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Experimental Study Of Lightweight Concrete Incorporating Coconut Shells And Glass Pieces

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Abstract:
This study investigates the potential of lightweight concrete formulated with recycled coconut shells (CS) and glass Pieces (GP) as partial substitutes for conventional aggregates. With a focus on sustainability, the study explores the impact of varying proportions of CS and GF on the mechanical properties, durability, and workability of concrete. The study meticulously examines the mechanical and performance characteristics of concrete mixtures where varying proportions of coconut shells and crushed glass serve as substitutes for conventional coarse aggregates. Notably, the composite aggregate mix achieved a maximum impact value of 34.05%, reflecting a remarkable 55.55% enhancement from the baseline value of 21.89%. Furthermore, the abrasion resistance of the mix improved significantly to 42.68%, representing a 42.07% increase over the original value of 30.04%. The crushing value also demonstrated a substantial rise to 41.14%, indicating a 45.57% increase compared to the traditional aggregate value of 28.26%. Compressive strength evaluations at 7 days showed an improvement from 20.72 N/mm² to 22.18 N/mm² with an 18% substitution, although subsequent increases in replacement levels led to a reduction in strength. By 28 days, compressive strength further increased from 30.81 N/mm² to 32.07 N/mm² with a 24% replacement, although further substitutions yielded diminished strength outcomes. The findings substantiate the viability of employing recycled materials, such as coconut shells and glass fragments, to enhance the sustainability and performance of concrete.

Keyword: *Glass pieces, light weight concrete, Coconut Shell, Mechanical Properties.*

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I. Introduction

The use of by-products in the development of lightweight concrete, addressing resource scarcity in traditional concrete production. The incorporation of these by-products reduces concrete's dead load and enhances mechanical strength, although excessive substitution may compromise fresh and hardened properties. An innovative approach is proposed to enhance concrete durability and ductility by incorporating ground blast furnace slag, recycled coarse aggregate, and coconut fiber. Two concrete groups, with 0% and 100% RCA, were tested, with GBFS replacing 25% of cement. CF was used at 0.25% volume fraction for reinforcement. The results showed that the modified recycled aggregate concrete outperformed natural aggregate concrete in strength, with 25% GBFS improving performance. RAC with 0.25% CF and 25% GBFS showed 30.5% higher flexural strength and 33% higher splitting tensile strength than NAC. GBFS reduced corrosion risks and water absorption, while adjusting superplasticizer dosage enhanced RAC's strength and permeability [1]. Recycled aggregates, such as crushed coconut shell aggregate (CCSA) and recycled brick aggregate (RBA), were tested as substitutes for natural aggregates to reduce costs and promote recycling. CCSA improved thermal conductivity and flexural strength, meeting structural lightweight concrete standards. However, high-temperature exposure caused significant strength loss in CCSA-incorporated concrete [2]. Coconut shell ash (CSA), a by-product of coconut processing, was explored as a pozzolanic material to partially replace cement. CSA was incorporated at replacement levels of 0–25%, and concrete's mechanical properties were evaluated. The study demonstrated CSA's potential as a sustainable cement substitute [3]. The use of coconut shells as coarse aggregate in concrete was evaluated, with replacements ranging from 5% to 25%. The addition of coconut shells improved workability and reduced concrete density, but compressive strength decreased by 24% at a 15% replacement level. The optimal replacement for performance and sustainability was 15% [4]. With increasing demand for lightweight concrete, this research emphasizes the need for evaluating agricultural and industrial wastes as alternative materials. The integration of local waste, such as coconut shells and ash, can meet structural and environmental requirements while reducing dependency on conventional aggregates and cement [5]. Research into integrating coconut shell waste in concrete offers both waste management solutions and resource conservation [6]. Additionally, the use of e-waste plastics and glass cullet as aggregates enhances concrete properties while providing a sustainable solution to waste disposal [7-8]. Incorporating recycled materials like tire powder, glass sand, and plastic aggregates improves thermal insulation and durability in non-structural applications. However, further research is needed to assess their long-term performance and environmental impact [9-11]. Excessive use of sustainable raw materials strains natural resources and limits their future availability, with 40% of GDP tied to construction sector materials, which are energy-intensive and release pollutants. Alternative sources, like coconut shells, can replace coarse aggregates in lightweight concrete, offering environmental benefits and waste reduction [12]. Using oil palm shell (OPS) and oil-palm-boiler clinker (OPBC) as aggregates in lightweight concrete demonstrated the potential to produce high-strength, sustainable concrete from industrial waste [13]. The objective of this study is to evaluate the influence of varying ratios of coconut shell and crushed glass substitutions on the mechanical properties and compressive strength of M30 concrete.

