Experimental Investigation of Mechanical Properties of Glass and Basalt Fiber Reinforced with SiO_2 Nanoparticles

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Abstract. Composite materials play an integral role in modern engineering, offering a unique balance of strength, durability, and versatility across diverse industries. The pursuit of advanced composites capable of surpassing conventional counter parts while promoting sustainability has fueled innovative research in material science. This project delves into this vibrant field by exploring the integration of basalt fibers and SiO2 Nano particles into composite materials, with a focus on fabricating and rigorously testing these novel composites. The work commences with a comprehensive literature review, revealing the current state of research and gaps in knowledge concerning basalt fiber-reinforced composites and SiO2nanoparticles. Material selection involves meticulous evaluation of basalt fibers and SiO2 Nano particles, considering the intrinsic properties, compatibility, and potential synergies. The composite formulation entails optimizing the fiber-to matrix ratio and Nano particle concentration with in a chosen polymer matrix, aiming to balance enhanced mechanical properties with ease of fabrication.

Keywords: Glass, Basalt Fiber, Nano-particles, Mechanical Properties

1 Introduction

Composites represent a remarkable synergy in materials science, where two or more disparate components combine to form a material with properties superior to those of its individual constituents. This transformative approach has revolutionized industries ranging from aerospace to sports equipment, offering a compelling blend of strength, versatility, and innovation. In this discourse, we delve into the fundamentals of composites, exploring their composition, manufacturing processes, diverse applications, and the driving forces behind their adoption. At its core, a composite material comprises two primary components the reinforcement and the matrix. The matrix serves as the binder, encapsulating and supporting the reinforcement. It can be a polymer, metal, ceramic, or hybrid thereof. The choice of matrix depends on the

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desired properties of the composite and the environmental conditions it will encounter. Polymers, such as epoxy and polyester resins, are commonly used due to their ease of processing, corrosion resistance, and versatility. Metals like aluminum and titanium find applications in high-temperature environments and structural components. Ceramics offer exceptional hardness, wear resistance, and thermal stability, which makes them suitable for demanding applications in defense and aerospace. In contrast, the reinforcement provides the composite with its distinctive mechanical properties. Reinforcements come in various forms, including fibers, particles, and flakes, and are typically made from materials like glass, carbon aramid any natural fiber. Each type of reinforcement imparts unique characteristics to the composite. Carbon fibers, renowned for their high strength-to-weight ratio and stiffness, are favored in aerospace, automotive, and sporting goods. Glass fibers, with their affordability and corrosion resistance, find extensive use in construction, marine, and automotive industries. Aramid fibers, known for their exceptional impact resistance and heat tolerance, are prevalent in protective gear and ballistic applications [1-5].

2 Materials and methods

Fabrication of 0.2% fiber reinforced composite using basalt fiber and glass fiber with SiO2 Nano particles. In the fabrication of this type of composite material we use 5 grams of SiO2 Nano particles and 4 layers of 30×30cm woven glass fibers and 4layers of 30×30cm of basalt fibers, together they become 8 layers of fibers with 100 grams of hardener-HY951,100 grams of epoxy resin-LY556 added to prepare the 30×30×32 cm laminate. The steps below show the process of the production of the w 2% of fiber reinforced composites:

- First place the lower mold firmly on to a plane ground.
- Add some lubricating oil onto the lower mold and add 1 transparent layer onto the lower mold.
- The purpose of the transparent sheet is to give shiny and good appearance to the fabricated laminate.
- Add some oil onto the transparent sheet.
- In bowl create a uniform mixture of 100 grams of hardener-HY 951,100 grams of epoxy resin-LY 556 and add 10 grams SiO2 nanoparticles.
- Then place one sheet of basalt woven fiber onto the transparent sheet and then add the CNT mixture over the basalt fiber fabric.
- Place the glass fiber woven fabric onto the basalt fiber woven fabric and then add the NP mixture onto the fiber sheets.
- Repeat this process until 8 layers of glass and basalt fiber woven fabric sheets are placed with the NP mixture.
- Add another transparent sheet with oil placed on it and place the upper mold on it.

- With the help of the mechanical hydraulic presser press the upper and lower mold firmly for 1 whole day, for the entire laminate to be pressed and forms into a fiber reinforced composite.

