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STRENGTH STUDIES ON BANANA FIBRE CONCRETE WITH COPPER SLAG AND ZEOLITE POWDER

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Abstract:

The properties of concrete reinforced with banana fibers that contains copper slag and zeolite powder are experimentally investigated in this work. Because of its high tensile strength and environmental friendliness, banana fiber—a naturally occurring substance that is collected from banana plants—shows promise as a reinforcement in concrete. In this investigation, different concentrations of 0.5%, 1%, and 1.5% of banana fiber are added to the concrete. At 20%, 40%, and 60% concentrations, copper slag—a byproduct of copper extraction—is utilized to partially replace cement. At levels of 3%, 6%, 9%, and 12%, zeolite powder—a microporous alumino silicate mineral—is added as a supplement to enhance the qualities of the concrete and partially replace fine aggregate for 28, 56, and 90 days to assess split tensile strength and compressive strength.

Key words: Banana Fibre, Copper slag, Zeolite Powder , Environmental, Compressive strength, Split tensile strength

1. INTRODUCTION

One of the most popular building materials in the modern world, concrete is prized for more than simply its adaptability. It is the material of choice for building due to its strength, affordability, durability, and versatility. Concrete is therefore acknowledged as a reliable and secure substance that may be used in a variety of ways. It is frequently utilized in residential buildings, multistory business buildings, and infrastructure projects including highways and bridges. In order to construct load-bearing components like slabs, beams, and columns, concrete is essential. Cement, water, aggregates (such sand and gravel), and occasionally admixtures or additives to enhance performance are its main components.

An inventive strategy to improve performance and sustainability is the use of copper slag in concrete as a partial substitute for cement. Because of its pozzolanic qualities, copper slag—a byproduct of the manufacture of copper—offers an environmentally benign substitute for conventional cement and adds strength and durability to concrete. In addition to lowering the environmental impact of producing concrete, this technique efficiently repurposes industrial waste by substituting copper slag for some of the cement, usually at concentrations between 20% and 60%. This method preserves or even enhances the mechanical qualities of concrete while lowering carbon emissions, conserving natural resources, and possibly lowering building costs.

A sustainable method for improving the longevity and functionality of concrete is to partially substitute zeolite powder for fine aggregate. The high silica content, pozzolanic activity, and capacity to increase the strength and resilience to chemical attacks of concrete make zeolite, a microporous aluminosilicate mineral, valuable. Zeolite powder, usually in proportions between 3% and 12%, can be used to partially replace fine aggregate (such as sand) in concrete to improve binding qualities and create a denser microstructure, which lowers permeability and increases durability. This method offers potential advantages for structural applications, particularly in areas that demand high durability and chemical resistance, in addition to using environmentally acceptable materials and reducing the consumption of natural resources.

Banana fiber, which is made from the stems of banana plants, is a natural, environmentally friendly reinforcement that improves the mechanical properties and sustainability of concrete. It is a great substitute for synthetic fibers in construction because of its high tensile strength, low weight, and biodegradability. When added to concrete in different concentrations (usually 0.5%, 1%, and 1.5%), banana fiber increases the material's tensile strength, crack resistance, and flexibility, which can prolong the lifespan of concrete structures and lower maintenance costs. This method not only repurposes agricultural waste, but also supports green building initiatives by reducing the environmental impact of construction and reliance on non-renewable resources.

2. OBJECTIVES

1. Examine how adding zeolite powder, banana fiber, and copper slag affects the concrete's strength, flexibility, and ability to withstand cracks.

2. To improve concrete's mechanical qualities, namely its compressive and tensile strength.

3. MATERIALS

3.1 Cement: Cement is a finely ground powder composed of a blend of clay, limestone, and other minerals that, when mixed with water, go through a chemical process known as hydration to create a solid binding substance. It is the main component of concrete, giving different buildings stability and strength. Since the production of cement uses a lot of energy and releases a lot of carbon dioxide into the atmosphere, finding sustainable substitutes and additions is crucial to lessening its negative effects on the environment.