II. Experimental Procedure

Concrete specimens in the form of cubes (150 mm x 150 mm x 150 mm) and cylinders (150 mm diameter x 300 mm height) were cast for a series of evaluations. Each mix was replicated three times to ensure statistical robustness. The specimens were cured in water for 28 days to attain sufficient strength prior to testing. The compressive strength of the concrete cubes was measured at both 7 and 28 days using a universal testing machine. The detailed composition of the concrete incorporating the replacement materials is presented in Table 1.

In the MCG series, the concrete mixes are methodically designed to progress from MCG06 to MCG30, corresponding to aggregate replacement levels of 6%, 12%, 18%, 24%, and 30%. This strategic formulation results in aggregate content reductions to 94%, 88%, 82%, 76%, and 70%, respectively. Such controlled variations in the proportions of coconut shells and crushed glass fragments facilitate a systematic investigation into the collective effects of these alternative aggregates on the properties of concrete. This approach not only enhances the understanding of material behavior under varying replacement levels but also generates critical data that supports the advancement of sustainable construction practices. By assessing the interplay between these innovative materials, the study aims to contribute to the development of eco-friendly concrete solutions that meet both performance and environmental sustainability criteria.

Table 1 Mix Formulation of concrete with Coconut Shell and Crushed Glass Pieces

Mix	Cement	Aggregate	Sand	Coconut Shell + Glass Pieces
M30	100%	100%	100%	0%
MCG06	100%	94%	100%	6%
MCG12	100%	88%	100%	12%
MCG18	100%	82%	100%	18%
MCG24	100%	76%	100%	24%
MCG30	100%	70%	100%	30%

III. Result And Discussion

This section show that coconut shell and glass pieces together in mix have distinct impacts on the mechanical and durability properties of concrete.

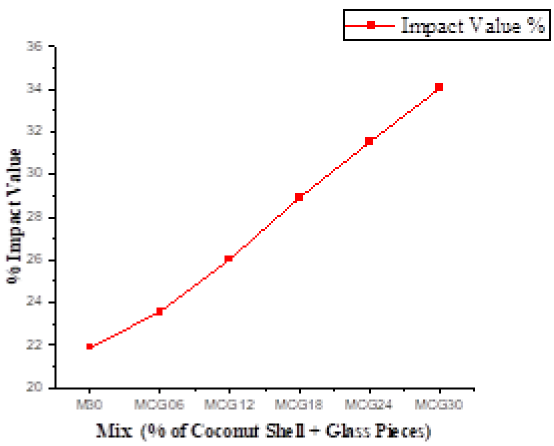

Figure 1 Impact Value Of Coarse Aggregates Mix With Glass Pieces & Coconut Shell

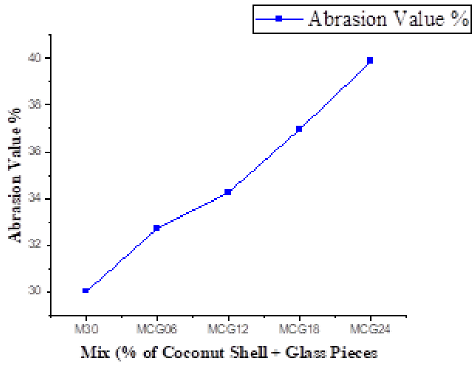

Figure 2 Abrasion Value Of Coarse Aggregates Mix With Glass Pieces & Coconut Shell

