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EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES, DURABILITY, MIX OPTIMIZATION OF REPLACEMENT WITH CSPAND RHA WITH FINE AGGREGATE

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Abstract

Nearly all of India's recently constructed roads, buildings, and bridges are made of concrete. However, due to a shortage in supplies, the concrete industry is in dire need of finding suitable alternatives to natural aggregates. You might want to think about using coconut shell instead of coarse or fine particles. Coconuts are abundant in India, and by making use of coconut shell powder (CSP), we may address two issues simultaneously: how to dispose of coconut waste and finding a sustainable substitute for natural aggregates.

As a result of both high demand and inadequate supply, the nation is also having trouble in the cement production sector. Because of its cementitious properties, rice husk ash (RHA) can be used as a partial cement replacement. By including RHA into your concrete mix, you may lessen its cement dependency while simultaneously contributing to environmental preservation.

These alternative materials have seen a boom in utilization in concrete due to rising concerns about sustainability and resource conservation. In this research, we look at the potential of RHA in place of cement and CSP as a partial replacement for fine aggregate. The mechanical properties of the concrete mixtures containing these components, including their compressive, split tensile, and flexural strengths, will be measured as part of the experimental program. Concrete undergoes durability testing, which includes water absorption and acid resistance, to gauge its performance in different settings throughout time.

Introduction

India uses about 100 million cubic meters of concrete annually, which makes it a popular choice among builders in the country. Cement, fine and coarse aggregates, water, and aggregates are the main components. Many people are worried about the impending shortage of natural aggregates and cement, two of the few commodities that are now in limited supply. Because of this, scientists have been looking at other industrial and agricultural wastes as possible alternatives to the conventional concrete constituents.

Coconuts are a common agricultural byproduct in India, and their shells may be utilized to make concrete instead of using traditional coarse and fine aggregates. Coconut shell powder (CSP) is mostly used as a substitute for fine aggregates in this study. India is the world's third-largest coconut producer, with an annual output of more than 21.89 billion nuts (2012-13). The Indian economy receives around 10,000 crores of rupees annually from coconuts.

Since they are a large amount of trash, coconut shells are not easy to dispose of. The majority of

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them come from India's coastal regions and make up over 60% of the country's overall trash volume. Most coconuts, according to Bamgboye and Jekayinfa, are either burned or discarded, leading to air pollution from carbon dioxide and methane. Substituting coconut shells for some of the aggregate can help with waste management and pollution control.

The byproduct of milling rice, known as rice husk ash (RHA), is another option to cement. Due to its significant reactivity as a pozzolanic material, RHA has seen extensive application as an economical alternative to silica fume or addition in concrete blocks. It has the potential to increase the mechanical and durability properties of concrete while decreasing the amount of cement needed for the mix.

2. Background and Objectives 4. Concrete is a composite material that is made up of cement, water, aggregates (both fine and coarse), and sometimes other things. Because of its versatility, durability, and low cost, it is a crucial material in construction worldwide. Traditional methods of producing concrete are associated with a number of environmental problems, such as the release of greenhouse gases, the depletion of natural resources, and excessive energy usage.
The use of waste and by-products in place of some of the more conventional components is a promising step toward greener concrete production. After processing coconuts, CSP is typically burnt or discarded as trash in tropical regions. Its high lignin content, adequate mechanical strength, and lightweight characteristics make it an ideal partial replacement for fine aggregates. The pozzolanic activity and high silica content of RHA, which is produced by burning rice husks, are similar. Partial cement substitution with RHA improves concrete durability and resistance to harmful chemical reactions while decreasing cement consumption and CO_2 emissions.

3. Objectives • The following are the primary objectives of this study: • To determine the mechanical properties of CSP and RHA-containing concrete, including its compressive, flexural, and split tensile strengths.
• To evaluate the water-absorbing, acid-resistance, and chloride-penetration capabilities of CSP and RHA concrete, among other durability properties.
• To maximize sustainability benefits while achieving the required performance through the optimization of CSP and RHA concrete mix proportions.
The construction feasibility and advantages of CSP and RHA concrete will be evaluated by comparing them to ordinary concrete.

