INVESTIGATION ON KENAF FIBER CONCRETE WITH ZEOLITE POWDER AND POFA

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Abstract:

This study examines the strength characteristics of concrete reinforced with kenaf fiber, in which cement is partially replaced by zeolite powder and palm oil fuel ash (POFA). As an environmentally friendly way to increase tensile and flexural strength while lowering total weight, the use of natural fibers, like kenaf, in concrete is being investigated. POFA, a byproduct of the palm oil industry, is used to further improve cementitious qualities and lessen the environmental impact, while zeolite powder is added to increase the concrete's durability and resilience to chemical attacks.The compressive, tensile, and flexural strengths of concrete samples with different proportions of zeolite and POFA replacements were assessed by a variety of tests.The goal of the study is to identify the ideal ratio of POFA, kenaf fiber, and zeolite powder that will increase strength without sacrificing workability. According to preliminary findings, concrete's mechanical qualities are improved when zeolite powder and POFA are used in place of some of the cement and reinforced with kenaf fibers. This study offers a sustainable answer for the building sector by presenting an environmentally friendly substitute for conventional concrete that may lessen the carbon footprint of cement production.to assess split tensile and compressive strength after 28 days, 56 days, and 90 days.

Key words: Kenaf fiber , Palm Oil Fuel Ash, Zeolite Powder , Reinforcement, Compressive strength and Split tensile strength .

1. INTRODUCTION

Because of increased worries about the impact cement production has on the environment, resource depletion, and greenhouse gas emissions, the building industry has been looking more and more into sustainable alternatives to conventional materials. Using natural fibers and supplemental cementitious materials (SCMs) to enhance concrete's mechanical qualities while lowering its need on conventional cement is one promising approach. The potential of using kenaf fiber, zeolite powder, and palm oil fuel ash (POFA) in concrete as a partial substitute for cement is examined in this study.The renewable natural fiber kenaf has drawn interest due to its biodegradability, high tensile strength, and light weight. By increasing the composite's tensile and flexural strength, it can be added to concrete to improve durability and crack resistance. In the meantime, zeolite powder, a mineral with a strong pozzolanic activity, serves as an SCM, enhancing chemical durability and strength. Its high surface area and porous structure facilitate the hydration process, which may increase the density and decrease permeability of the concrete. Additionally, a rich source of silica, palm oil fuel ash (POFA), a byproduct of the palm oil industry, can aid in the pozzolanic reactions in concrete, increasing its compressive strength and offering a sustainable waste management solution. POFA replaces cement at percentages of 10%, 20%, and 30%, whereas zeolite powder is utilized as a partial substitute for cement at different percentages of 5%, 10%, and 15%. Furthermore, 0.5%, 1%, and 1.5% of kenaf fiber are added to the concrete mixture.

2. OBJECTIVES

1. To investigate the impact of POFA and zeolite powder as partial cement substitutes on the split tensile and compressive strengths of concrete.

2. To examine how kenaf fiber strengthens concrete and whether it can increase durability.

3. To determine the best combination of these materials that preserves workability while optimizing strength characteristics.

3. MATERIALS

3.1 Cement: Cement is a finely crushed powder made of a mixture of clay, limestone, and other minerals that undergo a chemical reaction called hydration to form a solid binding material when combined with water. It is the primary ingredient of concrete, which gives various structures their strength and stability. Finding sustainable alternatives and additions is essential to reducing cement's detrimental environmental consequences because its manufacture consumes a lot of energy and emits a lot of carbon dioxide into the atmosphere.

3.2 Fine aggregate: Granular material that may pass through a 4.75 mm (No. 4) sieve is known as fine aggregate. It usually consists of crushed stone, crushed gravel, or natural sand. It helps create a solid, well-graded mixture in mortar or concrete by filling the spaces in coarse aggregate. Because they provide the combination a smoother, more cohesive texture, fine aggregates are essential for improving the mixture's workability, strength, and general quality.

