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Utilization of Coconut Shell as Greener Concrete

Saraswati Prajapati[1], Kirti Sahu Tirpude[2]
[1]*M.Tech in Structural Engineering,* [2]*Assit. Professor Department of Civil Engineering, Kalinga University Raipur (C.G.), India*

Abstract: ***Every year, the world produces millions of tons of waste. Nowadays the production of waste material is increasing day by day. Disposal of these waste materials is very difficult. Recycling garbage also requires energy and emits pollutions. Thus need to find some alternative coarse material that can be used as replacement of coarse aggregate. In this study coconut shell is using in place of coarse aggregate. It is easily available in nature in low cost. It is a agricultural waste which pollute the environment. Coconut shell has their own potential to use as a construction material in construction industry. A large amount of coconut shell is generated in India from temples and industries of coconut product. It's non degradable material. It takes 100-200years to dispose in nature. In this study coconut shell is taken as a greener concrete. Greener concrete can be defined as concrete which is made up of waste of material. Coconut shell is easily available in nature. It's eco friendly and cost effective material. According to laboratory test result carried out using coconut shell as a replacement of coarse aggregate used in concrete. In this particular study M20 grade of concrete was prepared by using coconut shell as coarse aggregate. In this study for experimental work coarse aggregate is replaced by 5%, 10%, 15%, 20%, 25%, 30% and 35% of coconut shell.***
Keywords: Coconut shell, Greener concrete.

I. INTRODUCTION

In this modern era, infrastructural development activities around the globe are increasing at a faster rate. The concrete forest is spreading almost to the each corner of the world. Aggregate is one of the basic infrastructural materials used worldwide on large scale. Huge part of this aggregate is extracted from the natural stones. Such huge scale extraction of natural stone from the mountains or natural resources will result adverse changes in ecological system and nature's functions. Here's the need arises of a sustainable eco-friendly substitute for coarse aggregate. Coconut shell shares the same properties like high strength and modulus as coarse aggregate does. India accounts for 34% of the global coconut production in year 2020-21. Undegradable nature of the coconut shell poses the environmental issues. Using crushed coconut shell as aggregate in concrete can effectively solve our problem to a certain point. This will reduce the excessive weight of the concrete and provides an efficient solution for the disposal of coconut shell. The concrete is obtained by mixing cement, aggregates and water in required proportions with or without a suitable admixture.

Coconut is grown in over 86 different countries. With an annual production of 13 billion nuts, India is the world's leading producer. India's coconut sector produces around a sixth of the world's total coconut oil and is expected to expand in response to rising worldwide demand. Table 1 lists the top five coconut-producing countries in the world. However, as a solid waste in the form of waste coconut shells, it contributes to the nation's pollution problem. Natural conventional aggregates are rapidly decreasing and becoming rare due to high demand. Coconut shells that have been discarded could be used as a substitute, Apeksha Kanojia, Sarvesh K. Jain (2017).

Availability of coconut shell in the world:-

S.No.	Country	Coconut production (in 2012)	Percent of world total
1.	Indonesia	18,000,000 t	30.0%
2.	Philippines	15,862,386 t	26.4%
3.	India	10,560,000 t	17.0%
4.	Brazil	2,888,532 t	4.8%
5.	Sri Lanka	2,000,000 t	3.3%

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As the construction industry is rapidly growth in the world today, the use of concrete increase because the concrete is the widely used structural material. A higher demand involves the higher needs for course aggregate. The development of construction industry also would be considered as the factors that cause the increase of waste production. Hence, some alternatives must be established because of the economic, environmental and technological benefits. In this study a potential exists for the use of coconut shells as replacement of course aggregate in concrete production because its chemical composition is similar to wood. The use of coconut shells as a replacement for course aggregates should be encouraged as an environmental protection and construction cost reduction.
Properties of coconut shell which may make it suitable coarse aggregate for concrete are:

1) Its high lignin content that makes the composites more weather resistant.
2) Coconut shell is high potential material due to its high strength and modulus properties.
3) Its low cellulose content due to which it absorbs less moisture as compared to other agricultural waste.

A. Objective

If light weight concrete structure can be obtained from coconut shell, which is easily available in nature, it would be a great achievement for the local construction industries. The main purpose of using coconut shell as coarse aggregate is for light weight concrete.

