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Review on physical properties of glass fiber and reinforced glass fiber composite with their effect

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ABSTRACT
This paper offers a literature review in the area of GF reinforced composites from the literature survey of various authors. GF reinforced with polymers and natural fibers results in lowering density, enhanced strength, and ease of manufacturing over the base-material are some of the beneficial characteristics of GF composites. Because of these advantages of GF-composites, over others it is used in many fields such as aerospace, automotive, marine, dental treatment and construction. In this paper we are going to review how the GF is use in above mention industries. We also have reviewed some hybrid reinforced composites of GF and mentioned their advantage over GF.
Keyword: Glass Fiber, composite, glass fiber-reinforced polymer,

Nomenclature

GF	Glass Fiber
EA	Emulsified asphalt
FEA	Fiber-reinforced EA
SEM	Scanning electron microscope
FTIR	Fourier-transform infrared spectroscopy
DSR	Dynamic shear rheometer
CF	Carbon Fiber
Tg	Glass transition temperature
TMA	Thermomechanical Analyzer
GFRP	Glass fiber-reinforced polymer
G-B-J-B-G	Glass fiber-Bamboo-Jute-Bamboo-Glass fiber
G-J-B-J-G	Glass fiber-Jute-Bamboo-Jute-Glass fiber
PLA	Poly Lactic Acid

1. Introduction

Composite materials cannot be produced from fiber or matrix when they are acting alone, a composite can be manufactured by combining two dissimilar materials into a new material which will have some enhance property than any of them carry alone. Automobiles, furnishings, space and aircraft, navy ships, and many other items were made in large part using composite materials [2]. GF composite is an example of material that performs well , has a variety of its inexpensive and has a high degree of

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mechanical strength [3].GF also mix with concrete to enhance the flexural strength of concrete, the modulus of rupture of concrete increases and ductility of concrete was improved as well [11]. GF when reinforced with natural fibers like jute, bamboo, gives excellent physical and mechanical properties to the composite making it a primary choice is selecting these composites for construction and aerospace industries. when GF reinforced by using stack layup method provides phenomenal reduction of water absorbing qualities of GF [8-10].

2. Literature Survey

Guilong Wanga et. al [1] research shows that the composite demonstrated an about 2-fold enlarge in strength, rigidity and shows additional than 3-fold improvement in collision toughness in the existence of 20 wt% glass fiber. By significantly raising the expansion ratio, shrinking the size of the cells, and boosting cell nucleation, Glass fiber can significantly increase PLA's foaming capacity. The result shows that Microcellular PLA/m-GF foam with an expansion rate greater than 20 and cell diameters under 10 µm was produced using 15 wt% GF.

In another research by Md. Naimul Islam1[2] et. al Unsaturated Polyester Resin-based thermoset hybrid were auspiciously discovered using the traditional hand lay-up method. When differentiate to the matrix material, 50% E-GF reinforced hybrid showed an improvement in mechanical properties of about 389%. Due to the hydrophobic nature of twain the fiber and the matrix, the connection among them was superb, as demonstrated by a SEM study. The hybrid that were created have good mechanical characteristics and could be employed in traditional civil construction.

Deshang Han [3] et. al analysis the frictional wear bearing of GF/rubber composites on metals. This study examined the impact of blending rubber with various concentrations of GF on the abrasion wear of metal on the end face. The result shows that the degree of the salinization reaction of the composite material first enlarge and then dropped with the addition of more GF to the composite matrix. The study shows that the experimental group's roughness difference enhanced by 191.8%, 97.4%, 103%, and 232% respectively with 0, 1, 5, and 7 phr of GF. The hybride of GF and rubber had the stubby wear on metal when the inclusion of GF was 3 phr.

