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Manufacturing and Testing of Natural Fiber Composites Reinforced with Natural Resin

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ABSTRACT: The rising need for biodegradable and sustainable materials has led to extensive research on natural fiber-reinforced composites. In this project, we focused on creating eco-friendly composite materials using natural fibers like jute, banana, bamboo pulp, and pineapple, along with an environmentally safe resin (Beyond Mix). These materials were chosen for their mechanical strength, availability, and biodegradability. After studying the physical properties of fibers and resin, we fabricated samples using the hand lay-up method and tested them for compression and impact strength. While good compressive strength (75.36 N/mm²) was achieved, brittleness and lack of flexibility were observed. This project demonstrates the potential of plant-based composites in sustainable engineering, though balancing strength and elasticity remains a challenge.

I. INTRODUCTION

Natural fiber–reinforced composites (NFRCs) have attracted increasing interest as an alternative to metals and synthetic fiber–reinforced composites primarily because of the growing demands for light weight in materials and a reduced environmental footprint. Currently, glass fibers are the dominant reinforcing fiber in the polymer matrix. In 2015, 95% of the fiber composites were reinforced using glass fibers. Compared with glass fiber, natural fibers have several advantages, such as lower density, biodegradability, abundant availability, good damping properties, less abrasive damage to equipment, and high health safety (i.e., low skin irritation), making them a promising alternative reinforcing material for composites. Additionally, life-cycle assessment (LCA) studies have reported that NFRCs are environmentally superior to glass fiber–reinforced composites. The Natural Fiber Composites Market forecast report has projected that the global NFRCs market size is expected to reach $10.89 billion by 2024, from $4.46 billion in 2016. NFRCs will keep growing in the market due to rising consumer demand for lightweight and fuel-efficient automobiles. The characteristics of base matrix, the reinforcing fiber, and the inter facial contact between the fiber and matrix (such as chemical bonding, mechanical interlocking and physical adhesion) all work together to influence the performance of plant based NFRCs. Notwithstanding the enormous potential of natural fibers as previously discussed a number of inherent characteristics of natural fiber have been regarded as significant technical obstacles to the creation of high performance composites and their uses. The demand of NFRCs and their application will continue to grow as a result of their improved performance. We give a summary of latest developments in plant based NFRCs in this review Additional Naturally occurring fibers such as animal fibers (i.e., protein fibers such as silk and wool) and bacterial fibers are not covered in this review. Firstly, we quickly go over the mechanical characteristics and quality of natural fibers derived from plants that are frequently used to make NFRCs. NFRCs composed of three commonly used thermoplastic polymer matrices -polypropylene (PP), polyethylene (PE), and poly lactic acid (PLA) are examined. Following that the methods and innovations for enhancing the performance of NFRCs are emphasized and explored. Sustainable materials are crucial in manufacturing as they help protect the environment, conserve resources and reduce carbon emissions. They ensure cost savings over time, ensure compliance with environmental regulations and meet the growing consumer demand for eco-friendly products. Using such materials also enhances brand value, drives innovation, improves health safety, and promotes a circular economy by encouraging reuse and recycling. Overall, sustainable materials enable manufacturers to build a responsible, future-ready industry. Natural Resin Soybean oil is mainly composed of triglyceride molecules. Each triglyceride contains three fatty acid chains joined by a glycerol center. The fatty acid chains have 0–6 double bonds and vary in length from 16 to 22 carbon atoms. In order to produce a rigid cross linked thermoset, the triglycerides must be chemically functionalized. The preferred degree of functionalization is from 4 to 6 groups per triglycerides. Several types of functionalization can be obtained at various active sites within the triglyceride structure: the double bond, the ester group, the allylic carbons and the carbons a to the ester group. Various chemical pathways for functionalization of these triglycerides have been studied. For this

