Journal of
Polymer & Composites

ISSN: 2321-2810 (Online)
ISSN: 2321-8525 (Print)
Volume 11, Special Issue 4, 2023
DOI (Journal): 10.37591/JoPC

http://engineeringjournals.stmjournals.in/index.php/JoPC/index

Research JoPC

Mechanical Properties Investigation of Green Waste Composite Material

Viyat Varun Upadhyay*

Abstract

Widespread accessibility and abundance of natural fibres are driving forces behind renewed focus on eco-friendly solutions. Researchers have recently begun to focus on natural fibres as reinforcement due to their many advantages over more conventional materials. Natural fibre is an attractive ecological and biodegradable alternative to most common glass fibre, synthetic reinforcement, because of its high specific and low cost mechanical capabilities. India is home to a wealth of untapped natural resources. The majority is a result of forest and agricultural growth. This paper presents results of experimental study into green hybrid composite mechanical characteristics. The approach starts with a study, moves on to an examination of their characteristics, production method, and refinement, and concludes with experimental evaluations of the mechanical properties of the final compositions. Green hybrid composites made with different ratios of coconut and wheat straw fibres produced intriguing outcomes. The composites had better results than those obtained by using only coconut and wheat straw fibres. Mechanical properties include things like tensile strength, impact energy, and bending strength. The results showed that a composite with a weight distribution of 50% coconut coir and 50% wheat straw fibre had an impact strength of 49.27 N/mm^2, which was greater than that of a composite formed from either fibre alone. While its tensile strength (110.7 MPa) and bending strength (115.7 MPa) are also higher than those of coconut fibres, the 65% coconut 35% wheat straw composite is lighter (18.80 MPa). Numerous determinations can be made using these composites.

Keywords: Bending Strength, Coconut Coir, Composite, Tensile Strength, Wheat straw,.

INTRODUCTION

The desire for effective improvement, which may be measured in a variety of ways including lower weight, considerably enhanced, and decreased cost, frequently tests the limits of today's materials. As a result, professionals in the field of substances are consistently pushing to create either improved iterations of already materials available or new materials altogether. To illustrate the second kind, consider composites. Composites, plastics, and ceramics have dominated the market as new materials for the last thirty years. Composites continue to expand in both volume and variety of uses [1], infiltrating and eventually dominating new markets. From commonplace items to specialized niches, modern composites take up a sizable chunk of the engineered materials industry.

The value of composites as lightweight materials has been established; the present problem is to make them affordable. Several cutting-edge manufacturing processes are presently employed in the composites sector as a direct consequence of the industry's tireless efforts to manufacture economically appealing composite components [2]. Because of the massive transportation industry, composites industry has

*Author for Correspondence
Viyat Varun Upadhyay
E-mail: viyat.upadhyay@gla.ac.in

Assistant Professor, Department of Mechanical Engineering, GLA University, Mathura, Uttar Pradesh, India

Received Date: December 12, 2022
Accepted Date: May 19, 2023
Published Date: June 15, 2023

Citation: Viyat Varun Upadhyay. Mechanical Properties Investigation of Green Waste Composite Material. Journal of Polymer & Composites. 2023; 11(Special Issue 4): S528–S36.

realized that commercial composites use promise to give significantly bigger income possibilities than the aerospace sector.

The most widely accepted definition of composites is that they are multifunctional material systems that offer properties not attainable from any one material [3]. They are built from a wide variety of materials that compliment one another in appearance and function. Consequently, the term composites can be used to describe a wide variety of both organic and man-made items, including wood, bones, shells, and even some surface coatings, resin-bound superconductors, powder-charged polymers, paper, and etc. materials like laminates, etc [4]. This definition lacked precision since it allowed for the inclusion of any combination of materials in the category of composites without providing any indication of the uniqueness of the mixture or the rules which should provide it any meaningful distinction from other highly generic mixtures, emphasises repeatedly that composites are more than just a splice of two different materials. The combination has unique characteristics in the wider sense. It's either fundamentally different from both parts or it outperforms both parts individually in some desirable way (such as heat resistance, strength, etc.).

