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Acoustical and Mechanical Characterization of Natural Fibre-Reinforced Composite : A Review

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ABSTRACT

Noise pollution is increasing in this era as countries' development is faster. This noise pollution causes serious non-auditory effects on human health. As a result, it needs effective controls on noise pollution. Hence, use a natural fibre-reinforced composite for acoustical applications. Natural fibre-reinforced composites have various benefits, such as being eco-friendly, easy to manufacture, and effective in cost, and natural fibre improves the sound absorption, mechanical strength, and structural stability of the composite. The present review describes various techniques for measuring the acoustical and mechanical characteristics of natural fibre-reinforced composites. In addition to these acoustical (sound absorption coefficient, sound transmission losses, etc.) and mechanical (tensile, flexural, impact, etc.) characteristics are reviewed. Furthermore, this review paper studied an influencing parameter that affects the acoustical and mechanical characteristics of natural fibre-reinforced composites. these influencing parameters, such as fibre properties, density, porosity, sample thickness, binder amount, and filler material. In natural fibre-reinforced composites, increasing the percentage of the fibre density, binder amount, and filler material enhances sound absorption and mechanical strength, but these parameters have certain limitations, and crossing the limitation decreases the characteristics. reduce the porosity, decrease sound absorption, and increase sample thickness to increase acoustical characteristics. The conclusion states that the acoustical and mechanical characteristics of natural fibre-reinforced composites are enhanced when considering the performance-influencing parameters.

Keywords: Natural fibre-reinforced composite, Acoustical characteristics, Mechanical characteristics, Noise pollution, Sound absorption coefficient, Influencing parameters.

I. INTRODUCTION

Composites are a very beneficial material in this era. A composite is made of two or more different materials that have distinct physical or chemical properties. They are combined to create a new material with properties that are different from the individual material elements (M. Dawoud & M. Saleh, 2019). Composites are classified into three types: 1. metal matrix composites (MMCs), 2. ceramic matrix composites (CMCs), and 3. polymer matrix composites (PMCs). Polymer matrix composites have two different types: fibre-reinforced polymer composites and particle-reinforced polymer composites. Various short or continuous fibres are linked together by an organic polymer matrix to form polymer matrix composites (PMCs). The purpose of polymer matrix composites (PMCs) is to transmit loads between a matrix's fibres [2]. Natural fibres are combined with a polymer matrix to produce natural fibre composites. Natural fibres are taken from plants and animals in the environment. Natural fibre provides the best properties for composites [3]. This composite uses normally two categories of polymer: thermoplastics and thermosets. The eco-friendly concepts of bio composites work well with thermoplastic matrix, but mechanical performance and recyclability are severely limited. High temperatures tend to make the thermoplastic matrix softer, but cooling restores its characteristics. The thermoset is a highly cross-linked polymer; it gives the structure beneficial qualities including as high flexibility, strong strength, and modulus [4], [5]. Thermoset plastics such as polyvinyl alcohol [6], polyethylene [7], polypropylene [8], polystyrene acrylic resin [9], and thermoset such as phenolic resin [10], polyester [11], and epoxy resins [12].

Natural fibre-reinforced composites are increasing in popularity gradually in both research and industrial applications. They are eco-friendly, easy to manufacture, effective in cost, biodegradable, fully or partially recyclable, and provide impressive structural rigidity. This composite has high mechanical properties such as tensile strength, flexural strength, hardness, etc. and high acoustical properties such as sound absorption coefficient, noise reduction coefficient, and sound transmission losses. It also has good thermal and vibration properties [3], [5], [13]–[15]. As these properties get higher hence natural fibre composites are used in construction work or applications.

In this era, noise pollution increases because countries' development is faster, which then increases urbanization, industrialization, and transport. This pollution causes serious non-auditory effects on health, such as physiologic disorders, stress, annoyance, hearing loss, cardiovascular diseases, and sleeping disturbances, and it also affects plants and animals. Therefore, it needs those pollution controls are effective. Hence, use a natural fibre-reinforced composite in acoustical applications such as ceiling panels, partition boards, and so on. [14], [16]– [19].

