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Experimental Investigation of Static and Dynamic Bahavior of Natural and Artificial Composite for Automobile and Aerospace Application.

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Abstract*: The aim of this study is to provide a comprehensive overview of the fabrication, design, and characteristics of sustainable composites based on natural, artificial, and hybrid fibers, particularly with coconut, banana, and jute fibers. It emphasizes these materials as resources that are very friendly to the environment for application in the automotive and aerospace sectors. This discusses the influences of mixing together natural fibers of banana and jute with synthetic fibers in hybrid composites with an objective to increase the shelf life and the performance of the epoxy-based composites. Key techniques in the manufacture of fiber composites include fiber choice, surface modifications, and composition of the epoxy matrix; processing techniques like compression molding, vacuum infusion, and traditional lay-up all became important contributors. Mechanical tests return tensile strengths from 12 MPa (abaca) to 1627 MPa (fruit-based composites), and densities from 295 kg/m³ for kenaf up to 1560 kg/m³ for pineapple, so these are versatile materials. The study underlines that mechanical performance, tensile strength, thermal conductivity, and impact resistance are highly influenced by fiber-matrix interaction, fiber orientation, and interfacial adhesion. Hybrid composites show immense potential for use in structural and non-structural applications in automotive and aerospace industries, especially in load-bearing and interior components. The research concludes that the integration of coconut, banana, and jute fibers in epoxy-based composites offers a promising solution to reduce environmental impact while maintaining durability and performance, supporting sustainable advancements in high-performance sectors*

Keywords: Natural Fiber Composites, Hybrid Fiber Composites, Coconut, Banana, Jute Fibers Sustainable Materials, Automotive Applications and Aerospace Applications

I. INTRODUCTION

Epoxy-reinforced natural fibre composite materials provide an appealing alternative to typical synthetic fibre combinations owing to their unique mix of physical qualities and sustainable development as well as affordability[1]. These materials are made up of an epoxy resin matrix strengthened with natural fibres including flax, sisal, jute, hemp, bananas, and coconuts [2]. By adding natural fibres, the composites' mechanical durability is improved and they may be used in a variety of industries. An essential component fibres derived from multiple kinds of plants. In addition to lowering carbon emissions, these naturally occurring substances increase the variety of uses for composite materials. With a focus on their importance in promoting durability in material development, this paper examines the diverse range of plant sources accessible for the synthesis of natural fibres. A comparison of glass and natural fibres for composite manufacture is shown in Figure 1.

Two popular fibre types utilised in the creation of composites are glass and natural fibres, each having special qualities and uses. Natural fibres that come from plants or animals are sustainable and biodegradable, which makes them good for the environment. Epoxy-reinforced natural fibre materials may be used in the automobile sector for internal components like consoles and door panels, which lower vehicle mass and increase fuel economy. Additionally, using fibres that are natural has the possibility to lessen the vehicle industry's carbon impact[3].building materials like concrete or steel when used for structural components like posts and beams. Epoxy-reinforced natural fibre composites' high durability and rigidity guarantee structural integrity, whilst their lightweight design makes deployment and transit

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easier.The use of these plastics for nonstructural elements like internal panels and fairings in the aircraft sector is another exciting use case [4-6] Because these materials are lightweight, aeroplane makers may significantly decrease their weight, which improves fuel economy and lowers pollutants [7].

Additionally, the aviation sector's growing emphasis on sustainability and environmentally friendly components is consistent with the usage of fibres from plants in aerospace projects. Epoxy-reinforced organic fibre composites are used in consumer products like sports equipment and furnishings in addition to automotive and aerospace sectors. These components are appealing for eco-friendly product design because they provide a balance among environmental conscience, resilience, and aesthetics [8]. Renewable energy applications may benefit from natural fibre composites' excellent strength-to-weight ratio and resisting fatigue in wind turbine blades [9]. This makes it possible to create turbines for winds that are more robust and efficient, which helps to increase the production of renewable energy. Furthermore, the maritime sector may find use for epoxy-reinforced natural fibre composites for boat decks and hulls [10]. Naturally fibres' durability is guaranteed by their immunity to water absorption and deterioration, and their small size enhances vessel performance and fuel economy.

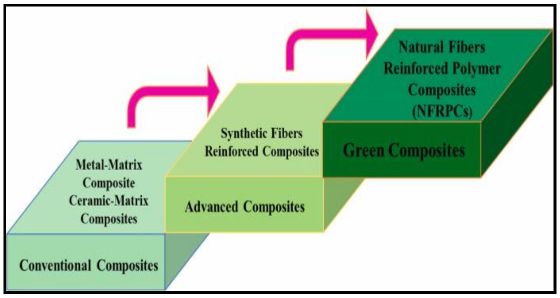

Figure 1: A view of composites emergence

The common natural fibres shown in Figure 2—banana, jute, coconut, and sisal—are all thought to be appropriate for natural fibre composites made of epoxy resin. Natural fibres are combined with epoxy resins to create epoxyreinforced composites, which are materials with improved chemical, biological, and thermal properties, these fibres are useful reinforcements throughout Composite substances. The way they interact with epoxy resin contributes to a variety of manufacturing processes by improving the durability and resilience of the substrat[11]. Epoxy-reinforced cellulose materials provide a broad variety of potential uses across several industries by combining mechanical achievement, environmental sustainability, and economic efficiency. Development efforts made to enhance these materials' properties and production processes are expected to have a greater influence on building a future that is more sustainable. This study highlights how epoxy-reinforced renewable fibre composites, including fibres like sisal, jute, flax, and hemp, provide improved mechanical properties, benefits for the environment, and a variety of uses in the building, automobiles, and aviation sectors. Their sustainability, affordability, and compact size make them a compelling substitute for traditional synthetic fibre composites.

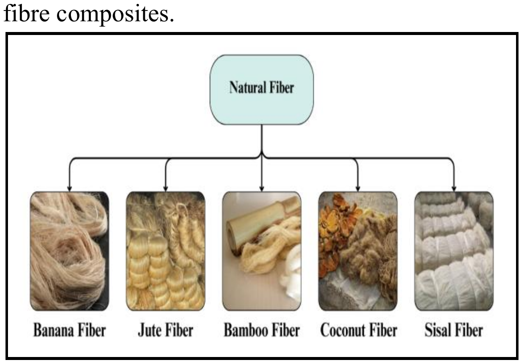

Figure 2:Types of Fibers

1.1. NATURAL FIBRE SYNTHESIS USING PLANT SOURCES

Aggregation of long, decaying plant cells held together by pectin and other noncellulosic materials make up plant fibres. A single fibre (or cell) is made up of two walls [12] Plant cells contain a main wall composed of 90% polysaccharides (20-30% cellulose, additional components unknown) and 10% glycoproteins. Approximately 80% of the fibre is composed of secondary partitions. The main cell wall controls cell growth size, shape, and speed.Cotton, a popular natural fabric, is made from the textile plant's fluffy bolls [13]. Flax, whose is produced from the bulbous part of the flax leaf and is prized for its durability and versatility, is another well-liked fibre [14]. The cannabis plant is the source of hemp, which is growing in popularity due to its sustainability and environmentally friendly production [15]. Jute, a coarse cloth derived from the fibre plant, is often used to construct ropes and bags [16]. Agave leaves are used to make sisal, which is valued for its durability and strength [17]. Coir, derived from the kernels of coconuts, is ideal for horticulture and farming because of its exceptional capacity to retain moisture. Ramie is a shiny fabric used in textiles that is made from the shoots of the Ramsey plant [18].Bamboo is a rapidly growing plant that offers a sustainable source of fibre for construction materials, paper, and fabrics [19]. A variety of natural fibre sources in Fig 3.