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study, the triglycerides are first epoxidized and then reacted with acrylic acid to obtain acrylated epoxidized soybean oil (AESO), which is commercially available. After that, the resin is mixed with a co-monomer to enable free radical co polymerization through redox breakdown. Lascala and wool have recently examined the selection of plant oil (soy,corn,linseed,sunflower,genetically engineered high oleic,etc.),the optimization of chemical functionalization, and its impact on the mechanical and thermal properties of the resin.[1] Natural Fibers Natural fibers serve as the low-cost reinforcement of the resin in bio composites improving both the strength and stiffness of the resulting composites. Natural fibers are typically grouped into four different types: leaf, bast, fruit and seed, depending on their source. The leaf and bast fibers are generally used in composite processing. Examples of leaf fiber include sisal, henequen and pineapple leaf fiber (PALF). Bast fiber examples are flax, hemp, ramie, cellulose and jute. One of the major difficulties of natural fibers is that their properties are intrinsically dependent on where they are grown (locality), what part of the plant they are harvested from (leaf or stem), the maturity of the plant (age) and how the fibers are harvested and preconditioned in a form of mats or chopped fibers, woven or unwoven. These factors result in significant variation in properties compared to their synthetic fiber counterparts (glass, aramid and carbon).[10] Fig 1.2: Mechanical properties of bio composite [10]

II. LITERATURE REVIEW

In the project the main aim is to increase the use of environment friendly products, the materials that are biodegradable and cost efficient too. This literature review results about the various materials tested and their advantages and disadvantages. U. Tamilarasan, P.V. Inbanaathan, "Mechanical property evaluation of banana jut fiber along with carbon fiber epoxy composite material" Carbon Fiber: To form a composite material, the carbon fiber are combined with other materials. It takes a name as element texture supported polymer when it is linked accompanying a flexible sticky substance material and it gives very high fighting to wear, disintegration and extreme substance to burden percentage. It is stiff though it is fragile. It can change in 5-10 length in width which generally exists only of the element atoms. The figure one shows the planned element of the fiber.[6] Fig 2.1.1: Carbon Fiber Banana Fiber: The banana plant's pseudo stem sheath is used to extract the banana fiber. This extraction of the fiber is one by using mechanical extraction method. It will be dried for a day after extraction. Then it will be packed in high polyethylene bags. It should be kept away from moisture and light. Pillows, cushions, mattress etc. in furniture industries use mainly the banana fibers. The figure 2 depicts the prepared banana fiber [6] Fig 2.1.2: Banana Fiber Jute Fiber: These are the fiber prepared from malvaceae family vegetables which are spun into strong threads. These fibers are 1 – 4 m in length and looks whitish brown in color. It is often called as golden fiber for its colour. The figure 3 represents the prepared jute fiber. The table 2 and 3 represents the mechanical properties and chemical composition of jute, banana fiber respectively.[6] The current research work depicts the potentiality of jute & banana fibre composites along with the carbon fibre, emphasizing both physical and mechanical properties. Fig 2.1.3: Jute Fiber Mohamad Nor Hishamuddin Manaf1, Nurul Farhanah Azman1, Mohamad Nor Musa1, Syahrullail Samion, Nor Azwadi Che Sidik, Yutaka Asako,Fire Resistance Rating for Gypsum and Kapok Fiber Composite Materials. (2022) Gypsum and Kapok: Gypsum and Kapok fiber were selected to be used as fire resistant material due to their environmental friendly, low cost and local availability. Gypsum was commonly used fire resistance material due to its ability to retain and release moisture to cool down the surrounding temperature after burning. The properties of gypsum are soft, perfect cleavage, specific gravity and low harness. It's extremely soft, and can be easily scraped with a fingernail and has a Mohs hardness number of 2. Gypsum has a specific gravity and thermal conductivity of 2.3 and 0.17 w/ (m.K). Kapok fiber is a natural fiber with good heat insulation due to its air-filled lumen structure.[11] Fig 2.1.4: Kapok Fiber Carlo santullia, Sivasubramanian Palanisamy, K mayandi, Pineapple fibers, their Composites and application. Pineapple fiber: Pineapple (Ananas comosus) leaf fibers (PALF), as a by-product of one of the largest productive systems in the agro-industrial field, appear as very promising for use in composites and for prospective applications in a number of fields, such as building and automotive. Despite these perspectives, the practical uses have been quite limited so far. This work investigates on this mismatch between the proposals and the concrete realization, suggesting that a number of options have been explored, yet limitations to industrialization are substantial at the moment.[14] Types of resin: - Soyabean oil-resin: - Soybean oil resin is a bio-based, sustainable material derived from soybean oil, often used as an eco-friendly alternative to petroleum-based resins. It is produced by chemically modifying soybean oil through processes like polymerization or epoxidation to create durable, flexible resins. These resins are widely used in applications such as coatings, adhesives, composites, plastics, and even in automotive and construction industries. Soybean oil resins offer benefits like biodegradability, reduced carbon footprint, good mechanical properties, and lower toxicity, making them an important material for advancing sustainable manufacturing and green product design.[1] Epoxy resin: - Epoxy resin is a strong, durable thermosetting polymer formed by mixing a resin and a hardener. The Epoxy Resin used in this study are Araldite LY556 and Araldite HY951 (Hardener). The Importance of these Epoxy