Natural fiber reinforced composite fabricates different process such as Hand lay-up technique [20], vacuum bag moulding process, vacuum infusion, or vacuum assisted resin transfer moulding process [21], compression moulding process [22], and injection moulding process [23]. The most popular and extensively used method of production is hand lay-up because it is a simple and inexpensive process; other processes are complex and expensive [5], [24]. These composite acoustical properties are measured by different methods such as impedance tube method, reverberation chamber method, etc., and Several tests, such as tensile, flexural, and impact, etc., are used to describe mechanical properties.

It is essential to study the influencing parameters that affect the natural fibre-reinforced composite acoustical characteristics, such as sound absorption coefficient, sound transmission losses, noise reduction coefficient, etc., and the mechanical characteristics, which include tensile strength, flexural strength, impact strength, etc. This study helps select the best natural fibre-reinforced composite for acoustical and mechanical characteristics. Coconut coir, bagasse, sisal, bamboo, jute, and banana fibre are widely used natural fibres. These fibres provide the best acoustical and mechanical properties for a natural fibre-reinforced composite. and composites fabricated with natural fibre reinforcements appear to have various benefits over synthetic fibres. synthetic fibre composite is harmful to nature and humans.

In this review, the classification of natural fibres, as well as their properties and significance described in section 1. Section 2 focuses on the acoustical characterization of natural fibre-reinforced composites as well as the experimental technique for measuring these acoustic characteristics. Section 3 describes the mechanical characterization of natural fibre-reinforced composites and the characteristics measurement method and Section 4, discusses the various influencing factors that affect the acoustical and mechanical properties of the natural fibre-reinforced composite.

II. NATURAL FIBRE

Natural fibres are those produced by geological processes or from plant or animal bodies. Natural fibres are a relatively accessible and widely distributed resource in nature. And this natural fibre use has been documented approximately since 8000 BC. These natural fibres are divided into three types: plant fibres, animal fibres, and mineral fibres. [25] In this review, plant fibres are mainly studied, and some natural fibres are shown in Fig. 1.

Plant fibre is divided into several categories, including seed, grass, leaf, bast/stem, wood, fruit, and stalk fibres. These fibres are produced from a rigid, crystalline, cellulose, microfibril-reinforced amorphous lignin and/or hemi cellulosic matrix. The major elements of plant fibres include cellulose, hemicellulose, lignin, waxes, and a few other water-soluble compounds. Varied fibres have different percentage compositions of each of these elements. Plant fibres have outstanding properties like biodegradability, effectiveness in cost, high sound absorbing capacity, best strength, and specific rigidity [25]– [28].

Natural fibre-reinforced composites appear to have various advantages over synthetic fibre. Such advantages include significantly reduced pollution, expense, toxicity, and weight. These fibres improve the sound absorption, mechanical strength, and structural stability of the composite. These plant fibre composites are used in transportation, including automobiles, railway coaches, and aerospace, as well as in building or construction work, such as ceiling panels, roof tiles, partition boards, walls, floors, etc. [2], [4], [25]– [27].

Fig 1.- Natural Fibers: 1.[6], 2.[22], 3.[63], 4.[20], 5.[58], 6.[11], 7.[64], 8. [41], 9.[65], 10.[66], 11.[67], 12.[68].

III. ACOUSTICAL CHARACTERIZATION

An important role is played by natural fibre-reinforced composites in the acoustic field. Natural fibres have excellent acoustical properties due to their ability to absorb sound. In today's world, the use of natural fibre composites as sound-absorbing materials is becoming increasingly important in the construction of building absorbers. Natural fibers acoustic performance may be altered by modifying their composition, porosity, thickness, and other qualities, and most natural fibres exhibit porous absorber behaviour when it comes to sound absorption. These natural fibres bind with a binder, which provides the best structural stability for acoustic applications. Natural fibre composites are biodegradable and low-cost [14], [15], [29]– [31].

The acoustical characteristics of sound absorbing material are described using several methods. Those methods are the impedance tube method [32], the reverberation chamber method [33], the free field method [34], and the in-situ method [35]. The impedance tube method is an extensively used method. This method needs only a small sample, while another method needs a large sample [36]. The impedance tube method measures several parameters like sound absorption coefficient (α), reflection coefficient (R), and surface impedance (Zs), etc., while other methods characterize the nonuniform sound incidence on the absorbing sample.

