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MECHANICAL PROPERTIES OF BAMBOO FIBER REINFORCED CONCRETE WITH GGBS AND ZEOLITE POWDER

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ABSTRACT

Concrete is the most frequently used material in construction, characterized by its composite nature where fine and coarse aggregates are bound together by a flow able cement paste. This study explores the mechanical properties of bamboo fibre reinforced concrete, incorporating Ground Granulated Blast Furnace Slag (GGBS) as a partial cement replacement and zeolite powder as a fine aggregate substitute. The investigation involves replacing zeolite powder with 5%, 10%, and 15% of the fine aggregate, while substituting cement with 0%, 10%, 20%, 30% and 40% GGBS. Additionally, the study examines the combined effects of incorporating bamboo fibre and 0.5%, 1%, and 1.5% GGBS on the concrete mix. Key performance indicators, including compressive strength and split tensile strength are measured after curing periods of 7 and 28 days. The results are expected to provide insights into optimizing the mix design for improved structural performance, sustainability, and longevity of concrete structures. By integrating alternative materials, this study seeks to contribute to the advancement of eco-friendly construction practices, addressing both the environmental impact and the mechanical robustness of concrete.

***KEYWORDS**: Zeolite Powder, Ground Granulated Blast Furnace Slag, Bamboo Fibre, Compressive Strength and Split Tensile Strength.*

1. INTRODUCTION:

Concrete is the widely known constructional material in this world, it is used for the structural development of any kind. There are a variety of techniques to achieve various required conditions may be of a higher strength than the

conventional, concrete will also support the methods like post & pre tensioning to achieve a higher strength at a time with the reduction of concrete. The concrete is a combination of material like cement, coarse aggregate, fine aggregate and water in which the cement is binding agent. when cement comes contact to water there will be an exothermic reaction takes place such that the contents of the concrete are being hardened.

A mineral called natural zeolite is created from sedimentary ash. When molten rock and volcanic ash come into contact with seawater, zeolite is produced. Mineral zeolite, which is based on silica, has strong antiviral and antioxidant properties. It can also help our bodies rid themselves of heavy metals and pollutants. When used in a detox bath, powdered zeolite is safe to apply to human skin as well as to consume.

(Ground Granulated Blast Furnace Slag) GGBS is a type of slab made from the furnaces used to refine iron ore. It is white in color, has some cementitious properties, and makes a good partial replacement for cement. It also protects concrete from thermal cracking and the alkali-silica reaction. This slag must be quickly quenched in a lot of water if it is to be utilized in the production of GGBS. It is tapped off as a molten liquid on a regular basis. The process of quenching yields granules that resemble coarse sand while optimizing the cementitious qualities.

The silkiness of bamboo cloth is comparable to that of silk. Bamboo fabric is hypoallergenic and ideal for people who respond allergicly to other natural fibers like wool or hemp since the fibers are naturally rounder and smoother without any sharp spurs to irritate the skin. Additionally, bamboo has antibacterial and antifungal properties. This is due to bamboo's natural ability to thrive in the wild without the need for fertilizer or pesticides since it possesses a bio-agent called "Bamboo Kun" that has anti-bacterial and bacteriostatic properties.

2. OBJECTIVES

1. To use GGBS (Ground Granulated Blast Furnace Slag) as a partial replacement for cement to optimize the cement content in bamboo fibre reinforced concrete.

2.To utilize zeolite powder as a partial replacement for fine aggregate to improve the fine aggregate properties in the concrete mix.

3. To assess the mechanical properties of the concrete by conducting compressive strength test and split tensile strength test.

3. MATERIALS

3.1 Cement: Ordinary Portland cement is the type of cement that is most frequently used. It is an essential part of most building supplies, such as non-specialty mortar, grout, and concrete. Cement is the main ingredient of concrete. The characteristics of concrete will change dramatically with the amount of cement. In compliance with IS 12269-2013, ordinary Portland cement of Grade 53 was used for this project.

3.2 Fine Aggregate: Fine aggregate, commonly known as sand, plays a crucial role in the composition of concrete. It acts as a filler material, occupying the spaces between the coarse aggregates and contributing to the overall density and strength of the concrete mix. The selection and quality of fine aggregate significantly influence the workability, durability, and strength of the final concrete product. Typically sourced from riverbeds, quarries, or manufactured

sand, fine aggregates must meet specific gradation and cleanliness standards to ensure optimal performance in concrete applications.

3.3 Coarse Aggregate: Coarse aggregate, a vital component of concrete, significantly contributes to its overall strength, durability, and structural integrity. Comprising materials such as crushed stone, gravel, or recycled concrete, coarse aggregate provides the bulk and stability necessary for the concrete mix. The size and shape of coarse aggregate particles, which typically range from 4.75 mm to 20 mm, play a crucial role in determining the workability, strength, and durability of the concrete.

3.4 Zeolite powder: Zeolite powder is a finely ground form of zeolite, a naturally occurring or synthetically produced crystalline aluminosilicate mineral. Zeolites have a unique porous structure with a high surface area, making them highly effective as adsorbents, ion exchangers, and catalysts.

3.5 GGBS : Ground Granulated Blast Furnace Slag (GGBS) is a byproduct obtained from the iron manufacturing process. It is produced by quenching molten iron slag from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. GGBS is used as a supplementary cementitious material (SCM) in concrete production, where it partially replaces Portland cement, improving the properties and sustainability of concrete.

3.6 Bamboo Fibre: Bamboo fiber reinforced concrete (BFRC) is a composite material where natural bamboo fibers are incorporated into the concrete mix to enhance its mechanical properties. Bamboo fibers, derived from the renewable and fast-growing bamboo plant, are typically treated, processed, and added to concrete as a reinforcement to improve its tensile strength, toughness, and crack resistance.