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Resins are: Industrial composites Excellent mechanical property Resistor to chemicals Better electrical resistance.[6] Linseed oil resin: - Linseed oil resin is a natural, sustainable resin made by polymerizing linseed oil, which is extracted from flax seeds. It offers good flexibility, water resistance, and durability, and is commonly used in paints, varnishes, coatings, and linoleum flooring. Linseed oil resins are valued for being eco-friendly, biodegradable, and providing a natural alternative to synthetic resins. Natural resin: - Plant oil-based resins are polymers derived from renewable plant oils such as soybean, linseed, castor, jatropha, and sunflower oil. These resins are produced by chemically modifying the oils through processes like epoxidation, polymerization, or curing with hardeners. They offer excellent mechanical properties, flexibility, chemical resistance, and biodegradability. Plant oil-based resins are widely used in coatings, adhesives, bioplastics, composites, automotive parts, and packaging materials. Compared to petroleum-based resins, they significantly reduce the environmental impact by lowering carbon emissions, conserving non-renewable resources, and supporting a circular economy. Their use promotes sustainable manufacturing while still maintaining high performance in industrial and consumer applications.[1] Study on mechanical, Thermal and durability properties: - M. Ramesh, K. Palanikumar, K. Hemachandra Reddy (2017), Renewable and Sustainable Energy Reviews. Mechanical properties: - Tensile Testing A tensile test involves placing the test specimen in a testing machine, subjecting it to loading until it fractures. The and Liao have analyzed the ability of bamboo and glass fiber reinforced composites and reported that there is a significant improvement in strength due to the incorporation of bamboo fibers with glass fiber. The properties such as tensile strength and elastic modulus of bamboo/glass fiber reinforced composites have been evaluated. The results indicated that the tensile strength and elastic modulus decreased after ageing of fibers. Jawaid et al have prepared composites by taking palm fiber as skin and jute as core material. They observed that there is significant improvement in tensile properties while using jute fiber as skin and palm fiber as core material. They have reported that the tensile properties of jute oil palm fiber composites are increased substantially with increasing the content of jute fiber loading as compared to oil palm composites. [4] Fig 2.3.1: Tensile stress/strain curve of bamboo fibre composites Impact Testing The impact performance of PFRCs depends on many factors including the nature of the constituent, fiber/matrix interface, matrix fracture, fiber pullout, the construction and geometry of the composite and test conditions. To simulate actual impact by a foreign object, a number of test procedures have been suggested by many researchers. The initial kinetic energy of the projectile is an important parameter to be considered, but several other factors also affect the response of the structure.They have reported that the impact properties of these composites are greatly influenced by addition of cenosphere as filler. The results indicated that the impact properties are depends on the concentration of the fillers and decrease in density of the composites which are also greatly depended on the content of fillers and fiber.[4] Fig 2.3.2: Comparison of impact strengths at different styrene concentrations Compression testing: Fig 2.3.3 Stress vs Strain The compression test stress-strain curve of the natural composite material shows a steady increase in stress with strain. The curve reaches a peak stress of approximately 21.5 N/mm² at around 0.45 strain, indicating the material's ultimate compressive strength. Before this peak, small fluctuations suggest internal cracking or fiber-matrix separation. Despite these, the material continued to bear load efficiently. After the peak, a sharp stress drop marks the onset of failure. However, complete breakage did not occur. The embedded natural fibers played a key role in maintaining integrity. This behavior highlights the material's ductility and energy absorption capacity under compressive loading. Issam Elfaleh ,Fethi Abbassi Mondher Nasri, Mohamed Habibi , Christian Garnier,A comprehensive review of natural fibers and their composites: An eco- friendly alternative to conventional materials(2023). Thermal Properties: - The selection of a suitable bio composite material for development and shaping is largely based on the melting temperature (Tm) criterion. It is important that Tm is lower than the degradation temperature of the natural fiber (~210 ◦C) [171,269]. This criterion often limits the choice of polymers, especially polyolefins such as PP, linear low-density polyethylene (PELLD), high-density polyethylene (HDPE), and low-density polyethylene (PELD). HDPE, one of the commonly used polyolefins, has interesting chemical properties that make it suitable for various applications. Its macromolecular structure is linear, regular, and semi-crystalline, with a density between 940 and 980 kg/m3 and thermal conductivity between 0.46 and 0.51 W/mK. HDPE has a glass transition temperature (Tg) of approximately − 110 ◦C and a melting temperature ranging from 128 to 135 ◦C, which represents an optimal temperature for shaping natural fiber composites. Typically, HDPE is formed between 150 and 170 ◦C.[10] Chemical properties: - Chemical treatment of plant fibers can improve their compatibility with polymer matrix and enhance the quality of the resulting composite. Chemically cleaning the fiber's surface can change its chemical makeup, reduce moisture absorption, elevate abrasion, alter mechanical capabilities, and enhance thermostability. Cellulose, the major component of fibers, is the target for chemical modification. The amorphous zone of cellulose is more accessible to attack by reagents than the crystalline zone. The chemical modifications carried out on natural fibers have been shown to enhance the appearance of the surface and improve adhesion to the polymer matrix.[10] A O. Donnell, M.A. Dweib, R.P. Wool, "Natural Fiber composites with plant oil- based resin" Resin was prepared using chemically modified soyabean oil in the form of AESO commercially known as Ebecryl 860. The AESO resin was first mixed with styrene in an optimized weight ratio 2:1. The resin mixture was then mixed with 3wt%intitator, cumyl