Impedance tube method: In this method and special instrument, there is a well-defined and controlled acoustical condition that is used to measure the effect of the material's appearance on the known sound field and to ensure accuracy and repeatability. This method needs a small specimen that is why this is a favourable and economical method [32], [37].

Impedance tube are classified according to number of microphones, as shown in figure 2. [38], [39]

a) Two-microphone impedance tube
b) Three-microphone impedance tube
c) Four-microphone impedance tube

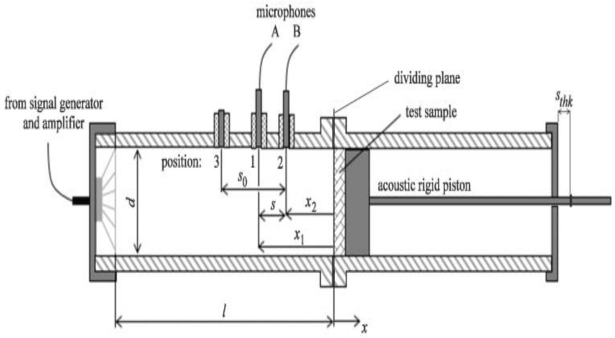

Fig2. a) Two microphone impedance tube [32]

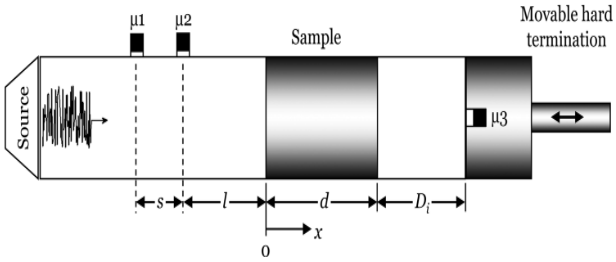

Fig2. b) Three microphone impedance tube [69]

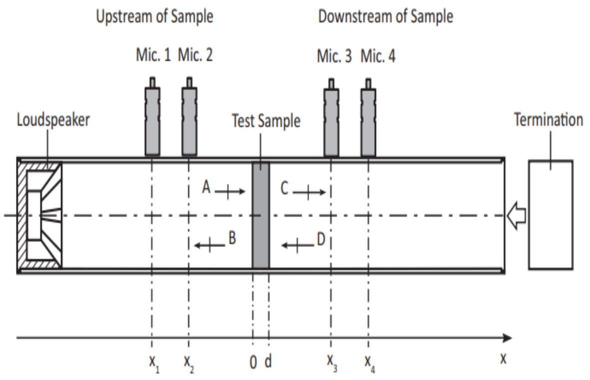

Fig 2. c) Four microphone impedance tube [37]

Dilbag Singh Mondloe et al. analyzed the acoustic properties of a natural fibre-reinforced hybrid composite with a varying volume percentage of musa-coir and a constant percent (60%) epoxy, preferably for applications in the interior of railway coaches. The results show that a composite made of 30% coir and 10% musa provides high acoustic properties [40]. Kuldeep Meena et al. studied the acoustic properties of a composite made of vetiver grass and magnesium oxide (MgO) cement. Composite samples are prepared from two different bulk densities, thicknesses, and fibre lengths by hand lay-up and compression moulding processes, and the reverberation chamber method is measured by their acoustic properties. The results indicate that the best sound absorption coefficient is given by an amalgamation of density and thickness, which is far more important than the length of fibre. [41]. Magdi El Messiry and Yasmin Ayman analyse the sound transmission loss (STL) of composite panels fabricated from a fibre combination (cotton, wool, and kapok), rubber crumb, and PLA meltblown. The results demonstrate that for high STL in kapok fibre, rubber crumbs, and PLA meltblown nonwoven composite panels compared to panels without a PLA meltblown nonwoven [42].