Berghezan [3] defines composites as compound materials distinguished from alloys in that individual components recollect their appearances while being sufficiently integrated into the composite to reap only the benefits of those components' strengths while avoiding their weaknesses.

VanSuchetclan [4] defines composites as heterogeneous materials with solid phases (two or more) in intimate interaction with each other on microscopic scale. If you look at them closely enough, you might be able to tell that they all have the same physical properties.

India has a wealth of natural fibre resources, including sisal, jute, bamboo, ramie, pineapple, banana, coir, and so on, and the country's researchers have been working to enhance natural fibre composites in order to discover new uses for these materials [5]. Utilizing composites made from natural fibres is a great alternative to using wood in the construction industry. Natural fibre composites in India are being developed using a two-pronged approach that seeks to both slow the pace at which forests are cut down and guarantee profitable returns on the materials' production.

Improvements in composite materials first aimed at the aerospace industry have filtered down to benefit regular people and commercial enterprises alike. In many cases, traditional materials like wood, metal, etc., have been phased out in favour of composites due to their low weight, high strength-to-weight ratio, and stiffness qualities. Experts from all over the world have been investigating natural composites as a means of cutting down on material costs.

Hybrids are the most advanced composites available today, even surpassing conventional FRP composites. In a half and half setup, either both strengthening stages and one lattice stage are present, or only one strengthening stage is present and many grid stages are present, or a different strengthening is present and multiple network stages are present. There is no other fibre reinforced composite that can compare to them in terms of adaptability. The normal composition consists of both high- and low-modulus fibres [6–7]. The low-modulus fibre increases the composite's damage tolerance and helps keep material cost down, while high-modulus fibre is responsible for giving the material its strength and load-bearing qualities. Changing the volume proportion and stacking order of different uses may alter the mechanical characteristics of half breed composite.

There is a significant strength and rigidity advantage to using fibres instead of the bulk form of a material. Bulk material is more likely to have faults that reduce its strength, while fibres almost never have internal imperfections. Fibers are extremely tiny crystals with highly precise molecular or crystallographic alignment. One other benefit of fibres is their low density [8–9]. A fibre reinforced composite material primarily consists of fibre. They make up the bulk of the composite material as well. The tensile stress is the only one that reinforcing fibres can handle. However, when utilized in fibre reinforced composites, the fibre is able to contribute significantly to the FRP composite's compressive, tensile, and shear or flexural strength and stiffness thanks to the matrix that surrounds it.

MATERIALS AND METHODS

Materials

Coconut and wheat straw were the two materials that were studied. Epoxy resin (Araldite AW106) and Hardener (HV 953 IN) are utilised to bind the fibres together during the matrix phase. Rectangular tubes have been cast in a mould. It has a fixed width and thickness but a variable length. This mould produces a specimen that is always 10 mm in width but whose depth is adjustable in relation to the amount of fibres used.

Primary Reinforcement Coconut Fiber

The coir fibres of coconut are located in space between outer layer and tough, interior shell. The cells that make up a fibre are long and skinny, with thick cellulose walls. When mature, a coating of lignin is produced on their walls, hardening and yellowing them from their formerly light appearance. About 1 mm (0.04 in) in length and 10–20 m (0.0004–0.0008 in) in width characterise each cell [10–11]. Fibers commonly range in length from 5 centimetres to 30 centimetres (about 2 inches to 12 inches). Coir comes in a brown and a white variety. Brown coir is thick, robust, and resistant to abrasion since it is extracted from mature coconuts. Mats, brushes, and sacks are common places to find it in usage. Due to their greater lignin and lower cellulose content, mature brown coir fibres are tougher but less flexible than other fibres like flax and cotton [12–13]. Figure 1 shows Coconut coir & Wheat straw FibersWhite coir fibres, which are harvested from immature coconuts, are softer, finer, and more fragile than their brown counterparts. Typically, they are spun into yarn for use in constructing mats or rope.