Kazi Md Masum Billah [4] et. al looked into neatly formed composite (ABS/CF)(Acrylonitrile Butadiene Styrene reinforced with carbon fibers) and (ABS/GF), In order to generate information and understanding that can be utilized for treating components by not damaging their features and to produce parts of outstanding quality in coming years. The deterioration behaviour was investigated using thermogravimetric analysis. In order to comprehend how heat is dissipated by plain and composite materials, differential scanning calorimetry (DSC) was used to analyse the 'Tg' and specific heat. Furthermore, in relation to the clean ABS, mechanical stiffness for ABS/CF and ABS/GF improved by 272% and 84%, respectively. The thermomechanical study distinguished the deformation activity before and after the point of transition and found that ABS/CF, ABS/GF, and plain ABS had the maximum thermal stability to maintain their shape at high temperatures. The outcome shows that for plain ABS, ABS/GF, and ABS/CF, accordingly, the mean change in size throughout the usual temperatures (108 °C-115 °C) was 12365.41, 362.32, and 111.08 m/m°C.

Wei-Chien Wang et. al.[5] study with the objective to examine the influence of one-hour extreme temperatures (440, 500, 580, 800, and 1000 C) on the compression strength and thermal conductivity of concrete, 0.60 and 2.54 cm GFs of 0.5%, 1.0%, and 1.5% of cement by weight, respectively were used. With an increase in fiber content, concrete's flexural strength will rise. Under the influence of excessive heat, the quantity of additional GFs and the length of the GF both improve the remaining compressive capacity of concrete. As more GFs are added, as well as the length of the GF, the heat conductibility drops. The largest impact on the decline of thermal conductivity is between 400 and 500 C. The result shows that concrete's lingering strength at compression with 0.5%, 1.0%, and 1.5% 0.60 cm GF make up 24.1, 28.9, and 31.9% of all fibers, respectively. The concrete with 0.5%, 1.0%, and 1.5% 2.54 cm glass fibers has residual compressive strengths of 24.3%, 30.5%, and 34.3%, respectively.

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Yanyan Liu et. al.[6] work on the glass fiber employed in this work, which is frequently used in the ISAC layer, was initially treated using six approaches (three etchants using a couple of concentrations). To create FEA samples, fibers were subsequently added to the EA. In order to assess the changes in both the chemical and physical attributes of glass fiber, EA, and FEA, laboratory tests like SEM test, FTIR test, angle of contact test, surface tension test, DSR test, and direct tensile examination were completed out. The effectiveness of FEAs depended on the glass fiber treatment method, and it was discovered that the interaction between glass fiber and EA was tangible connection. A 2 mol/L concentration of sulfuric acid was suggested as the ideal glass fiber etchant.
Vivekanandhan Chinnasamy et. al.[7] work, an intentional effort is being done to investigate how epoxy composite structural and geometrical behaviour is affected by nanoclay content. Tests were done on the specimens while epoxy composites were being reinforced with various nanoclay particle fractions. Glass fiber and kevlar fiber blended together with a range of layer thicknesses, and sheets are produced, then their mechanical characteristics are examined having upgraded epoxy that contains 2 weight percent of Cloisite 30B and hardener. The outcome shows that prior to reaching their breaking limit, kevlar fibers reported endothermic spikes at 472.0°C, 511.9°C, and 536.0°C, accordingly. When fibers are heated to temperatures of 800 °C, they lose up to 68.8% of their original weight. Based on the findings, it can be said that combining modified kevlar/glass fiber with derived materials enhanced their thermal features and raised the temperature at which glass transitions without compromising their ability to retain heat.
Ashish kumre[8] et.al. research in the current work about glass fiber and natural fiber polymer composites are combined to improve the composite's mechanical properties. These fibers include abaca, banana, bamboo, cotton, coir, hemp, jute, pineapple, and sisal. Because of its outstanding qualities, such as specific strength, low weight, cheap cost, reasonably excellent mechanical properties, non-abrasive, eco-friendly, and biodegradable features, natural fiber reinforced composites are employed in many technical applications. Natural fibers can be added to GFRP to enhance its qualities and be used as an alternative to glass fiber reinforced polymer composites. The figure 1 shows that tensile modulus of S10 was observed to be 35.6 percent, 4.2 percent, and 62.0 percent higher than S5, S15, and S20, respectively. Tensile strength of S10 was discovered to be 24.61 percent, 20.14%, and 20.26% higher than that of S5, S15, and S20, respectively. The result also shows that the flexural strength of S15 was found 25.05%, 41.29%, 22.91% and1.34% more than E, S5, S10 and S20 respectively while the flexural modulus of S10 was observed 167.33%,10.62%, 16.68% and 10.86% more than E, S5, S15 and S20 respectively. The result shows that impact properties of S20 were found 387.57%, 294.46%, 102.23% and 50.29% more than E, S5, S10 and S15 respectively.