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peroxide commercially available as trigonox 239A and 0.8wt% catalyst The Viscosity of this resin was118cPs at 25 degree Celsius with a density of 1.01g/cm^3. The resin was then infused into the various natural fiber mats using VARTAM and allowed to free radically copolymerize at room temperature. The effect on styrene room temperature cured AESO resin was studied using samples prepared with varying styrene contents from 11.8 to 43.4wt%of total resin system. M. Ramesh, K. Palanikumar, K. Hemachandra Reddy (2017), "Renewable and Sustainable Energy Reviews", Fibers extracted from plants are a type of renewable sources and a new generation of reinforcements and supplements for polymer-based materials. These fibers are renewable, cheap, completely or partially recyclable, biodegradable and environment friendly materials. Their availability low density and price as well as satisfactory mechanical properties, make them attractive alternative reinforcements to glass carbon and other manmade fibers. Interfacial adhesion between plant fibres and matrix will remain the key issue in terms of overall performance, since it dictates the final properties of the composites. Mi Li, Yunqiao Pu, Valerie M. Thomas, Chang Geun Yoo, Soydan Ozcan, Yulin Deng, Kim Nelsol, Arthur J. Ragauskas, "Recent Advancements of Plant based Natural Fiber- Reinforced Composites & Their Applications", Exploration of new natural fiber with abundance can diversify fiber sources and reduce material cost. The critical issues are fiber quality inconsistency, poor fiber/ matrix adhesion, hard fiber dispersion, limited composite manufacturing condition, and moisture absorption. The future market of NFRC's is increasing, and their application, particularly in automotive, civil engineering, sports and biomedical sectors is quite promising. Particularly natural fibers with superior strength and modulus such are Nano scaled cellulosic fibers have emerged and could play a pivotal role as new reinforcing components for polymer. W. fatrisari: "A review on Natural fibers for development of eco-friendly bio- composites" Eco- friendly composites mainly light-weight composites and textiles are two of the most popular uses of natural fibers in Indonesia with Ramie and Kenaf being the most promising for Textile and automotive components. The fascinating properties of natural fibers include lesser density thus lighter weight, more considerable cost, biodegradable, abundantly available, minimal health hazards during processing, reasonably good specific strength and modulus, good thermal, good acoustic insulation characteristics, good physical properties, and ease of availability. Table 2.1: Performance Analysis of Different Natural fiber Composites. Md Syduzzaman, Md Abdullah Al Faruque, Kadir Bilisik, Maryam Naebe: "Plant- Based Natural Fibre Reinforced Composites: A Review on Fabrication, Properties and Applications" This review thoroughly illustrated the required properties of the cellulosic fibres and the polymeric matrices for the fabrication of the NFRCs. Additionally, the mechanical properties, challenges and potential application areas of the NFRCs have been discussed. Although it is evident that the