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# A Review on Carbon fiber Reinforced Polymer Composites and their applications

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## ABSTRACT

Recently in the engineering field, conventional metals are being largely replaced by composite materials due to their great mechanical behaviors. Among all composite materials, Polymer matrix materials as carbon fiber reinforced composites have proved to be a exceptional success and also called extreme of the material world due to their remarkable chemical, electrical, mechanical, thermal properties and excellent strength to weight ratio. Material selection for particular structures plays a vital role in the success of any industry as well as for safety aspects. CFRP has a wide area of applications including aeronautics, automobile, manufacturing, chemical and electronic industries, wind power plants, naval, nuclear sector, etc. This review attempt to study various applications and future trends of CFRP for structural applications worldwide.

**KEYWORDS:** Carbon Fibers,Mechanical Behaviour,Composites.

## INTRODUCTION

Polymer matrix composites are often utilised in aerospace. Fiber reinforced composites have been used as alternative materials for some years. Polymer matrix composites feature low density, high specific strength and stiffness, better corrosion resistance, and better fatigue performance than metals. The performance of these fibre reinforced composites under axial, torsion, and impact loading is critical for structural component design. The mechanical characteristics of FRP composites are determined by the fibre, matrix, and interface. Carbon fibre reinforced polymers are gaining popularity because to the unique features of carbon fibres and polymer matrix. Several extracts can improve the properties of CFRP.

Carbon fibre polymer-matrix composites are now being utilised in vehicles to save weight and fuel. Body panels, structural parts, bumpers, wheels, drive shaft, engine components, and suspension systems are all made of carbon fibre epoxy-matrix composites.

## OBJECTIVES

The aims and objectives of the present study are as follows: -

**a.** To study the Polymer reinforced composites in detail.
**b.** To investigate various applications and future trends of CFRP.
**c.** To analyze the economical and environmental effects of CFRP.
**d.** To review an increase in safety measures by using CFRP.

**e.** To discuss methods of reducing wastage and recycling of CFRP.

### 3. LITERATURE REVIEW:

Engineers regarded fibre reinforced polymer composites as a significant material class. They have excellent mechanical qualities, design freedom, and manufacturing simplicity. Lightweight, corrosion resistant, high tensile and flexural strengths are further benefits. The major load-bearing elements are polymer matrices with discrete interfaces between the two constituent phases, and the matrix functions as a load transfer medium between fibres. The matrix also shields the fibres from damage during and after composite production. The mechanical and physical qualities of natural fibres are vital to know before using them to achieve maximum performance. Several attempts have been made to replace glass with natural fibre composites in both non-structural and structural applications. Many vehicle parts and components that formerly used glass fibre composites are now made with eco-friendly natural fibres and composites [1, 2]

**Sirong Yu et al. [3]** the influence of nano rubber particles on epoxy tribological characteristics under dry sliding friction and various loads The results showed that 5% nano rubber particles concentration reduced wear mass loss and friction coefficient of nanocomposites the most. The nanorubber particles agglomerated, and the hardness of the nanocomposites reduced, increasing the specific wear rate. Epoxy and its nanocomposites wear mass losses increased with sliding time and applied load. This affects the wear mass loss and friction coefficient of nanocomposites. Epoxy and its nanocomposites' friction coefficients rose initially with applied force, but reduced when applied load exceeded 50 N..

**A. Alavudeen*et al.* [4]** investigated braided banana/kenaf hybrid fibre composites' mechanical characteristics. This is because the hybridization of kenaf and banana fibres boosts the mechanical strength. The woven hybrid composite of banana/kenaf fibres has improved tensile, flexural, and impact properties. SLS treatments appear to improve mechanical strength by improving interfacial bonding. SEM morphological investigations of cracked mechanical testing samples were undertaken to investigate fiber/matrix de-bonding.

**M. Ramesh *et al.* [5]** studied sisal, jute, and glass fibre reinforced polyester composites. They found that adding glass fibre to jute fibre composite increased tensile strength. The greatest flexural strength and maximum impact strength were attained for the sisal fibre composite.

**Amar Patnai*et al.* [6]** study of particle loaded glass epoxy composites abrasive wear and mechanical properties Their research focused on the abrasive wear behaviour of RGF reinforced with epoxy resin containing Al2O3, SiC, and pine bark dust. RWAT (dry sand/rubber wheel abrasion) tests were performed at 100 rpm. The experiments used 50 and 75 N loads with abrading distances ranging from 200 to 600 m. Experiment findings showed that composite wear was responsive to differences in abrading distance but not to sliding velocity.

**Hemalata Jena *et al.* [7]** study of bamboo fibre composite with cenosphere. They found that adding cenosphere as a filler and lamina substantially affects the impact property of bio-fiber reinforced composite. The impact strength of a laminated composite is raised by adding filler up to a point and then lowered by adding more filler. The results show the impact characteristics are sensitive to filler concentration. The impact strength increases from 3 to 7 lamina and decreases from 7 to 9 lamina. The maximal impact strength of all 7 layers composite with 1.5 wt% cenosphere is 18.132 KJ/m2. The composites' density also decreases, which is dependent on the filler and fibre content.