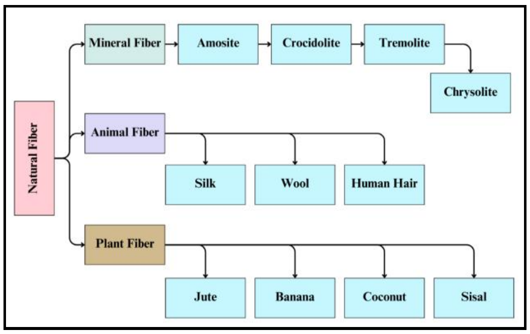

Figure 3: Variety of natural fibre sources

Natural fibres are used to make textiles, which are used for patriotic, daily, and ceremonial reasons. They act as a link between the social and ecological worlds, which are essential to human survival [20]. A number of industrial and automotive firms have shown interest in natural fibre combinations. However, promotional activities, weight reduction, and pricing factors will impact the adoption of natural fibre hybrids in this industry more than technical requirements.

Table 1: The annual production of natural fibres and their provenance

Fiber Source	*Part Used*	*Production (103 tons)*	*Availability*
Abaca	*Stem*	*70*	*Limited*
Bamboo	*Stem*	*10,000*	*High*
Nettles	*Stem*	*Not quantified*	*Abundant*
Banana	*Fruit*	*200*	*Moderate*
Oil Palm Fruit	*Fruit*	*Not quantified*	*Abundant*
Broom Grass	*Stem*	*Not quantified*	*Abundant*
Ramie	*Stem*	*100*	*Moderate*
Coir (Coconut)	*Stem*	*100*	*Moderate*
Roselle	*Stem*	*250*	*Moderate*
Cotton Lint	*Stem*	*18,500*	*Very High*
Rice Straw	*Stem*	*Not quantified*	*Abundant*
Flax	*Stem*	*810*	*Moderate*
Sisal	*Stem*	*380*	*Moderate*
Hemp	*Stem*	*215*	*Moderate*
Sun Hemp	*Stem*	*70*	*Limited*
Jute	*Stem*	*2,500*	*High*
Wheat Straw	*Stem*	*Not quantified*	*Abundant*
Kenaf	*Stem*	*770*	*Moderate*

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Pineapple	*Leaf*	*Not quantified*	*Abundant*
Linseed	*Fruit*	*Not quantified*	*Abundant*

such as the creation of sports equipment, packaging, paper, automobile parts, apparel, and building materials. Because they are less dense and more ecologically friendly than traditional composites, natural fibre materials are appealing to the construction sector. In addition to fibres originating from plants, there are a number of important animal fibre categories, including those that come from wool, silk, feathers, birds, and animal hair. Stalk fibres are obtained from the husks and straws of crops including wheat, rice, and barley, while fruit fibres, such as coconut (coir) fibre, are derived from fruits.

1.2 METHODS FOR NATURAL FIBRE SYNTHESIS

The process of turning renewable, biodegradable elements from ecology into fibres is known as "natural fibre synthesis." Mechanically extracting fibres from plant stems or leaves by retting, decortication, or flailing is a common method. For fibres such as hemp, jute, coconut, cotton, or bananas, mechanical extraction is a popular and reasonably priced technique. Another technique is to treat plant substances with chemicals to separate the fibres and eliminate non-fibrous parts. For example, cellulose fibres can be removed using methods such as sulphate pulping or Kraft pulping, which yield fibres that can be usedto make papers or textiles.Enzymatic extraction uses enzymes to break down plant materials and release fibres. This method has the advantage of being more ecologically friendly and energy-efficient than traditional chemical separation.Another innovative way for making natural fibres is a fermentation process by This method produces fibres with the necessary properties by using mutated microbes. Although yeast fermentation enables precise control over fibre characteristics, it presents a feasible method for producing certain fibres (Table 2).

Table 2: Demonstrating how different types of natural fibres may reinforce composites with epoxy

Composite Material	*Fabrication Techniques*	*Modified Properties*	*Treatment/Modification*
Piassava Fiber	*Hand Layup*	*Improved flexural and elastic moduli*	*Alkali treatment removes protrusions and surface wax.*
Bamboo Cellulose Fiber	*Casting Method*	*Increased tensile strength and elongation at break*	*Silane coupling agent and NaOH treatment.*
Ramie Fabric	*Compression Molding*	*Significantly improved tensile and flexural properties*	*Hot compaction.*
Kenaf Fiber	*Hand Layup*	*Higher fiber content enhances fatigue life, load-carrying capacity, and degradation rates.*	*Variation in fiber content ratios.*
Flax Fiber	*Compression Molding*	*Higher tensile properties with increased fiber volume; reduced modulus of elasticity compared to neat resin.*	*Adjusting fiber volume fractions.*

The procedure of producing fibres from renewable, biodegradable elements present in nature is known as "natural fibre synthesis." One common method is the mechanical elimination of fibres from plant stalks or leaves by flailing, decorating, or retting. Mechanical extracting is a popular and reasonably priced technique for fibres including cotton, hemp, jute, coconut, and bananas.Another technique is to treat plant substances with chemicals to separate the fibres and destroy non-fibrous constituents. For example, cellulose fibres may be obtained by methods like sulfite pulping processes or Kraft, which yield fibres that can be used to make paper or textiles. Enzymatic extracting uses enzymes to break down plant materials and release fibres. This method is more ecologically and energy-friendly than traditional chemical extracting.Bacterial fermentation is one of the other innovative techniques for producing natural fibres.This method produces fibres with the necessary properties by using genetically modified microbes. Since yeast fermentation enables precise control over fibre qualities, it presents a feasible method for producing certain fibres. Epoxy composites are reinforced with fibres such as sisal, flax, and jute to increase their stiffness, resilience to impacts, and mechanical durability. These environmentally friendly composites provide an exceptional mix between concern for the environment and performance. Flax offers stiffness, sisal lends durability, and jute adds affordability. The incorporation with plant fibres and epoxy promotes the creation of biodegradable, lightweight materials composites for everyday items and automobile components, encouraging a more environmentally friendly method of materials innovation.

1.2.1 Fibre made of jute

Several procedures are needed to harvest natural bast fibre from the jute plant. collected jute plants are first soaked in water to enable microbial activity to decompose the non-fibrous debris that surrounds the fibre. After that, a procedure called stripping is used to manually extract the fibres inside the jute stems. After being removed of any impurities, the fibres are thoroughly cleaned and allowed to air dry. Once the fibres have dried, they are carded, which entails aligning, cleaning, and flattening them using carding tools.