plant fibres are not free from some drawbacks, such as possessing higher moisture retention, these can be overcome by applying various physical and chemical modifications. Moreover, it is difficult to produce 100% green bio composites wherein both the polymeric matrix and the reinforcing material are derived from the natural and renewable sources. Therefore, more focus is required to commercially develop pure green bio composites to support sustainability. It also defines us the whole cycle of NFRC's. U. Tamilarasan, P.V. Inbanaathan: "Mechanical Property Evaluation of Banana Jute Fibre Along with Carbon Fibre Epoxy Composite Material." The current research work depicts the potentiality of jute & banana fibre composites along with the carbon fibre, emphasizing both physical and mechanical properties. The ultimate tensile strength of Banana-Jute composite is 21.308 MPa& flexural strength is 65.35 MPa. The ultimate tensile strength of Carbon Banana Jute composite is 59.586 MPa& flexural strength is 87.17 MPa. It also emphasis variation in mechanical properties of composites of natural fibre when non-natural fibre such as carbon fibre is added in equal ratio. The test shows the hybrid composites are much superior in properties than the homogenous composite. Issam Elfaleh a , Fethi Abbassi b,* , Mohamed Habibi: "A comprehensive review of natural fibers and their composites: An eco-friendly alternative to conventional materials." To improve composite technologies based on natural fibers, several avenues can be explored. First of all, it is important to develop efficient and reproducible methods to extract and pre-treat natural fibers, to obtain high-quality and homogeneous fibers. Then, it is essential to develop appropriate surface treatments to improve the adhesion between natural fibers and the polymer matrix, thus favoring the transmission of loads and mechanical resistance. In addition, efforts should be made to optimize the formulations of the polymer matrix, taking into account the specific properties of natural fibers, to maximize the performance of the composite. Third, the hybridization of natural fibers with synthetic fibers (carbon or glass fibers) reduces the water absorption behavior of natural fibers and improves the overall mechanical properties of composite materials. In conclusion, natural fiber composite technologies are facing significant challenges, but thanks to the continuous research and development of new methods and formulations, making it is possible to optimize the properties and performance of natural fiber-based composites, thus opening new ways to many promising applications of natural fiber composites in various industries, especially the automobile industry. Leonard Y. Mwaikambo, Ezio Martuscelli, Maurizio Avella: "Kapok/cotton fabric– polypropylene composites" Alkalisation and acetylation of the kapok/cotton fabric results in low tensile strength of iPP composites compared to the untreated fabric composite. Similar effects of caustic soda treatment on the same reinforcement material on the polyester matrix have been reported by Mwaikambo and Bisanda. It is believed that caustic soda and acetylation reduces the amount of crystalline 918 L.Y. Mwaikambo et al. / Polymer

