A STUDY ON ADVANCED MODELING TECHNIQUES FOR COMPOSITE FIBERS

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ABSTRACT

The study of natural fiber-based composites through the use of computational techniques for modelling and optimizing their properties has emerged as a fast-growing approach in recent years. Ecological concerns associated with synthetic fibers have made the utilization of natural fibers as a reinforcing material in composites a popular approach. Computational techniques have become an important tool in the hands of many researchers to model and analyze the characteristics that influence the mechanical properties of natural fiber composites. This recent trend has led to the development of many advanced computational techniques and software for a profound understanding of the characteristics and performance behavior of composite materials reinforced with natural fibers. The large variations in the characteristics of natural fiber-based composites present a great challenge, which has led to the development of many computational techniques for composite materials analysis. The oil and gas sector, building, transportation, healthcare, sports, and aviation are just a few of the many everyday uses for composites. Certain applications, like rocket ships, rely on composite materials for liftoff. The study delves into the advantages of fibre composite materials, including their basic concepts, production methods, and practical applications. It delves into several facets, including materials' chemical make-up, production and development processes, qualities, and numerous uses.

Keywords: *natural fibers, fiber composite materials, chemical make-up, reinforcing material, computational techniques.*

INTRODUCTION

LITERATURE REVIEW

vette S. Tankpinou Kiki (2023) This work focused on the search for biobased materials capable of being used in road techniques as soil inclusions, and on studying the influence of their incorporation on the characteristic parameters of pavement layers. To this end, pineapple, cyperus and imperata plant fibers, due to their endemic availability, were used as reinforcement on sourced materials, notably bar soil, lateritic gravel and silty sand. Complete identification and mechanical tests (Proctor and CBR) were carried out on materials in their natural state (soil) and on composite materials (soil + plant fibers) in the laboratory to determine their classification in road geotechnics, their compaction parameters and their mechanical behavior. Firstly, the various types of 2.5 cm long fibers were incorporated into the different types of soil at mass contents of 1% and 2%.

M Palanivendhan [2021] Automobile manufacturers are now compelled to seek innovative methods to improve the fuel efficiency of their vehicles in response to the substantial rise in fuel prices across all transportation sectors. The reduction in vehicle emissions and the decrease in the use of non-renewable fossil fuels are directly linked to the decrease in fuel consumption. Every road vehicle is meticulously designed to expertly manage the airflow around it, taking into account its shape and frontal area, during typical driving conditions. The aerodynamic resistance of the air around a car is a significant factor that hinders its forward motion. The amount of drag force that the vehicle encounters is directly related to its speed. Understanding the behavior of vehicles is crucial for someone with expertise in mechanics. They should be aware that reaching a goal can result in a noticeable increase in resistance force at specific speeds. Due to regulations and passenger capacity limits, passenger cars often have a more geometric and rectangular shape.

Md Abul Shahid (2021) In every phase of life, from clothing to technical textiles, natural fibers are used. Water absorption of fibers is considered really important in many aspects, e.g., Sportech, Medtech, Geotech, etc. This work analyses water absorption of raw and alkali-treated cotton, arecas, pineapple leaves, and banana fibers. Fibers were scoured with different concentrations of alkali (2, 4, 6 gm/L NaOH), washed and neutralized with the dilute acetic acid solution, then dried. Later on, the fiber samples were immersed into distilled water, and water absorption percentages of the fibers were determined every 10 minutes within 1 hour in total. It appeared that at untreated conditions, the areca fiber has the highest water absorption capacity compared to the other fibers.

Mike R. Bambach (2020) Recent decades have seen substantial interest in the use of natural fibers in continuous fiber reinforced composites, such as flax, jute and hemp. Considering potential applications, it is of particular interest how natural fiber composites compare to synthetic fiber composites, such as glass and carbon, and if natural fibers can replace synthetic fibers in existing applications. Many studies have made direct comparisons between natural and synthetic fiber composites via material coupon testing; however, few studies have made such direct comparisons of full structural members. This study presents compression tests of geometrically identical structural channel sections fabricated from fiber-epoxy composites of flax, jute, hemp, glass and carbon. Glass fiber composites demonstrated superior tension material coupon properties to natural fiber composites. However, for the same fiber mass, structural compression properties of natural fiber composite channels were generally equivalent to, or in some cases superior to, glass fiber composite channels. This indicates there is substantial potential for natural fibers to replace glass fibers in structural compression members.