Nibesh A. G. and Jebakani D. examined the acoustic characteristics of different types of fibre (screw pine fibre and fish scale fibre) and bio-polymer (Neem or Thennamarakudi oil) combination composites, manufactured by hand lay-up method. In the 100-2000Hz frequency range, the sound absorption coefficient of neem resin and screw-pine composite are 30% greater than other composites [43]. Santhanam Sakthivel et al. analyse the sound-absorbing and insulating capabilities of hybrid composites having different volume fractions of sugarcane bagasse and bamboo charcoal with a constant percentage of polyurethane resin. They also investigate the effect of physical parameters on the sound absorption coefficient of composites. They found that a composite of 70 % bagasse and 30 % charcoal and 30 % bagasse and 70 % charcoal had the best physical and acoustical properties [22]. L. Yuvaraj et al. studied the effect of sound absorption coefficient and sound transmission losses of jute fibre composites with a 30 mm thickness sample and different partial perforations (depths of 7.5 mm, 15 mm, and 22.5 m). The sound absorption coefficient and sound transmission loss are measured by measurements in two and four microphone impedance tubes, respectively. The results show an increase in perforation depth with increasing sound absorption coefficients (0.9–1 at 1600 Hz) and better sound transmission losses for maximum depth [44]. Muna S. Kassim et al. investigated the sound transmission losses (STL) of natural composite materials concerning variables such as types of fibres (natural and synthetic), fibre thickness, and types resin (polyester and epoxy). combination of these variables and the fabrication of the 20 different composite specimens. The sound pressure level is used to measure STL in an acoustic chamber method. The result demonstrated that fibre size and thickness enhanced acoustic properties [45]. Ebrahim Taban et al. compared the experimental result to empirical models (Delany–Bazley, Miki, and Johnson–Champoux–Allard models) of natural coir fibre composite. Increased sample thickness and the presence of an air gap improve sound absorption. The experimental result consistent with the Johnson–Champoux–Allard model [6].

Yashwant S. Munde et al. examine the acoustic and vibrational damping properties of different weight percentages of sisal fibre and polypropylene (10/90, 20/80, and 30/70) composites. The composite sample was made by the twin screw extrusion–injection moulding process. high sound transmission losses of 23.35 dB for 30 percent sisal fibre composite and a high sound absorption coefficient of 0.23 at 4000 Hz for 20 percent sisal fibre composite [23]. Sair et al. investigated the acoustical properties of *distinct* weight percentages (5%, 10%, 15%, 20%, 25%, and 30%) of alkalised alpha-fibre-polyurethane composites. The impedance tube measures sound absorption coefficient, Alfa fibre ratio, and acoustic properties, which are correlated, with an increase in the fibre ratio followed by an increase in the acoustic properties [46]. TeckHern Teng et al. compare the sound absorption properties of epoxy resin to different biomass ashes in various ratios (1:1, 1:2, 1:3, 2:1, and 3:1). Composites are tested on an oscilloscope. The result demonstrated that a ratio of 1:2 coconut coir ash composite had a better sound absorption coefficient than another composite [47]. Rahmad R. and Ahmad Sukri A.S. investigated the acoustic characteristics of composites with varying volumes of palm coir fibre in a 2 cm thickness. Palm coir fibre with the best sound absorption coefficient was found to have a weight of 40 g. For the impedance tubes, the sound absorption coefficients were good at medium to low frequency, i.e., 630 Hz to 2000 Hz, in the range of 0.65 dB to 0.90 dB [48].

Musli Nizam Yahya et al. comparative Study of Acoustic Performance on Natural Fiber Composites. Composites are prepared using different weight percentages of natural fibre (Kenaf, Ijuk, coconut coir, and palm oil) to latex rubber (0/100, 80/20, 70/30, 60/40) in 50mm of thickness. a sound absorption coefficient value that was higher than 0.7 at its best was demonstrated by each natural fibre composite [49]. M. Shafiq M. et al. use the once-shot method to create different-thickness (10, 20, and 30 mm) polymer foam composites with varying weight percentage ratios of polyol (10%, 15%, or 20%) with wood filler. An experimental study was conducted on the effects of percentages and loadings, thickness, pore size, and density on the acoustical properties of composites. And they found that high percentage loading, thickness, small pores, and increased density gave a higher sound absorption coefficient [50] Mohamed Ali studied the Calotropis procera (Apple of Sodom) fibre microstructure, thermal analysis, and acoustic properties. In this, they prepare composites using various types of resin (phenol–formaldehyde resin and corn starch) and varying mass proportions of resin polymerized with dried fibre. According to the findings, using corn starch as a binder and high-fibre density composites improved the sound absorption coefficient [51]. The experimental results