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Testing 19 (2000) 905–918 cellulose, which is largely responsible for the mechanical properties of plant fibres. The 2% caustic soda treatment on the cellulose fibres lowers the energy on tensile loading at higher fibre content while acetylation seems to favour applications where the polypropylene composites are supposed to exhibit stable energy absorption with the advantage of using more fibre than the matrix. P.J. Herrera-Franco, A. Valadez-Gonza´lez: "Mechanical properties of continuous natural fibre-reinforced polymer composites." The fibre-matrix interaction was changed by modifying the surface properties of the fibre, first to increase the area of contact and to further expose the cellulose microfibrils, and then to improve fibre wetting and impregnation. Also, a chemical interaction was promoted by using a silane coupling agent and an optimum value for the concentration of the coupling agent solution was found. It was also found that the mechanical properties, specifically, the tensile strength did not improve significantly when high silane concentrations were used to treat the fibre surface. Alexander Harta and John Summerscalesa: "Effect of time at temperature for natural fibres." Figure shows the change in colour of jute fibers with increasing time and increasing temperature. A.K. Bledzki, J. Gassan: "Composites reinforced with cellulose-based fibres." As in the case of all natural products, the mechanical and physical properties of natural fibres vary considerably, these properties are determined by the chemical and structural composition, which depend on the fibre type and its growth circumstances. Cellulose, the main component of all natural fibres, varies from fibre to fibre. The moisture sensibility is remarkable, natural fibres are easily influenced by environmental effects. Generally speaking, rising moisture content lowers the mechanical properties. Natural fibres when used as reinforcement compete with technical-fibres, such as glass-fibres or carbon-fibres. The advantages of technical-fibres are good mechanical properties, which vary only little. Kuruvilla Joseph* and Sabu Thomast: "Effect of chemical treatment on the tensile properties of short sisal fibre-reinforced polyethylene composites." Alkali treated fibre composites showed better tensile properties than untreated composites due to their rough surface topography and increased aspect ratio. It has been seen that CTDIC treated composites exhibit superior mechanical properties. This may be due to the fact that the long chain structure of CTDIC linked to the cellulosic fibres makes the fibre hydrophobic, compatible and highly dispersible in the PE matrix. Peroxide treated composites showed an enhancement in tensile properties due to the peroxide induced grafting. Permanganate treated composites also showed a similar trend due to the permanganate induced grafting. Among the various types of treatments, CTDIC and DCP treatments showed the maximum properties. Finally, it is worth mentioning that these composites have wood like appearance and can be used as a substitute for wood. Min Zhi Ronga, Ming Qiu Zhang, Yuan Liu: "The effect of fiber treatment on the mechanical properties of unidirectional sisal-reinforced epoxy composites." Sisal fibers can be effectively modified by chemical and physical treatments. Chemical methods usually bring about an active surface by introducing some reactive groups, and provide the fibers with higher extensibility through partial removal of lignin and hemicellulose. In contrast, thermal treatment of the fibers can result in higher fiber stiffness due to the increased crystallinity of hard cellulose. In the case of tensile tests, an enhancement of the interaction at the first type of interface prevents transverse failure and serves as the prerequisite for an improvement in strength and modulus, while a weaker intercellular bonding would facilitate pull-out of ultimate cells, leading to stretching and uncoiling of microfibrils in the cells which imparts high mechanical performance to the composites. Abdu Mohammed Seid, Solomon Alemneh Adimass: "Review on the impact behavior of natural fiber epoxy-based composites." In conclusion, this review has provided valuable insights into the impact strength of natural fiber epoxy composites, shedding light on the key factors influencing their performance and potential for various industrial applications. The review highlighted the effect of fiber content, fiber length, stacking sequence and their inherent mechanical properties in determining the impact resistance of natural fiber epoxy-based composite. Different natural fibers such as jute, hemp, flax, sisal, coir, etc have shown promise in enhancing impact strength due to their unique characteristics, including high strength and stiffness. Among polymer matrix materials available, epoxy matrix has high impact strength, low density, high resistance to temperature, and low shrinkage properties. Due to this several researchers have developed a composite material from natural fiber and epoxy as a matrix. The impact strength of natural fiber epoxy-based composites reported by different scholars was discussed in this review work. Muthuselvan Balasubramanian, R. Saravanan, Sathish T : "Exploring natural plant fiber choices and treatment methods for contemporary composites: A comprehensive review." The environmental benefits of natural plant fibers are underscored, supporting the growing trend towards sustainability and coconscious solutions. Countries like India and Bangladesh are exploring the large-scale production of natural plant fibers like jute to replace plastics in packaging. Bangladesh produces over 900,000 tons of jute per year, with growing demand for sustainable packaging and textiles contributing significantly to the local economy. The European Union's policies encouraging the use of biodegradable materials have promoted the use of natural plant fiber composites in automotive and construction industries. By 2030, the EU aims to have 30 % of car parts made from renewable or biodegradable materials. Farah Samsi Prome, Md Foisal Hossain, Muhammed Sohel Rana: "Different chemical treatments of natural fiber composites and their impact on water absorption behavior and mechanical strength." Fiber treatments significantly influence the water absorption and swelling behavior of composite materials. Sodium chlorite treatment is particularly effective in reducing water uptake