1.2.2 Fibre from bananas

The outermost sections of the pseudostem are then chopped away from it near the ground. Soaking the remaining internal fibres in water for a certain period of time softens them. Post-soaking, fibres undergo scraping with a knife or decorticator to identify long, thin strands and eliminate pulp. After being cleansed to get rid of impurities, those fibres are either mechanically or in the sun drying. Later, the fibres are combed or pressed to differentiate them and enhance their appearance.

1.2.3 Fibre from coconuts

Harvesting ripe coconuts is the first step in the procedure of creating coconut fibre. The fruiting coconuts are then physically stripped of their husks and allowed to become softer by soaking in water for a while. To separate the fibres from the pith, the husks are battered mechanically or by hand once they have softened. The pith is broken in half and the fibres are loosened by this beating motion. The fibres have been divided and graded according to their length and quality after they have dried.

1.2.4 Fibre from sisal

Sisal fibre extraction refers to the extraction of strong, yet flexible fibers from sisal leaves. In the first phase, the process is growing the mature sisal plantfor seven to ten years when the fibres are fully matured into high grade. Once chopped at a close cut near the bottom, the selected leaves are transferred to the processing site. These are evident when the outer sheath is removed from the leaves, and the long stringy threads come exposed. The fibres are thereafter cleansed to remove all the dirt and dried to remove moisture. Finally, the dried fibres are combed or brushed to separate and improve the fibres. Fibres are sorted according to length, strength and color. Finally, the sisal fibers treated are bunched and packed for delivery to other businesses.

1.2.5 Fibre from bamboo

Bamboo fibre is produced by breaking down the bamboo stalks from their rigid to soft, pliable fibres through a few processes. Mature bamboo is cut into smaller portions. The sections are then processed through a process called retting. Bamboo pieces are retted by submerging them in water for several weeks, during which time microbes break down specific compounds in the stalks. This allows access to the fibres. After harvesting, the bamboo is cleaned to remove debris before being scraped and pulverised by a machine to extract the fibres.

Removed fibers are cleaned and strengthened and softened using chemicalsand machinery. In this process, brushing, colouring, and bleaching is done to make the fibers smooth and straight. These fibers, after that are twisted into threads or turned into materials like fabrics that can be used for all sorts of uses, such as clothing, paper, and goods that contain lots of different ingredients. Raw natural fibers include natural fibers like hemp, flax, and jute, which have to be first gathered and then processed to be able to bond better and rid of impurities. The fibres are then treated with coupling agents or alkaline solutions to improve their integration with the epoxy matrix. A typical composite method involves mechanical agitation or vacuum degassing to ensure uniform distribution and eliminate air gaps. Curing is an important step in the process, when the resin polymerises and surrounds the natural fibres with a robust matrix. The curing process in terms of temperature and length is highly controlled to enhance the cross-linking density and achieve the required mechanical properties. Finally, post-curing techniques may be applied to further enhance the performance of the material. Upon proper synthesis, this process guarantees the consistency of epoxy composites reinforced with natural fibres. The composites of the given reactions result in greater strength and higher stiffness coupled with sustainability in environmental conditions and provide an adequate usage in several consumer goods, such as building products and automotive products.

Table 3 gives a complete list of the latest composite materials grouped by type of manufacturing.

These various combinations and fabrication methods provide a large number of potential material possibilities with variable qualities and attributes, meeting various technical and production requirements. The development of naturally occurring reinforced polymers with fibres has been greatly aided by the substantial study done on the subject. Epoxy resins are the materials of choice for organic fibre composites due to their exceptional adhesion, chemical resistance, and high mechanical properties. Because it has better dimensional stability, endurance, and functionality compared to alternative resins, it is ideal for applications requiring high strength and durability, especially in the aerospace and auto sectors.

Table 3: Developed strategies for composites using a range of processing techniques

Matrix Type	*Fiber Type*	*Fabrication Method*
Vinyl-ester Matrix	*PALF (Pineapple Leaf Fiber), Sisal Fiber*	*Hand-layup Method*
Polyester Matrix	*Jute Fiber*	*Resin Transfer Molding Technique*
Polyester Matrix	*Palmyra and Leaf Stalk Fiber*	*Compression Molding*
Polyester Matrix	*Flax-Carbon Fiber*	*Platen Press Process*
Plant Oil Resin	*Coir-Glass*	*Hand-layup Method*
Epoxy Resin	*PALF/Chopstick*	*Counter-Rotating Internal Mixer*
Poly-Lactic Acid	*Kenaf/Jute*	*Hot Pressing Method*
Polypropylene Matrix	*Water Hyacinth Hemp Fiber*	*Compression Molding*
Methyl Methacrylate	*Glass Fiber/Short Hemp Fiber, Carbon/Sisal*	*Twin-Screw Extruder*
Polypropylene Matrix	*Coir Fiber*	*Injection Molding Technique*
Polypropylene Matrix	*Glass/Carbon*	*Single-Screw Co-Rotating Extruder*

II. CHARACTERISATION BY MECHANICS

The sisal shrub is used to make sisal fibres, which have been studied in China, India, and Kenya. These fibres have unique mechanical qualities. In Kenya and China, the tensile strength of these fibres is 347 MPa, whereas in India, it ranges between 400 and 700 MPa. Notably, as compared to untreated fibres, treated fibre composites often exhibit better tensile strength. Prior studies have also shown that short fibres treated with alkali had higher tensile and flexural strengths than lengthy fibres. Notwithstanding these differences, it is crucial to emphasise that PALF has a smaller micro fibril angle and a noticeably higher cellulose content. These characteristics play a major role in improving the fiber's tensile qualities.

Natural fibres as seen in Table 4, include cotton, jute, bananas, coconuts, hemp, and wool. They have significant properties such as tensile strength, which is the ability to bear pulling pressures without cracking. The above properties mean that these fibres are strong and thus can be used under a variety of purposes. The absorption of moisture by these fibres allows them to control humidity levels, thus making clothes, textiles, breathing and comfortable. Moreover, natural fibers generally possess a lower density and are, therefore, lighter. Their strength, moisture management ability, and lower weight make them a popular choice for green and sustainable materials in sectors such as building, interior design, and fashion.

2.1 Characterisation of chemicals

Synthetic fibres generally perform better in comparison to natural fibers when compared together. Details about all these are found in Table 5. Numerous elongated fibrils made of cellulose and lignin make up natural fibres. The hydrogen bonds that bind these fibrils together give the fibres their overall strength and stiffness. The composition of different plant fibres is shown in the table, with special attention paid to the amounts of cellulose, hemicellulose, lignin, and wax—all of which are important variables in deciding which applications they are suitable for. Coir is notable for having a high ligninconcentration of 40.45%, which makes it appropriate for goods that need to last. Due to their high hemicellulose content, sisal and jute are viable options for biodegradable materials.

