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Experimental Investigation of Coconut Shell Replacement to Aggregates in Concrete: A Case Study

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ABSTRACT: Concrete is the most widely used construction material globally, primarily composed of cement, water, fine and coarse aggregates. With increasing demand for natural aggregates and growing environmental concerns, sustainable alternatives are gaining interest. Coconut shells, a waste by-product from the agricultural sector, possess sufficient strength and toughness, making them a viable partial replacement for coarse aggregates in concrete.

Coconut shell can be used as a replacement for coarse aggregate in concrete cubes, promoting sustainability by utilizing agricultural waste. It's lightweight in nature may reduce overall concrete weight and potentially lower costs.

In testing, crushed coconut shells are mixed into concrete at various replacement percentages (e.g., 10%, 20%, 30%). Key evaluations include compressive strength, workability, and durability. Results can demonstrate that coconut shell aggregates maintain adequate performance, making them a viable eco-friendly option in construction.

Ongoing research can help identify optimal mix designs, explore the effects of varying shell sizes, and assess the long-term behavior of coconut shell concrete in diverse environmental conditions.

Incorporating coconut shells as coarse aggregate in concrete cubes presents an innovative approach to sustainable construction. While maintaining structural performance, this method encourages resource efficiency and environmental stewardship, making it a promising avenue for future building practices.

I. INTRODUCTION

The construction industry is increasingly recognizing the importance of sustainable practices in response to environmental concerns and resource depletion. Traditional concrete, a staple material in construction, relies heavily on natural aggregates, which are often extracted through environmentally damaging processes. This has led to a growing interest in finding alternative materials that can reduce the ecological footprint of concrete production.

Coconut shells, a byproduct of the coconut processing industry, offer a unique solution as a potential partial replacement for coarse aggregate in concrete. With millions of tons of coconut shells generated annually, utilizing this agricultural waste not only helps in waste management but also introduces a sustainable component to concrete mixes. Coconut shells are lightweight, have good mechanical properties, and can contribute to enhanced performance in concrete applications.

This study aims to evaluate the performance of coconut shells as coarse aggregate in concrete by examining their effects on various mechanical properties, such as compressive strength, tensile strength, and durability. By conducting thorough experimental analyses, the research seeks to identify optimal replacement percentages of coconut shells and assess their implications for structural performance and sustainability.

Ultimately, this investigation aims to demonstrate that incorporating coconut shells in concrete can lead to innovative and eco-friendly construction solutions, paving the way for more sustainable practices in the industry.





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II. LITERATURE REVIEW

All the research paper gave a brief idea about the Coconut shells represent a viable alternative to traditional coarse aggregates in concrete production, which can be implemented in our project and gives better results.

1.2. Literature Review:

- A. Gowri Nandhan R S¹, Ismayil Hussain², Sreelekshmi U S³, Asish Prasad, May, (2023) (1), "Performance of Coconut Shell as Coarse Aggregate in Concrete.", International Journal of Engineering Research & Technology (IJERT), Vol. 12, Issue 05, Page 707, Published by : http://www.ijert.org ISSN: 2278-0181 This experimental investigation aimed to quantify the effects of replacing partially the conventional coarse aggregate with coconut shells to produce concrete. It was found that with an increasing proportion of coconut shells, there is a decrement in compressive strength.
- B. Dewanshu Ahlawat, L.G.Kalurkar, (2014) (2), , " Coconut Shell as Partial Replacement of Coarse Aggregate in Concrete ", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 61-64 www.iosrjournals.org, 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. In this study, M 20 grade of concrete was produced by replacing granite by coconut shell. Forty five cubes were casted and their compressive strength and workability were evaluated at 7, 14 and 28 days. The compressive strength of concrete reduced as the percentage replacement increased. Concrete produced by 2.5%, 5%, 7.5%, 10% replacement attained 28 days compressive strength of 19.71,19.53,19.08,18.91 respectively. These results showed that Coconut shell concrete can be used in reinforced concrete construction. Its utilization is cost effective and eco friendly.
- C. K. Gunasekaran, G. Pennarasi, S. Soumya, L. Shruti, (2017) (3), "ALL-IN-ONE ABOUT A MOMENTOUS REVIEW STUDY ON COCONUT SHELL AS COARSE AGGREGATE IN CONCRETE.", International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 3, March, pp. 1049–1060 Article ID: IJCIET_08_03_, Many researchers are taking their efforts to replace all the traditional constituents used for the concrete productions such as cement, fine and coarse aggregate and even for eater. Because of these many special concretes are coming out to meet out the special requirements in special situations in the construction industries. Almost one decade back, it was started by many researchers to use coconut shell as coarse aggregate in place of conventional coarse aggregate for the concrete production. They all reported encouraged results on their respective parameters studies. Authors are aimed to group the findings of coconut shell concrete under one place.
- **D.** A.Karthik, S.Akshay kumar, V. Sravya, K.Harish, M. Khalique Baig, (2024) (4)," Behavior Of Coconut Shell As Coarse Aggregate In Concrete.", Journal of Engineering Sciences Vol 15 Issue 05, The usage coconut shell as a coarse aggregate in concrete it comes under light weight concrete explores the influence of different replacements percentages on the structural integrity, load-carrying capacity and durability of the concrete elements. Considering the economic and environmental implications highlighting its potential as an eco-friendly and cost effective. In this evaluation series of concrete cubes are casted with varying percentages of coconut shell as a partial replacement to evaluate the various properties through the experimental investigations including compressive strength test at 28 days. The main objective is to encourage the use of these 'seemingly' waste products as construction materials in low-cost housing. It is expected to serve the purpose of encouraging housing developers in investing these lightweight concrete materials in house construction.
- E. M Agnisha, L. NaveenKumar, K. Navatha, K. Naga Durga Saile, (2016) (5), "Strength Properties of Coconut Shell as Coarse Aggregate In Concrete." International Conference of Computer & Mathematical Sciences IJCMS ISSN 2347 8527 Volume 3, Issue 5 July, Concrete is an artificial material similar in appearance and properties to some natural limestone rock. It is a manmade composite, the major constituent being natural aggregate such as gravel or crushed rock, sand and fine particles of cement powder all mixed with water. 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-