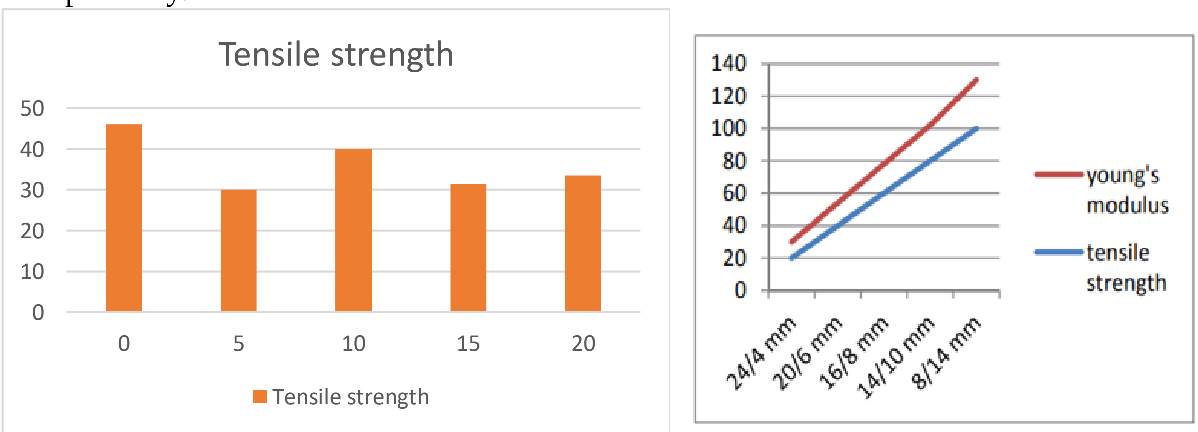

Figure 1: Strength of sisal epoxy composite in tensile tests; (b) Glass sisal fiber epoxy composite's tensile strength

Roham Rafiee [9] et.al. discover the fatigue lifespan of composite pipes under periodic internal hydrostatic pressure having varying amplitudes is studied. The progression of damage in composite structures is tracked using a progressive damage modelling approach based on stiffness degradation.

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The three steps of modeling—stress analysis, damage assessment, and mechanical property degradation—are carried out concurrently with the random creation of the fatigue loading sequence. The highest stress amplitude, average stress amplitude, and cycle count are only a few of the elements that make up the fatigue loading method that are considered as random variables that closely resemble the actual operating circumstances of pipes. The primary problem for GFRP pipe makers is assessing the lengthy efficiency of GFRP tubes as they are essential components in the infrastructure. The findings have a range between 37 and 42 years, with a 39.3 year average. The figure(2) represents that while the frequency of the projected average lifetime, or 39.3 years, is 2.7%, the most frequent predicted lifetime is 37.4 years, with a frequency of 4.1%. It is certain that the most typical lifespan is between 37 and 38 years. According to statistics, there is a higher than 50% chance of seeing lifespan under 40 years.