Fig. 1. Basalt fiber

Fig. 2. Glass fiber

Fig. 3. Epoxy

Fig.4. SiO_2 nanoparticles

3 Mold preparation

The mold, normally fabricated from metallic or composite materials, is preheated to a selected temperature. This is appropriate for curing the resin. The mold can also be covered with a launch agent to facilitate smoothed lamination of the cured parts.

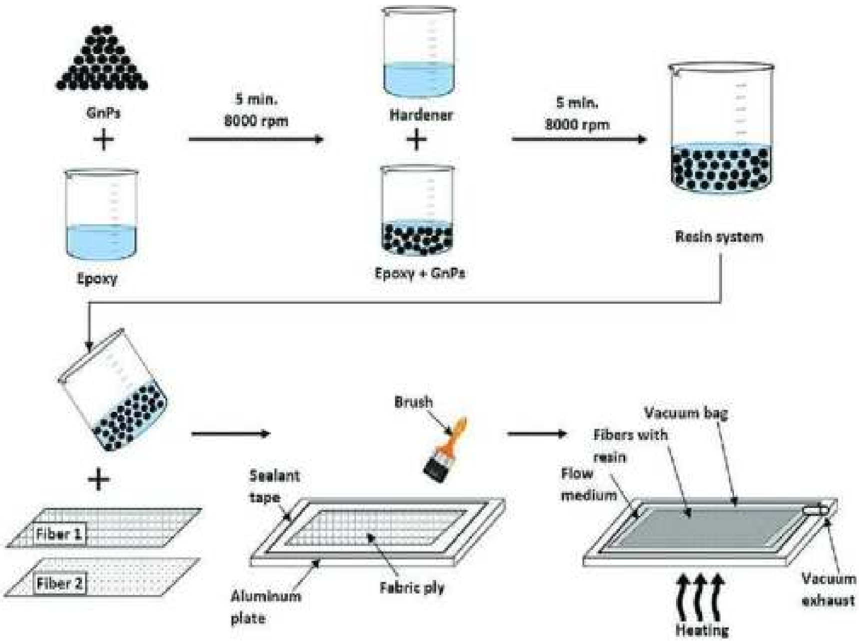

Fig. 5. Mold preparation

The mold consists of layered fiber performs, and resin-infused layers. The mold is closed, and stress is carried out with the use of a press of hydraulic. In the mean while, heat is applied to activate the resin's curing process. Due to pressure and heat combination helps consolidate the fibers, and it also help in removal of air voids, and promote adhesion between layers. The composite is held below stress and at a multiplied temperature for a selected duration, permitting the resin to the rapy and harden. The curing method relies upon the resin device used and might remain from mins to hours. After the curing cycle, the mold is steadily cooled down earlier than demolding to save you thermal stress. The cured composite component is cautiously eliminated from the mold.

Fig. 6. 2%NP Laminate

Fig. 7. 4%NP Laminate

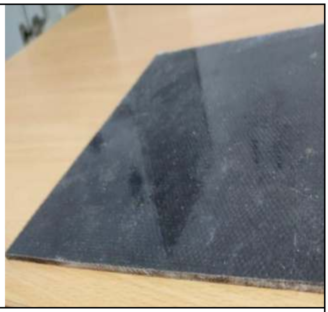

Fig.8. 6%NP Laminate

Excess fabric or flash is trimmed, and extra completing processes, together with sanding or floor treatments, can be implemented to reap the favored very last look and dimensions.

Table 1. Composition of composite materials

S. No.	Fillers	Matrix	Fibers
C1	2%	44%	54%
C2	4%	42%	54%
C3	6%	40%	54%

Fig. 9. Tensile specimen

Fig. 10. Flexural specimen

Fig. 11. Impact specimen

4 Results and discussion

Table 2. Mechanical properties of specimen

Sl. No	Sample Details	Results			
		Te nsile Strength (MPa)	Elongation (%)	Flexural Strength (MPa)	Impact Energ y (kJ/m^2)
1	2%W–Sample	289.96	9.60	340.34	183.60
2	2%W–Sample	324.07	10.48	353.07	164.63
3	4%W–Sample	289.99	8.81	349.38	271.61
4	4%W–Sample	306.83	8.98	378.65	254.31
5	6%W–Sample	298.67	8.44	420.71	121.87
6	6%W–Sample	353.94	9.60	353.09	177.01

The average tensile strength of 2% SiO_2 sample is 307.015 MPa. The average tensile strength of 4% SiO_2 sample is 298.41 MPa. The average tensile strength of 6% SiO_2 sample is 326.305 MPa. 6 weight percentage SiO_2 sample shows the highest tensile strength among all the remaining weight percentage of samples. The lowest average tensile strength is noted by 4% of SiO_2 and the value is 298.41 MPa.

