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A Study on Production of Green Concrete using Coconut Fibre and Rice Husk Ash

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ABSTRACT

The increasing demand for green concrete has spurred demand for high-quality concrete products, the desire of nations to reduce greenhouse gas emissions, the need for conservation of natural resources, and limited landfill spaces. Green concrete comes in various forms such as high-volume Coconut Fiber concrete, ultra-high-performance concrete, geopolymer concrete, and lightweight concrete to mention a few This study presents a review of the use of CF and RHA as mineral admixtures in the concrete. The results showed substantial enrichment in the mechanical properties specifically the compressive strength of concrete when CF and RHA were added together with cement in amount of 10%, 15%, and 20%. It can be concluded that the optimal percentage of CF and RHA gives better compressive strength than ordinary Portland cement.

INTRODUCTION

Green Concrete

The utilization of green concrete in construction is increasingly adopted by the construction industry owing to the drawbacks of conventional concrete and the numerous inherent benefitsof green concrete. The increasing demand for green concrete has spurred demand for high- quality concrete products, the desire of nations to reduce greenhouse gas emissions, the need for conservation of natural resources, and limited landfill spaces. Green concrete comes in various forms such as high-volume Coconut Fiber concrete, ultra-high-performance concrete, geopolymer concrete, and lightweight concrete to mention a few.

Green concrete offers numerous environmental, technical benefits and economic benefits suchas high strength, increased durability, improved workability, reduced permeability, controlledbleeding, superior resistance to acid attack, and reduction of plastic shrinkage cracking. These characteristics promote faster concrete production, reduction of curing waiting time, reduction of construction costs, early project completion, reduction of maintenance costs, and increased service life of construction projects.

Green concrete promotes the sustainable and innovative use of waste materials and unconventional alternative materials in concrete. Suitable standards, more demonstrationprojects, as well as adequate training, public awareness, cross-disciplinary collaborations, and further research and developments are required to promote the global adoption of green concrete in large-scale infrastructure projects.

To avoid pollution and reuse the e material, thepresent study is carried out. As the properties are as good as the cement, the Class Coconut Fiber and silica fume are used as fine partial replacements in the cement concrete because they possess pozzolanic properties.

Coconut Fiber

Coconut fiber is a natural fiber extracted from the outer husk of coconut and used in products such as floor mats, doormats, brushes, and mattresses. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Other uses of brown coir (madefrom ripe coconut) are in upholstery padding, sacking and horticulture.

Coconut fibers with strength of 21.51 MPa are strongest one among all natural fibers. It is ableto take strains 4 to 6 times higher than other fibers Coconut fibers has examined by many researchers to various purposes. There are significant variations some of characteristics are, forexample the diameter of the coconut fibers is almost identical and the amounts of tensile strength are relatively different, for example the fibroblasts of different individual cells were depends on type of plant, its location and puberty

Coconut fiber contains cellulose, cellulose sugar and lignin as a main composition. These formulations effects dissimilar properties in coconut fibers. Pre-treatment of fibers led to a change in composition and ultimate changes occur due to their properties and also their properties of composite materials. Sometimes it improve behavior of fibers. But, Sometimes it effect was unfavourabe.

Rice Husk Ash

Rice husk ash (RHA) fillers are derived from rice husks, which are usually regarded as agricultural waste and an environmental hazard. Rice husk, when burnt in open air outside therice mill, yields two types of ash that can serve as fillers in plastics materials. The upper layer of the RHA mound is subjected to open burning in air and yields black carbonized ash. The innerlayer of the mound being subjected to a higher temperature profile results in the oxidation of the carbonized ash to yield white ash that consists predominantly of silica. Rice husk ash (RHA) isan abundantly available and renewable agriculture by-product from rice milling in the rice- producing countries. It has the highest proportion of silica content among all plant residues Rice husk ash provides good compressive strength to the concrete. It is a by-product; hence, it helps in cutting down the environmental pollution. The high silica content makes it a good supplementary cementitious material or pozzolanic admixture. The density of concrete containing rice husk ash is similar to the normal weight concrete; hence, it can also be used forthe general-purpose application too. The impervious microstructure of rice husk ash concreteprovides better resistance to the sulphate attack, chloride ingress, carbonation etc. Rice hullconcrete has good shrinkage property and increases the durability of concrete.

Objective of the Study

The objectives of the present study are presented below:

- Utilization of waste materials such as Coconut Fiber and Rice Husk Ashto make greenconcrete.

LITERATURE REVIEW

Sustainable production of concrete using rice husk ash, March 2022: Journal of Critical reviews.