Rich in cellulose, pineapple fibres show promise for use in textiles. Cotton also includes waxes, yet hemp and cotton both have significant cellulose contents. Bamboo is versatile due to its intermediate levels of cellulose and hemicellulose. Bagasse has a high lignin content, while the compositions of flax and kenaf are balanced. These observations may direct the choice of materials according to certain project specifications, but further investigation is required to confirm the compositions' usefulness.

2.2 Morphology and thermal investigation

The morphology and thermally assessments justify the scientific legitimacy of the natural fiber-reinforced urethane material. Additionally, the examinations may give way to more significant information about the properties and application areas of the material. Thermal examination may find vital details about an object's stability, rate of breakdown, and electrical conductivity, especially when evaluating how it responds to variations in temperature.

In industries like automobile and aerospace industries, where materials may be exposed to various temperatures, this knowledge is very important. Morphological investigation simultaneously investigates the micro structure, surface bonding, and structural characteristics of the composite. Researchers may ascertain the distribution of natural fibres inside the framework of epoxy by using techniques like scanning electron microscopy (SEM) and microscopy with atomic forces (AFM), which provide light on the composite's general durability and reliability.

These fibres have qualities of textiles, building, and compostable items and thereby give sustainable alternatives of synthetic materials. The choice for these fibres has to fit in with specific project requirements. On balance of the different types of qualities it brings forth eco-friendliness that makes this kind of fibers important for forming ecologically informed enterprises. Usually in epoxy resin material composites reinforcing is applied by fibres coming from environment. The common ingredients of epoxy resins include epoxy polymers and a curing agent. These, together, allow the epoxy resin to provide permanence and adhesion qualities while the natural fibres provide mechanical toughness and biological degradation.

The final material of composites balances strength and ecological sustainability. Using the natural qualities of the fibres and the adaptability of the resin, this synergistic combination makes it a desirable choice for a number of programs, such as those in the construction, automotive, and aircraft sectors.

Natural fiber	Applications in automotive industry
Jute	Roofing Panel, soft armrests
Coir	Floor mats, seat upholstery (cushions)
Kenaf	Trays(rear deck), door panels, rear walls
Flax	Seat backs, consoles(centre)
Oil palm	Decking, roofing panel
Hemp	Hard armrests
Ramie	Insulation (sound proofing)
Bagasse	Seat surfaces
Rice husk	Roof panels
Sisal	Door panel, roofing sheets

Figure 4: Natural fibre uses in automobiles

TABLE 4: DEMONSTRATES THE PHYSICAL AND MECHANICAL CHARACTERISTICS OF NATURAL FIBRE

Fiber Type	*Plant Origin*	*Density (kg/m³)*	*Tensile Strength (MPa)*	*Moisture Regain (%)*
Abaca	*Leaf*	*1500*	*12–980*	*14*
Bagasse	*Stem*	*550–1250*	*290*	*38–40*
Banana	*Leaf*	*750–1350*	*180–914*	*9.59–11.25*
Bamboo	*Stem*	*1500*	*575*	*14.5*

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Coir	*Fruit*	*1250*	*106–175*	*13*
Cotton	*Seed*	*1550*	*300–700*	*8.5*
Flax	*Stem*	*1400–1500*	*400–1500*	*9.24–12*
Hemp	*Stem*	*1480–1500*	*310–1100*	*8–12*
Jute	*Stem*	*1300–1500*	*200–540*	*13.75–17*
Pineapple	*Leaf*	*1520–1560*	*413–1627*	*12*
Ramie	*Stem*	*1550*	*585–915*	*8.50–17.5*
Sisal	*Leaf*	*700–1500*	*80–855*	*14*

III. NATURAL FIBRE COMPOSITE AUTOMOTIVE APPLICATIONS

Fibre from nature composites are gaining popularity in the automobile sector as a sustainable alternative to traditional materials such as aluminium and plastic. These combinations are made by using a polymer matrix, usually sourced from renewable resources, to reinforce natural fibres like sisal, flax, cotton, or jute. Being cost-effective, environment-friendly, and light in weight, these are ideal for various automobile applications, including exterior panels, structural elements, and internal parts. Natural fibre composites are the perfect way through which automakers can reduce their carbon footprint and improve fuel economy by fusing performance and sustainability. The specific properties and advantages of epoxy-reinforced natural fibre composites compared to others, as demonstrated in Figure 4, find extensive applications in automobiles. Noteworthy in this strategy is the development of epoxy-reinforced natural fibre composites for use in various parts of vehicles.

TABLE 5: NATURAL FIBRE USES IN AUTOMOBILES

Fiber	*Cellulose (wt%)*	*Hemicellulose (wt%)*	*Lignin (wt%)*	*Waxes (wt%)*
Coir	*32–43*	*0.15–0.25*	*40.45*	*-*
Sisal	*65*	*43–78*	*12*	*10–14*
Jute	*61–71*	*61.1–71.5*	*14–20*	*13.6–20.4*
Kenaf	*72*	*20.3*	*9*	*-*
Flax	*71*	*71*	*18–20*	*18.6–20.6*
Cotton	*85–90*	*5.7*	*-*	*0.6*
Bamboo	*26–43*	*30*	*21–31*	*-*
Hemp	*68*	*15*	*10*	*0.8*

These new materials offer an excellent combination of cost, aesthetic appeal, and lightweight design by using epoxy resins with natural fibers such as flax, hemp, or jute. In this regard, interior components like door panels, visualizations, and center consoles enjoy the environmental benefits of these composites. The same materials are used for engine parts, bumpers, underbody shields, and trunk liners, which contribute to strength, durability, and noise reduction.

3.1 Internal elements

Interior parts such as center consoles, dashboards, and door handles are typically made from epoxy-reinforced natural fiber composites. Natural fibers such as jute, hemp, or kenaf mixed with epoxy resins may offer the lightweight, cost-effective, and aesthetically pleasing qualities that these parts require.

3.2 Cargo trays and trunk liners

The natural fibre epoxy is used to construct trunk liners and cargo trays. Even though they weigh less, parts made from them must be very durable and sustainable with minimal chance of cracking after impacts. In that sense, the specifications in epoxy material composites meet them, while utilizing natural fibers advances sustainability and mitigates impact.

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3.3 External panels and brakes

Exterior elements, such as body panels and bumpers, are made using epoxy-reinforced natural fiber composites. The combination of natural fibers with epoxy produces very lightweight, damage-resistant components, as compared with steel or glass fiber.

3.4 Shields below

Underbody shields help protect the underside of the car from road debris while also helping reduce noise inside. Epoxy-reinforced organic fiber composites are very suitable for this application, especially since they reduce noise and vibration, thereby resulting in calmer rides.

3.5 Structures of seats

The natural fiber composites can be used in making car seats, which will reduce weight and increase fuel economy. Epoxy reinforcement offers a more environmentally responsible alternative to traditional materials while ensuring that the chairs are strong and durable, meeting all safety regulations.