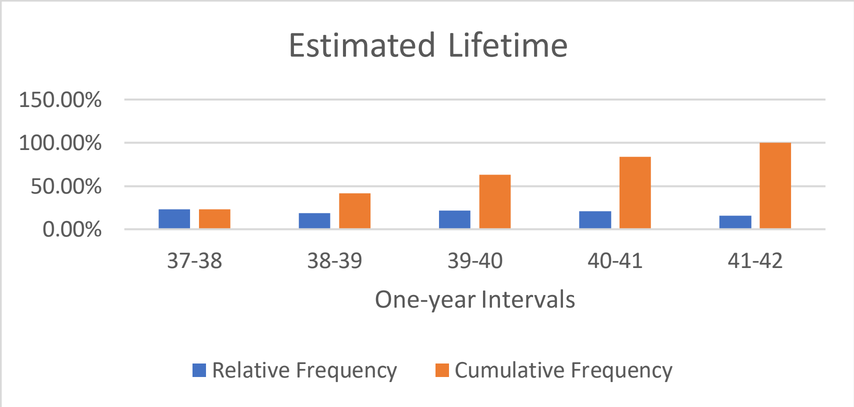

Figure 2: Expected fatigue life relative and cumulative rates of occurrence

D. Chandramohan[10] et.al. studied that, GFRP, when combined with jute and bamboo fibers have been shown to have superior mechanical characteristics, durability against wear, and water absorption resistance, making them a suitable replacement for GFRP. The hand layup technique was used to create seven unique composites with distinct patterns of layers of natural fiber and glass fiber. The composite G-B-J-B-G has an acceptable shear strength of 97.5 MPa (dry) and 98.92 MPa (wet), according to the shear data. hybrid composite G–B–J–B–G absorbed 0.99 g of water. The reduction in weight data from the abrasion test showed that the composites G-B-J-B-G (0.213 g in dry conditions and 0.198 g in moist) and G-J-B-J-G (0.348 g in dry and 0.249 g in wet) lost weight in both circumstances (dry and wet).The composite G-B-J-B-G had the highest tensile strength in both dry and wet conditions, with values of 77.23 and 78.86 MPa, respectively, and its tensile modulus was 2.85 MPa in dry condition and 3.581 MPa in wet condition, followed by the composite specimen G-J-B-J-G. The results of the flexural test revealed that the composition G-B-J-B-G has values of 57.21 and 58.91 MPa in both the dry and wet conditions respectively, as well as a flexural modulus of 4.987 MPa (dry) and 5.753 MPa (wet).

Hibretu Kaske Kassa[11] et.al. work focuses on the experimental assessment of the flexural properties of glass fiber-reinforced polymers with varying glass fiber content percentages. In accordance with ASTM requirements, all beams, including control and concrete with fiber reinforcement beams, are evaluated by third point load at 7, 21, and 28 days following casting. The addition of glass fibers to concrete boosted its flexural strength, load bearing capability, and strength. The structural application of fiber-reinforced polymer (FRP) material proved successful. As shown in fig (3.1) & fig (3.2) Glass fiber additions at 0.25%, 0.50%, and 0.75% exhibited greater strength than standard mix concrete . Because of its increased flexural strength and fracture resistance, glass fiber-reinforced concrete is a suitable choice for strengthening concrete structures.

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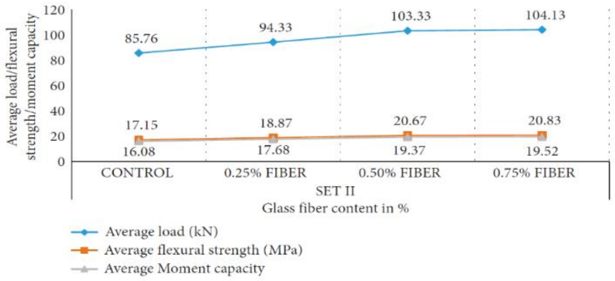

Fig 3.1: The average failure load, moment, and flexural strength of glass fiber and reinforced bar-reinforced concrete beam samples after 28 days.

Table 1: Average failure load, moment, and flexural strength of glass fiber and reinforced bar reinforced concrete beam samples after 28 days.

Sample spacemen	Average load (kN)	Average flexural strength (MPa)	Average Moment capacity
Control	85.76	17.15	16.08
0.25% fiber	94.33	18.87	17.68
0.50% fiber	103.33	20.67	19.37
0.75% fiber	104.13	20.83	19.52

In this research B. Seshavenkat Naidu [12] et.al.with the addition of additives, an E-glass fiber-based composite material is created. Various samples are created by varying the additive mixture.
Seven distinct specimens, each with a unique additive mix, were created. The same size of the seven distinct specimens are guaranteed. As mentioned in Table 2 These specimens' additive pairings are as follows, with every pair designated as Sp-1, Sp-2, etc., denoting one of seven potential pairings. These samples are tested for thermal dispersion performance at elevated temperatures and durability after being exposed to elevated temperatures. The Time taken by samples to show deformation is shown in Table 2:). According to the findings of the simulation, the composite could bear loads better than metals like copper and aluminum but not as well as mild steel.