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structural floors, and strip footings. Coconut is grown in more than 93 countries.

- F. Bernardo Lejano, Kenneth Jae Elevado, Maria Angelika Fandi[~] no, Ethan Andrew Ng, Zamantha Ann Nicole Datinguinoo, Selwyn Bert Olive et al (2024) (6), " Experimental investigation of utilizing coconut shell ash and coconut shell granules as aggregates in coconut coir reinforced concrete", Cleaner Engineering and Technology, In the agricultural industry, coconut shells are one of the most generated wastes worldwide. In particular, studies in the Philippines show that the maximum capacity of the organic decomposition processes of agricultural products is exceeded due to the increasing agricultural activities. On the other hand, in the construction industry, cement production accounts for billions of tons of carbon dioxide emissions yearly. To address the said biowaste disposal problem, and environmental implications of the growing construction industry, this study evaluated the potential of utilizing coconut shell ash (CSA) and coconut shell granules (CSG) in concrete production as al ternatives to cement and sand, being the conventional aggregates, respectively. Additionally, coconut coir (CC) was incorporated as fiber reinforcements in concrete. The experiment consisted of 15 mix designs using different proportions of CSA and CSG, ranging from 0% to 20%, and CC fiber reinforcements, ranging from 0% to 2%. The tests conducted on fresh concrete involved measuring its slump and unit weight, while the 28-day cured samples were tested for compressive and tensile strengths. Results showed that high concentrations of CSA, CSG and CC, when combined in the concrete mix, leads to poor workability; on the other hand, the modified mixes generally had lower unit weights than the conventional concrete.
- G. Rudi Dungan, Pingkan Aditiawati Sasa Sofyan Munawar, Eka Mulya Alamsyah , Widya Fatriasari, Trimurti Hesti Wardani, (2024) (7), "Case Studies in Chemical and Environmental Engineering", Case Studies in Chemical and Environmental Engineering, This study examined the physical, mechanical, and electrical conductivity properties of coconut shell-based activated carbon (AC-CS) activated with H 3 PO 4 composite. The AC-CS was incorporated as a filler in epoxy composites at concentrations of 1 %, 2 %, and 5 %. The addition of nanostructured AC-CS notably affected the mechanical and electrical characteristics of the epoxy nanocomposites. Microcracks, matrix cracks, particle- bridging cracks, and steady-state cracks, were observed.
- H. Murthi Palanisamy, Poongodi Kolandasamy, Paul Awoyerab, Ravindran Gobinatha, Sivaraja Muthusamyc , Thirumalai Raja Krishnasamy d, Amelec Viloriae , (2020), "Permeability properties of lightweight self-consolidating concrete made with coconut shell aggregate", General of material resistant technology, 2238-7854/© 2020 https://doi.org/10.1016/j.jmrt.2020.01.092 , The use of lightweight self-consolidating concrete (SCC) incorporating coconut shell as an aggregate alternative has drawn interest for its sustainable and eco-friendly potential in construction. Coconut shells, due to their lightweight and wide availability, offer a practical substitute to conventional coarse aggregates, aiming to reduce concrete's density and environmental impact. However, achieving optimal permeability is crucial for the material's durability.Studies indicate that coconut shell aggregates, with their natural porosity, can increase the permeability of concrete, impacting its resistance to environmental damage and chemical ingress. Research highlights that while coconut shell-based SCC maintains flowability and sufficient compressive strength, its porous structure can lead to higher water absorption, necessitating adjustments in mix design.To mitigate permeability issues, researchers have explored the inclusion of supplementary cementitious materials (SCMs), such as fly ash and silica fume, which densify the concrete matrix and reduce water pathways. Proper grading of coconut shell aggregate, control of the water-cement ratio, and thorough curing are also emphasized as methods to enhance the impermeability of coconut shell SCC.
- I. R. Kumutha, K. Vijail and S. Vijayragavan, (2018), "MECHANICAL PROPERTIES OF CONCRETE USING COCONUT SHELLS AS COARSE AGGREGATES", ARPN Journal of Engineering and Applied Sciences, VOL. 13, NO. 20, OCTOBER 2018, Research on using coconut shells as a replacement for conventional coarse aggregates in concrete highlights its potential to reduce environmental impact, production costs, and dead load in structures. Coconut shells, being a lightweight and readily available agricultural byproduct, are investigated for their influence on the mechanical properties of concrete, including compressive strength, tensile strength, modulus of elasticity, and workability. Studies show that concrete with coconut shell aggregate generally exhibits lower density, which can benefit structures requiring reduced dead load. However, the mechanical properties of this type of concrete can vary depending on the mix design and percentage of coconut shell replacement. Compressive strength typically decreases as the proportion of coconut shell increases due to its lower crushing strength compared to traditional aggregates. Despite this, certain adjustments in the mix, such as adding