The coir fibre is one of the few natural fibres that can withstand the corrosive effects of seawater. Brown coir requires the use of fresh water in its processing, whereas white coir requires both saltwater and freshwater. Avoid getting it mixed up with coir pith, also known as cocopeat, the powdery byproduct of coir fibre manufacturing. Corah is the native term for coir fibre. A crop that is both biodegradable and environmentally beneficial. In addition, it is a natural fibre that is strong, stable, and flexible, and it has been acknowledged as a key component in composite materials.

Secondary Reinforcement: Wheat Straw

Wheat straw is remaining stalk from milling wheat into flour. The common practise has been to discard it. Farmers in certain countries burn it, which increases air pollution and poses a health risk to the local population. Even yet, these stalks are not worthless. We recycle it into new wheat straw goods. Figure 1 shows Coconut coir & Wheat straw Fibers. After the grain and chaff have been removed from cereal plants, the dried stalks are a byproduct known as straw. In terms of cereal grains like barley, oats, rice, rye, and wheat, it represents nearly half of the harvest.

Figure 1 Coconut coir & Wheat straw Fibers.

In today's agricultural systems, wheat straw is a common by product [14]. These leftovers after harvest may contain a variety of cell wall components including as lignin, hemicelluloses, and cellulose. Fibrous viscose and lignin are examples of robust compounds [15]. Wheat straw contains a significant amount of surface carboxyl, hydroxyl, ether, amino, and phosphate groups, making it excellent for use in generating adsorbent materials for the treatment of wastewater and slow-release fertilisers. Multiple studies have demonstrated that wheat straw is useful as a reinforcement and/or filler in composites, both structural and non-structural [16–17].

Epoxy Resin

Epoxy resins are kind of sticky polymer with firmly connected structure that is often used for coatings and adhesives on the surface. This thermosetting resin is used in robust adhesives, coatings, and laminates. When cured, epoxy resins produce a strong, cross-linked polymer structure. When it comes to withstanding heat and chemicals, epoxy adhesives are hard to beat. Epoxy is now often used to describe a broad variety of materials other than those made from fibre reinforced polymer composite. Figure 2 shows Epoxy resin Epoxy is utilized as the resin matrix in fiber-reinforced plastics because it effectively maintains the fiber's position. It may be used with any kind of reinforcing fibre, including glass, aramid, or natural fibres [18–19].

Both Epoxy resin (Araldite AW 106) and hardener (HV 953 IN) were utilized to accomplish this task. These have a viscosity of 10–20 poise at 30 degrees Celsius. It takes around 12 hours for the adhesive and hardener to fully set. Its drying period is just right for making composites, falling between the extremes of too fast and too slow.

Figure 2. Epoxy resin.

METHODS

Fabrication Specimen

The specimens used in tests were hand-laid. Both coconut and wheat straw fibre were prepared by being chopped into short, 28 mm-30 mm lengths. Three 20-gram specimens each of 100% coconut fibres (Specimen-S1), 70% coconut fibre with 30% wheat straw (Specimen-S2), 50% coconut fibre with 50% wheat straw (Specimen-S3), 30% coconut fibre with 70% wheat straw (Specimen-S4), and 100% wheat straw (Specimen-S5) were prepared (Specimen-S5). The mould is then brushed out and coated with a thin plastic layer to prevent specimen fragments from sticking to the mould [13]. A glass rod was used to combine 4 parts resin to 5 parts hardener in a mixing dish. Bubbles were carefully avoided by using this precautionary measure. Due to the trapped air bubbles in the matrix, the material may fail. The bundle of fibres was created by applying a combination of glue and hardener over a layer of prepared fibres. The bundle of fibres is moved to the mould, where it is pressed under a weight of 20 kilogrammes. After 24 hours at room temperature, the castings were ready for use. Composites have been removed from the mould and are now ready for inspection. After that, the composite specimens are measured and weighed once again (Figure 3).

Journal of Polymer & Composites
Volume 11, Special Issue 4
ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

Figure 3. Fabrication specimen Mechanical analysis of specimen.