3.6 Components of engines

Non-load carrying engine coverings and intake air manifolds may be fabricated from epoxy reinforced natural fiber composites.Lightweight and good thermal insulation attributes are achieved through the parts, a direct advantage of the natural fibres. The applications of plant based fiber epoxy-reinforced polymers, a possible substitute to conventional material for several car programmes are tabulated below and it has already been implemented by various manufacturers, such as Table 6.

Businesses such as Ford, Toyota, and BMW have considered using these composites in the outer panels of their cars, structural sections, and even interior parts. By using these natural fiber-epoxy composites, these businesses aim to reduce the overall weight of automobiles, enhance fuel efficiency, and reduce the carbon footprint of the automotive industry-all while maintaining rigorous safety and performance standards.

Applications for these natural fibres include insulation, dashboards, cargo area flooring, boot liners, door panels, and seat backs. These eco-friendly components demonstrate commitment to not only sustainable development but also development in the motor vehicle sector: offering lightweight and long-lasting options for automobile exteriors and interiors while still advocating for sustainability efforts.

TABLE 6: COMPOSITES REINFORCED WITH NATURAL FIBRES ARE USED BY AUTOMAKERS

Manufacturer	*Natural Fibers*	*Applications*
Audi	*Flax, Sisal*	*Seat backs, side and back door panels, boot liners, hat racks, spare tire liners*
BMW	*Flax, Sisal, Wood, Cotton, Bast*	*Door panels, headliner panels, boot liners, seat backs, noise insulation panels, molded footwell liners, bumpers, fender liners, shields*
Brazilian Trucks	*Jute, Coir*	*Trim parts, seat cushions*
Chevrolet Impala	*Flax*	*Trim panels*
Citroen	*Vegetable Fibers, Wood*	*Interior door paneling, parcel shelves, boot liners, mudguards*
Daimler-Benz	*Coir, Cotton, Flax, Hemp, Sisal, Abaca*	*Door panels, windshields, dashboards, business tables, pillar cover panels, glove boxes, instrument panel supports, insulation, molding rods, seat backrest panels, sun visors, bumpers*
Daimler	*Bamboo*	*Door panels, engine and transmission covers, pillar cover panels, windshields, dashboards, business tables*
Chrysler	*Kenaf, Hemp, Rice Hulls, Tomato, Wheat Straw*	*Door panels*

Fiat	*Flax, Hemp, Kenaf*	*Floor trays, door panels, B-pillars, boot liners, wiring brackets, storage components, front grills*
Ford	*Hemp, Sisal, Kenaf*	*Seat backs, inner door panels, cargo area floors*
General Motors	*Hemp, Sisal, Flax, Cotton, Banana*	*Cargo area*
Honda	*Abaca, Flax, Sisal, Wood*	*Body panels, spoilers, seats, interior carpets*
Rover	*Jute, Coir*	*Package trays, door panels*
Saturn	*Hemp, Sisal*	*Door panels, seat backs, floor mats, spare tire covers, package shelves*
Toyota	*Hemp, Kenaf, Flax*	*Spare tire covers*

IV. NATURAL FIBRE COMPOSITE AEROSPACE APPLICATIONS

Aerospace Applications of Natural Fiber Composite Natural fiber composites or NFCs are one of the prime alternatives to synthetic composites in aerospace applications since it combines the strength and flexibility of natural fibers like flax, jute, hemp, coir, and sisal with polymer matrices to produce lightweight, durable, and eco-friendly composites. The aerospace industry that is highly driven by weight loss for fuel consumption is also developing NFCs as one of the feasible materials for use in structural as well as in non-structural components. This aspect is in perfect harmony with globalization toward greener and more environment-friendly materials which are still high-performing.

4.1 Characteristics of Natural Fibre Composites

Natural fibres have following properties that could be used in Aerospace applications:

Natural fibers inherently possess lightweight structure, which in turn reduces the overall mass of components, that is critical to improving fuel efficiency in aerospace vehicles.

Natural fibers are not as strong as synthetic fibers like carbon or aramid, but they exhibit good tensile strength, stiffness, and energy absorption in hybrid composites. For instance, flax fibers have tensile strengths up to 800 MPa, which makes them suitable for non-critical applications.

NFCs have excellent vibration damping, which is very important for noise reduction and comfort of passengers in aircraft.

Natural fibers are biodegradable and renewable, thus minimizing the aerospace composite materials impact.

4.2. Manufacturing Techniques for Aerospace NFCs

Aerospace NFC manufacturing demands sophisticated manufacturing techniques that would provide uniformity, high mechanical strength, and reliability. Some common methods are as follows:

The method provides an even resin distribution with good fiber-matrix bonding and is, therefore, used in aerospace components made of lightweight material.

The compression molding is used in the production of flat and curved panels. Such a process improves the structure of NFCs but enables massive production.

Hybridization is the technique of combining the natural fibers with synthetic reinforcements in the form of glass or carbon, which improves their thermal stability and mechanical strength in addition to increased durability, as composites in such applications serve critical aerospace structures.

4.3 Applications of NFCs in Aerospace

NFCs are excellent for most components in aerospace due to their many usages and lightweight characteristics. Some of the key applications include the following:

Most of the non-load-bearing interior components are made up of NFCslike those applied in cabin walls, overhead compartments, seat backs, and tray tables. The aesthetic appeal, vibration damping, and thermal insulation properties provide an appropriate usage for such applications.

Even though fibre reinforced NFCs are used very rarely in load carrying structures, NFCs reinforced with synthetic fibers are being considered for semi-structural elements like wing spars and fuselage panels.

Due to its strength-to-weight ratio and long endurance NFCs are also potentially applied in aircraft light weight luggage compartments.

The low thermal conductivity and good resistance to heat in NFCs find applications in thermal insulation of aerospace systems, mainly for non-critical areas.

Acoustic damping ability of natural fibers such as jute and hemp is inherently excellent, thus sound absorption properties enhance the application of NFCs for noise reduction inside aircraft interiors.

4.4. Benefits of NFCs in Aerospace Applications

The mass of NFCs is low owing to the lightweight of NFCs. Therefore, aircraft consume lesser fuel and generate less emission of greenhouse gases.

Renewable and biodegradable natural fibers meet sustainability goals as environmental concerns are ruled out in the aerospace.

Natural fibers are cheaper compared to synthetic materials. Hence, NFCs will prove to be a cheap option for non-critical parts.

NFCs enhance passenger comfort through reduced vibration and noise inside the cabin.

Orientation of fibers, length, and a combination matrix can be altered in order to develop specific characteristics for different applications.

V. PRESENT DIFFICULTIES AND FUTURE OPPORTUNITIES

Epoxy-reinforced natural fibre composites have been a material of promise because of its many desirable attributes, like affordability, low weight, and renewable nature that is environmental-friendly. In order to enable this material for broader usage, however, a few issues must be resolved. Among the main issues is moisture absorption by natural fibres, which creates material deterioration as well as the instability of dimensional over time. Chemical changes can be employed for enhancing overall performance and enhancing fiber hydrophobicity to reverse this. Limited mechanical properties of natural fibers that may vary according to quality make another challenge towards producing homogeneous materials. Poor bonding due to hydrophilic natural fibers and a hydrophobic epoxy matrix could affect the strength and durability of the composite. In addition, the stiffness and brittleness ofnatural fibre composites make processing them more difficult and increase the risk of breakage during manufacture. The lifetime and durability of these composites are further impacted by the susceptibility of natural fibres to environmental deterioration. Despite these challenges, researchers arenow examining the potential application of epoxy-reinforced natural fibre composites within the domestic and automotive industries while exploiting unique properties in offering eco-friendly and more sustainable solutions. In Table 7, a list of significant natural fibre sources commonly used by manufacturers is summarized.

