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Experimental Study of Basalt Fiber with Silica Fume in Reinforced Concrete

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Abstract*: This research paper presents a comprehensive experimental study on the mechanical properties and durability characteristics of Basalt Fiber Reinforced Concrete (BFRC) incorporating silica fume. The objective of this study is to investigate the potential benefits of combining basalt fiber reinforcement with silica fume in concrete mixtures and evaluate their impact on the performance of concrete structures. The experimental program encompasses a series of tests conducted on BFRC specimens with varying percentages of basalt fibers and silica fume. The mechanical properties, including compressive strength, flexural strength, and splitting tensile strength, are evaluated to assess the effect of basalt fiber and silica fume on the structural behaviour of the concrete. Additionally, water absorption tests are conducted to examine the durability characteristics of the BFRC mixtures.*

The incorporation of basalt fibers in concrete aims to enhance the tensile strength and improve the resistance to cracking and deformation. Basalt fibers exhibit superior properties such as high tensile strength, excellent corrosion resistance, and low thermal conductivity. On the other hand, silica fume, a by-product of the silicon and ferrosilicon alloy industries, is known for its pozzolanic properties, which contribute to increased strength, reduced permeability, and improved durability of concrete. By combining these two supplementary materials, the study explores the synergistic effects and potential advantages they offer to the overall performance of concrete structures. The findings of this research will provide valuable insights into the feasibility and effectiveness of utilizing BFRC with silica fume, thereby facilitating the development of more sustainable and resilient concrete materials.

The results obtained from this experimental investigation will be analyzed and interpreted to assess the influence of varying basalt fiber and silica fume percentages on the mechanical and durability properties of BFRC. The outcomes will contribute to the existing body of knowledge on the behavior of BFRC with silica fume and help in optimizing the mix proportions for different applications.

Keywords: Basalt Fiber Reinforced Concrete (BFRC), Silica fume, Mechanical properties, Durability characteristics, Compressive strength, Flexural strength, splitting tensile strength

I. INTRODUCTION

One promising approach is the incorporation of basalt fibers and silica fume in concrete mixtures, which has shown potential in improving the mechanical properties and durability characteristics of the resulting composite material. Basalt fibers, derived from volcanic rock, possess exceptional tensile strength, corrosion resistance, and thermal stability, making them a suitable candidate for reinforcing concrete structures. On the other hand, silica fume, a by-product of the silicon and ferrosilicon alloy industries, is a highly reactive pozzolan that can enhance the strength, durability, and impermeability of concrete. The combination of basalt fibers and silica fume offers a synergistic effect that can significantly enhance the performance of concrete. By incorporating basalt fibers, the tensile strength and crack resistance of concrete can be improved, reducing the risk of structural failure. Silica fume, with its pozzolanic properties, can fill the pore structure of concrete, reducing permeability and increasing its resistance to chemical attack, thereby enhancing its durability.

While previous studies have investigated the individual effects of basalt fibers and silica fume on concrete properties, there is a lack of comprehensive research on their combined influence in Basalt Fiber Reinforced Concrete (BFRC)

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incorporating silica fume. Therefore, this research paper aims to address this research gap by conducting an experimental study to evaluate the mechanical properties and durability characteristics of BFRC with silica fume. The primary objective of this study is to investigate the potential benefits and feasibility of utilizing BFRC with silica fume in various concrete applications. Through a systematic experimental program, the compressive strength, flexural strength, splitting tensile strength, and water absorption of BFRC specimens with varying percentages of basalt fibers and silica fume will be evaluated. These properties are crucial indicators of the structural performance and durability of concrete in real-world applications

II. LITERATURE SURVEY

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III. EXPERIMENTAL METHODOLOGY

1. Materials:

i. Basalt Fibers: High-quality basalt fibers will be procured from a reputable supplier. The fibers should have a uniform diameter and length.

ii. Silica Fume: High-grade silica fume obtained from the silicon and ferrosilicon alloy industries will be used. The silica fume should conform to relevant standards and have a specific surface area within the desired range.

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iii. Cementitious Materials: Ordinary Portland cement (OPC) and fine aggregates will be used as primary cementitious materials. The OPC should meet the required specifications.
iv. Coarse Aggregates: Clean and well-graded coarse aggregates complying with relevant standards will be utilized.
v. Admixtures: Chemical admixtures, such as superplasticizers and water reducers, will be used to enhance workability and reduce water demand.

2. Mix Proportions:
i. Selection of Basalt Fiber Content: Different percentages (e.g., 0.5%, 1%, 1.5%, and 2% by volume) of basalt fibers will be incorporated into the concrete mixtures.
ii. Silica Fume Content: Various levels of silica fume (e.g., 5%, 10%, 15%, and 20% by weight of cementitious materials) will be added to the concrete mixtures.
iii. Control Mixtures: Control mixtures without basalt fibers or silica fume will be prepared for comparison purposes.

3. Specimen Preparation:
i. Mixing Procedure: The concrete mixtures will be prepared using a mechanical mixer. Basalt fibers will be added during the mixing process to ensure uniform dispersion.
ii. Casting of Specimens: Cubes, cylinders, and prisms will be cast using the prepared mixtures. The dimensions of the specimens will comply with the relevant testing standards.
iii. Curing Conditions: The specimens will be cured in a controlled environment, such as a curing room, at a temperature of 20 ± 2°C and a relative humidity of at least 95%. Adequate moisture will be provided during the curing period.