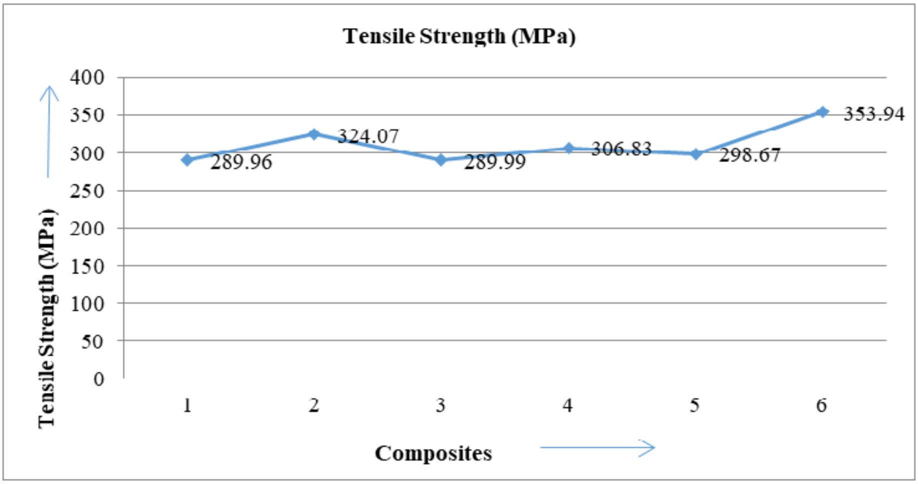

Fig. 12. Tensile strength of specimen

The average % elongation noted for 2 weights % samples is 10.40. Similarly, the average % elongation of 4 weight % is 8.89. The average % elongation of 6 weight % is 9.02. The highest average % elongation value is 10.40 and it is noted for 2 weights %samples.8.89isthelowestvalueofaverage %elongation noted for 4 weights % samples.

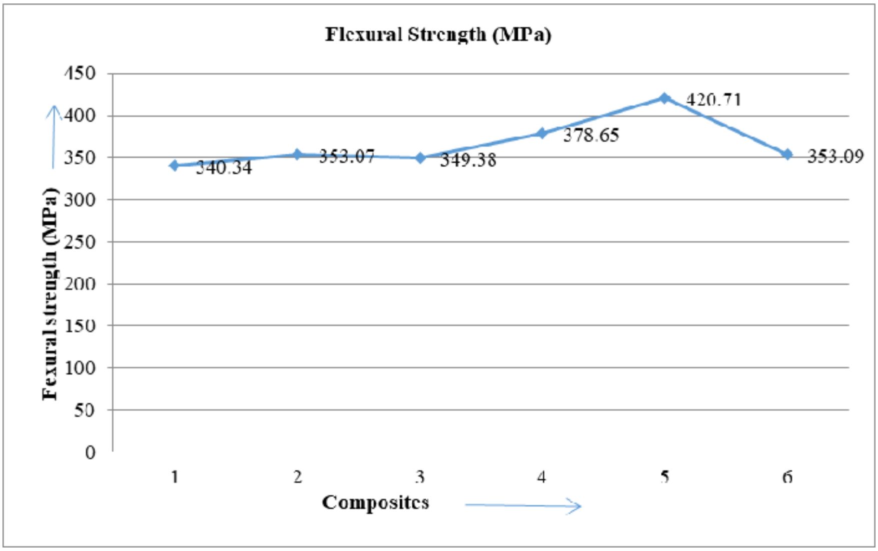

Fig. 13. Flexural Strength of specimen

5 Conclusions

The tensile strength, flexural strength and strength of impact, glass and basalt fiber reinforced epoxy resin composite studied. From the results it was observed that the flexural strength increased with increasing silicon dioxide. The 6 % of silicon dioxide, Glass basalt fiber will possess good flexural strength and can withstand the strength up to 386.85 MPa. This may be due to the complete filling of voids in the matrix by the SiO2 particles. These Glass basalt composite samples possess good tensile strength and can withstand the strength up to 326 MPa. The impact strength was decreased with increasing silicon dioxide this is due to increasing of SiO2 to composite will become brittle in nature

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