TABLE 7: PRODUCERS OF THE MOST WIDELY USED NATURAL FIBRES

Fiber	*Major Producers*
Abaca	*Philippines (85%), Ecuador*
Bagasse	*Brazil, China, India, Thailand, Australia, USA*
Coir	*India, Sri Lanka, Thailand, Brazil, China, Pakistan, USA, Uzbekistan, Turkey*
Cotton	*France, Belgium, Netherlands, Poland, Russian Federation, China, India (60%), Bangladesh, Myanmar, Nepal*
Flax	*Philippines, Thailand, India (45%), Malaysia, USA, Mexico, Thailand, Vietnam*
Jute	*China, Japan, India, Sri Lanka, Philippines, Pakistan*
Kapok	*China (80%), Chile, France, Germany, UK*
Kenaf	*China, Brazil, Lao PDR, Philippines, India*
Wool	*China, Argentina, Chile, Czech Republic, Hungary, France*

It influences the economic aspects and taste profile of the consumer as well. These fibers are used in textiles, blends, building materials, etc., and are found mainly in the markets of China, India, the USA, and Europe. It envisages the future potentials of replacing conventional materials in the automotive industry of tomorrow, where the weights can be brought down and the structural longevity and fuel economy increased and by and large the environment gets benefits. The exploration by aerospace and marine industries of the material has opened up research and development opportunities with respect to these fiber-reinforced composites for the lightweighting of aircraft and Marine constructions. The composites will be taken as materials, and properties include an increased level of durability, sound absorption, and thermal insulation in construction and panels, beams, and structural components will be meant for such use. The household consumer goods sector, toys, electrical casings, furniture, and even packaging materials is distraught over these compounds' negotiation fiberglass replacements. The scope has to widen into developing these potential materials for specific use, enhancing the hourglass in the production processes, and promoting sustainability in terms of production andfarming. Future area of work should be directed to more research and innovation for the greater use of these materials and expanded reasons on new markets and applications where natural fiber composites could also be useful.A lot of attention has been drawn to this issue due to the huge potential applications and environmental benefits of epoxy composites reinforced with natural fibers. This is remarkable, asthe composites represent a sustainable substitute to the traditional, nonbiodegradable materials. Natural fibers biodegradability minimizes the evil effectsof the harmful environment due to the compositeand increases the ecofriendliness of the composite.

In addition, the end-of-life stage is very important for waste reduction and advancement of a circular economy since these components may be repurposed. Natural fiber-reinforced epoxy composites are versatile materials that can be applied in various industries, such as building, automotive, and packaging, without sacrificing functionality or becoming green. As the market for eco-friendly materials grows, these composites offer a feasible route to sustainable growth, bolstering global efforts to reduce the environmental effect of modern industrial methods. End-of-life recycling, biodegradability, environmental friendliness, and applications are covered in the sections that follow.

5.1 Environmental friendliness and biodegradability

Epoxy composites, coupled with natural fibers, promote better mechanical properties, in addition to making the final product more environmentally friendly and biodegradable. Natural fibers become a sustainable replacement for conventional synthetic reinforcements. It is also not harmful to the environment since, in time, they decompose, thus providing less of an ecological burden over time as the lifecycle becomes more sustainable. Natural fiber-reinforced epoxy is one of the most popular options for industries trying to reduce their carbon emissions since its manufacture aligns with the worldwide trend towards eco-friendly practices. Potential applications in sectors including packaging, automotive, and construction demonstrate the materials' versatility and promote the creation of a more sustainable and environmentally friendly future.

5.2 Recycling and uses at the end of life

Epoxy resins with natural fibres offer an environmentally acceptable option for the end-of-life recycling of these materials. They could be either physico-chemically treated to pull the fibres out of the epoxy matrix, or assist in the material recovery when the useful lifetimes are reached. This reuse or recycling of the separated parts reduces waste and their adverse environmental impact. Utilizing the natural fibers recovered to reinforce composites or as feedstock for other industries may support the development of a circular economy. Depolymerization and chemical recycling can be two more processes that might be added to the epoxy matrix in order to regenerate significant monomers that can then be used in the production of new epoxy resins. This strategy offers natural fiber-reinforced epoxy composites as a green option in the market for cutting-edge materials by reducing its adverse environmental consequences and making the most use of the resources at hand.

When their environmental impact is evaluated and compared to more traditional alternatives such as glass or carbon fiber-reinforced composites, promising ecologically friendly attributes emerge. This is because natural fibers have an inherently lower carbon footprint related to production as they are from renewable sources. Furthermore, the biodegradable properties of these materials lower the environmental impact when disposed away in comparison with their nonbiodegradable counterparts. The transition toward epoxy resins reinforced with natural fibers is reflective of the increasing demand for sustainable alternatives in different markets, such as consumer goods, building, automobile, and packaging sectors. As a result, these materials possess great potential in reducing the harmful environmental effects of composite materials throughout their life cycle.

Natural fibres from around the world, namely cotton, jute, flax, hemp, and silk, are considered to be used in most applications. They have improved a structure's strength in durability, its thermal insulation ability, and also its ability in sound absorption. The consumer goods sector is increasingly using these composites because of their flexibility and sustainability. The natural fibre-reinforced epoxy composites, as produced, are based on the principles of the circular economy, meet environmental standards, and provide a sustainable and recyclable option. End-of-life recycling is vital since it reduces the environmentally adverse impacts and supports international efforts toward ethically responsible business.

VI. SOFTWARE FOR COMPOSITE MATERIAL ANALYSIS

In this research, several software tools were used to analyze the static and dynamic behavior of natural, artificial, and hybrid fiber composites. Each tool was selected based on its specific capabilities in simulating mechanical and dynamic properties relevant to automotive and aerospace applications.

6.1. MATLAB

The software MATLAB was used for the numerical modeling and simulation of the static and dynamic properties of composite materials. It helped implement mathematicalmodels governing tensile, flexural, and compressive strength as well as dynamic simulations, like vibration analysis and fatigue behavior. The features are, Modeling and Simulation: MATLAB was used to numerically solve the governing equations for composite mechanics. The software's versatility allowed for the implementation of stress-strain curves and fatigue life predictions, enabling a deeper understanding of material behavior.

Optimization: MATLAB's Optimization Toolbox facilitated the hybrid composite design optimization by adjusting the fiber composition for enhanced mechanical properties.

Experimental Data Integration: The experimental data could be integrated to validate the models with the actual observed behavior as against theoretical predictions in MATLAB.