were analysed and compared to empirical models (Garai-Pompoli and Delany-Bazley models) of different natural fibre composites (ramie, flax, and jute) by YANG WeiDong and LI Yan. and investigated the differences in the sound-absorbing properties of synthetic (carbon and glass fibres) and natural (ramie, flax, and jute) fibre composites. Experimental results consistent with the empirical models, particularly when frequencies are high, reveal that natural fibre is superior to synthetic fibre in reinforced composites [52]. S. Mahzan et al. evaluate the coconut coir fibre-reinforced composite's capacity to absorb sound when mixed with recycled rubber. This composite is prepared by adding different percentages of coconut coir to recycled rubber (0/100, 10/90, 20/80, 30/70, and 40/60) with a 25 and 35% polyurethane binder. and A two-microphone impedance tube is used to measure the acoustic properties. The best acoustic properties are provided by compositions including 25% polyurethane and, more specifically, 40% coconut fibre and 60% recycled rubber [53].

A summary of the best acoustical characteristics ((sound absorption coefficient (SAC), Noise reduction coefficient (NRC) and sound transmission losses (STL)) of natural fiber-reinforced composites as well as the parameters that influence the composite's acoustical characteristics are shown in table 1.

TABLE 1. Acoustical characteristics of natural fiber-reinforced composite

Composite	Parameters	Maximum SAC, NRC & STL at peak frequency range	Experimental techniques	Researcher
Musa fiber + Coir fiber + Epoxy	Fiber density	0.76 @ 500 to 4000 Hz	Two microphone impedance tube method	[40]
Vetiver bunchgrass fiber + Magnesium Oxide (MgO) cement	Fiber density, thickness, Length	0.72 @ 20000 Hz	reverberation chamber method	[41]
Kapok fiber + rubber crumbs + PLA meltblown	Fiber Thickness and density	54 to 60 dB @ 200 to 1600 Hz,	Acoustical chamber method	[42]
screw pine fiber + neem resin	Amount of binder	>0.2 @ 100-2000Hz	Impedance tube method	[43]
Bagasse fiber + bamboo charcoal + Polyurethane	Fiber density	>0.6 @ 3000 Hz	Impedance tube method	[22]
jute fiber + Epoxy	Perforation depth	0.9–1 at 1600 Hz	two microphone impedance tube method	[44]
1. Epoxy +fiber glass+ plan fronds 2. polyester + Random + wool	Fiber Thickness	1. >0.4 @ 0 to 8000 Hz 2. >40 dB @ 0 to 8000 Hz	Acoustical chamber method	[45]
Coir Fiber + polyvinyl alcohol	Sample Thickness	0.58 @ 63–6300 Hz	two microphone impedance tube method	[6]
sisal fiber + polypropylene	Composition	0.23 @ 4000Hz	two microphone impedance tube method	[23]
Alfa fiber + polyurethane	Fiber density	>0.325 @ 50–2000 Hz	Impedance tube method	[46]
coconut coir ash + Epoxy	Composition	0.103 @ 500 – 6000 Hz	oscilloscope	[47]
Palm Coir fiber + Epoxy	Fiber density	0.90 dB @ 350 Hz - 6400 Hz.	Impedance Tube Method	[48]
Ijuk fiber+ latex rubber	Amount of binder	0.92 @ 3000 Hz to 4500 Hz	two-microphone transfer function method	[49]
wood dust + polymer foam	Sample Thickness and Amount of binder	0.999 @ 0-6000 Hz	Impedance Tube Method	[50]

