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EXPERIEMENTAL INVESTIGATION ON BAMBOO FIBER CONCRETE WITH GROUNDNUT SHELL ASH AND DOLOMITE

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ABSTRACT

This study explores sustainable concrete by partially replacing fine aggregate with groundnut shell ash. Dolomite powder is used as a partial substitute for cement to reduce carbon emissions. Bamboo fibers are added to enhance the tensile resistance of the concrete matrix. Concrete mixes are prepared with varying proportions of GSA, dolomite, and bamboo fibers. Compressive strength tests are conducted on specimens at 28, 56, and 90 days to assess load-bearing capacity. Split tensile strength is also evaluated at the same intervals to determine cracking resistance. The results show that appropriate replacement levels improve mechanical performance. Strength development at different ages is influenced by material reactivity and fiber dispersion. Significant gains in both compressive and tensile strengths are observed in optimized mixes, especially at 90 days. The findings support the use of agro-waste and natural fibers in eco-efficient concrete production.

***KEYWORDS**: Dolomite,Bamboo fibers,Ground Shell Ash,agro-waste, Compressive strength and Split tensile strength*

1. INTRODUCTION

Concrete is the most widely used construction material worldwide, valued for its versatility, durability, and adaptability. It primarily consists of cement, fine and coarse aggregates, and water. Through the chemical process of hydration, concrete gains strength by forming a solid, rock-like mass. Its ability to be molded into various shapes before hardening makes it suitable for a wide range of applications, including buildings, bridges, roads, and dams. However, conventional concrete production, especially cement manufacturing, contributes significantly to environmental degradation due to high carbon emissions. As a result, modern innovations in concrete technology focus on enhancing sustainability without compromising mechanical performance. The incorporation of alternative materials and admixtures is being explored to improve both environmental impact and structural integrity.

One major concern in concrete production is the over-extraction of natural fine aggregates, which has led to the depletion of riverbeds and ecological imbalance. At the same time, agricultural waste like groundnut shells is frequently discarded or burned, contributing to environmental pollution. Transforming this waste into groundnut shell ash (GSA) offers a sustainable solution by converting agro-waste into a useful construction material. GSA, with its fine particle size and pozzolanic properties, is suitable for partial replacement of sand in concrete. Its use not only conserves natural resources but also helps reduce landfill waste. Research has demonstrated that when used in appropriate proportions, GSA can enhance the compressive and tensile strength of concrete, while also improving bonding within the cementitious matrix. This approach supports eco-friendly construction practices and promotes the reuse of agricultural by-products.

This study also investigates the application of dolomite powder as a partial substitute for cement in concrete. Dolomite, a naturally occurring mineral composed mainly of calcium and magnesium carbonates, exhibits properties beneficial for cementitious applications. By replacing a portion of cement with dolomite, the aim is to reduce the environmental footprint of concrete production while preserving or enhancing mechanical performance. Concrete mixes with varying percentages of dolomite were tested for compressive and split tensile strength. The findings suggest that an optimal level of replacement can improve the strength and durability of concrete. Additionally, the use of dolomite contributes to cost-effectiveness and resource efficiency, supporting the development of more sustainable concrete technologies.

Bamboo fibers are emerging as a promising natural reinforcement in concrete due to their excellent tensile strength and ecological benefits. As a renewable and biodegradable material, bamboo provides an environmentally friendly alternative to synthetic fibers. When incorporated into concrete by weight, bamboo fibers enhance crack resistance, post-cracking behavior, and energy absorption under tensile stress. Their lightweight nature does not significantly affect the density of the concrete mix, and when properly dosed, they disperse evenly to form strong bonds within the cement matrix. The integration of bamboo fibers aligns with sustainable construction practices and the broader goals of green building, offering improved mechanical performance while reducing the environmental impact of conventional materials.

2. OBJECTIVES

1. To assess the impact of partially replacing fine aggregate with groundnut shell ash on the compressive strength and split tensile strength of concrete.
2. To examine the performance of concrete incorporating dolomite powder as a partial replacement for cement, with a focus on strength development and durability.
3. To evaluate the effect of adding bamboo fiber by weight on the mechanical properties and crack resistance of modified concrete mixtures.