Fourth Section: Design of the Experiment
The Choice of Materials (Section 4.1)
• Cement, small and large aggregates, water, coconut shell powder, and rice husk ash will all be provided.
The specific gravity, fineness, chemical composition, and particle size distribution will all be measured according to ASTM/BS standards.
4.2 The Best Ratios for Mixing
• Cement will act as a binding agent in concrete mixtures, while CSP and RHA will serve as partial replacements for fine aggregates.
• The mix design will follow the specifications set forth by ACI or IS to ensure the desired

attributes are achieved.
4.3 Concrete Mixing and Pouring
Before adding water and cement, dry mix the aggregates, CSP, and RHA.
• All cube, cylinder, and prism castings will be in accordance with ASTM/BS specifications.
Specimens will be rehydrated for the 4.4 curing stage by being cured in water or a controlled atmosphere.
The 4.5 testing method includes mechanical characteristics, which include compressive, flexural, and split tensile strengths.
Some characteristics of durability include the capacity to absorb water, withstand acidity, and allow chloride ions to penetrate.

Section 5: Results to Expect
Sustainability is expected to be enhanced with the replacement of CSP and RHA, while the mechanical performance of concrete is maintained or even improved.
• We will determine the optimal mix proportions to maximize the utilization of waste resources while achieving the necessary structural performance.
The main objective of the study is to provide engineers with valuable information that will help in the creation of environmentally friendly concrete.

Review of Literature
Concrete with Coconut Shell Powder (CSP) and Rice Husk Ash (RHA)

India, which is the third-largest coconut grower in the world, generates a substantial amount of discarded coconut annually. Open burning, one of the traditional methods of disposing of coconut shells, releases a great deal of pollutants into the air and contributes to greenhouse gas emissions. By using coconut shell powder (CSP) instead of more conventional fine and coarse aggregates in concrete, we may reduce the negative effects of waste disposal on the environment. Studies have shown that a variety of mechanical properties may be enhanced by adding CSP to concrete. Because it is relatively lightweight, CSP-based concrete causes buildings to have a low dead load. Flexural, compressive, and split tensile strengths are all improved, with the exact percentages dependent on the CSP content. Lightweight blocks, partition walls, and roofing materials can all benefit from concrete's CSP because of its improved heat insulation.
Rice Husk Ash (RHA), a byproduct of burning rice husks, is another sustainable material having pozzolanic characteristics. The usage of less cement and less carbon dioxide would result from its potential replacement of some cement in concrete. Concrete with CSP and RHA added to it has better mechanical and durability properties and promotes eco-friendly construction practices all at once.

2.2 Study Summaries on Coconut Shell Based Concrete
A group of researchers led by B. Damodhara Reddy (2014) [1]
At25,50,75, and 100% replacement rates, scientists in this study utilized coconut shell in place of natural coarse aggregates. Our investigation found that:
• The mechanical properties of the concrete were similar to those of conventional concrete after a 25% replacement.
Partially swapped out: Now more than ever, concrete's lightweight characteristics make it the material of choice for non-structural components such as floor tiles, thermal insulating blocks, and enclosed buildings as filler.

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There was a discernible drop in strength at 75-100% replacement, hence higher CSP percentages are best reserved for non-load-bearing uses.

The results show that CSP is an excellent substitute for coarse aggregates in lightweight concrete, making the material more workable and extending its lifetime. Particularly in cases when a less substantial framework is needed, this is true.