1) To accomplish that the strength properties of concrete in replacement of coarse aggregate.
2) To accomplish that the behavior of compressive and split tensile strength.
3) To produce the light weight concrete for structures.

II. LITERATURE REVIEW

Olanipekun, Olusola and Atia[1] investigated the strength characteristics of concrete in which crushed granular coconut and palm kernel shells were used as the substitutes for conventional coarse aggregate in gradation of 0%, 25%, 50%, 75% and 100%. It was carried out that as the percentage of the shell increased in the mixture the compressive strength of the concrete decreased and the concrete who had coconut shell as aggregate exhibited more strength than the concrete with palm kernel shells in two mix proportion.

Amarnath and Ramachandrudu[2] studied the various effect of fly ash on concrete with coarse aggregate partially replaced with coconut shell aggregate. It was carried out that coarse aggregate which was replaced with equivalent weight of fly ash had no noticeable influence when compared to the properties of corresponding coconut shell replaced concrete.

O.T. Olateju[3] made a study on the periwinkle shells as the substitute for conventional aggregate in construction work. He casted 300 concrete cubes each of size of 150X150X150 with different compositions of crushed granite and periwinkle shells. The composition order he followed was 100:1, 75:25, 50:50, 25:75 and 100:0. He tested and observed the physical and mechanical properties.

Dewanshu Ahlawat et al. (2014)[4] Found out through his investigation that coconut shell can be used as partial replacement of conventional course aggregate. He concluded that as the percentage of shell aggregate was increased the compressive strength of the concrete was decreased.

B. Damodhara Reddy ET al. (2014)[5] was conducting a study on use of coconut shell as a replacement of conventional course aggregate in concrete. He used coconut shell as light weight aggregate in concrete. His work was aimed analyzing and Compressive strength properties of M30 grade concrete. His work was also aimed towards showing the potential of coconut shell as construction material and it can also reduce the undegradable problem of coconut shell.

Amarnath Yerramala et al. (2012)[26] studied the properties of coconut shell as the concrete material control concrete with normal aggregate two mixes made up of concrete share and fly ash

In this study the concrete properties like compressive strength water absorption and modulus property were observed. The main focus of the study was to provide as much data or information that collected properties or strength of coconut shell. The results that carried out of this study were as add coconut shell the workability of concrete decreased and in addition of fly ash in place of cement or aggregate this increased the workability of coconut shell. In addition of coconut shell the compressive strength and split tensile strength also decreased.

Abdulfatah Abubakar and Muhammed Saleh Abubakar[29] Department of Civil Engineering, Kaduna Polytechnic, Kaduna were studied on the exploratory Study of Coconut Shell as Coarse Aggregate in Concrete. They were investigated on the Design grade – M10, M15 & M20.

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Aggregate Crushing Value -
For Coarse Aggregate – 21.84
For CS Aggregate – 4.71
Aggregate Impact Value –
For Coarse Aggregate – 7.25
For CS Aggregate – 4.26
Elongation index –
For gravels – 58.54
For CS Aggregate – 50.56
Flakiness index –
For gravels – 15.69
For CS Aggregate – 97.19

Grade	7 days	14 days	21 days	28 days
M10 M10 CS replace	9.6 6.4	10.4 8.7	12.9 10.7	15 11
M15 M15 CS replace	19.1 8.6	22.5 9.6	26.7 13.6	28 15.1
M20 M20 CS replace	18.5 8.9	23 11.2	24.9 13.1	30 16.5

Olanipekun et al. (2006)[31] were studied the comparative cost analysis and strength characteristics of concrete produced using crushed, granular coconut and Palm kernel shell as substitutes for conventional coarse aggregate. The main purpose of using these waste products as construction materials in low cost building. According to study compressive strength of concrete decreased as we increase the percentage of coconut shell aggregate as substitution. According to study in all cases coconut shell concrete gives higher compressive strength as compare to palm kernel shell concrete in two mix proportion. Palm kernel shell is cheaper than coconut shell. According to studies on durability of both type of shell concrete they concluded that coconut shell would be more suitable than palm kernel shell when used as replacement of coarse aggregate. According to experimental work both shell have similarly equal water absorption capacities.