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supplementary cementitious materials (e.g., fly ash or silica fume), have been found to improve compressive strength, making coconut shell concrete suitable for non-structural and low-load-bearing applications.

J. ernardo Lejano, Kenneth Jae Elevado *, Maria Angelika Fandino[~], Ethan Andrew Ng, Zamantha Ann Nicole Datinguinoo, Selwyn Bert Oliveros, 21 (2024) 100779, "Experimental investigation of utilizing coconut shell ash and coconut shell granules as aggregates in coconut coir reinforced concrete", Cleaner Engineering and Technology, https://doi.org/. This study investigates the use of coconut shell ash (CSA), coconut shell granules (CSG), and coconut coir fibers in concrete. The goal is to create a more sustainable concrete by substituting traditional aggregates with coconut-based materials, which are abundant agricultural by-products in tropical areas. Coconut shell granules have favorable properties, such as light weight and toughness, making them suitable as aggregate replacements. Additionally, coconut shell ash exhibits pozzolanic properties, allowing it to partially substitute cement. Coconut coir fibers add strength, ductility, and crack resistance to the concrete, enhancing its durability. Together, these materials aim to produce an eco-friendly, cost-effective alternative for traditional concrete.

III. METHODOLOGY

- For study of optium for addition in concrete casting of 24 Cubes are held in carrying different layers
- Size of cube : 150x150x150 mm
- Cement Grade: 43 OPC
- Concrete Grade: M30
- Methodology for Evaluating Coconut Shell as Coarse Aggregate
- Materials Selection
- Preparation of Coconut Shell Aggregate
- Concrete Mix Design
- Testing of Concrete
- Analysis of Results

IV. RESULT AND CONCLUSION

In Conclusion, using coconut shells as a partial substitute for coarse aggregates in concrete presents a sustainable solution for reducing waste and promoting eco-friendly construction practices. Research has shown that replacing up to 10% to 20% of traditional coarse aggregates with coconut shells does not significantly affect the strength of the concrete, making it suitable for certain low-strength or non-structural applications. The coconut shells provide the added benefit of reducing the overall weight of the concrete, which can be useful in specific construction scenarios.

However, when the substitution level surpasses 30%, the strength of the concrete starts to degrade noticeably. This decline occurs because coconut shells are less dense and have weaker bonding properties compared to conventional aggregates like crushed stone or gravel. As a result, the concrete's ability to transfer stress efficiently between particles is compromised, leading to reduced strength and durability.

Based on these findings, the use of coconut shells in concrete should ideally be limited to a 10% to 20% replacement rate to ensure the material meets strength and durability requirements. While further research may help improve the performance of coconut shell-based concrete, current evidence suggests that excessive substitution (above 30%) results in unsatisfactory concrete performance for most structural application.

V. FUTURE SCOPE OF STUDY

The scope of this project focuses on the use of coconut shell as a partial replacement for coarse aggregate in concrete. The study aims to evaluate its feasibility and performance through a systematic approach.





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Material Selection and Preparation:

Coconut Shell Sourcing: Identifying reliable sources for collecting coconut shells from agricultural waste. **Processing of Coconut Shells**: Cleaning, drying, and shredding the shells to achieve the appropriate particle size for use in concrete.

Experimental Design:

Concrete Mix Formulation: Developing a series of concrete mixes with varying percentages of coconut shell as a partial replacement for coarse aggregate (e.g., 0%, 10%, 20%, 30%).

Control Mix Design: Establishing a control mix using 100% conventional coarse aggregate for baseline comparisons. **Testing Procedures**:

Mechanical Property Testing: Measuring compressive strength of concrete samples at various curing periods (e.g., 14, and 28 days).

Data Analysis:

Comparative Analysis: Analyzing the performance of coconut shell concrete in comparison to the control mix, identifying trends in strength, workability, and durability.

Compliance with ethical standards

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