Work has been done to examine bending, tensile, and impact characteristics of a composite material made from coconut fibre and wheat straw. Epoxy resin made up of AW106 resin and HV 953 IN hardener, combined in the right proportions, is used to bond these composites together. Using both coconut and wheat straw fibres, hybrid composites were created with varying percentages of coconut fibres (0.70 in Specimen 1, 0.30 in Specimen 2, 0.50 in Specimen 3, and 0.30 in Specimen 4). Wheat straw fibres, 4 specimens, 100% Ratios of weight fractions for Specimen 5, with the total fibre weight held constant at 20 grammes. Three different composites made from coconut husks and wheat straw have been developed [14]. In this location, we prepare specimens. The bending strength, impact test, and tensile test, test of hybrid composites made from coconut and wheat straw fibres are all shown. The specimens are made using the hand layup technique, and the fibres are organized in a unidirectional fashion. Tensile and compressive tests were performed on specimens ranging in size from 1010 to 50 mm in length, but with varied amounts of material. On the same Izod/Charpy testing system, we ran an impact test (the Charpy test) on the specimen.

Impact Test

These strains appear all of a sudden. The strains imposed on these components are several times greater than those produced by progressive loading. Because of this, impact testing is used to evaluate a material's resilience to the impact of rapidly applied loads. I) These characteristics may be quantified by their I Rupture energy, (ii) Modulus of rupture, and (iii) Notch impact strength.

The Charpy test and the Izod test are two common types of notch impact testing Figure 4 shows Mechanical Testing of Composite Specimen. The "cantilever beam" arrangement is used for the specimen in the charpy test. The specimen has a notch in it at an angle of 45 degrees, formed like a V. Possible alternative shapes for the notch include a U. Figure 5 shows impact energy test of epoxy composite. The notch should be on the tension side of the specimen so that it doesn't become deformed too much under impact stress. Notch depth is usually between 0.5 and 0.3 of the specimen thickness.

Figure 4. Mechanical Testing of Composite Specimen.

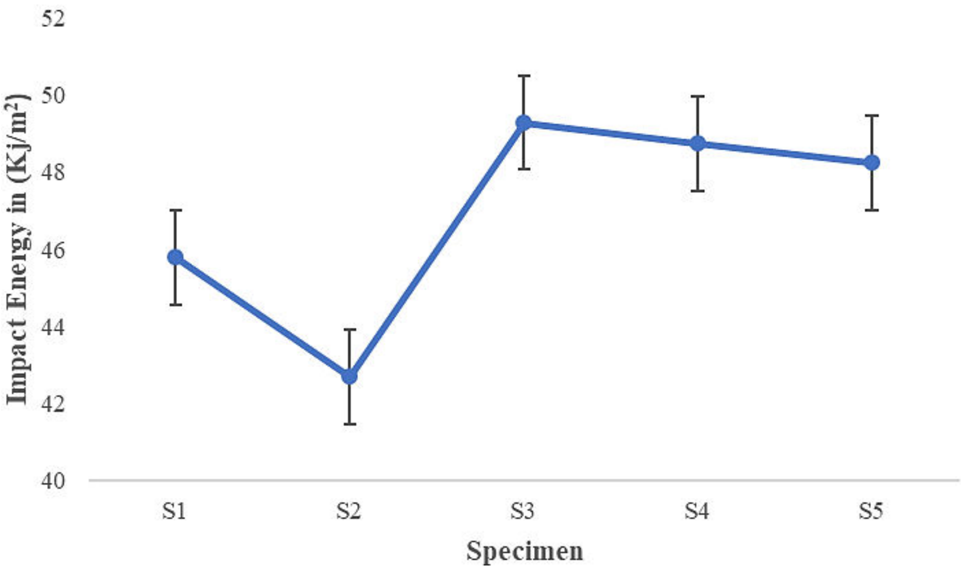

Figure 5. Impact energy test of epoxy composite.