The Compressive strength of the concrete cubes made with partial replacement of Rha is observes

Workability and compressive strength of Mortar with addition of rice husk ash as partial cement replacement in engineered cementitious composite, June 2022: IOP Publishing.

This paper looks at high-volume percentage replacements from 40 to 70%. The environmentalbenefits included a reduction in smog, human health effects, and fossil fuel use as compared tothe same element built with a 100% Portland cement mix. The economic benefits included capital cost reduction and life-cycle cost reduction when compared with a 100% Portland cement mix.

Tensile behavior and hardness of Coconut fiber, October 2019: Global Journal of Science frontier Research.

In this study, composite modeling was developed from paste level to coupon level for 10 concrete mixtures containing Coconut Fiber, and silica fume, individually as well as in combination, at two different w/cm ratios. Then a two-step composite model was used; firstly, to find the shrinkage of mortar from the paste and then the range of the concrete shrinkages was determined using the shrinkage of the mortar. The prediction model agreed well with the experimental data.

The predicted shrinkages were computed and the predicted model was foundto be in close agreement with the experimental results.

Use of Coconut Fiber as an enhancement of concrete, 2019: Journal of Engineering andTechnology.

This paper presents experimental results on the porosity and pore size distribution of Coconut Fiber and silica fume-modified cement pastes and mortars. It was found that the replacement of cement with Coconut Fiber increases the porosity but decreases the average pore size of thepastes at the ages of 28 and 56 days. The additional replacement of cement by up 5% silica fume did not significantly change the pore size distribution and porosity of either the plain cement pastes orthe Coconut Fiber cement pastes. The interfacial porosity was much reduced when Coconut Fiber and silica fume were incorporated.

Use of highly reactive rice husk ash in the production of cement matrix reinforcedwith green concrete fiber, 2019: IPC Journals.

This study emphasized the effect of silica fume on workability level and its maintenance of fresh concrete; strength development, strength optimization, and elastic modulus of hardened concrete; and chemical and mechanical durability of mortar.

The experimental program comprised six levels of silica-fume contents (as partial replacement of cement by weight) at 0% (control mix), 5%, 10%, 15%, 20%, and 25%, with and without super plasticizer. The durabilityof silica-fume mortar was tested in chemical environments of sulfate compounds, ammonium nitrate, calcium chloride, and various kinds of acids. It was found that there was an optimal value of silica-fume content at which concrete strength improved significantly.

The potential of Rice husk ash and Coconut fibre as Partial replacement of cement, 2020:AIP Publishing.

This study examined the use of waste materials such as crushed glass, ground tire rubber, and recycled aggregate in concrete. Compressive strength and elastic modulus were the primary parameters of interest. Results demonstrated that ground tire rubber introduced significant amounts of air into the mix and adversely affected the strength. Overall, while lightweight, low-carbon-footprint concrete materials seem possible from recycled materials, significant further optimization remains possible.

Strength and Durability study of Concrete by using Rice husk ash and Coconut fibre, 2019: International Journal for Research in Applies Science and Engineering Technology.

This paper deals with the possibility of using fresh concrete waste as recycled aggregates in concrete. An experimental program based on two variables (proportion of fine aggregates replacement and proportion of coarse aggregates replacement) was implemented.

Several mechanical properties were tested as compressive and tensile strengths. The results show a good correlation between aggregates replacement percentage and concrete properties. Concerning mechanical properties, a gradual decrease in compressive, splitting, and flexural strength with the increase in recycled aggregate percentage was shown.

A Review on Compressive and Tensile Strength of Concrete Containing Rice Husk Ash and Coir Fibre, 2019: Scholars Journal of Engineering and Technology.

The paper covers the aspect of how to choose a material for green concrete. It presents the feasibility of the usage of by-product materials like Coconut Fiber, query dust, marble powder/granules, plastic waste, and recycled concrete and masonry as aggregates in concrete.

The use of Coconut Fiber in concrete contributes to the reduction of greenhouse emissions with negative impacts on the economy. To avoid pollution and reuse the material, the present study is carriedout. It was observed that over and above all green concrete has greater strength and durability than normal concrete.