3.7 Water: Potable water, also known as water fit for human consumption, is typically utilized as mixing water. On the other hand, non-potable water sources can also be used, provided that they do not negatively impact the properties of concrete. Potable water can be used to mix and cure concrete. Water's PH ranges from 6 to 8.

4. EXPERIMENTAL INVESTIGATIONS:

4.1**Compressive Strength Results:** Test specimens need to be 150 x 150 x 150 mm in size, and the concrete to be tested cannot have nominal maximum aggregate sizes greater than 20 mm. 7 and 28 days are usually enough time to analyze the concrete sample.

Table 1: Compressive Strength Results of Concrete with Partial Replacement of Fine aggregate by Zeolite Powder.

S.No	% of Zeolite Powder	Compressive strength results, N/mm^2	
		7 days	28 days
1	0%	27.57	39.68
2	5%	29.65	42.43
3	10%	31.48	44.45
4	15%	30.02	42.96

Table 2: Compressive Strength Results of Concrete with Partial Replacement of Cement by Ggbs.

S.No	% of Ggbs	Compressive strength results, N/mm^2	
		7 days	28 days
1	0%	27.57	39.68
2	10%	28.03	40.92
3	20%	29.91	43.27
4	30%	31.07	44.26
5	40%	30.46	42.89

Table 3: Compressive strength of concrete increases with the addition of bamboo fibers.

S.No	% of Bamboo Fibers	Compressive strength results, N/mm^2	
		7 days	28 days
1	0%	27.57	39.68
2	0.5%	31.35	45.98
3	1%	34.83	49.62
4	1.5%	33.01	47.22

Table 4: Combined effect of partial replacement of fine aggregate with zeolite powder, cement with GGBS, and addition of bamboo fibers enhances the compressive strength of concrete.

S.No	ZP+Ggbs+Bf	Compressive strength results, N/mm^2	
		7 days	28 days
1	0%	27.57	39.68
2	10% ZP+30% Ggbs+1% Bf	37.96	54.24

4.2 Split Tensile Strength Test: The loading surfaces of the compression testing equipment are separated horizontally using a typical test cylinder of concrete specimen, measuring 300 mm by 150 mm in diameter. Up to the point where the cylinder fails at its vertical diameter, the compression force is applied consistently and symmetrically along its length.

Table 5: Split tensile Strength Results of Concrete with Partial Replacement of Fine aggregate by Zeolite Powder.

S.No	% of Zeolite Powder	Split tensile strength results, N/mm^2	
		7 days	28 days
1	0%	2.64	3.88
2	5%	2.92	4.25
3	10%	3.38	4.79
4	15%	2.61	3.83

Table 6: Split tensile Strength Results of Concrete with Partial Replacement of Cement by Ggbs.

S.No	% of Ggbs	Split tensile strength results, N/mm^2	
		7 days	28 days
1	0%	2.64	3.88
2	10%	2.77	4.04
3	20%	3.01	4.32
4	30%	3.26	4.63
5	40%	2.61	4.28

Table 7: Split tensile strength of concrete increases with the addition of bamboo fibers.

S.No	% of Bamboo Fibers	Split tensile strength results, N/mm^2	
		7 days	28 days
1	0%	2.64	3.88
2	0.5%	3.03	4.37
3	1%	3.68	5.21
4	1.5%	3.32	4.76

Table 8: Combined effect of partial replacement of fine aggregate with zeolite powder, cement with GGBS, and addition of bamboo fibers enhances the Split tensile strength of concrete.

S.No	ZP+Ggbs+Bf	Split tensile strength results, N/mm^2	
		7 days	28 days
1	0%	2.64	3.88
2	10% ZP+30% Ggbs+1% Bf	4.08	5.85

5. CONCLUSIONS:

1. The Normal Concrete Compressive Strength Results for 7 and 28 days is 27.57 and 39.68 N/mm^2.
2. The optimum compressive strength results of concrete with a 10% partial replacement of fine aggregate by Zeolite powder are 31.48 N/mm^2 at 7 days and 44.45 N/mm^2 at 28 days.
3. The optimum compressive strength results of concrete with a 30% partial replacement of Cement by Ggbs are 31.07 N/mm^2 at 7 days and 44.26 N/mm^2 at 28 days.
4. Compressive strength results of concrete show improvements with the addition of 1% of bamboo fibers at both 7 days and 28 days are 34.83 and 49.62 N/mm^2.
5. Combined effect of partial replacement of fine aggregate with 10% zeolite powder, cement with 30% GGBS, and addition of 1%bamboo fibers enhances the Compressive strength of concrete at 7 and 28 days are 37.96 and 54.24 N/mm^2.
6. The Normal Concrete Split tensile Strength Results for 7 and 28 days is 2.64 and 3.88 N/mm^2.
7. The optimum Split tensile strength results of concrete with a 10% partial replacement of fine aggregate by Zeolite powder are 3.38 N/mm^2 at 7 days and 4.79 N/mm^2 at 28 days.
8. The optimum Split tensile strength results of concrete with a 30% partial replacement of Cement by Ggbs are 3.26 N/mm^2 at 7 days and 4.63 N/mm^2 at 28 days.
9. Split tensile strength results of concrete show improvements with the addition of 1% of bamboo fibers at both 7 days and 28 days are 3.68 and 5.21 N/mm^2.
10. Combined effect of partial replacement of fine aggregate with 10% zeolite powder, cement with 30% GGBS, and addition of 1%bamboo fibers enhances the Split tensile strength of concrete at 7 and 28 days are 4.08 and 5.85 N/mm^2.

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