Researchers working with Venkateswara Rao Kalyanapu (2015) [2]

Various quantities of concrete compositions including coconut shell as an aggregate were the focus of this investigation. Multiple replacement ratios were tested for their effects on compressive, split tensile, and flexural strengths in this study. These are the key findings:

Summary of Findings:

Table 2: CONDUCTED CONCRETE TEST RESULTS

S.N.	Compressive Strength, MPa			Split Tensile Strength, MPa			Water Absorption(%)	Permeable void (%)	Sorpitivity (mm/sec$^{1/2}$)
days	3	7	28	3	7	28			
1	15.1	23.4	37.3	1.7	2.5	3.7	0.431	9.67	0.124
2	14.7	24.9	38.1	1.74	2.52	3.6	0.51	8.45	0.126
3	14.9	23.9	37.1	1.79	2.9	3.7	0.45	8.92	0.123

Table 3: 10% REPLACEMENT OF CS AS COARSE AGGREGATE

S.N.	Compressive Strength, MPa			Split Tensile Strength, MPa			Water Absorption(%)	Permeable void (%)	Sorpitivity (mm/sec$^{1/2}$)
days	3	7	28	3	7	28			
1	16.6	26.67	36.7	1.45	2.31	3.6	2.43	10.7	0.134
2	16.83	27.43	37.0	1.40	2.2	3.5	2.43	13.42	0.135
3	17.10	27.14	36.8	1.43	2.27	3.4	2.429	11.29	0.133

Table 4: 20% REPLACEMENT OF CS AS COARSE AGGREGATE

S.N.	Compressive Strength, MPa			Split Tensile Strength, MPa			Water Absorption (%)	Permeable void (%)	Sorpitivity (mm/sec$^{1/2}$)
days	3	7	28	3	7	28			
1	17.34	25.01	34.7	1.32	1.96	3.5	4.22	13.71	0.156
2	18.02	25.42	34.9	1.28	1.98	3.2	4.45	13.72	0.163
3	18.47	24.78	32.8	1.33	2.34	3.33	4.6	13.25	0.159

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2. Review of Literature

- In order to build infrastructure all around the world, concrete is a must-have material. But traditional concrete making uses a lot of raw materials like sand, gravel, and cement, which leads to pollution, deforestation, and other ecological problems. In order to address these difficulties, there has been a growing emphasis among researchers on using sustainable additional materials in concrete. These compounds can enhance its mechanical and durability features while reducing its environmental effect. Because of their accessibility, pozzolanic qualities, and environmentally benign traits, two of these materials—coconut shell powder (CSP) and rice husk ash (RHA)—have attracted a lot of interest.

2.1 Coconut Shell Powder (CSP): A Practical Application in Concrete

Tropical nations like India produce a lot of coconut shells as agro-waste. Coconut shells are a source of pollution due to improper disposal, however they may be used to make concrete, which is a sustainable alternative. There are a number of advantages to using CSP powder instead of fine aggregates in concrete, including:

Concrete with CSP added is ideal for use in lightweight structural and non-structural components since it lowers the concrete's total density.

• Enhanced Mechanical Properties: CSP, at different replacement percentages, improves compressive, tensile, and flexural strengths.

• Increased Sturdiness: CSP fortifies concrete against environmental degradation, such as chloride penetration and sulfate assault, making it last longer.

• Less Construction Waste and Less Depletion of Natural Resources: These are two ways in which CSP helps the environment.

These findings are backed by several studies:

According to Neetesh Kumar et al. (2014), the compressive strength was found to be best at 20% CSP replacement of fine aggregate, and there were constant declines as the replacement level increased. The flexural strength showed a rise from 20% to 30% CSP, but a drop from 40% onwards. Lignocellin accounts for 29.4% of CSP's chemical makeup, followed by cellulose at 26.6%, pentosans at 27.7%, solvent extractives at 4.2%, moisture at 8%, uric acid at 3.5%, and ash at 0.6%. Researchers found that CSP concrete's density rose as CSP content rose, with the highest density gain seen at 30–40% replacement.