Yashida Nadir, A. Sujatha (2018)[32] Have done various experiments to check the properties of coconut shell as aggregate. They also added some of the extra admixture such as blast furnace flag and fly ash instead of the cement to test the durability of such concrete. The specimens were casted from the material and various experiments were performed for testing the durability. Many characteristics like water absorption resistance chemical attack test and sorptivity. There were four concrete mixtures first one was control mix, in this 18.5% of the coarse aggregate was replaced by coconut shell by weight.

In second one 18.5 of coconut shell used as aggregate and 30% fly yes was used instead of cement and 15% of the cement was replaced by ground granulated blast furnace slag . Study carried out various results that all mixture work comparable to concrete and the durability properties over scene increasing why adding minerals at mixtures

III. METHODOLOGY

The procedure of methods used for testing concrete, cement, fine aggregate, coarse aggregate and coconut shell are given below:

A. Material and Grade of Mix

1) Selection of type of grade of mix design by an appropriate method, trial mixes, final mix proportions.
2) The amount of concrete required to the whole project.
3) The amount of cement, fine aggregate, coarse aggregate and coconut shell required for the project.
4) Testing of properties of cement, fine aggregate, coarse aggregate and coconut shells.

IV. PRODUCTION OF CONCRETE MIXES

Production of mix (normal concrete of grade M20) in the experiment is carried out by IS method of concrete mix design. Coconut shell concrete is made by replacing some of the concrete with coconut shells in various percentages.

V. TEST ON INGREDIENTS MATERIALS

The ingredients of coconut (cement, fine aggregate, coconut shell) tested before producing concrete. For conducting various tests on the concrete's ingredients and materials, the corresponding Indian standard codes are used.

A. Grade of Concrete

M20 grade of concrete was considered in this experimental work. Nominal concrete is designed as per IS 456:2000 and concrete mix is designed as per IS 10262-1982 [10]. As per IS code 456:2000 M20 grade of concrete is adopted for experimental work. The concrete mix proportion is 1:1.5:3 (cement: fine aggregate: coarse aggregate) by volume and water cement ratio of 0.50.

B. Mixing of Materials

Concrete is mixed with required proportion. In this experiment coconut shell is used in place of coarse aggregate. Proper mixing of materials is necessary to produce the uniform coarse aggregate. The mixing should be homogeneous, uniform in colour and consistency. The replacement percentage of coarse aggregate by coconut shell aggregate are 5%, 10%, 15%, 20%, 25%, 30% and 35% respectively.



Fig 3.1 :-Mixing of materials

C. Casting of Cubes

After mixing of material, concrete mix is fill in the cube mould and cylinder mould the compact the concrete to remove the air voids from concrete mix. Compaction is done by hand or vibrators. Presence of air in the concrete will reduce the strength of concrete cubes and cylinders. Sizes of cubes are (150mm x 150mm x 150mm).



Fig 3.2:-Casting of cubes



Fig 3.3 :-Casting of cylinders

D. Curing of Cubes and Cylinders

After moulding cubes and cylinders are kept in wet for certain time to proper curing of specimen.

Durability of concrete is increase by proper curing. Due to proper curing shrinkage is reduced. Due to high water absorption of coconut shell, they were presoaked in water for for 24 hours.



Fig 4.3 :-Curing of cubes and cylinders

Coconut shells produce light weight concrete structure. Coconut is locally available in Kerala in huge amount. It would be great achievement for the local construction industries. The main purpose of using this solid agricultural waste coconut shell as coarse aggregate for light weight concrete structure.

VI. RESULT AND DISCUSSION

The observed values of compressive strength, split tensile strength and flexural strength of concrete when coconut shell aggregate (CSA) was added to control concrete of grade M20. The cement content was kept at 383kg/$m^{3.}$

A. Test Results For Compressive Strength, Split Tensile Strength And Flexural Strength

Table 4.1:- Results with 5% replacement of coconut shell aggregate

Mechanical Property	7 days	28 days
Compressive strength (N/mm^2)	17.5	22
Split tensile strength (N/mm^2)	1.08	2.32
Flexural strength (N/mm^2)	1.94	2.25

Table 4.1 shows the observed value of compressive strength, split tensile strength, flexural strength with 5% replacement of coarse aggregate as coconut shell aggregate. The cement content was taken 383 kg/m^3.