Calotropis procera (Apple of Sodom) fiber + polymerized corn starch resin	Amount binder	0.85 @ 6300 Hz	Impedance Tube Method	[51]
jute fiber + Epoxy	Fiber density	>0.9 @>1000 HZ	Impedance tube transfer function method	[52]
Coconut Coir Fibre + Recycled Rubber + polyurethane	Amount binder	>0.5 @ 1400 – 6300 Hz	two microphone impedance tube method	[53]

IV. MECHANICAL CHARACTERIZATION

The natural fibre-reinforced composite demonstrates excellent specific strength and modulus, high fatigue resistance, great damage resistance, and the best damping. Mechanical characteristics of composites, include as best tensile, impact, flexural, compressive, etc., are applicable for transportation, industrial, and building applications. Composites with high fatigue and damage resistance avoid crack formation, and structures with high damping resistance have structural stability [1], [4], [5], [54]. The mechanical characteristics of the material are described using several tests according to the specified standards and machines, as follows:

- Tensile Test: According to the ASTM D 3039 standard, tensile tests are performed on a universal testing machine. [20], [55], [56].
- Flexural Test: Universal testing machine in accordance with the ASTM D790 standard, flexural tests were conducted. [20], [21], [55].
- Charpy Impact Test: According to ASTM D256, Charpy impact tests were performed using an impact testing machine. [20], [55].
- Hardness Test: Hardness tests were conducted on a Shore-D hardness tester according to a specific test standard [55].
- Quasistatic indentation test: Quasistatic indentation testing is used to measure resistance to penetration and energy absorption of the material, and on a universal testing device, this test is conducted [9].

Swaroop Nair and Arvind Dasari studied the composite panels of oil palm fibre with two different compositions (with and without fly ash (FA)). Water-based acrylic resin (20 wt.%) is used in the without FA composition, along with a variety of metal oxides (25 wt.% gypsum and magnesia) and a minor addition of phosphates. In another composition, a FA (25 wt.%) is used instead of metal oxide. Composite panels have better flexural strength, but at warm water tests there is an enormous reduction in flexural strength, and panels with FA are more rigid than the panel without FA on a quasistatic test and a drop weight test [9]. N. Dhandapani and A. Megalingam et al. investigated the tensile, flexural, and impact properties of sisal and palm fibre-reinforced hybrid composites with different weight ratios. The researchers use compression moulding to create three different samples with a constant weight percent (65) of epoxy resin. Maximum mechanical properties were observed in a 20% sisal and 15% palm fibre sample [20]. Abdel-Hakim et al. investigated the tensile strength and flexural strength of sawdust/recycled expanded polystyrene composites with distinct loading levels (0, 20, 40, 60, and 80 wt.% of sawdust). The result shows that the 20 and 40 wt. % sawdust specimen give high mechanical properties and more 40 % increasing sawdust then after decreasing the mechanical properties [57]. Hilal Olcay and Emine Dilara Kocak et al. conducted an experimental analysis of the mechanical characteristics of treated with 10% NaOH and untreated rice plant waste fibre in different weight ratios (5%, 10%, 15%, and 20%) with polyurethane. Tensile strength, elongation, and elasticity module values of these mechanical properties are best in untreated and treated 5% fibre-reinforced composites, but alkaline treatment reduces fibre strength and elongation [58]. Jiahui Shen et al. examined the tensile and flexural strengths of jute fibre-reinforced polypropylene composites. These composite samples had different residual gum rates (19.52, 12.23, and 3.96%) and *distinct* treated (by NaOH) fibre contents (5, 20, 35, and 50%) and were fabricated by the hot press method. The residual gum proportion of 3.96% and fibre content of 35% show better mechanical properties [8]. Tufail Hassan et al. studied the impact and flexural strength of a green composite of different natural fibres (cotton, coconut, and sugarcane) with green epoxy resin, and this prepared *distinct* fibre volume fractions (10, 15, and 20%) of each fibre. And found that cotton fibre (20%) has high mechanical properties. They conclude that increasing the fibre percentage enhances the properties of the composites [59]. The mechanical behaviour of hybrid and homogenous jute-luffa composites was studied by Yusuf Saygili et al. Modal tests are used in this work to measure the mechanical characteristics of the composite plates. They found that hybrid composite samples had higher damping and elasticity modulus than homogeneous composite samples [12].