3.2 Fine aggregate: Sand or small particles that fit through a 4.75 mm screen make up fine aggregate, a building ingredient. It adds smoothness and structural stability to concrete or asphalt by filling in the spaces between larger particles. The mixture's workability and polish are enhanced by fine aggregates.

3.3 Coarse aggregate: Larger particles, typically broken stone or gravel, that are trapped on a 4.75 mm filter make up coarse aggregate. In concrete, it serves as the main load-bearing component and gives the mixture bulk, strength, and longevity. In concrete buildings, coarse aggregate decreases shrinkage and increases overall stability..

3.4 Water: Water is an essential building component for a number of construction processes, such as mixing cement, making mortar, and curing. The quality of the water used directly affects the strength and durability of cement concrete and mortar, which in turn affects the overall performance of the project.

3.5 Zeolite powder: Natural or artificial zeolites, which are crystalline aluminosilicate minerals, are used to make zeolite powder, a fine, porous mineral powder. It is extensively utilized for purification, catalysis, and ion-exchange in a variety of industrial and environmental applications due to its strong cation-exchange capacity and adsorption qualities. Additionally, by increasing durability and decreasing shrinkage, zeolite powder improves the performance of cement and concrete.

3.6 Copper Slag: A byproduct of the copper smelting process, which separates impurities from molten copper, is copper slag. It is a granular substance that is frequently used in construction as an abrasive in blasting and as a sand substitute in concrete. By recycling industrial waste, copper slag improves the strength and durability of concrete and contributes to sustainable waste management.

3.7 Banana Fibre: Known for its strength, resilience, and biodegradability, banana fiber is a naturally occurring fiber that is taken from the pseudo stems of banana plants. It is utilized in eco-friendly materials, ropes, and textiles and resembles bamboo fiber in texture and appearance. Because of its lightweight and environmentally friendly qualities, this sustainable fiber is also utilized in composites for the building and automotive industries.

4. EXPERIMENTAL RESULTS

4.1 Compressive strength

The compressive strength of cubes is the measure of a material's ability to withstand crushing loads without failure, typically assessed in concrete. It is determined by applying a gradually increasing load to a concrete cube until it fails, usually measured in megapascals (MPa). This strength is a crucial property in construction, indicating the concrete's ability to bear structural loads.\

Table 1: Compressive strength results of concrete with zeolite powder as a partial replacement for fine aggregate.

Sl.no	% of Zeolite Powder	Compressive Strength Results, N/mm²		
		28 days	56 days	90 days
1	0%	27.43	29.85	32.06
2	3%	29.83	32.46	34.88
3	6%	29.44	32.18	34.49
4	9%	30.36	33.09	35.53
5	12%	29.79	32.47	34.86

Table 2: Compressive strength results of concrete with Copper slag as a partial replacement for Cement.

Sl.no	% of Copper slag	Compressive Strength Results, N/mm²		
		28 days	56 days	90 days
1	0%	27.43	29.85	32.06
2	20%	29.67	32.51	34.73
3	40%	31.32	34.17	36.64
4	60%	28.61	31.25	33.48

Table 3: Compressive strength results of concrete with the addition of banana fiber

Sl.no	% of Banana fibre	Compressive Strength Results, N/mm²		
		28 days	56 days	90 days
1	0%	27.43	29.85	32.06
2	0.5%	31.56	34.39	36.92
3	1%	33.97	37.02	39.75
4	1.5%	32.36	35.27	37.89

Table 4: The combined replacements of 9% zeolite powder as a substitute for fine aggregate, 40% copper slag as a replacement for cement, and the addition of 1% banana fibre result in improved compressive strength.

Sl.no	9% of ZP+40% CS+1%BF	Compressive Strength Results, N/mm²		
		28 days	56 days	90 days
1	0%	27.43	29.85	32.06
2	9% of ZP+40% CS+1%BF	37.42	40.78	43.49

4.2 Split tensile strength

Split tensile strength is a measure of a material's tensile (pulling) resistance, determined by placing a concrete cylinder horizontally in a testing machine. A compressive load is applied along the cylinder's length until it splits vertically, measuring tensile strength indirectly. This test is crucial for assessing concrete's resistance to cracking under tension.