3. MATERIALS

3.1 Cement: Cement is a fine, gray powder that serves as a binding agent in concrete and mortar. When mixed with water, it forms a paste that hardens through a chemical process called hydration, giving strength and cohesion to construction materials.

3.2 Fineaggregate: Fine aggregate consists of small-sized particles, such as natural sand or crushed stone. It fills the gaps between coarse aggregates and enhances the workability of the concrete mix. Fine aggregates typically pass through a 4.75 mm sieve.

3.3 Coarse aggregate: Coarse aggregate is made up of larger particles like crushed stone or gravel. It contributes to the overall volume, strength, and stability of concrete. These aggregates are usually retained on a 4.75 mm sieve.

3.4 Water: Water is a crucial ingredient in concrete, as it initiates the hydration reaction with cement, allowing the mix to harden and gain strength. It also acts as a lubricant, improving the mixture's workability for easier placing, compacting, and finishing.

3.5Groundnut shell ash : Groundnut shell ash is produced by burning peanut shells and is used as a pozzolanic material in concrete. When used as a partial replacement for cement, GSA promotes sustainability, lowers environmental impact, and reduces construction costs.

3.6 Dolomite: Dolomite is a naturally occurring sedimentary rock mainly composed of calcium magnesium carbonate. When ground into a fine powder, it is used as a filler or partial cement substitute in concrete, helping improve durability and minimize thermal cracking.

3.7 Bamboo Fiber: Bamboo fiber is a natural reinforcement material derived from bamboo plants. It is incorporated into concrete to enhance tensile strength and control cracking. Lightweight, biodegradable, and sustainable, bamboo fiber is ideal for eco-friendly construction.

4. EXPERIMENTAL RESULTS

4.1 Compressive strength:-Compressive strength measures a material's capacity to withstand crushing or compressive forces. It is typically determined by applying a gradually increasing load to a standard cube specimen using a compression testing machine, with tests commonly conducted at 28,56 and 90 days.

Table 1: Compressive strength results of concrete with different percentages of Groundnut shell ash used as a partial replacement of fine aggregate.

Sl.no	% of Ground Shell Ash	Compressive Strength Results, N/mm^2		
		28 days	56 days	90 days
1	0%	49.59	53.72	57.54
2	5%	51.59	53.80	60.26
3	10%	52.64	57.29	60.45
4	15%	51.66	56.25	60.22

Table 2: Compressive strength results of concrete with different percentages of Dolomite used as a partial replacement of Cement.

Sl.no	% Of Dolomite	Compressive Strength Results, N/mm^2		
		28 days	56 days	90 days
1	0%	49.59	53.72	57.54
2	5%	52.01	56.47	60.53
3	10%	54.63	59.24	63.84
4	15%	56.16	61.07	65.71
5	20%	53.65	58.37	62.86

Table 3: Compressive strength results of Bamboo fiber concrete.

Sl.no	% Of Bamboo fiber	Compressive Strength Results, N/mm^2		
		28 days	56 days	90 days
1	0%	49.59	53.72	57.54
2	0.5%	57.53	62.42	67.18
3	1%	62.21	67.49	72.83
4	1.5%	58.14	63.19	67.99

Table 4: Compressive strength results of combined replacement of 10%GSA+15%DOL+1%BFin concrete.

Sl.no	10%GSA+15%DOL+1%BF	Compressive Strength Results, N/mm^2		
		28 days	56 days	90 days
1	0%	49.59	53.72	57.54
2	10%GSA+15%DOL+1%BF	67.05	73.09	78.46

4.2 Split tensile strength

Split tensile strength is an indirect method used to assess concrete's resistance to tensile forces, given its inherent weakness in direct tension. In this test, a cylindrical concrete specimen is positioned horizontally, and a compressive load is applied along its diameter. This loading generates tensile stresses perpendicular to the applied force, ultimately causing the cylinder to split along its length.To cracking in concrete constructions for 28,56 and 90 days.