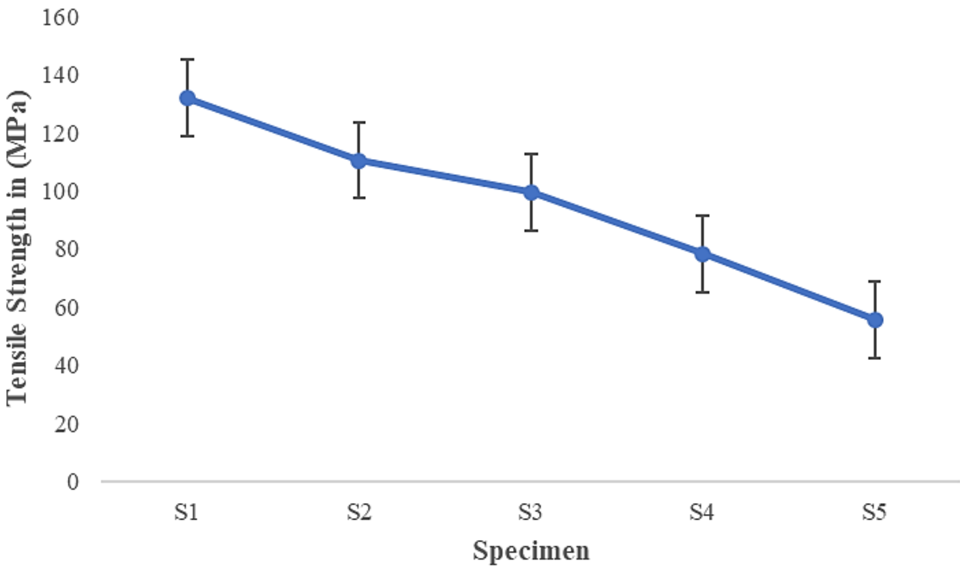

Figure 6. Tensile strength test of epoxy composite.

Tensile test

Many factors, including fibre loading and fibre length, influence the mechanical characteristics of composites. It is common practise to conduct tensile testing on flat specimens. Dog-bone and straight-side types with end tabs are the most typical specimen geometries. The tensile testing of composites is performed using an Instron 1195 Universal Testing Machine in accordance with ASTM D3039-76 test models. Composite specimens were tested by attaching a load to both sides of the material. Figure 6 displays the tensile test apparatus and specimen. The length of specimen was 42 mm. These tests were conducted at constant strain rate of 2 mm/min.

Flexural Test (Bending Test)

The material's flexural qualities were evaluated using a series of three-point bend tests conducted to ASTM D 790, method. The dimensions of these specimens were 100 mm in length, 10 mm in breadth, and 10 mm in thickness. In a three-point bending test, there is a 64 mm separation between the outer rollers. Since a multiple bend test uses less material and does not need the precise production of center-point deformations by testing equipment, it is selected for this application. Based on our prior work [9], we determined the elastic strength and the maximum composites stress. Figure 7 shows that bending strength of the composite. At a strain rate of 0.5 mm/min, an electronic tensiometer measured the strength of specimens that were replicated three times for each volume concentration of fibre. Fiber and its composites' densities were determined using a pycno-metric method. The following formula was used to calculate the flexural strength of composites:

$$\tau = \frac{3fl}{2bt^2}$$

Where

t = thickness of specimen under test.