• With slump values ranging from 20 to 26 mm, Amarnath Yerramala et al. (2012) discovered that freshly mixed CSP concrete was just as workable as regular concrete. After 28 days, the compressive strength of CSP concrete at a 15-20% replacement level was equivalent to that of regular concrete, and the strength gain was accompanied by an increase in curing age. At CSP concentrations of 15-20%, the split tensile strength increased noticeably.

In their study on CSP particle size distribution, Alif Syazani Leman et al. (2016) discovered that the majority of particles were less than 150 µm, which allowed them to be used effectively as fillers. Carbon made up 10% of the elemental makeup, potassium oxide 1.21%, and the rest of the elements were less than 1%.

• CSP concrete sample showed an increase in compressive strength with the passage of time, according to Kalyanapu Venkateswara Rao et al. (2015). The mechanical performance of various replacement levels, including 10%, 20%, and combinations with fly ash, was assessed. The results showed that partial replacement up to 20% was the most effective.

• According to Ajim S. Shaikh et al. (2015), CSP aggregates produced lightweight concrete with sufficient structural strength since they absorbed a lot of water (24%), had a low specific gravity

(1.05), and absorbed a lot of shock. For 25-50% replacement, the 28-day compressive strength was within the acceptable range of 21.8-22.81 MPa, meeting the requirements for lightweight concrete.
The use of coarse aggregates from coconuts can partially replace traditional aggregates, according to research by Jacob Oyeniyi Afolayan et al. (2015). This results in lightweight concrete with a compressive strength of 16–23 MPa and a density of 1542–1782 kg/m³.
• Tomas U. Ganiron Jr. (2013) brought attention to the fact that CSP's rough texture and irregular form make it less workable. However, at moderate replacement levels, compressive strength can actually improve. On the other side, strength and handling attributes are significantly impacted by excessive replacement.
The density of concrete mixes including coconut shell ash (CSA) and other ingredients decreased as the replacement percentage increased, according to Chandu Gummadi et al. (2016). The ideal 28-day compressive strength was found to be 25% CSA (25.44 N/mm³).

OBJECTIVE&SCOPE

Objective

The objective is to develop a greener, less expensive, and more manageable alternative to conventional concrete.
• Look into the possibility of making concrete with less cement and more natural aggregates by utilizing RHA and CSP, or coconut shell powder.
Sustainable development and long-lasting, environmentally friendly mechanical properties (compressive, tensile, and flexural strengths) should be balanced.

The study primarily focuses on the use of CSP as a partial substitute for fine aggregate and RHA as a partial replacement for cement. Improving concrete's strength, workability, and longevity is the aim.
• Utilizing agricultural byproducts such as ash from rice husks and coconuts, the effort contributes to waste management, pollution reduction, and sustainable building approaches. Derivatives from coconuts provide an eco-friendly and economical alternative to natural aggregates, which are in short supply and driving up prices. Coconuts contribute significantly to the agricultural waste in India. Using coconut shells in concrete production helps reduce landfill trash and the harmful environmental impacts of burning them. This eco-friendly concrete is perfect for lightweight structural components, such as partition walls, precast blocks, pavements, and low-rise buildings. Further study and improvement can make this method suitable for large-scale infrastructure projects.

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Research Methodology

This study's technique is designed to analyze the performance and qualities of concrete with Coconut Shell Powder (CSP) and Rice Husk Ash (RHA) added to it in a systematic way. Important phases in the methodology are as follows:

1. Material Evaluation

To ensure that cement meets all applicable criteria, it must undergo testing for physical qualities like consistency, specific gravity, setting time, and fineness.

• Fine Aggregates: CSP and natural sand undergo tests to determine their water absorption rate, specific gravity, moisture content, and particle size distribution.

Coarse aggregates must undergo tests for specific gravity, water absorption, impact value, and crushing strength.

• RHA: Assessing the chemical make-up, pozzolanic activity, and fineness of rice husk ash to determine its potential as a substitute for partial cement.