3.3 Coarse aggregate: Large, robust particles, such gravel, crushed stone, or slag, that usually range in size from 4.75 mm to 40 mm make up coarse aggregate. It gives the mixture volume, stability, and structural strength and serves as the main load-bearing element of concrete. Because they increase the concrete's durability, reduce shrinkage, and enhance its overall mechanical qualities, coarse particles are crucial to producing a strong, dense concrete matrix.

3.4 Water: A key ingredient in concrete is water, which starts the hydration chemical reaction that hardens the cement and binds the aggregate particles together. Concrete's workability, strength, durability, and setting time are all strongly impacted by the quantity and quality of water used in the mix. The ideal balance between workability and strength is usually achieved by carefully controlling the water-to-cement ratio; too little water can make the concrete difficult to work with and compact properly, while too much water can weaken the finished concrete by increasing porosity.

3.5 Zeolite powder: To improve the qualities of concrete, zeolite powder, a natural or artificial pozzolanic substance, is partially substituted for cement. Zeolite powder, which is well-known for its large surface area and porous structure, boosts the reactivity of the cement and facilitates the pozzolanic reaction, which raises the density and durability of concrete. Zeolite powder decreases the permeability of concrete, increases its resistance to chemical attacks, and gradually increases its strength by consuming calcium hydroxide during hydration. It is also a sustainable substitute for cement in concrete mixtures because its use can reduce the carbon impact of cement production.

3.6 POFA: A byproduct of burning palm oil leftovers in biomass power plants is called palm oil fuel ash, or POFA. Being a pozzolanic substance, it possesses qualities that, when mixed with cement, might improve concrete. POFA can be used in place of some of the cement in the production of concrete, which has both technical and environmental advantages. By improving the microstructure of the concrete, this substitute can increase workability, lower carbon emissions, and frequently increase durability.

3.7 Kenaf Fibers : The Hibiscus cannabinus plant, a member of the hibiscus family, is the natural source of kenaf fiber, a cellulose-based fiber. Kenaf fiber is utilized in many different applications, including as composite materials, paper manufacture, textiles, and environmentally friendly building materials, because of its high tensile strength, lightweight nature, and biodegradability. In sectors that prioritize sustainability, its robust, long-lasting, and renewable characteristics make it a desirable substitute for synthetic fibers and non-renewable materials.

4. EXPERIMENTAL RESULTS

4.1 Compressive strength

The greatest load that a cube-shaped concrete sample can sustain before failing under a compressive force is known as the concrete cube's compressive strength. After 28, 56, and 90 days of curing, the cube is crushed in a compression testing machine to determine the measurement. This number represents the durability and load-bearing capacity of the concrete.

Table 1: The compressive strength results of concrete with partial replacement of cement by zeolite powder.

Sl.no	% of Zeolite Powder	Compressive Strength Results, N/mm^2		
		28 days	56 days	90 days
1	0%	32.34	35.26	37.83
2	5%	34.56	37.67	40.51
3	10%	36.32	39.58	42.49
4	15%	34.95	38.09	40.88

Table 2: The compressive strength results of concrete with partial replacement of cement by Pofa.

Sl.no	% of pofa	Compressive Strength Results, N/mm^2		
		28 days	56 days	90 days
1	0%	32.34	35.26	37.83
2	10%	33.68	36.73	39.41
3	20%	34.96	38.11	40.92
4	30%	34.27	37.35	40.09

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

Sl.no	% of Kenaf fiber	Compressive Strength Results, N/mm²		
		28 days	56 days	90 days
1	0%	32.34	35.26	37.83
2	0.5%	33.04	36.12	38.67
3	1%	34.36	37.46	40.21
4	1.5%	33.95	37.01	39.72

Table 4: The combined replacements of 10% zeolite powder and 20% Pofa as a replacement for cement, and the addition of 1% kenaf fiber result in improved compressive strength.