**Girisha, C. *et al.* [8]** investigated the mechanical characteristics of composites made of chemically treated arecanut husk and tamarind fruit fibres. They found that treated fibres outperformed untreated fibres. They also discovered that the strength of hybrid composites improves with fibre volume fraction. In this study, arecanut husk and tamarind fruit fibres were reinforced with Epoxy matrix and composites were hand laid up. All hybrid natural fibre composites had maximal mechanical characteristics for 40% - 50% of the fibre reinforcements, according to the experiment.

**Pooja Bhatt et. al (2017) [9]** studied applications of carbon fibers for the structural design field. They suggested these composites are the best building materials with suitable chemical, electrical, and mechanical properties.

**R. Masilamaniet. al (2017) [10]** discussed the composite material used in the production of automobiles which has the greatest impact on fuel economy, high speed, and safety concerns. They concluded carbon fibers are lighter than the conventional materials and can be more beneficial for cost-effective production.

**S.R. Naqvi et. al (2018) [11]** investigated the utilization of CFRP in automotive, aerospace, and many other engineering fields. Also, they have discussed the negative impact of composite materials on an environment.

**Shubham S Narwadeet. al (2018) [12]** evaluated a woven carbon fibre reinforced cloth wrapping's potential to strengthen architectural components. Concrete cubes were produced and carbon wrapped to test strength.

**BelalAlemouret. al (2018) [13]** provided a comprehensive review of electrical properties of conductive carbon composites, and how these composite materials can be utilized to improve and enhance the electrical properties of some polymers such as epoxy resin to be used in more applications.

**A. Kausar (2019) [14]** presented a state-of-the-art review on polyamide/carbon fiber composites. They stated various applications of carbon composite materials in the field of aerospace, automobile, construction, and other industries.

**AbbasaliSaboktakin (2019) [15]** covered 3D textile accomplishments and composite specifications and various types of damages in these materials. NDT techniques developed for detecting defects in 3D preforms and composite were presented.

**BelalAlemouret. al (2019) [16]** presented various problems that aircraft faces in the air. They discussed the contribution of composite materials towards reducing their weight and gain more efficiency.

**D. Suresh et. al (2019) [17]** discussed how adding graphite powder in the CFs composite increases the mechanical behavior of the resulting specimen. They concluded that the inclusion of graphite powder in CFs reinforced epoxy composites increases its properties compared to the untreated one.

**Suhyun Lee et. al (2019) [18]** prepared various types of CFRP with improved mechanical behavior and electrical properties. They showed the electrical behavior of the composites was improved significantly with the addition of carbon fibers.

**Yingwu Zhou et. al (2020) [19]** researched the dual function of a carbon fiber-reinforced polymer bar working as reinforcement and impressed current cathodic protection anode for reinforced concrete structures.

**Onalet al. [20]** studies the properties such as tensile and flexural strength of glass/carbon hybrid specimen withlayer by layer sequence before impact and after impact. It is found out that carbon fire on the end surfaces increases flexural strength and also the tensile property of hybrid is better.

## 4. RESEARCH GAPS

Very less work is carried out on compassion between the conventional fibers and CFRP on basis of cost and productivity. Very less literature is available regarding the long-term service performance of CFRP. Big data collection on a large scale and performance analysis of CFRP as compare to natural or conventional fibers yet to be done properly worldwide. Literature regarding simulations of structures made of CFRP is yet limited. Very less research work available regarding the recycling and waste disposal for CFRP.

## 5. APPLICATIONS

Carbon composites show a significant change in their electrical behavior with applied external pressure. Due to this unique characteristic, they become useful for the health monitoring of engineering structures *[21]*. Carbon fibers can be added to concrete to control the propagation of cracks, limit the crack width, and to increase its durability and strength *[22]*. The carbon fiber reinforced concrete is made up of adding the CFRP to the normal concrete. Effective reinforcement leads to increase resistance against earthquakes *[23]*. These materials have wide applications such as in the manufacturing of hybrid smart memory composites, aeronautical applications, wind power generation, marine applications, medical equipment and prosthetic devices, thermoplastic applications, for engineering constructions (bearings, gears, cams, fan, and turbine blades), in telecom applications, in automobile sectors, textile industries, in high-end sports equipment, for high-quality audio components and musical instruments, etc*[24]*.

## 6. OPPORTUNITIES & FUTURE TRENDS

In the future, CFs research will be focused on cost reduction and property enhancements. As the research in the area of optimization of the crystallite size, shape, and distribution by changing processing parameters and their effect on the fiber properties is limited yet. Innovative cost-effective waste disposal and recycling methods are the major challenges for the CFRP field in the future. There will be large opportunities to recycle composite materials without causing any negative environmental impact. Quantitative analysis of intrinsic safety factors by using simulations for advanced composite structure based on a knowledge of the physical damage processes can be analyzed. There is an urgent necessity for the classification of all grades of composite materials based on their various properties, manufacturing techniques, and production costs. Economical and portable non-destructive kits to quantify undesirable defects in hybrid composites should be made.

## 7.SUMMARY

This work presents a detailed review of applications and future trends of CFRP composites in various fields. Through literature, we found CFRP significantly increases the life of structures, strengthened infrastructure, and minimized the maintenance requirements. Discrepancy related to tensile and compressive strengths of CFs observed in a significant amount. Therefore, integrated efforts may be used in the CFRP area to reduce the existing gap between theoretical and practically calculated tensile strengths, and work should be done to improve the compressive behavior of carbon fibers.

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