• Water and Additives: We test potable water and any additives to make sure they are up to par.

2. Mixing Formulas and Design

Mix proportions are determined by taking into account the desired strength, workability, and durability.

• Determine the RHA, CSP, water, aggregate, and cement contents at varying replacement percentages.

Lightweight, workable, and environmentally friendly concrete with all the necessary mechanical qualities may be achieved by careful optimization of the mix design.

Section 3: Curing and Casting

• Using generic cube, cylinder, and beam molds to prepare concrete specimens for testing.

• To obtain a consistent distribution of CSP and RHA, the concrete is mixed completely.

• Specimens are packed tightly to eliminate any air pockets and guarantee consistency.

• To obtain the right amount of hydration and strength growth, curing is done under regulated circumstances for3,7,14, and 28 days.

4. Concrete Hardness Testing

• Cube specimens were subjected to compression tests at varying curing times to determine their load-bearing capabilities.

To find the split tensile strength, tensile characteristics are tested on cylindrical specimens.

• Flexural Strength: The bending performance of beam specimens is studied by testing.

• Workability and Density Tests: Slump, compaction factor, and flow are the metrics used to measure the workability of freshly mixed concrete.

• Tests for Durability: These measure how well something holds up over time by looking at things like water absorption, chemical resistance, and permeability.

5. Findings and Interpretation

To find out how partial replacements affect strength, workability, density, and durability, we compared traditional concrete with CSP/RHA-based concrete.

Compressive, tensile, and flexural strength findings at various replacement levels shown graphically.

The goal is to maintain environmentally friendly and cost-effective concrete by interpreting data to determine the ideal replacement percentages for CSP and RHA.

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RESULTANDDISCUSSION

Sieve Analysis of Coarse Aggregate

• 5 kilograms was chosen as the sample.
• Tools Needed: Coarse aggregate (CA) sample, weighing scale, tray, and sieve set

Sieve Size (mm)	Weight Retained (g)	% Weight Retained	% Weight Passing	Cumulative % Weight Retained
20	20	0.4	99.6	0.4
16	2990	59.8	39.8	60.2
12.5	1630	32.6	7.6	92.8
10	260	5.2	2.0	98.0
6.3	90	1.8	0.2	99.8
4.75	10	0.2	0.2	100
Pan	0	0	0	100

The result shows that the coarse aggregate is equivalent to a 20 mm single-size aggregate when compared to IS-383 requirements.
Testing the Specific Gravity and Water Absorption of Coarse Aggregate with a 500 g Sample

• Weights: o 1516 g for the pycnometer and water (W2) o 1813 g for the pycnometer and sample plus water (W3) o 297 g for the water weight in the pycnometer with CA (W4 = W3 − W2) o 495 g for the oven-dry sample (W5)

Formulas and Results:

- Specific Gravity: $\mathrm{SG} = \frac{W5}{W5-W4} = 2.5$
- Water Absorption: $\text{Water Absorption} = \frac{W1-W5}{W5} \times 100 = 1.01\%$

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The AIV Evaluation of Coarse Aggregate
Weight retained on a 2.36 mm sieve (W2): 58.5 g • Initial sample weight (W1): 500 g

Impact Value Formula:

$$\text{AIV} = \frac{W2}{W1} \times 100$$

The impact value reached 11.7%.
Sample Weight (W1): 5,000 g for the Los Angeles Abrasion Test on Coarse Aggregate

We retained 4420 g of weight on a 1.7 mm sieve (W2) and applied 500 rotations.