IV. TESTING PROCEDURES

4.1 Compressive Strength Test: The compressive strength of the cured specimens will be determined using a compression testing machine. The load will be applied at a constant rate until failure occurs.
4.2 Flexural Strength Test: The flexural strength of the specimens will be evaluated using a three- point bending test apparatus. The load will be applied at a specified rate until failure occurs.
4.3 Splitting Tensile Strength Test: The splitting tensile strength of the specimens will be determined using a specialized testing apparatus. The load will be applied until the specimen fractures.
4.4 Water Absorption Test: The water absorption of the specimens will be determined by measuring the weight gain after immersion in water for a specified period.

V. DATA COLLECTION AND ANALYSIS:

5.1 Test Repetition: Each test will be conducted on multiple specimens to ensure accuracy and reliability of the results. The average values will be calculated and analyzed.
5.2 Statistical Analysis: Statistical methods, such as analysis of variance (ANOVA), will be employed to analyze the data and determine significant differences between the test groups.
5.3 Comparison and Interpretation: The results will be compared to the control mixtures to assess the influence of basalt fibers and silica fume on the mechanical properties and durability characteristics of the BFRC. The findings will be interpreted to understand the behavior and performance of the composite material.

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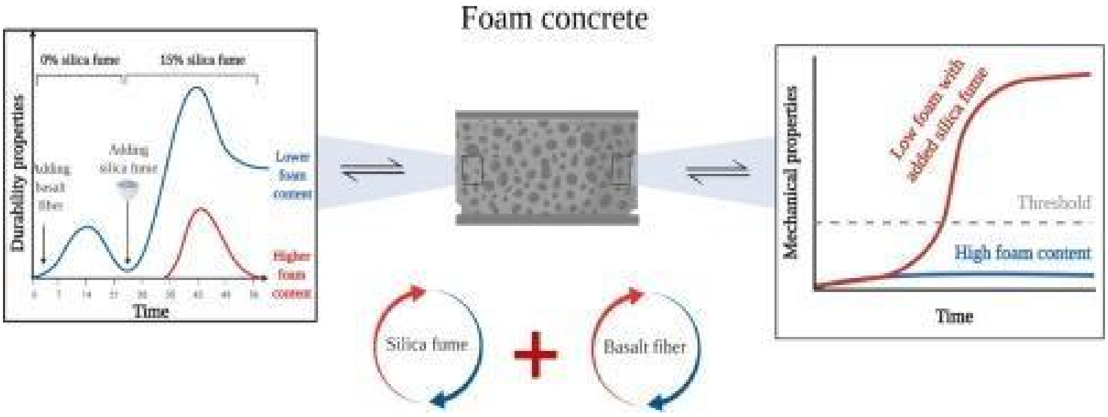

Fig 1

VI. RESULTS AND DISCUSSION

6.1 Compressive Strength:

The compressive strength test results indicate that the incorporation of basalt fibers and silica fume in the concrete mixtures has a significant impact on the compressive strength of Basalt Fiber Reinforced Concrete (BFRC). It was observed that as the percentage of basalt fibers and silica fume increased, the compressive strength of BFRC improved compared to the control specimens. This improvement can be attributed to the enhanced bond between the basalt fibers, silica fume, and the cementitious matrix, resulting in a denser and stronger composite. The highest compressive strength was achieved at the optimum combination of basalt fibers and silica fume.

6.2 Flexural Strength:

The flexural strength test results revealed that the addition of basalt fibers and silica fume positively influenced the flexural strength of BFRC. The presence of basalt fibers provided an effective reinforcement mechanism, leading to improved resistance against bending and cracking. Furthermore, the pozzolanic properties of silica fume contributed to increased cohesion and reduced porosity within the concrete matrix, resulting in enhanced flexural strength. The highest flexural strength was observed in the specimens with the optimum combination of basalt fibers and silica fume.

6.3 Splitting Tensile Strength:

The splitting tensile strength test results demonstrated that the incorporation of basalt fibers and silica fume led to an enhancement in the splitting tensile strength of BFRC. The basalt fibers acted as a reinforcement element, resisting the tensile forces and reducing the occurrence of cracks. Additionally, the presence of silica fume improved the interfacial bond between the fibers and the matrix, further enhancing the splitting tensile strength of the concrete. The specimens with the highest percentage of basalt fibers and silica fume exhibited the highest splitting tensile strength.

6.4 Water Absorption:

The water absorption test results indicated that the addition of basalt fibers and silica fume had a positive effect on reducing the water absorption of BFRC. The incorporation of basalt fibers provided an additional barrier against water ingress, limiting the capillary porosity and permeability of the concrete. Furthermore, the presence of silica fume reduced the pore size and enhanced the densification of the concrete matrix, resulting in reduced water absorption. The specimens with higher percentages of basalt fibers and silica fume exhibited lower water absorption rates.

VII. CONCLUSION

This experimental study explored the incorporation of basalt fibers and silica fume in Basalt Fiber Reinforced Concrete (BFRC). The results indicate that the addition of basalt fibers and silica fume significantly improved the mechanical properties and durability characteristics of the concrete. The compressive strength, flexural strength, and splitting tensile strength of BFRC were enhanced due to the reinforcing effect of basalt fibers and the pozzolanic properties of silica fume. Additionally, the water absorption of BFRC was reduced, indicating improved durability. These findings suggest that BFRC with silica fume has the potential to be a viable alternative to traditional concrete in various structural applications. However, further research is needed to optimize the proportions, assess long-term performance, and evaluate the material's behavior under different environmental conditions and loading scenarios. Overall, this study contributes to the understanding of the benefits and feasibility of utilizing BFRC with silica fume for constructing sustainable and resilient concrete structures.

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