Nnomo Elobi Didine (2020) In this work we determine the physical and mechanical properties of local composites reinforced with papaya trunk fibers (FTP) on one hand and particles of the hulls of the kernels of the garlic (PCNFA) in the other hand. The samples are produced according to BSI 2782 standards; by combining fibers and untreated to polyester matrix following the contact molding method. We notice that the long fibers of papaya trunks improve the tensile/compression characteristics of composites by 45.44% compared to pure polyester; while the short fibers improve the flexural strength of composites by 62.30% compared to pure polyester. Furthermore, adding fibers decreases the density of the final composite material and the rate of water absorption increases with the size of the fibers. As regards composite materials with particle reinforcement from the cores of the winged fruits, the particle size (fine ≤ 800 μm and large ≤ 1.6 mm) has no influence on the Young's modulus and on the rate of water absorption. On the other hand, fine particles improve the flexural strength of composite materials by 53.08% compared to pure polyester; fine particles increase the density by 19% compared to the density of pure polyester.

Modern Composites

Exposure to cutting equipment may degrade composites, which can lead to the fracture of the reinforcing fibres. Cutting tools, on the other hand, may swiftly slice through metal. In order to avoid tool friction while dealing with composites, it is essential to have sharp cutting edges and enough space. Because it changes the geometry of the cutting edge, tool wear is a major source of difficulties including overheating, edge degeneration, and component quality concerns. Extreme care must be used when dealing with CFRPs and modifying the cutting zone temperature. Because of limitations in heat transport to the chips, cutting CFRP might be difficult owing to temperature-related concerns. Workers whose jobs include working on flat surfaces have specific tooling requirements. The state-of-the-art indexable insert technology guarantees these instruments' top-notch performance. Use a facemill or endmill with diamond-tipped or diamond-coated inserts if you're dealing with a composite material that includes many fibres. Solid carbide cutters, carbide inserts, and diamond inserts are just a few of the many alternatives available for high-quality edging and trimming.

The Benefits of Composite Manufacturing in the Aerospace Industry

The aviation sector greatly benefits from composites due to their lightweight nature. Composites used in aircraft construction have exceptional impact resistance, thermal stability, and tensile strength, all of which contribute to their superior crash test results. Composites outperform more conventional materials in corrosion and fatigue tests. In addition, assembling them is a breeze. These advantages are starting to stand out more and more as composite technology keeps becoming better and aerospace components made of composites become cheaper. Composites, especially for use in aircraft, are the wave of the future. As a result of growing fuel prices, the commercial aerospace industry must now face the problem of increasing aircraft performance while decreasing weight. It is quite likely that future aero planes will be built using composite materials, considering the tremendous advancements in composite manufacturing technology. As composite science keeps making huge strides forward, materials like basalt or carbon nanotube composites could revolutionize the way aero planes are built.

Differences between fibrous and particulate composites

When compared to traditional metals, fibre and particle composites stand out due to their distinctive properties. Isotropic qualities describe typical metallic and a particle composite material, which means their strength and stiffness are constant in all directions. But fibrous composites are anisotropic, thus their properties change depending on the load's direction relative to the fibres' orientation. Bending a little piece of balsa wood parallel to its fibres makes it more pliable but also more fragile than bending it at an angle. This anisotropy may be solved by carefully stacking very thin layers, often less than one millimeter, in a stack. Laminates have several layers with fibres arranged at various angles. Even though there will be less of a difference in features across orientations, the laminate will nonetheless behave anisotropic ally. To ensure the laminate can withstand certain pressures and enhance its properties, an additional treatment is usually necessary for aviation applications. An exact arrangement of layers, ranging in amount from a few to maybe several hundred, must be carefully built to achieve this goal.

Fibrous composites

Strong, inflexible fibers and a resin matrix are the primary components of a composite material. Natural composites include things like wood and bone. Wood is made up of cellulose fibers embedded in a lignin matrix, while bone is composed of hydroxyl-apatite particles encased by a collagen matrix. Highly regarded synthetic materials, carbon and glass fiber reinforced plastic (GFRP) find widespread use across many industries, but notably in the aerospace industry. Composites made of carbon and glass fibers are quite strong and stiff for their weight, yet they may break easily. These items are more durable thanks to a polymer matrix, although they may not be very strong or rigid. Composites having desirable properties (e.g., low density, high strength, stiffness, and toughness) may be efficiently produced by combining components with complementary features, thereby reducing the negative effects of any one component.

RESEARCH METHODOLOGY

Experiments have been performed on the natural fibers such as coconut sheath naturally woven mat, sisal and banana fibers for the development of natural fiber based polyester composites. Glass fibers are used to fabricate sandwich composites in the present work. The glass fibers in the form of weaved pattern are obtained from the GVR Enterprises, Madurai, India. Initially, the fibers are washed with distilled water and dried in air. Few researchers reported the free vibration characteristics of natural fiber composites. Very limited attempts have been made by the researchers to study the effect of inter lamina fiber orientation on mechanical properties of composites. This research vacuum has motivated to study further on mechanical with free vibration studies on different fiber inter lamina orientations by using sisal and banana fibers in polyester composites. But there is no work on hybrid composites made up of sisal, banana and coconut sheath combination of different layering patterns whereas the hybrids are surface modified. There are limited works to analyze the free vibration characteristics such as natural frequency and damping of short sisal and short banana fiber reinforced polyester composites. Although some of the studies have been reported on sisal and banana fiber reinforced with polyester matrix composites hybridized with some other natural fibers, no work is available by hybridizing with coconut sheath fiber with different layering patterns. Even though authors have reported the effect of surface modifications on the mechanical properties of sisal and banana fiber reinforced.