Table 4.2:- Results with 10% replacement of coconut shell aggregate

Mechanical Property	7 days	28 days
Compressive strength (N/mm^2)	16.5	22
Split tensile strength (N/mm^2)	1.21	2.52
Flexural strength (N/mm^2)	2.02	3.11

Table 4.2 shows the observed value of compressive strength, split tensile strength, flexural strength with 10% replacement of coarse aggregate as coconut shell aggregate. The cement content was taken $386kg/m^3$.

Table 4.3:- Results with 15%, 20%, 25%, 30%, 35% replacement of coconut shell aggregate

Mechanical Property @ 28 days	15%	20%	25%	30%	35%
Compressive strength (N/mm^2)	24.4	20.2	20.6	21.4	21
Split tensile strength (N/mm^2)	2.55	1.92	2.44	2.44	2.42
Flexural strength (N/mm^2)	2.80	2.3	3.1	3.22	3.30

Table 4.3 shows the observed value of compressive strength, split tensile strength, flexural strength with 5%, 10%, 15%, 20%, 25%, 30% AND 35% replacement of coarse aggregate as coconut shell aggregate. The cement content was taken 387, 389, 391, 392, $394kg/m^3$ respectively.

Variation of compressive strength after 28 days with the replacement percentage of coconut shell aggregate was between 5-15%. It shows that the compressive strength value was approximately near to the target mean strength value of M20 grade of concrete. The compressive strength varies from 25 to 21 N/mm^2 for 0% to 35% replacement of coarse aggregate with coconut shell aggregate.

According to experiment observed that the split tensile strength value was near to target mean strength value when percentage replacement of coarse aggregate as coconut shell aggregate is between 5-15%. The split tensile strength varies from 2.80 to 2.42 N/mm^2 for 0% to 35% replacement of coarse aggregate as coconut shell aggregate.

The flexural strength varies from 3.15 to 3.30 N/mm^2 for 0% to 35% replacement of coarse aggregate with coconut shell aggregate. Experiment shows that flexural strength value was near to target mean strength value when the replacement percentage is between 5-15%. According to test after 15% replacement of coarse aggregate by coconut shell aggregate the strength value of concrete is decreased.

V. CONCLUSIONS

After study all the fundamental details of the papers, we can say that the coconut shells are easily available in nature with huge amount. Coconut shell can use as replacement of coarse aggregate in concrete or we can say that coconut shell can use as greener concrete. Coconut shell is non degradable agricultural waste. If waste is used as construction material in the form of coarse aggregate in concrete, it can lead to disposal of a large amount of waste. Coconut shell provides light weight concrete. It is much useful for low cost construction due to the concrete structure is economic and the disposal problem will be solved. The purpose of this study was to demonstrate the benefits of utilizing coconut shell in concrete. If the house is constructed of natural materials, it will give a cooler environment. Because the coconut shell has an air chamber, it can naturally cool and reduce heat. This helps to lower indoor temperatures, which eliminates the need for energy-intensive air conditioners. Its eco friendly product. Recycling and reusing waste effectively thus protecting the environment from possible pollution effect. Coconut shell aggregate have lower density.

VI. FUTURE SCOPE

My study had very time constraints among which time was a major one. Coconut shell was used as the light weight aggregate. Addition of more of the coconut shell in the concrete caused decrement in compressive strength which is not a good characteristics. In this experimental work we have tested M20 and we can test various mix designs. According to the experimental studies that I have performed, the coconut shell can be partially used as a replacement of conventional coarse aggregate. The compressive strength and flexural strength are comparable in some designs and 30% of the results are satisfactory.

If we add some of admixture which form strong bonds between the molecules of the concrete when coconut shell is used as it happens in case of coarse aggregate then you would be able to provide the more compressive strength and rest of the mechanical properties.