METHODOLOGY

Flowchart

A brief summary of the procedure followed during the project is given below:

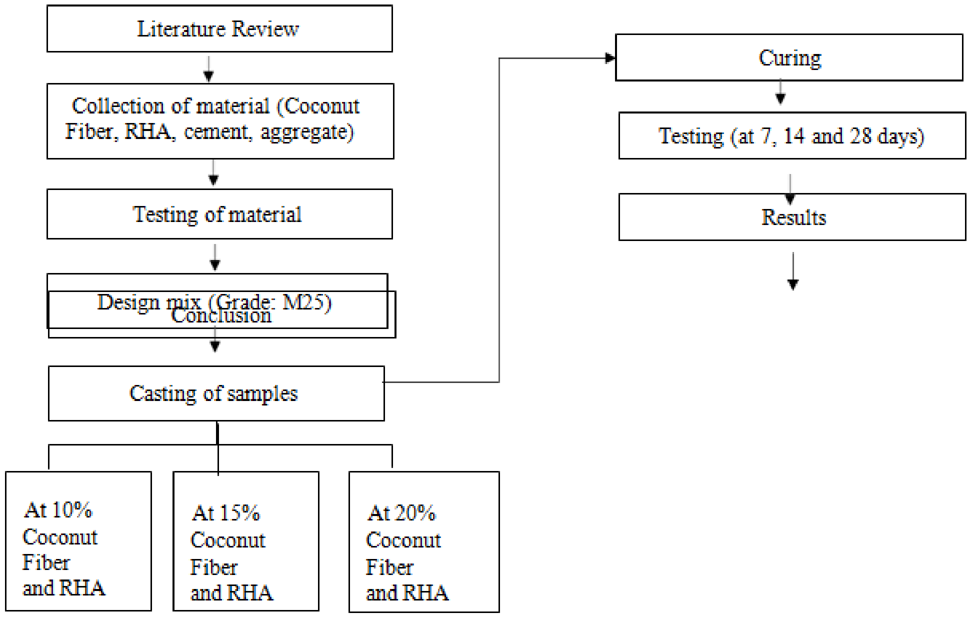

Fig. 1: Procedure followed during the project

PROCEDURE

Testing of Cement

The following tests were conducted for testing OPC 43 cement:

1. Fineness Test i.e., testing of cement by sieving the sample in IS sieve. The weight of cement whose particle size is greater than 90 microns is determined and the percentage of residue retained cement particle on a 90-micron sieve are calculated.
2. Consistency Test i.e., to calculate the percentage of water at which the cement and water mixture acts like a paste. It is calculated using the Vicat apparatus, by measuring the depth of the Vicat plunger penetrated inside the cement water paste. The depth should be between 5mm to 7mm.
3. Initial and final setting time is also calculated using the Vicat apparatus. 85% of the water required for the standard consistency of cement is added. The time when water isadded till the time at which the Vicat plunger fails to penetrate the cement paste by 5mmis calculated i.e., the initial setting time. For the final setting time, the needle is replaced with an angular attachment, and the time at which it fails to make an impression on cement is calculated i.e., the final setting time.

Fig. 2: Vicat Apparatus

Testing of Aggregate

The following tests were done for testing of aggregate:

1. Fineness modulus test i.e., to calculate the mean size of particles in fine aggregate. It is calculated by performing sieve analysis with standard sieves and the cumulative percentages retained on each sieve are added and subtracted by 100 to obtain the valueof fineness modulus.
2. Aggregate Impact Test i.e., compacting of aggregate using impact testing machine thencrushed using 15 blows of the hammer, the crushed aggregate is passed through a 2.36mm, the ratio of the weight passing through a sample and total weight of the sampletaken gives the impact value of aggregate.
3. Crushing value test i.e., used to calculate the percentage by weight of the crushed material obtained when aggregate is subjected to a specified load under standardized conditions. The test is conducted using a compression testing machine.

Fig. 3: Sieving of aggregate

Fig 3 shows the sieving of aggregate done using standard size sieves.

Casting of Concrete

The following steps were followed for the casting of concrete.

1. Made a design mix of concrete for M25 grade, replacing cement with green materials, that are coconut fiber and rice husk ash. The mixing of concrete was done by a concrete mixer.
2. After the concrete was made as per the design mix, it was poured into cubes/moulds of150x150mm each in three layers.
3. Compacted each layer with 35 strokes with the tamping rod.
4. Finished the top layer by trowel after compaction of the last layer and left it to dry.
5. After 24 hours, removed the specimen from the mould and submerged that specimenin a curing tank.

Fig. 4: Mixing and Casting of samples

Fig 4 shows the casting of concrete in cube moulds of dimensions 150x150mm each.

Curing of Concrete

Concrete curing is the process of maintaining adequate moisture in concrete within a proper temperature range in order to aid cement hydration at early ages. Hydration is the chemical reaction between cement and water that results in the formation of various chemicals contributing to setting and hardening.