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in JUCO composites (around 3.5 %), while banana fiber composites show generally higher water absorption and diffusion characteristics, with $NaClO_2$ treatment leading to the highest water absorption and diffusion rate Banana fiber composites showed lower impact strength overall compared to JUCO composites. The pH 7 conditioned samples for both JUCO and banana fiber composites showed a significant drop in impact strength. For JUCO composites, the NaOH-treated samples exhibited the most significant decrease in impact strength after water aging, with a reduction of approximately 40 % strength. Banana fiber composites showed even greater reductions in post water immersion, particularly for the NaOH and stearic acid-treated samples, with reductions reaching up to 50 %. K.L. Pickering , M.G. Aruan Efendy , T.M. Le: "A review of recent developments in natural fibre composites and their mechanical performance." Improvement has occurred due to improved fibre selection, extraction, treatment and interfacial engineering as well as composite processing. This paper has reviewed the research that has focused on improving strength, stiffness and impact strength including the effect of moisture and weathering on these properties; long- and short-term performance was addressed. NFCs now compare favorably with GFRPs in terms of stiffness and cost; values of tensile and impact strength are approaching those for GFRFs. The lower densities for NFCs lead to better comparison for specific properties. Research Gap Applications and limitations observed in earlier research. The applications of PALF reinforced composites can span in different sectors: in particular, the production of boards proved of interest for thermal insulation properties. It is remarkable, however, that not.

III. RESULTS

Compression Test

A compression test was conducted on a composite sample made from natural composite materials to evaluate its mechanical strength under load. Using a Universal Testing Machine, the sample with a diameter of 90.85 mm and a cross-sectional area of 6482.46 mm² was tested. The ultimate load recorded was 488.50 kN, resulting in an ultimate compressive strength of 75.36 N/mm². The peak displacement reached 34.50 mm over a test duration of 505.25 seconds.

Young's Modulus = 0.1667 kN/mm².

Impact Test

The impact test was performed using a notched specimen in a Charpy or Izod testing machine, where the specimen fractured at an absorbed energy of 5 joules. The fracture surface showed typical signs of brittle failure, including sharp, uneven breaks and fiber pull-outs, with little to no plastic deformation. This low energy absorption indicates that the material has low toughness and is likely to fail suddenly under impact or dynamic loading.

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