τ = flexural strength,

l = gauge length,

f = load,

b= width

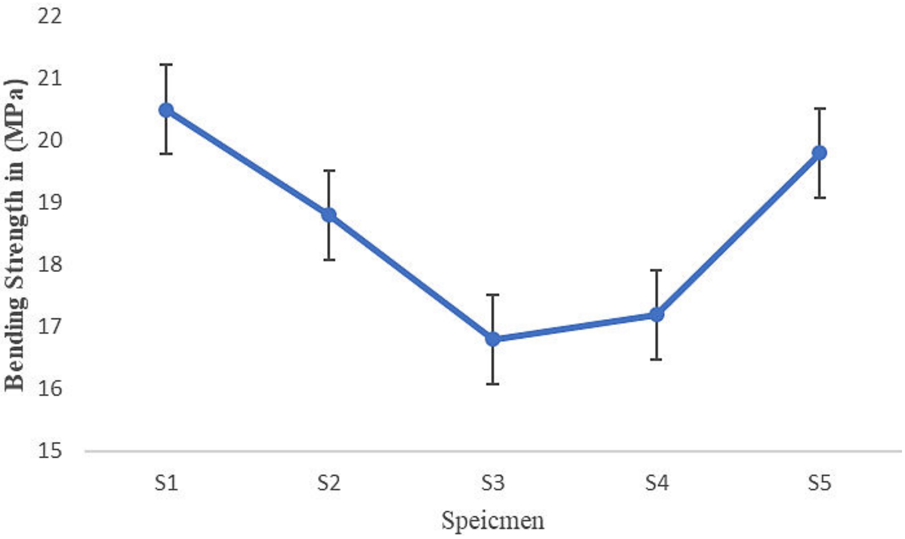

Figure 7. Bending strength test of epoxy composite.

RESULTS AND DISCUSSION

Several specimens of a fibre composite made from coconut husks, wheat straw, and epoxy were evaluated for their mechanical characteristics, including their resistance to impact, bending, and tensile stress. The ASTM D 3039-76 standard was used to conduct a tensile test on a UTM machine. All the specimens had parallel sides and end tabs measuring (110 × 20 × 20) mm. According to ASTM D 3039-76, an impact test was conducted using a (Izod & Charpy) Impact test equipment. All the specimens had parallel sides and end tabs measuring 50 × 10 × 10 and 65 × 20 × 20 millimeters. Flexural qualities were evaluated with a three-point bend test under ASTM D 790 M-86 method I. Table 1 shows that composite comparative mechanical properties The dimensions of the specimens were 100 millimeters in length, 20 millimeters in width, and 10 millimeters in thickness.

Table 1 Comparative mechanical properties of composite

S.N.	Specimen	Tensile Strength in (MPa)	Impact Energy in (Kj/m^2)	Bending Strength in (MPa)
1	S1	132	45.8	20.5
2	S2	110.57	42.7	18.8
3	S3	99.65	49.29	16.8
4	S4	48.75	17.2	16.20
5	S5	48.25	19.8	15.80

CONCLUSION

Coconut coir and wheat straw fibres, at varying percentages by weight, form the reinforcing phase of a polymer matrix composite. Composites reinforced with coconut and wheat straw fibres were examined for their material characteristics after fabrication. It has been discovered that put it another way, the world's coconut harvest is the greatest of any fruit. The results of the tests showed that wheat straw is not as strong as coconut fibre when used alone. However, composites made from coconut and wheat straw fibres have shown impressive strength for their low weight. Green hybrid composite made of wheat straw fibres and coconut has increased impact strength because to the addition of wheat straw fibres:

- The tensile and bending strengths of a composite made of coconut and wheat straw fibres decrease as proportion of coconut fibres in the mixture decreases.
- It has been discovered that increasing the proportion of coconut fibre in a composite helps to lower composite's density and that adding coconut fibre increases the composite's impact strength.
- Strength-to-weight ratio of hybrid composites formed from wheat straw and coconut by varying the weight ratio of the constituents is better than that of composites manufactured from either material alone.
- Using a hybrid composite of 50% coconut and 50% wheat straw, we were able to achieve maximum impact energy and notable tensile and bending strength.
- These various hybrid composites have potential to replace widespread synthetic use fibres in many applications.