M. K. Marichelvam et al. investigated the mechanical characteristics of Bagasse – coconut coir-based hybrid reinforced composite. Composite samples are prepared using treated and untreated fibres and different weight percentages of bagasse, coconut coir fibre, and epoxy resin. The result shows that composite specimens that contain 20% bagasse fibre, 40% coir fibre, and 40% resin have a great tensile, flexural, impact, and hardness properties, and found that fibre treatment enhances mechanical properties [55]. Marwa Lahouioui et al. fabricated a unique composite of *distinct* mass proportions (2.5%, 10%, and 20%) of chemically treated and untreated palm fibres that were blended with cement, sand, and water. and evaluate the mechanical behaviour; measure the compressive strength. higher compressive strength (14.85 MPa) in treated fiber (2.5%) composite and found that treated fiber composites give the best compressive strength and fibre percentage increases, but reduce the mechanical strength of both types of composites [60]. Ahmad Safwan Ismail et al. calculated the mechanical characteristics of kenaf/bamboo fibre-reinforced epoxy hybrid composites. The 50:50 weight ratio of the kenaf/bamboo fibre hybrid composite gives the highest tensile strength (55.18 MPa) and modulus (5.15 GPa) [56]. Xinwu Xu et al. investigated the composite panels of rubber crumbs, fibreboard sawdust, and high-density polyethylene and fabricated them by hot press moulding. Calculate the mechanical properties of composite panels and give acceptable properties (tensile: 10.69 MPa; three-point bending: 26.24 MPa; impact: 8.6 MPa) [7]. Elammaran Jayamani et al. examined the tensile and yield strengths of different weight ratios of treated and untreated betelnut fibre and unsaturated polyester composite. Tensile testing was performed with the Universal Testing Machine, and those composites that contain 10 % treated fibre have the best tensile and yield strengths [11]. Prabhakaran et al. manufactured flax and E-glass fibre-reinforced composites by vacuum-assisted resin transfer moulding. And they studied the flexural strength and modulus of different specimens in novel layers and combinations of different layer fibres (flax/epoxy, glass/epoxy, and glass/flax/epoxy). Flax fibre-reinforced composites are equal to glass fibre-reinforced composites in terms of specific flexural strength and modulus [21]. Narimane Mati-Baouche et al. constructed the experimental design to determine the grading size of particles, the proportion of chitosan to sunflower particles, and how the stress of compaction affected the mechanical properties of the bio-based composite (sunflower stalk particles and chitosan). The found that the mechanical characteristics of the composites improved correspondingly as the compaction pressure increased [61]. Han-Seung Yang et al. prepared the composite boards with a specific gravity of 0.8 and different weight ratios of rice straw-waste tyre particles with polyurethane adhesive. They evaluate three-point bending strength and show better flexural properties than wood particle boards but lower bending strength. And they also examine different weight ratios of the rice straw–wood particle composite board with different specific gravities. And shows specific gravity 0.8 and 10 % fibre contain gives better mechanical properties than wood particle board [62].

A summary of the best mechanical characteristics (tensile, flexural and impact strength) of natural fiber-reinforced composites are shown in table 2.

TABLE 2. Mechanical characteristic of natural fiber reinforced composite

Composite	Tensile strength (Mpa)	Flexural Strength (Mpa)	Impact Strength (Mpa or J or KJ/m2)	Researcher
Sisal fiber + Palm fiber + Epoxy resin	18.129	45.449	0.68	[20]
Sawdust + polystyrene	19.58	47.5	-	[57]
rice plant waste + polyurethane	0.254	-	-	[58]
Jute fiber + Polypropylene	30.61	38.83	-	[8]
Cotton fiber + Green epoxy	-	81.7	9.73	[59]
Bagasse fiber + Coconut Coir fiber + Epoxy	49.08 ± 0.78	42.2	3.5	[55]
Kenaf Fiber + Bamboo Fiber + Epoxy	55.28	-	-	[56]
Rubber tire particles + sawdust + High density poly	10.69	26.24	8.6	[7]
Betelnut Fiber + polyethylene	20	-	-	[11]
Glass fiber + Flax fiber + Epoxy	-	2.352 ± 0.47 MPa	-	[21]
sunflower stalks particles + chitosan	250	--		[61]