Table 5: Split tensile strength results of concrete with different percentages of Groundnut shell ash used as a partial replacement of fine aggregate.

Sl.no	% of Ground Shell Ash	Split tensile Strength Results, N/mm^2		
		28 days	56 days	90 days
1	0%	4.85	5.25	5.66
2	5%	4.69	5.09	5.47
3	10%	5.08	5.52	5.96
4	15%	5.01	5.44	5.81

Table 6: Split tensile strength results of concrete with different percentages of Dolomite used as a partial replacement of Cement.

Sl.no	% Of Dolomite	Split tensile Strength Results, N/mm^2		
		28 days	56 days	90 days
1	0%	4.85	5.25	5.66
2	5%	5.05	5.48	5.89
3	10%	5.38	5.85	6.28
4	15%	5.59	6.08	6.53
5	20%	5.32	5.78	6.21

Table 7: Split tensile strength results of Bamboo fiber concrete.

Sl.no	% Of Bamboo fiber	Split tensile Strength Results, N/mm^2		
		28 days	56 days	90 days
1	0%	4.85	5.25	5.66
2	0.5%	5.74	6.23	6.69
3	1%	6.11	6.64	7.14
4	1.5%	5.08	5.53	6.45

Table 8: Split tensile results of combined replacement of 30% QD+10% HS+0.5% AF in concrete.

Sl.no	10%GSA+15%DOL+1%BF	Split tensile Strength Results, N/mm^2		
		28 days	56 days	90 days
1	0%	4.85	5.25	5.66
2	10%GSA+15%DOL+1%BF	6.63	7.23	7.74

5. CONCLUSION

1. **Normal concrete** without any admixtures reached compressive strengths of **49.59 N/mm² at 28 days**, **53.72 N/mm² at 56 days**, and **57.54 N/mm² at 90 days**.
2. Concrete with **10% Groundnut Shell Ash (GSA)** as a partial replacement for fine aggregate achieved **52.64 N/mm² at 28 days**, **57.29 N/mm² at 56 days**, and **60.45 N/mm² at 90 days**.
3. The use of **15% Dolomite** as a cement replacement resulted in strengths of **56.16 N/mm² at 28 days**, **61.07 N/mm² at 56 days**, and **65.71 N/mm² at 90 days.**
4. Incorporating **1% Bamboo Fiber** into the mix produced compressive strengths of **62.21 N/mm² at 28 days**, **67.49 N/mm² at 56 days**, and **72.83 N/mm² at 90 days.**
5. The **combined mix** of **10% GSA + 15% Dolomite + 1% Bamboo Fiber** yielded the highest compressive strength among all mixes, with **67.05 N/mm² at 28 days**, **73.09 N/mm² at 56 days**, and **78.46 N/mm² at 90 days**..
6. **Normal concrete** without any admixture showed split tensile strengths of **4.85 N/mm² at 28 days**, **5.25 N/mm² at 56 days**, and **5.66 N/mm² at 90 days.**
7. The addition of **10% Groundnut Shell Ash (GSA)** as a partial replacement for fine aggregate resulted in improved strengths of **5.08 N/mm² at 28 days**, **5.52 N/mm² at 56 days**, and **5.96 N/mm² at 90 days**.

8. Using **15% Dolomite** as a cement replacement yielded split tensile strengths of **5.59 N/mm² at 28 days**, **6.08 N/mm² at 56 days**, and **6.53 N/mm² at 90 days.**
9. Incorporating **1% Bamboo Fiber** into the mix led to the highest individual improvement, with tensile strengths reaching **6.11 N/mm² at 28 days**, **6.64 N/mm² at 56 days**, and **7.14 N/mm² at 90 days.**
10. The **combined replacement** of **10% GSA + 15% Dolomite + 1% Bamboo Fiber** achieved the **maximum split tensile strength**, reaching **6.63 N/mm² at 28 days**, **7.23 N/mm² at 56 days**, and **7.74 N/mm² at 90 days**,

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