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Development and Analysis of Mechanical Properties of Natural FRP Composites for Marine Applications

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ABSTRACT

Polymer matrix composites with filler reinforcements have undergone considerable advancements recently. In a variety of industries, including aerospace, automotive, construction and marine, these composites have showed considerable promise. The mechanical qualities of the composite material, such as strength, stiffness, and toughness, can be enhanced while keeping a low weight by the inclusion of natural fiber and filler reinforcements. Filler and fiber reinforcements has shown a great promise in improving the performance and versatility of composite materials, and further research and development in this area are expected to continue. Despite the many benefits of polymer matrix composites with filler and fiber reinforcements, there are still problems that need to be solved. For example, it is difficult to achieve uniform reinforcement dispersion, to manage the interfacial bonding between the particles and the polymer matrix, and to scale up production without increasing costs. Numerous crucial fundamental features of a composite material are heavily influenced by the homogeneous distribution of filler particles throughout the material. The enhancement is significantly affected by the uniformity of the dispersion of these particles, inclusions, filaments, or fibers within the matrix material. In this proposed work mainly deals with the development and analysis of the Natural FRP polymer composites with added natural filler which are abundantly available in and around our vegetation such as coconut, bamboo, cactus etc. The Natural composites can be fabricated and tested for its mechanical, metallurgical and Thermal characteristics and compare with the properties of existing material and explore the opportunities of introducing the natural fibers and fillers in the existing Marine composite materials such as Ferro cement, Glass reinforced plastic, Aramid fiber Composites etc.

Keywords: Composites, interfacial bonding, FRP

1 Introduction

In recent years, composite cross-arms made of high-performance fibre-reinforced polymer (FRP) have made it possible to replace conventional steel cross-arms. Due to their benefits for



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lightning protection, saving space along line corridors, and lowering the weight of each tower, composite cross-arms are used in transmission projects for high-voltage and ultra-high voltage ranging from 10 to 1000 kV. Research is being conducted at Queen's University in collaboration with the National Research Council (NRC) of Canada and industry partners to examine the effects of fire on the mechanical and thermal properties of FRP, reinforcing steel, and various insulation materials used in fireproofing FRP.

FRP offers numerous advantages over steel, including high strength to weight ratios, resistance to electro chemical corrosion, and ease and speed of application. To describe the mechanical and thermal characteristics of these materials, small-scale material tests are being carried out. These clever materials will enable the creation of features that are almost ideal. Hence FRP composite is prepared to demonstrate that technical advancements know no bounds and will significantly improve our quality of life. A fibre reinforced polymer composite is defined as a blend of a polymer (plastic) matrix (either a thermoplastic or thermoset resin such as polyester, vinyl ester, epoxy, or phenolic) and a reinforcing material such as glass, carbon, aramid, or other reinforcing material with a sufficient aspect ratio (length to thickness) to provide discernible reinforcing functions in one or more directions. Additionally, FRP composite may include core components, fillers, and additives that improve and modify the finished product. When working together to provide a variety of advantages perfect for structural applications, the constituent elements in a composite maintain their identities (they do not entirely melt or merge into one another). Tensile, flexural, impact, and compressive strengths are just a few of the mechanical qualities that composite materials can be made to offer. Additionally, composites can have their strengths orientated to fit certain design specifications of an application, unlike traditional materials. Compared to most metals, FRP composites offer greater strength per unit of weight.

Modelling of the composite layered parts' performance under load is required because it is anticipated that they would be used in functional goods. The addition of the reinforcing fibres alters the matrix material's intrinsic mechanical properties in fibre reinforced composite materials. The amount of reinforcing materials used in the geometrical arrangement inside the matrix, as well as the material properties of the two consistent components of their interface, all affect the mechanical properties of composite materials. The composite fabrication method determines how many reinforcements are used and how they are arranged.