Curing has been done of the concrete blocks by keeping them in a curing tank for a period of 7, 14, and 28 days.

Fig. 5: Curing of Concrete

Fig. 5 shows the curing of the concrete blocks in the curing tank.

RESULTS

Testing of Cement

Sieve Test
Weight of cement taken (W1) = 200g
Weight of cement retained on 90-micron sieve (W2) = 9gFineness of cement = W2/W1 x 100
= 9/200 x 100 = 4.5 %

Consistency Test
Weight of cement taken = 400g
Depth of penetration of needle in vicat apparatus = 7mm
% of water at 5mm - 7mm depth = 35%Standard consistency of cement = 35%

TESTING OF AGGREGATE

Impact Value Test

Weight of aggregate sample filling the measuring cylinder (W1) = 500g
Weight of aggregate sample passing through 2.36mm sieve after the test (W2) = 74gImpact value = W2/W1 x 100
= 74/500 x 100 = 14.8%

Crushing Value Test

Weight of aggregate sample filling the measuring cylinder (W1) = 3.53kg
Weight of aggregate sample passing through 2.36mm sieve after the test (W2) = 0.755kgCrushing value = W2/W1 x 100
= 0.755/3.53 x 100 = 21.2 %

The following results were obtained from testing ordinary Portland cement of 43 grade.

Table 1: Fineness and consistency test

Serial No.	Test type	Weight taken	Result
1.	Sieve Test	200g	9/200 *100= 4.5%
2.	Consistency test	400g	7mm reading at 35% wt. of water

Table 1 shows the results obtained for the sieve test and consistency test, the results obtainedfor the initial and final setting time are as follows:

Initial Setting Time =52minFinal setting time = 598min

The specific gravity of cement = 2.93

Testing of Aggregate

The results obtained for aggregate tests are as follows

Table 2: Impact value, crushing value and fineness modulus of aggregate

Serial No.	Type of test	Result
1	Aggregate Impact Test	14.8%
2	Crushing value Test	21.2%
3	Fineness modulus Test	2.81

Table 2 above table shows the results obtained for impact test, crushing value test andfineness modulus test.

The following results were obtained in the sieve analysis of aggregate.

Table 3: Sieve Analysis of aggregate

Sieve size	Weight Retained (gm)	Cumulative Wt. Retained	Cumulative % wt. retained
80	0	0	0
63	0	0	0
40	0	0	0
20	0	0	0
12.5	240	240	4.8
10	900	1140	22.8
6.3	2390	3530	70.6
4.75	610	4140	82.8
Pan	860	5000	100
Total	**5000g**		**281**

Table 3 was used to calculate the fineness modulus of aggregate by adding the cumulativepercentages of weight retained on different sieves.

Fineness modulus of aggregate = 281/100 = 2.81The specific gravity of fine aggregate = 2.65 The specific gravity of coarse aggregate = 2.78

Testing of Concrete

The concrete cubes were tested at 7, 14, and 28 days, and compressive strength for four differentsamples was obtained.

Table 4: Compressive strength of concrete

Sample	% of Green Material(RHA andCF)	7 Day Compression value (N/mm^2)	14 Day Compression value (N/mm^2)	28 Day Compression value (N/mm^2)
1	0%	18.5	20.5	23.5
2	10% (5+5)	20.5	20.9	24
3	15% (7.5+7.5)	22.22	23.5	25.2
4	20% (10+10)	21.2	21.9	24.5

Table 4 shows the values obtained for different concrete samples, the testing of concrete blocks was done using a compression testing machine. For each cube load at failure was notedand divided by the area of the concrete.

Comparison

The comparison of results was done between four different samples.

CONCLUSION

1. Concrete cubes with 15% (7.5+7.5) of coconut fibre and rice husk ash each gave the maximum compressive strength at 7 -day testing, the compressive strength was 18% morecompared to conventional concrete.
2. At 14-day testing, the concrete cubes of 15% (7.5 + 7.5) of coconut fibre and RHA each gave the maximum compressive strength, 15% more than conventional concrete.
3. At 28-day testing of concrete cubes it was observed that the sample with 15%(7.5 + 7.5) ofcoconut fibre and RHA each gave the maximum compressive strength, 9% more than conventional concrete.
4. The sample at addition of 15% (7.5% coconut fibre and 7.5% rice husk ash) as per the weight of cement was found to be the optimum result for maximum compressive strength for 7,14 and 28 days respectively.
5. The compressive strength was observed to be decreasing at 20%(10+10) for 7,14,28 days after achieving maximum compressive strength at 15%(7.5+7.5).

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