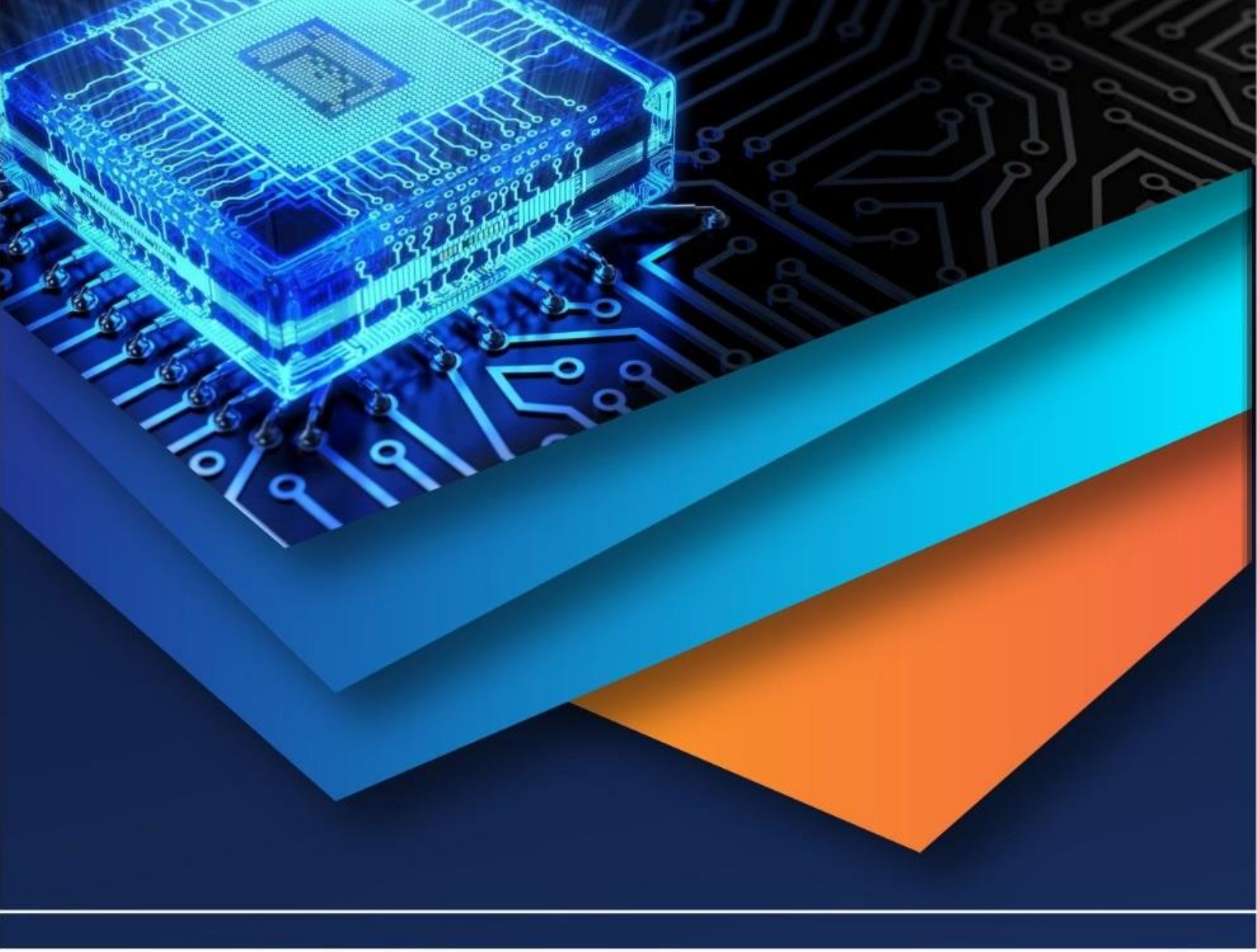
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My study had the purpose of making aware about the coconut shell as partial replacement of conventional coarse aggregate. As we are achieving technological goals day by day. With the help of these technological advancements certainly we will be able to replace the conventional ways concrete making with light weight materials.

1) It will help to keep ecological balance to reduce the depletion of natural resources.
2) Coconut shell is a light weight material so it will help to reduce the weight of structure.
3) It is easily available in nature at low cost. So it will help to provide the low cost structure.
4) In this experiment M20 grade of concrete is taken for test. In further research study we can conduct the test on different proportion of mix design.
5) The same research work can be extended along with the use of the other waste material.

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