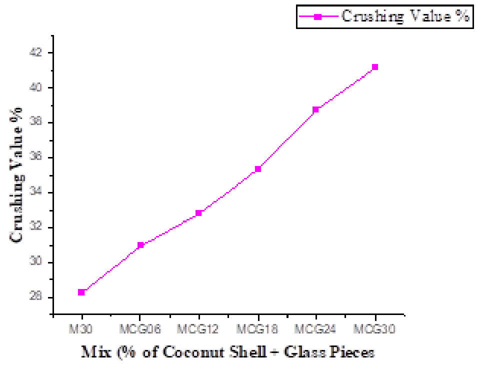

Figure 3 Crushing Value Of Coarse Aggregates Mix With Glass Pieces & Coconut Shell

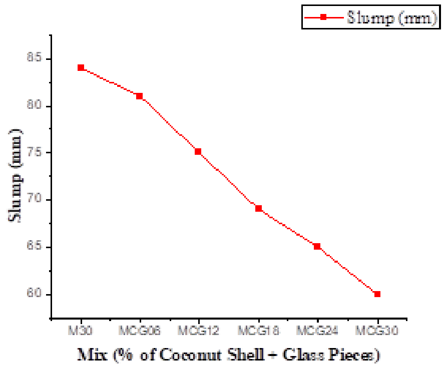

Figure 4 Slump Value Of Concrete Use Coconut Shell & Glass Pieces As Replacement Material

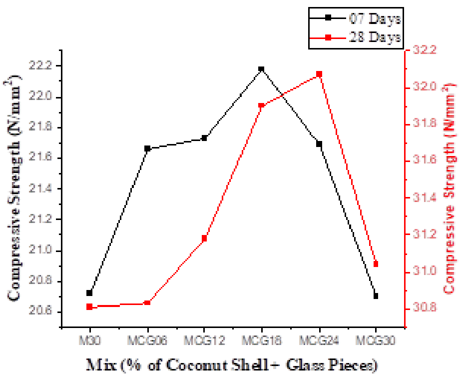

Figure 5 Compressive Strength Of Concrete By Using Coconut Shell & Glass Pieces As Replacement Material (7days And 28days)

IV. Conclusion

This study delves into the synergistic effects of incorporating coconut shell (CS) and crushed glass pieces (GP) into concrete mixtures, with the dual aims of minimizing environmental impact and achieving targeted structural performance standards. A compressive strength goal of 30 N/mm² was established for specimens cured over 28 days. Six innovative concrete mixes were crafted, utilizing CS and GP as substitutes for coarse aggregate at varying ratios of 0%, 6%, 12%, 18%, 24%, and 30%. These mixes were classified as M30, MCG06, MCG12, MCG18, MCG24, and MCG30, respectively.

The following significant outcomes in this study:

- The maximum impact value for coarse aggregates mixed with coconut shells and glass pieces was 34.05%, compared to an impact value of 21.89% for the control mix, resulting in a 55.55% increase.
- The maximum abrasion value for the coarse aggregates mix with coconut shells and glass pieces reached 42.68%, up from 30.04% in the control mix, indicating a 42.07% increase.
- The maximum crushing value for the coarse aggregates with coconut shells and glass pieces was 41.14%, compared to 28.26% for the control mix, demonstrating a 45.57% increase.
- The slump value of the standard concrete sample was 84 mm; this reduced to 60 mm with a 30% replacement of coarse aggregates by coconut shells and glass pieces, reflecting a slump reduction of 28.57%.
- At 7 days, the compressive strength of the standard concrete was 20.72 N/mm², which increased to 22.18 N/mm² with an 18% substitution of coconut shells and glass pieces, indicating a reduction of 7.04% compared to the conventional concrete.
- At 28 days, the compressive strength of the standard concrete was 30.81 N/mm², increasing to 32.07 N/mm² with a 24% replacement of coarse aggregates, reflecting a reduction of 4.09% from the conventional mix.

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