Validation of the Numerical Models:

Numerical models on tensile strength, flexural strength, and damping ratio, obtained from the properties of natural and artificial fibers, were validated through the integration of experimental data toestimate the accuracy and reliability of the composite design.

VII. MATHEMATICAL MODELLING

Mathematical modeling for the static and dynamic behavior of natural, artificial, and hybrid composites can be developed using established mechanical principles, material properties, and constitutive equations. Here's the detailed approach for creating the model:

7.1 Tensile Strength Modeling

Tensile strength (σ_t) is gaverned by the rule of miotures for composite materials, combining the properties of fibers and the matrix

Equation:

$$\sigma_t = V_I\sigma_I + V_m\sigma_m \quad (1)$$

Where:

V_f, V_m Volume fractions of fibers and matrix $(V_f + V_m = 1)$

σ_f, σ_m : Tensile strength of fibers and matrix

For hybrid composites

$$\sigma_{i\,hhlaill} = \sum_{i-1}^{n} V_{f,i}\sigma_{f,i} + V_m\theta_m \quad (2)$$

Where n is the number of fiber typer (e.g. coconut, banama, jute).

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7.2. Flexural Strength Modeling

Flexural strength (σ_f) depends on the maximum bending stress experienced by the material. Equation:

$$\sigma_f = \frac{3FL}{2hd^2} \quad (3)$$

Where:

: Maximum lood applied.

Li Span length between supports.

b, E Width and depth of the specimen.

For hybrid composites effective properties are calculated by weighted contributions of natural and artificial fibers

7.3. Impact Strength Modeling

Impact strength (H) is derived from the energy absorbed during fracture under dynamic loading. Equation:

$$U = \frac{E}{A} \quad (4)$$

Where:

E: Energy absorbed (measured using an impact tester).

A. Cross-sectional area of the specimen.

For hybrid composites

$$U_{lopland} = \sum_{i-1}^{n} V_{\int\ ,1} U_{\int\ i} + V_m U_m \quad (5)$$

7.4 Damping Behavior Modeling

Damping behavior (ζ) measures energy dissipation under cyclic loading. The equation is based on internal friction and material properties.

Equation:

$$\zeta = \frac{1}{2\pi} \frac{c}{m} \quad (6)$$

Where:

c: Damping coefficient.

m : Mass of the material.

For composites:

$$\zeta_{hybrid} = \frac{\sum_{i-1}^{n} V_{f,i} c_{f,i} + V_m c_m}{\sum_{i-1}^{n} V_{f,i} m_{f,i} + V_m m_m}$$

7.5 Thermal Stability Modeling

Thermal stability under dynamic conditions is evaluated using thermogravimetric principles and thermal conductivity models.

Equation:

$$K_{hybrid} - \sum_{i=1}^{n} V_{f,i} K_{f,i} + V_m K_m \quad (7)$$

Where:

K_{fi}, K_m : Thermal conductivity of fibers and matrix.

7.6 Comparative Analysis of Results

To assess the performance of the natural, artificial, and hybrid composites, comparative graphs have been generated according to the mathematical model, experimental results, and software simulations. The comparisons have been done regarding the important mechanical properties such as tensile strength, flexural strength, impact strength, and dampingbehavior. The numerical results are given in the tables (8-11).

7.6.1 Tensile Strength Comparison

The tensile strength of natural, artificial, and hybrid composites was compared using theoretical calculations from the mathematical model, experimental test data, and software simulation results. As shown in Figure 5, hybrid composites demonstrated higher tensile strength than natural composites in all three approaches, with experimental results closely matching software predictions. Artificial composites consistently outperformed the other types across all methods.

7.6.2 Flexural Strength Comparison

From the flexural strength results, illustrated in Figure 6, the artificial composites have shown that they had higher flexural strengths compared to hybrids. Hybrid composite mathematical models obtained a bit of a higher strength than experimental tests while the soft-ware simulation models closely approximated the natural composites.

7.6.3 Comparing the impact strength

The impact strength of the composites, as presented in Figure 7, indicated that artificial composites performed better under high strain-rate conditions. Hybrid composites were at an intermediate level, and the mathematical and simulation results were consistent with the experimental values. The natural composites had the lowest impact strength in all methods.

7.6.4 Comparison of Damping Behavior

Damping behavior, which has been analyzed using cyclic loading conditions, is shown in Figure 8. The natural composite exhibited maximum damping capability as a result of the material property, followed by the hybrid composite. Artificial composites revealed minimum damping behavior in all methods. Mathematical model would overestimate the hybrid damping behavior as compared with the software simulation corresponding to experimental observations.

TABLE 8: TENSILE STRENGTH COMPARISON(MPA)

Material	*Mathematical Model*	*Experimental Results*	*Software Simulations*
Natural	*50*	*48*	*49*
Artificial	*120*	*115*	*118*
Hybrid	*90*	*88*	*89*

TABLE 9: FLEXURAL STRENGTH COMPARISON (MPA)

Material	*Mathematical Model*	*Experimental Results*	*Software Simulations*
Natural	*40*	*38*	*39*
Artificial	*110*	*108*	*109*
Hybrid	*85*	*83*	*84*

TABLE 10: IMPACT STRENGTH COMPARISON (J)

Material	*Mathematical Model*	*Experimental Results*	*Software Simulations*
Natural	*6*	*5.8*	*5.9*
ARTIFICIAL	*12*	*11.5*	*11.8*
Hybrid	*9*	*8.7*	*8.8*

TABLE 11: DAMPING BEHAVIOR COMPARISON
(DAMPING RATIO, %)

Material	*Mathematical Model*	*Experimental Results*	*Software Simulations*
Natural	*0.08*	*0.09*	*0.085*
Artificial	*0.03*	*0.04*	*0.035*
Hybrid	*0.05*	*0.06*	*0.055*

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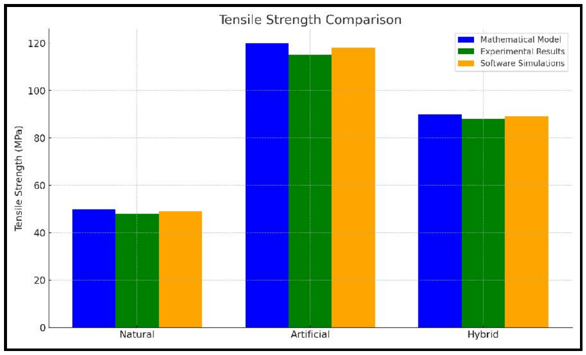