Specimen	Fibre Layer	Fumed silica	Alumina Trihydrate	Graphite	Calcium Carbonate
Sp-1	0	✓	✗	✗	✗
Sp-2	6	✗	✗	✗	✗
Sp-3	8	✓	✗	✗	✗
Sp-4	8	✓	✓	✗	✗
Sp-5	8	✓	✓	✗	✓
Sp-6	8	✓	✓	✓	✓
Sp-7	8	✓	✓	✓	✗

Table2: Specimens combined in different ways

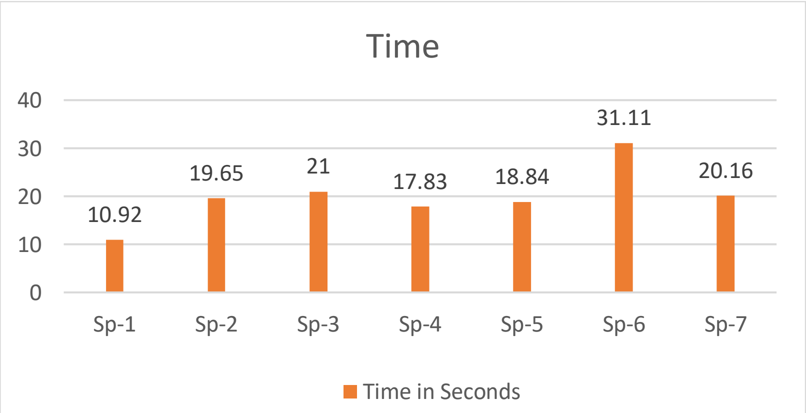

Fig 3: Samples' lag time before distortion is visible

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In this paper Arafater Rahman[13] et. al.using the relevant standard testing procedures, examined the mechanical and physical properties of the hybrid composites created from banana and jute fibers. For every experiment, the specimen's size was strictly maintained. The [0°J/G/G/0° J] and [0°B/G/G/0°B] orientations of the identical hybrid composite demonstrated greater tensile and flexural strength in comparison to the remaining orientations. By observing the tensile test in fig 4 and flexural test in fig 5 this work came to the conclusion that the [0°J/G/G/0°J] and [0°B/G/G/0°B] orientations exhibited exceptional characteristics.