Sl.no	10% of ZP+20% POFA+1%KF	Compressive Strength Results, N/mm²		
		28 days	56 days	90 days
1	0%	32.34	35.26	37.83
2	10% of ZP+20% POFA+1%KF	38.63	42.11	45.19

4.2 Split tensile strength

The split tensile strength of a concrete cylinder is a measure of its resistance to tensile stress, determined by loading the cylinder horizontally along its diameter.

Table 5: The split tensile strength results of concrete with partial replacement of cement by zeolite powder.

Sl.no	% of Zeolite Powder	Split tensile Strength Results, N/mm²		
		28 days	56 days	90 days
1	0%	3.16	3.43	3.62
2	5%	3.38	3.68	3.99
3	10%	3.62	3.91	4.23
4	15%	3.46	3.78	4.05

Table 6: The split tensile strength results of concrete with partial replacement of cement by Pofa.

Sl.no	% of pofa	Split tensile Strength Results, N/mm²		
		28 days	56 days	90 days
1	0%	3.16	3.43	3.62
2	10%	3.32	3.59	3.88
3	20%	3.78	4.12	4.43
4	30%	3.44	3.72	4.01

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

Sl.no	% of Kenaf fiber	Split tensile Strength Results, N/mm²		
		28 days	56 days	90 days
1	0%	3.16	3.43	3.62
2	0.5%	3.25	3.51	3.79
3	1%	3.39	3.69	3.97
4	1.5%	3.34	3.53	3.84

Table 8: The combined replacements of 10% zeolite powder and 20% Pofa as a replacement for cement, and the addition of 1% kenaf fiber result in improved split tensile strength.

Sl.no	10% of ZP+20% POFA+1%KF	Split tensile Strength Results, N/mm²		
		28 days	56 days	90 days
1	0%	3.16	3.43	3.62
2	10% of ZP+20% POFA+1%KF	4.18	4.56	4.89

5. CONCLUSION

1. The typical compressive strength values for normal concrete are 32.34 N/mm², 35.26 N/mm² and 37.83 N/mm² at 28, 56 and 90 days
2. With an optimum 10% zeolite powder as a partial replacement for cement, the compressive strength values are 36.32 N/mm², 39.58 N/mm² and 42.49 N/mm² at 28, 56 and 90 days.
3. With an optimum 20% pofa as a partial replacement for cement, the compressive strength values are 34.96 N/mm², 38.11 N/mm² and 40.92 N/mm² at 28, 56 and 90 days.
4. With an optimum addition of 1% kenaf fiber in concrete, the compressive strength values are 34.36 N/mm², 37.46 N/mm² and 40.21 N/mm² at 28, 56 and 90 days.
5. The combined replacements of 10% zeolite powder and 20% pofa as a replacement for cement, and the addition of 1% kenaf fiber result in compressive strength values of 38.63 N/mm², 42.11 N/mm² and 45.19 N/mm² at 28, 56 and 90 days.

6. The typical split tensile strength values for normal concrete are 3.16 N/mm^2, 3.43 N/mm^2 and 3.62 N/mm^2 at 28, 56 and 90 days.
7. With an optimum 10% zeolite powder as a partial replacement for cement, the split tensile strength values are 3.62 N/mm^2, 3.91 N/mm^2 and 4.23 N/mm^2 at 28,56 and 90 days.
8. With an optimum 20% pofa as a partial replacement for cement, the split tensile strength values are 3.78 N/mm^2, 4.12 N/mm^2 and 4.43 N/mm^2 at 28, 56 and 90 days.
9. With an optimum addition of 1% kenaf fiber in concrete, the split tensile strength values are 3.39 N/mm^2, 3.69 N/mm^2 and 3.97 N/mm^2 at 28, 56 and 90 days.
10. The combined replacements of 10% zeolite powder and 20% pofa as a replacement for cement, and the addition of 1% kenaf fiber result in split tensile strength values of 4.18 N/mm^2, 4.56 N/mm^2 and 4.89 N/mm^2 at 28, 56 and 90 days.

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