RESULTS AND DISCUSSIONS

The red on the top of the scale indicates the highest peak of strain developed and it is 0.000092936 mm/mm maximum under 1000N pressure load and the blue indicate the lowest strain developed occurrence ranges from 0.0000031243 mm/mm. The colour changing from red to blue indicates the strain developed is lessening gradually From top to bottom. The strain is optimum as the average strain at 1000N is 0.000030025mm/mm.

Table 1: The values of stress developed of S-Glass

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.	8.3602e-002	7.9541	2.5436

The red on the top of the scale indicates the highest peak of stress developed and it is7.9541MPa maximum under 1000N pressure load and the blue indicate the lowest stress developed occurrence ranges from1.83MPa-0.083602 MPa. The colour changing from red to blue indicates the stress developed is lessening gradually From top to bottom. The stress is optimum as the average stress at 1000N is 2.7071MPa.

Strain energy-

The strain energy of the S-Glass after the analysis gives the minimum strain energy of0.00000067484 mJ and the maximum value of 0.00076669 mJ and on the total of 0.52008mJ as mentioned in the below table. The values of the strain energy are the output of the force 1000N in the Ansys software.

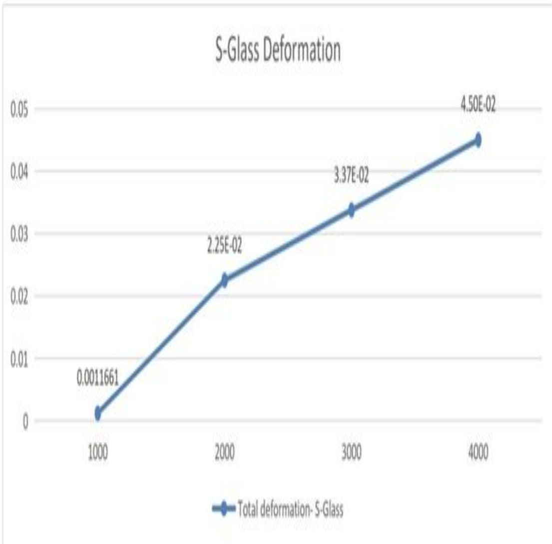
Table 2: The values of strain energy developed of s-glass

Time [s]	Minimum [mJ]	Maximum [mJ]	Total [mJ]
1.	6.7484e-007	7.6669e-004	0.52008

The red on the top of the scale indicates the highest peak of strain energy and it is 0.00076669 mJ maximum under force 1000N and the blue indicate the lowest strain energy occurrence ranges from 0.000256 mJ-0.00000067484 mJ. The colour changing from red to blue indicates the strain energy is lessening gradually. From top to bottom. The strain is optimum as the total strain energy at 1000N is 0.52008mJ. Similarly The results for E-glass at 2000Nare

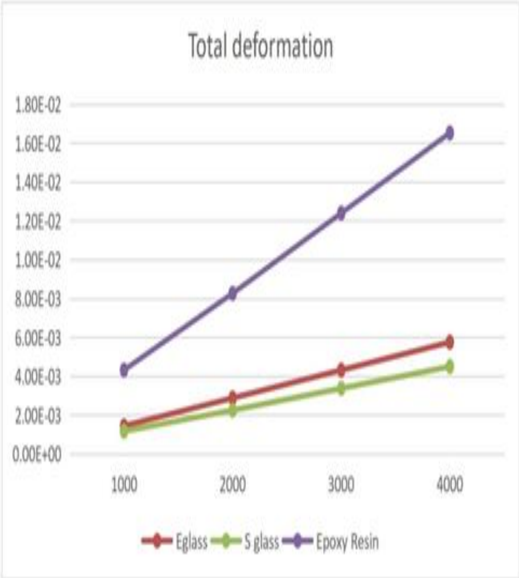
The overall result of the epoxy resin (1000N) Analysis

The Standard units meshing and the geometry as keep same for Epoxy Resin. The table briefs about total deformation, Stress, Strain, Stain energy respectively of composite S-glass at reinforced phase after the analysis.