2 Literature review

They are fascinating materials in polymers and present new opportunities for multifunctional materials due to their mechanical properties [2–5], high aspect ratio, high young's modulus, and high tensile and electrical strength. Conductive polymers with enhanced mechanical performance, for instance. The ease of processing and light weight of polymers are two benefits. High particle loadings during processing lead to finished products with substantially



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higher weights than those of the pure polymers. Consequently, it is desirable to have a composite with superior characteristics at low particle concentration. Compared to most metals, FRP composites offer greater strength per unit of weight. In actuality, FRP composites typically weigh half as much as steel. Additionally, the composite can be formed into a single complicated item, frequently replacing assemblies made up of numerous parts and fasteners. FRP composites are an effective material system because of the combination of these two advantages.

Structures can be transported on site, partially or fully prefabricated at the manufacturing facility, and installed in a matter of hours. The creep resistance of the properly designed FRP item is increased by adding reinforcement to the polymer matrix. If the stresses on the structure are kept below the required working stress levels, creep won't be a severe problem.

3 Test procedure

Tensile tests determine the amount of stretch or elongation needed to break a specimen as well as the force necessary to achieve that stretch or elongation. A stress-displacement diagram and a load-displacement diagram are produced during tensile tests and are used to calculate tensile modules. The information is frequently used as a material specification, to design parts that can bear application force, and as a material quality control check. To measure strength and elongation, ASTM D 638 specimens are loaded into the UTM's grips at a predetermined grip separation and pushed off the machine until they fail.

Table 1: composite combinations

Sample	Combinations	Percentage	Weight in gm
A	PR	85	1275
	FR	15	225
B	PR	80	1200
	FR	20	300
C	PR	75	1125
	FR	25	375
D	PR	70	1050
	FR	30	450

4 Results and discussion

The different weight percentage specimen combinations of natural fiber and polyester resin are shown in Table 1. The preparation of samples A, B, C, and D included both PR and FR. These moulded specimens were created in accordance with ASTM D 638, and they were tested at room temperature in a computerized universal testing machine at a speed of 50 mm/min. Plots of Ultimate Tensile Strength (UTS) in N/mm² versus specimens of various combinations are



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shown in the graph "Specimen Vs UTS." As can be seen, specimen A produced 266 N/mm^2 for 15% of FR, while specimen B produced 274 N/mm^2 for an additional 5% of FR, nearly an increase of 8% in UTS for a 5% increase in fibre due to improved bonding between FR and PR. Specimen C produced 309 N/mm^2 for the 5% FR increase's rose to 35% of the total. D produced 322 N/mm^2 for the 5% FR increase.

Plots showing yield strength against several specimens are shown in "Yield Strength vs. Specimen." For a 15-weight percent increment, FR specimen a produced 232.67 N/mm^2 , while for a 5-weight percent increment, FR B produced 234.24 N/mm^2 . For a 5-weight percent increase, FR yields 235.81 N/mm^2 for the specimen C. For a 5-weight percent increase in FR, specimen D produces 231.88 N/mm^2 . When 30 wt. % FR is applied, the yield strength decreases as FR continues to rise.

5 Conclusion

This study examined at room temperature the tensile behaviour of an experimentally made FRP in various combinations of PR and FR. The following is a summary of the findings. When FR is increased by 5%, the FRP has a suitably high ultimate tensile strength. On adding 5wt% of FR, yield strength improves to 235.81 N/mm^2 . A 5-weight percent increase in FR causes the Young's modulus in A to rise to $1.97 \times 10^3 \text{ N/mm}^2$. Lateral strain and the Poisson ratio were reduced in specimen D with the addition of 30% FR, and linear strain in specimen A was reduced with the addition of 5wt% FR.

The study's top six predictors of FR's effects on FRP are considerable increases in UTS, yield strength, and young's modulus, as well as decreases in linear strain, lateral strain, and poison's ratio.

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The above-mentioned work is a portion of my original research work. All the work done are correct to the best of my knowledge.

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