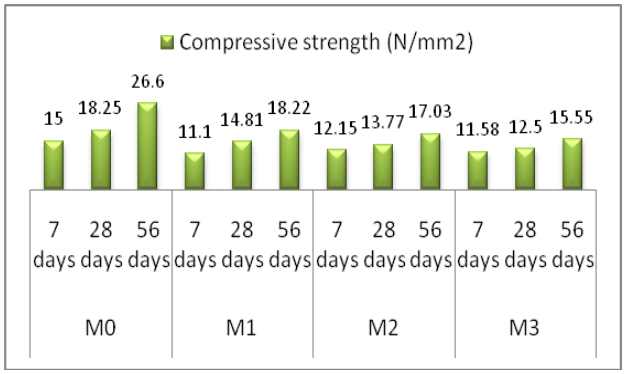

Fig. 4: Compressive strength

Table 5: Split tensile test results

Name	Age of concrete	Split tensile strength (N/mm^2)
M0	7 days	1.56
	28 days	2.26
	56 days	2.78
M1	7 days	1.49
	28 days	2.21
	56 days	2.71
M2	7 days	1.50
	28 days	2.25
	56 days	2.73
M3	7 days	1.42
	28 days	2.12
	56 days	2.57

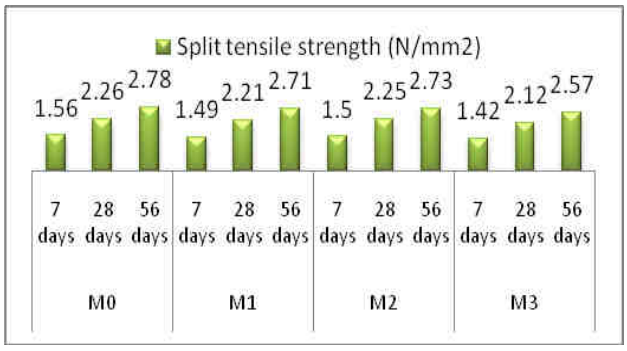

Fig. 5: Split tensile strength

Table 6: Flexure test results

Name	Age of concrete	Flexural strength (N/mm^2)
M0	7 days	3.64
	28 days	4.35
	56 days	4.57
M1	7 days	3.61
	28 days	4.40
	56 days	4.72
M2	7 days	3.45
	28 days	4.30
	56 days	4.53
M3	7 days	2.11
	28 days	2.50
	56 days	2.69

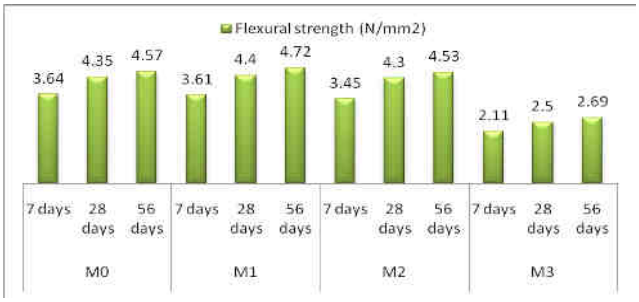

Fig. 6: Flexural strength

CONCLUSION

From the experimental results and discussion it can be concluded that Coconut shell can be replaced up to 10- 12.5% as a coarse aggregate. It is observed that Increase in percentage replacement by coconut shell reduces compressive strength of concrete. Similar to compressive strength, the split tensile strength also decreased with increase in Coconut Shell replacement. Increase in percentage replacement by coconut shell increases workability of concrete. Use of coconut shells in cement concrete can help in waste reduction and pollution reduction. The aim of this experimental study is to encourage the use of the waste product as a construction material in low-cost housing. 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 abundant agricultural waste. 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. Coconut shell concrete is also classified as structural lightweight concrete. It is concluded that the Coconut Shells are more suitable as low strength-giving light weight aggregate when used to replace common coarse aggregate in concrete production.

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