Table 5: Split tensile strength results of concrete with zeolite powder as a partial replacement for fine aggregate.

SL.no	% of Zeolite Powder	Split Tensile Strength Results N/mm²		
		28 Days	56 Days	90 Days
1	0%	2.71	2.96	3.11
2	3%	3.01	3.28	3.62
3	6%	3.18	3.45	3.79
4	9%	3.34	3.59	3.86
5	12%	2.89	3.21	3.51

Table 6: Split tensile strength results of concrete with Copper slag as a partial replacement for Cement.

SL.no	% of Copper Slag	Split Tensile Strength Results N/mm²		
		28 Days	56 Days	90 Days
1	0%	2.71	2.96	3.11
2	20%	2.92	3.19	3.43
3	40%	3.14	3.42	3.67
4	60%	2.83	3.08	3.39

Table 7: Split tensile strength results of concrete with the addition of banana fiber

SL.no	% of Banana Fibre	Split Tensile Strength Results N/mm²		
		28 Days	56 Days	90 Days
1	0%	2.71	2.96	3.11
2	0.5%	3.12	3.49	3.87
3	1%	3.35	3.64	3.93
4	1.5%	3.23	3.57	3.78

Table 8: The combined replacements of 9% zeolite powder as a substitute for fine aggregate, 40% copper slag as a replacement for cement, and the addition of 1% banana fibre result in improved split tensile strength.

SL.no	9% of ZP+40% CS+1%BF	Split Tensile Strength Results N/mm²		
		28 Days	56 Days	90 Days
1	0%	2.71	2.96	3.11
2	9% of ZP+40% CS+1%BF	3.85	4.19	4.56

5. CONCLUSION:

1. The typical compressive strength values for normal concrete are 27.43 N/mm² at 28 days , 29.85 N/mm² at 56 days and 32.06 N/mm² at 90 days.

2. With an optimum 9% zeolite powder as a partial replacement for fine aggregate, the compressive strength values are 30.36 N/mm² at 28 days, 33.09 N/mm² at 56 days and 35.33 N/mm² at 90 days.

3. With an optimum 40% copper slag as a partial replacement for cement, the compressive strength values are 31.32 N/mm² at 28 days, 34.17 N/mm² at 56 days and 36.64 N/mm² at 90 days.

4. With an optimum addition of 1% banana fiber in concrete, the compressive strength values are 33.97 N/mm² at 28 days, 37.02 N/mm² at 56 days and 39.75 N/mm² at 90 days.

5. The combined replacements of 9% zeolite powder as a replacement for fine aggregate, 40% copper slag as a replacement for cement, and the addition of 1% banana fiber result in compressive strength values of 37.42 N/mm² at 28 days, 40.78 N/mm² at 56 days and 43.49 N/mm² at 90 days.

6. The typical split tensile strength values for normal concrete are 2.71N/mm² at 28 days, 2.96 N/mm² at 56 days and 3.11 N/mm² at 90 days.

7. With an optimum 9% zeolite powder as a partial replacement for fine aggregate, the split tensile strength values are 3.34 N/mm² at 28 days, 3.59 N/mm² at 56 days and 3.86 N/mm² at 90 days.

8. With an optimum 40% copper slag as a partial replacement for cement, the split tensile strength values are 3.14 N/mm² at 28 days, 3.42 N/mm² at 56 days and 3.67 N/mm² at 90 days.

9. With an optimum addition of 1% banana fiber in concrete, the split tensile strength values are 3.35 N/mm² at 28 days, 3.64 N/mm² at 56 days and 3.93 N/mm² at 90 days.

10. The combined replacements of 9% zeolite powder as a replacement for fine aggregate, 40% copper slag as a replacement for cement, and the addition of 1% banana fiber result in split tensile strength values of 3.85 N/mm² at 28 days, 4.19 N/mm² at 56 days and 4.56 N/mm² at 90 days.

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