V. INFLUENCING PARAMETERS ON PERFORMANCE OF NATURAL FIBER REINFORCED COMPOSITE

In this describing the different parameters which affect the natural fiber reinforced composite acoustical and mechanical characteristics. This influencing parameter as follows

A. Effect of Fiber Properties:

Fibre diameter or thickness, and length: Fiber diameter has an important effect on the acoustical properties of natural fibre-reinforced composites. Fibre diameter decreases, followed by an increase in composite pores and area of contact due to a rise in sound absorption coefficient. And fibre treatment reduces fibre diameter, which improves mechanical properties to a certain extent. Fibre length is not much more important for acoustical and mechanical properties [22], [40], [55], [60].

B. Effect of Density:

Up to a certain extent, the acoustic characteristics of composites rise as fibre density increases. It increases fibre density, which reduces porosity and thus blocks sound waves. Decrease the fibre density, which traps more sound waves. And while increasing fibre density improves mechanical properties, there are some limitations [8], [9], [23], [46], [59].

C. Effect of Porosity:

The volume of the material's voids divided by its overall volume is known as the porosity of a porous substance. The material's sound-absorbing pores allow sound waves to flow through them, dissipating their energy and dampening themselves. More collisions between the sound wave and the fibre cell wall result from smaller pores. High sound absorption coefficient due to small pore size [48], [50], [52], [53].

D. Effect of Specimen Thickness:

The increased thickness of the specimen increases the sound absorption coefficient. As the sample thickness increases, the sound wave passes through more area, resulting in more sound losses and giving better acoustical properties [6], [50].

E. Effect of Binder Amount:

Binder amount has a significant effect on the acoustical and mechanical characteristics of natural fibre composites. Increase the binder amount to get a high sound absorption coefficient, but this comes with limitations. Across the limitation, increase the binder amount due to reduced pores. Pores reduce, which makes it more challenging for sound waves to penetrate the material and hence reduces the sound absorption coefficient. Increase the binder amount to get a better mechanical property, but there are certain limitations [8], [49]– [51].

F. Effect of Binder Amount:

The filler material enhances the acoustical and mechanical characteristics of natural fibre-reinforced composites. Filler materials such as industrial waste, recycled rubber, sawdust, fly ash, etc. mix with the composition of natural fibre and binder. Filler materials add to the composition; the material surface and air between them create viscous resistance, which then leads to more sound loss. Certain constraints necessitate the inclusion of filler material in the composition because it reduces the acoustic and mechanical properties [9], [42], [47], [53], [57].

VI. CONCLUSION

The paper provides an up-to-date review of the acoustical and mechanical characteristics of natural-fiber reinforced composites.

- Natural fibres are a widely available and easily accessible material in nature. They show excellent material properties, such as biodegradability, high sound-absorbing capacity, high strength and specific rigidity, and the best damping capacity. The features of polymer matrix composites built with natural fibre reinforcements appear to be more varied than those of synthetic fibres, including decreased weight, cost, environmental *contamination,* noxiousness, and recyclability.
- The field of acoustics greatly benefits from natural fibre-reinforced composites. The impedance tube method is a popular technique for determining

acoustical characteristics. The sound absorption coefficient is an important parameter in acoustics. While measuring the acoustical characteristics, increase the porosity and thickness of the composite to increase the sound absorption coefficient. It also reduces sound absorption capacity due to the cross-limitations of filler and the mixture of binder and fibre.

- Natural fiber-reinforced composites have excellent mechanical characteristics. While measuring mechanical properties, reducing the fibre diameter size or thickness gives the highest tensile, flexural, and impact strengths, and the right percentage of the mixture of binder and fibre provides the best mechanical properties; if the filler percentage increases, then mechanical properties increase.

When natural fibre-reinforced composites are prepared while considering the performance-influencing parameters, the acoustical and mechanical characteristics of the composites improve. This review will demonstrate a greater interest in the use of natural fibre-reinforced composites due to their environmental and economic benefits.

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