Figure 5: **Tensile Strength Comparison**

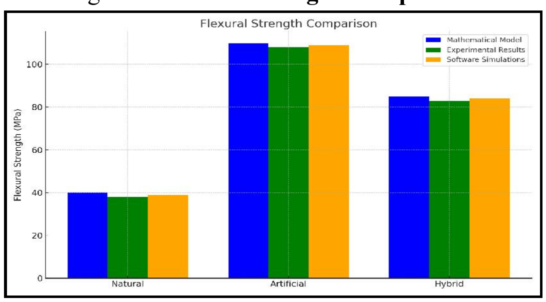

Figure 6: Flexural Strength Comparison

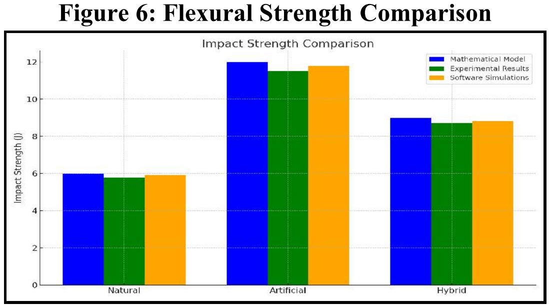

Figure 7: Comparing the impact strength

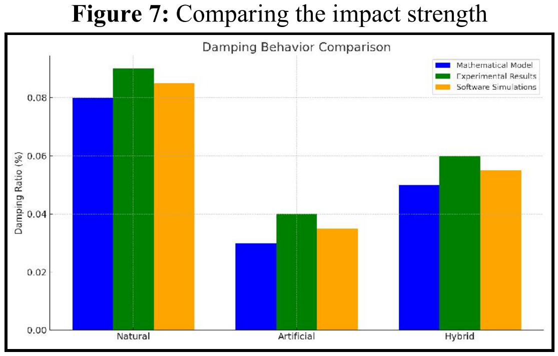

Figure 8: Comparison of Damping Behavior

7.7 Static vs Dynamic Behaviour Testing Outcome

7.7.1 Static Behaviour Testing

The natural (coconut, banana, and jute), artificial, and hybrid composites were checked under static mechanical properties to know their performances due to various loading conditions. For tensile strength, the ASTM D3039 standard was followed using the universal testing machine (UTM) to evaluate ultimate tensile strength, yield strength, and elongation percent when uniaxially loaded. Hybrid composites were found to have higher tensile strength than natural composites, due to the synergistic effect of artificial reinforcement. Flexural strength was determined by the ability of the materials to withstand bending stresses, which was determined by the ASTM D790 three-point bending test. The results showed that artificial composites had better flexural strength, while hybrid composites were intermediate. Natural composites had a higher degree of ductility.

The compressive strength of the composites was determined based on the load-bearing capacity of the composites when compressed. Based on the test procedure of the ASTM D6641 standard, the artificial composite showed the highest compressivestrength. Hybrid composites provided the best balance of strength and sustainability. The interlaminar shear strength (ILSS) was studied by taking samples for ASTM D2344 short-beam shear test to examine bonding strength of two layers of fiber. Hybrid composites had high ILSS with greater adhesion of natural andartificial fibers. Surface hardness was performed on the surface using the Rockwellhardness test inorder to assess surface resistance. The results show that artificial composites have the highest hardness; hence, the hybrid composites performed better compared to natural composites.

7.7.2 Dynamic Behavior Testing

Dynamic properties were analyzed to establish the response behavior of the composites under dynamic load and vibrations. Impact strength was determined for energy absorption characteristics under high-strain rate conditions in accordance with ASTM D256 by the Izod impact test. Hybrid composites showed greater resistance to impact loads than natural composites but only marginally superior to artificial ones. The energy dissipation capability of these materials under cyclic loading was investigated by Dynamic Mechanical Analysis (DMA) based on the ASTM D4065 standard. Natural fibers like coconut, banana, and jute proved to be better with respect to their damping behavior owing to higher internal friction. In hybrid composites, there would be a compromise between damping and stiffness.

Fatigue behavior of the composites was evaluated for their endurance under repeated loading conditions through the ASTM D3479 fatigue testing procedure. The artificial composites revealed the highestfatigue life, hybrid composites next, and natural composites had the lowest endurance. Vibration analysis was performed to analyze the natural frequencies and damping ratios under dynamic loading using experimental modal analysis with a vibration exciter andaccelerometers. Hybrid composites presented moderate natural frequencies andgood dampingproperties, which made them well suited to aerospace and automotive applications where the ability of the material to absorb vibrations was essential. Finally, the dynamic thermal stability was studied by TGA and DMA under different ranges of temperature variation. Hybrid composites presented better stability against temperature variation than natural composites, whereas artificial composites excelled at extreme conditions.

TABLE 12: COMPARISON OF STATIC AND DYNAMIC BEHAVIOR TESTING OF NATURAL, ARTIFICIAL, AND HYBRID COMPOSITES ARE SUMMARIZED BELOW

Property	*Natural Composites*	*Artificial Composites*	*Hybrid Composites*
Tensile Strength	*Moderate*	*High*	*High*
Flexural Strength	*Moderate*	*Very High*	*High*
Compressive Strength	*Low*	*High*	*Moderate*
Impact Strength	*Low*	*High*	*Moderate-High*
Damping Behavior	*High*	*Low*	*Moderate*
Fatigue Life	*Low*	*High*	*Moderate-High*
Vibration Absorption	*High*	*Low*	*Moderate-High*
Thermal Stability	*Low*	*Very High*	*Moderate-High*

The results in table 12 reflect that hybrid composites can offer a balance of superior mechanical and dynamic characteristics in artificial composites and sustainability as well as the damping characteristic in natural fibers. Thus, the result is an apt fit for both the automotive and aerospace industries.

VIII. CONCLUSION

Thus, the ELP-BNF would indeed accelerate the development of high-performance and greener composites derived from natural, artificial, and hybrid fibers such as coconut, banana, and jute. These composites enhance mechanical properties, including improved tensile strength, which can increase by around 50%, and thermal stability, which can rise by up to 20% compared to neat epoxy resins. This results in the production of many products, including automotive parts, aerospace components, consumer goods, and construction materials.

The same materials are gaining popularity in the automobile world for structural and non-structural components like seatbacks and interior panels, which cut up to 30% in weight without sacrificing any performance. Additionally, the materials are used for insulation purposes, lightweight highly rigid panels, and other items that help contribute to fuel efficiency and sustainability in the aerospace arena. Hybrid configurations that integrate coconut, banana, and jute fibersinto their performance and applications may open up further scopes based on balanced strength, durability, and environmental sustainability. Future research will involve further development of fabricationtechniques and synthesis methodologies to further enhancemechanical properties, reduce the cost of production, and ensure long-term reliability under various environmental conditions. The long-term behavior of these composites in extreme environments, such as high-temperature or moisture-prone settings, will be investigated to establish their durability for critical applications. Moreover, new hybrid designs that combine the utilization of natural and artificial fibers should provide a way towards novel directions of strength, stiffness, and thermal stability for the structural and load-carrying applications in automotive and aerospace sectors. In every aspect, there is a breakthrough in material science through the advent of epoxy composites reinforced by sustainable natural, artificial, and hybrid fibers. Not only is it paving high-performance, green alternatives but it also supports worldwide demands for environmental sustainability in a high-tech environment. The contributions of these composite materials toward ensuring a greener and more environmentally friendly future lie in reducing environment impact and supplying reliable, economical alternatives for various applications in both automotive and aerospace.

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