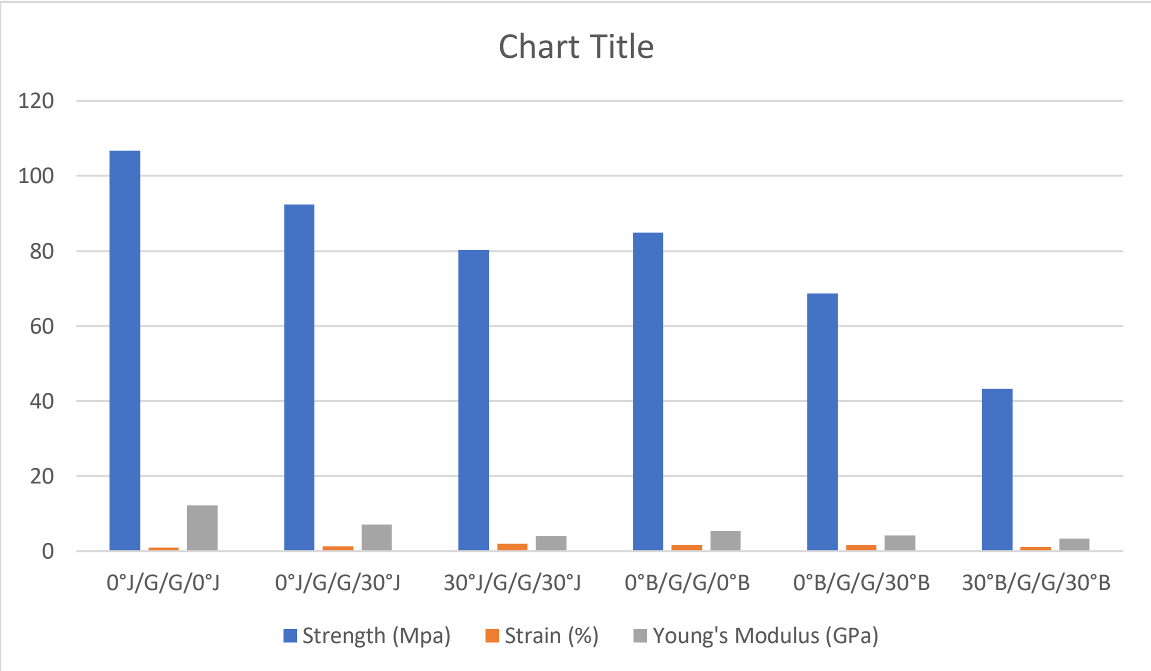

Fig 4: Tensile test outcomes for various hybrid laminates as a function of stacking orientations.

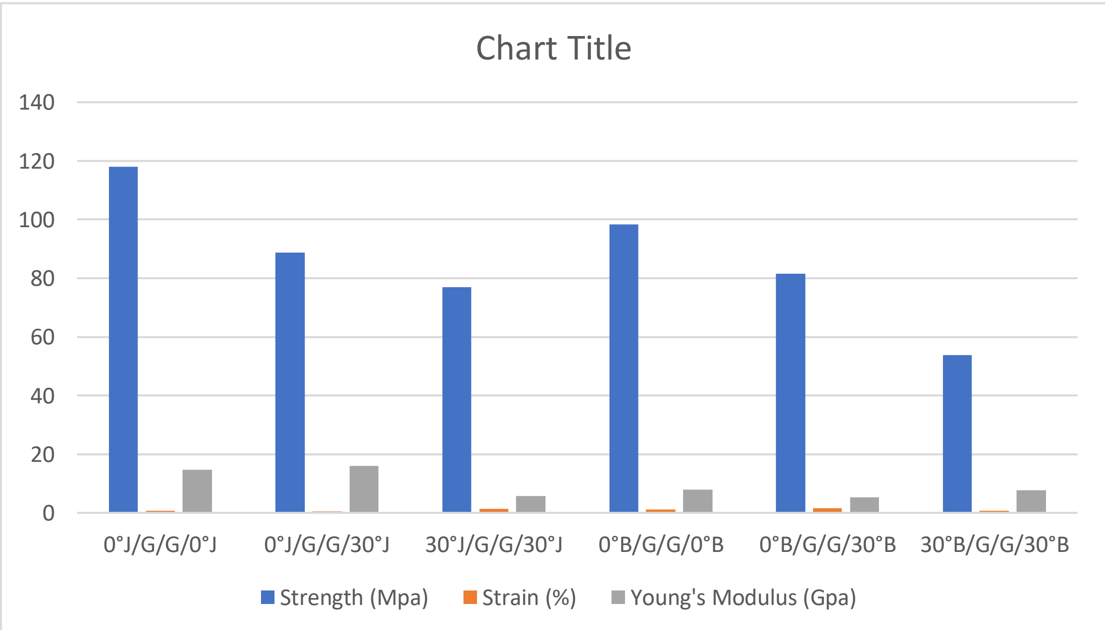

Fig 5: Flexural test results for several hybrid laminates and the impact of stacking orientations.

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CONCLUSION

In this review study, we have investigated and analysed numerous mechanical, chemical, and physical characteristics of GF composites and their use in a variety of industries, including construction and aerospace. Additionally, we have assessed the outcomes of GF reinforcement with natural fiber utilising various techniques, such as the hand layup technique, in terms of tensile strength, flexural strength, and impact characteristics. Fumed silica, alumina trihydrate, graphite, and calcium carbonate were used as additives to make an 8-layered composite that showed reduced deformation when exposed to higher temperatures.

The addition of glass fiber to a typical concrete mix improved the flexural strength, load bearing capacity, and fracture resistance of fiber-reinforced concrete structures. Additionally, we discovered a thermoset hybrid reinforced with 50% E-GF that is based on an unsaturated polyester resin and has potential applications in conventional civil construction. This material exhibits outstanding fiber-matrix bonding and a 389% enhancement of mechanical properties.

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