REFERENCES

1. Ramesh M, Rajeshkumar L, Balaji D, Bhuvaneswari V. Green composite using agricultural waste reinforcement. In Green Composites 2021 (pp. 21–34). Springer, Singapore.
2. Ramanaiah K, Prasad AR, Reddy KH. Experimental study on thermo physical properties of biodegradable borassus fruit fiber-reinforced polyester composites. Materials Today: Proceedings. 2021 Jan 1;44:1857–9.
3. Wondmagegnehu BT, Paramasivam V, Selvaraj SK. Fabricated and analyzed the mechanical properties of textile waste/glass fiber hybrid composite material. Materials Today: Proceedings. 2021 Jan 1;46:7297–303.
4. Sharma A, Chaturvedi R, Sharma K, Saraswat M. Force evaluation and machining parameter optimization in milling of aluminium burr composite based on response surface method. Advances in Materials and Processing Technologies. 2022 Feb 20:1–22.
5. Kumar A, Kumar V, Singh B. Cellulosic and hemicellulosic fractions of sugarcane bagasse: Potential, challenges and future perspective. International Journal of Biological Macromolecules. 2021 Feb 1;169:564–82.
6. Singh AK, Bedi R, Kaith BS. Mechanical properties of composite materials based on waste plastic–A review. Materials Today: Proceedings. 2020 Jan 1;26:1293–301.
7. Zindani D, Kumar S, Maity SR, Bhowmik S. Mechanical characterization of bio-epoxy green composites derived from sodium bicarbonate treated Punica granatum short fiber agro-waste. Journal of Polymers and the Environment. 2021 Jan;29(1):143–55.
8. Singh PK, Sharma K. Mechanical and viscoelastic properties of in-situ amine functionalized multiple layer grpahene/epoxy nanocomposites. Current Nanoscience. 2018 Jun 1;14(3):252–62.
9. Stănescu MM, Bolcu D. A study of some mechanical properties of composite materials with a Dammar-based hybrid matrix and reinforced by waste paper. Polymers. 2020 Jul 29;12(8):1688.
10. Dashtizadeh Z, Khalina A, Cardona F, Lee CH. Mechanical characteristics of green composites of short kenaf bast fiber reinforced in cardanol. Advances in Materials Science and Engineering. 2019 Jan 1;2019.Chaturvedi, R., Islam, A., & Sharma, K. (2021). A review on the applications of PCM in thermal storage of solar energy. Materials Today: Proceedings, 43, 293–297.
11. Nukala SG, Kong I, Kakarla AB, Kong W, Kong W. Development of wood polymer composites from recycled wood and plastic waste: Thermal and mechanical properties. Journal of Composites

Science. 2022 Jul 1;6(7):194

12. Chen X, Li J, Xue Q, Huang X, Liu L, Poon CS. Sludge biochar as a green additive in cement-based composites: Mechanical properties and hydration kinetics. Construction and Building Materials. 2020 Nov 30;262:120723.
13. Kumar A, Pratheba S, Rajendran R, Perumal K, Lingeshwaran N, Sambaraju S. An experimental study on the mechanical properties of concrete replacing sand with quarry dust and waste foundry sand. Materials Today: Proceedings. 2020 Jan 1;33:828–32.
14. Sun X, Wang X, Sun F, Tian M, Qu L, Perry P, Owens H, Liu X. Textile Waste Fiber Regeneration via a Green Chemistry Approach: A Molecular Strategy for Sustainable Fashion. Advanced Materials. 2021 Dec;33(48):2105174.
15. Kumar A, Sharma K, Dixit AR. A review of the mechanical and thermal properties of graphene and its hybrid polymer nanocomposites for structural applications. Journal of materials science. 2019 Apr;54(8):5992–6026.
16. Oladele IO, Abiodun Makinde-Isola B, Agbeboh NI, Iwarere BO. Thermal stability, moisture uptake potentials and mechanical properties of modified plant based cellulosic fiber-animal wastes hybrid reinforced epoxy composites. Journal of Natural Fibers. 2021 Jan 23:1–6.
17. Kumar A, Sharma K, Dixit AR. A review on the mechanical properties of polymer composites reinforced by carbon nanotubes and graphene. Carbon letters. 2021 Apr;31(2):149–65.
18. Al-Oqla FM, El-Shekeil YA. Investigating and predicting the performance deteriorations and trends of polyurethane bio-composites for more realistic sustainable design possibilities. Journal of Cleaner Production. 2019 Jun 10;222:865–70.
19. Nageswara Rao D, Mukesh G, Ramesh A, Anjaneyulu T. Investigations on the mechanical properties of hybrid goat hair and banana fiber reinforced polymer composites. Materials Today: Proceedings. 2020.