Comparing the results of E-glass, S-glass, Epoxy resin

Hence, there is decrease in the total deformation and by comparing the values of deformation for each E- glass, S-glass, Epoxy resin. The percentage of decrease in total deformation compared to E-glass and S-glass and Epoxy Resin where the Epoxy Resin which exhibits good strength, Hardness. Thus S-glass has good strength and hardness compared to others composites in rein forced phase.



Graph 1: The graph is values of total deformation for different composites

Hence, there is decrease in the total stress produced and by comparing the values of deformation for each E- glass, S-glass, Epoxy resin. The percentage of decrease in total deformation compared to E-glass and S-glass and Epoxy Resin where each composite gives at most same stress which exhibits good strength, Hardness. Thus any of 3 can be taken preferably S-glass has good strength and durability compared to others composites in reinforced phase.

CONCLUSION

Evaluate the performance of composite fibers under different loading conditions, considering factors such as tensile strength, stiffness, fatigue resistance, and impact resistance. This evaluation helps in understanding the suitability of these fibers for aerospace applications where high performance under extreme conditions is crucial. Identify optimal fiber configurations and composite architectures to maximize performance while minimizing weight and cost. This involves conducting parametric studies and optimization algorithms to find the best combination of fiber types, orientations, and matrix materials. Assess the durability and reliability of composite materials over the expected lifespan of aerospace structures. This includes studying the effects of environmental factors (such as temperature, humidity, and exposure to chemicals) on the mechanical properties of composite fibers. Failure Analysis: Investigate failure mechanisms in composite materials, including fiber breakage, delamination, and matrix cracking. Understanding these failure modes is crucial for designing robust aerospace structures that can withstand the demands of flight operations. Validate the modeling and analysis results through experimental testing. Comparison between experimental data and numerical predictions helps in verifying the accuracy of the models and provides confidence in their predictive capabilities.

Discuss potential avenues for further research and development to address current limitations and enhance the performance of composite fibers for aerospace applications.

REFERENCE

1. *Mike R. Bambach (2020), "Direct Comparison of the Structural Compression Characteristics of Natural and Synthetic Fiber-Epoxy Composites: Flax, Jute, Hemp, Glass and Carbon Fibers",Fibers,ISSNno:2079-6439,Vol.8(10),Pages. 62.DOI:10.3390/fib8100062*
2. *Sp.G.Pantelakis [2012] "A critical consideration for the use of Al-cladding*

for protecting aircraft aluminum alloy 2024 against corrosion", Theoretical and Applied Fracture Mechanics, Vol.57, Issue.1, Pages.36-42.https://doi.org/10.1016/j.tafmec.2011.12.006.

3. *SufangTang [2017] "Design, Preparation and Properties of Carbon Fiber Reinforced Ultra-High Temperature Ceramic Composites for Aerospace Applications: A Review", Journal of Materials Science & Technology, ISSN 2410-4701,Vol.33,No.2,Pages.117-130,https://doi.org/10.1016/j.jmst.2016.08.004.*
4. *Sujata Warambhe [2017] "A Mini Review on Properties and Application of Composite Materials",International Journal of Composite Materials and Matri-ces,ISSN:2582-435X,Vol.3,No.1,https://doi.org/10.37628/jcmm.v3i1.283.*
5. *Md Abul Shahid (2021), "Analysis of Water Absorption of Different Natural Fibers",Journal of Textile Science and Technology,ISSNno:2379-1551,Vol.7, No.4,Pages.152-160.*
6. *T.G. Yashas Gowda [2018] "Polymer matrix-natural fiber composites: An overview", Cogent Engineering, Vol.5, Issue.1,https://doi.org/10.1080/23311916.2018.1446667.*
7. *Mohan Jagadeesh Kumar M [2013] "Effect of Vortex generators on Aerodynamics of a Car: CFD Analysis", International Journal of Innovations in Engineering and Technology, ISSN:2319-1058, Vol.2, Issue 2.*
8. *M Palanivendhan [2021] "Aerodynamic simulation of optimized vortex generators and rear spoiler for performance vehicles", Materialstoday Proce-edings, Vol.45, Pages.7228-7238.https://doi.org/10.1016/j.matpr.2021.02.537.*
9. *vette S. Tankpinou Kiki (2023), "Influence of Some Plant Fibers on the Mechanical Performance of Composite Materials",Open Journal of Civil Engineering,ISSNno:2164-3172,Vol.13,No.4,Pages.814-826.*
10. *Nnomo Elobi Didine (2020), "Elaboration and Characterization of Composite Materials Reinforced by Papaya Trunk Fibers (Carica papaya) and Particles of the Hulls of the Kernels of the Winged Fruits (Canarium schweinfurthii) with Polyester Matrix",Journal of Minerals and Materials Characterization and Engineering,ISSNno:2327-4085,Vol.8,No.5,Pages.341-352.*