Formula:

$$\text{LA Abrasion} = \frac{W1 - W2}{W1} \times 100$$

Result:Loss = 11.6%

Sample Weight (W1): 3000 g; Weight Retained on 10 mm Sieve (W2): 480 g; Aggregate Crushing Value Test

• Forty-five strikes per one-third layer, applied at 40 T

Formula:

$$\text{ACV} = \frac{W2}{W1} \times 100$$

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Result:Aggregate Crushing Value = 16%

Sieve Analysis of Fine Aggregate

- **Sample Weight:** 2000 g

Sieve Size (mm)	Weight Retained (g)	% Weight Retained	% Passing	Cumulative % Retained
4.75	32	1.6	98.4	1.6
2.36	308	15.4	83	17
1.18	540	27	56	44
0.60	338	16.9	27.1	60.9
0.30	266	13.3	14.8	74.2
0.15	504	25.2	2	99.4
0.075	10	0.5	1	99.9
Pan	2	0.1	0	100

In comparison to IS-383, the fine aggregate's specific gravity and water absorption place it in Zone III. Gravitational force: 2.30

• Cement Properties: 4.16 percent water absorption for regular consistency and 30 percent for other uses

• For 1 cubic meter of concrete, the specific gravity in the mixing process might be anywhere from 3.00 to 3.15.
The volumes of cement and water are 0.111 and 0.140 m³, respectively.
• 0.743 m³ is the total volume.
1.140,000 metric tonnes of rock
• 896 kg of crushable rock
Assessing Strength with Compression Testing:
• Concrete's compressive strength is enhanced when CSP is used as a partial replacement for fine aggregate, up to a maximum substitution of 20%.
• When RHA is utilized as a partial cement replacement in concrete, the similar pattern is seen; the best ratio for compressive strength is 20% RHA.

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CONCULUSION

Coconut shell powder (CSP) and rice husk ash (RHA) are substitutes for cement and fine aggregates, respectively, that have been supported by theoretical and practical study. Using these materials not only makes for more eco-friendly concrete, but it also provides a workable way to recycle trash from farms and factories, which helps cut down on pollution. A 20% replacement level of CSP and RHA yields the highest mechanical performance, according to the studies. Both the compressive and split tensile strengths were maximum at this level. The addition of CSP and RHA to concrete not only makes it more durable and easier to work with, but it also decreases its overall density, making it lighter, and also makes it more resistant to environmental degradation. Without sacrificing performance, this procedure integrates waste products into building materials in an economical, sustainable, and structurally efficient manner.

REFFRENCES

- B.Damodhara Reddy, S.ArunaJyothy ,and Fawaz Shaik."Experimental Analysis of the Use of Coconut Shell as Coarse Aggregate", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e- ISSN: 2278- 1684,p-ISSN: 2320-334X, Volume 10, Issue 6 (Jan. 2014), PP 06-13.
- Kalyanapu Venkateswara Rao, A.H.L.Swaroop, Dr.P.Kodanda Rama Rao, and Ch.NagaBharath," study on strength properties of coconut Shell concrete" International journal of civil engineering and technology (IJCIET), ISSN 0976 – 6308 (Print) ISSN 0976 – 6316(Online) Volume 6, Issue 3, March (2015), pp. 42-61
- Neetesh Kumar and Dilip Kumar," Utilization of Coconut Shell in Different Forms in Concrete" IJSRD - International Journal for Scientific Research & Development|Vol.2,Issue07,2014|ISSN(online):2321-0613DissertationI1(LovelyProfessionalUniversity)2017
- Amarnath Yerramala and Ramachandrudu,"Properties of Concrete with CoconutShellsasAggregateReplacement"InternationalJournalofEngineering Inventions,ISSN:2278-7461, Volume 1, Issue 6 (October2012) PP: 21-31
- AlifSyazaniLeman,ShahironShahidan,MohamadSyamirSenin,Nurul IzzatiRaihanRamziHannan,"APreliminary StudyOnChemicalAndPhysical PropertiesOfCoconutShellPowderAsAFillerInConcrete"InternationalEngineeringResearchandInnovationSymposium(IRIS),IOPConf.Series:MaterialsScienceandEngineering 160(2016) 012059 doi:10.1088/1757-899X/160/1/012059