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A Review on Properties of Natural Fiber Reinforced Composite Materials for Automotive Application

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Abstract

The use of composite polymer matrix materials is growing rapidly in automotive, marine and aerospace applications due to their light weight and recyclable properties. In the automotive industry, the use of polymer matrix for interior panels, trims, exterior panels and fender assemblies is rapidly increasing in the 21st century. It also stimulates the use of polymer compounds reinforced by natural fibers. Natural fiber polymer composites are a growing industry due to their eco-friendliness. It is very suitable and has suitable mechanical properties in addition to its wide availability of raw materials. The natural fiber polymer matrix consists of binding fibers such as bamboo, hemp, cannabis, date, pineapple leaf, Kevlar, sisal, hemp, rice husk, corn husk, bagasse, plum fiber, etc. This article provides an overview of the use of natural fiber composite materials for automotive applications, taking into account the mechanical properties of impact strength, tensile strength and bending strength. Various techniques of making materials are discussed, including empirical testing and analysis. The review paper presents a comprehensive review of the researches of evolution of the materials in the field of composites, hybrid composites and natural fiber composites for industrial, electronics, sports, transportation, building constructions and automotive applications respectively. Though the natural fibers, lack its potentiality in terms of strengths which can be enhanced using the fillers are discussed in the paper. The paper also discusses the scope of research in the field of natural fibers which can be promoted in order to increase the application of Natural Fibers.

Keywords: Composite materials, natural fibers, automotive applications, tensile strength, impact strength

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INTRODUCTION

Natural fibers, derived from plants or animals, are gaining popularity as polymer reinforcements due to their eco-friendliness, low cost, availability, and strong mechanical properties. Natural fiber composites are increasingly used for their biodegradability, efficiency, and cost-effectiveness, especially in automotive applications. This paper explores polymer, hybrid, and natural fiber composites, focusing on their mechanical performance based on existing research.

The car front shock absorber system is a complex energy absorber system in vehicle design that must meet the requirements of pedestrian safety and low-speed collision [1] and more than 270,000 people die in pedestrian accidents, accounting for 22% of road deaths worldwide [2]. The crash box structure as a vehicle passive safety system is expected to absorb kinetic energy in frontal crashes, maintain the vehicle deceleration at a safe limit, and decrease the chance of injury to the vehicle's passenger during collision [3] An Automobile expects collision in various forms which include 21% from the front side of the vehicle along with 12.3 % front offset, and maximum 33.6% angular frontal [4].

The collision component must convert kinetic energy into tension energy in a controlled manner, provide adequate retention space for the protected component, and maintain force and acceleration on the collision component [4]. The car power absorber is the crease area of the car. It is subject to deformation after trauma, thus ensuring the vehicle's shock resistance and driver safety [6]. Collision transmits energy evenly throughout the structure [5]. The use of polyurethane as an energy-absorbing component with Proper finite component analysis is performed using the properties of functional graded polyurethane [7]

COMPOSITE MATERIALS

Composite materials are widely used in daily life and various industries (Figure 1) due to their superior properties over traditional materials. Common in aerospace, automotive, energy, construction, marine, electrical, chemical, and packaging sectors, they offer key advantages like reduced weight, high strength-to-weight ratio, energy absorption, and resistance to wear, corrosion, impact, and fire. Typically, they are bonded with thermoset resins like epoxy, though thermoplastics such as polyester, vinyl ester, or nylon are also used [8]. FGF filled bumper beam [9], aluminum in bumper beam aluminum, chrome-plated mild steel and glass thermoplastic resin for impact velocity are research predominantly due to the ability to absorb shock during road collisions [15].

HYBRID COMPOSITES

A composite made with one type of reinforcement is called a nano-composite, while hybrid composites use a single matrix with multiple fiber types [10]. Hybrid composites, combining natural and synthetic fibers, are studied for improved structural properties, particularly impact resistance and penetration behavior [11]. Research (Table 1) has examined energy absorption under static axial crushing using fibers like Kevlar, Kenaf, jute, and glass-reinforced epoxy [12].

Foam-filled materials are also explored for vehicle impact protection and pedestrian safety [35, 36]. Natural rubber, due to its flexibility, absorbs more energy than steel, aluminum, or epoxy glass under low-speed impact, with a contact strength. [37, 38]. Braided rod composites show versatility in shape formation after strand rotation, offering enhanced energy absorption [39]. Tests on polypropylene staple fiber composites indicate 50% fiber content by weight, combining bent and stretched modulus glass fibers, polypropylene, and mica [40, 41].

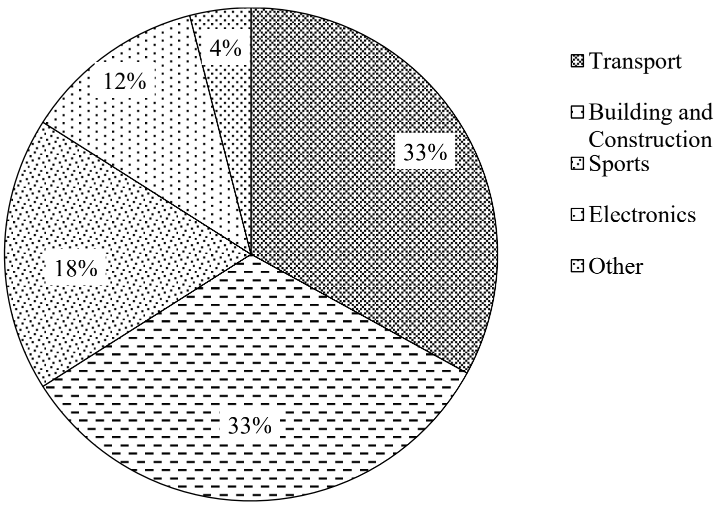

Figure 1. Sector wise application of composite materials [38].

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NATURAL FIBER COMPOSITES

Natural fiber composites are gaining popularity (Table 2) in regular industries as well as automobiles (Table 3) due to their mechanical strength, low cost, sustainability, and eco-friendliness Studies using Kevlar with neem or kenaf in epoxy matrices showed peak impact energy.

Table 1. Research Findings for Hybrid Composites

Parameter	Finding	References
Banana fiber, Polypropylene	Banana fiber reinforces with polypropylene gives good tensile and flexural strength	[16]
Kenaf fiber	kenaf based polymer composites, increased tensile, flexural strength & modulus, impact & thermal behavior of hybrid composite	[17]
Corn Husk, Polyster.	Corn husk fiber with Polyster provides better water absorption capacity	[19]
Carbon fiber, Pineapple leaf finer, Epoxy resin.	Pineapple leaf fiber along with carbon fiber increases the impact strength of the material	[22]
Kenaf fiber, glass fiber, crushing strength.	The more the layer of Fibers, the more crushing capacity	[28]
Date palm, Kevlar	Automobile bumper using date palm fiber (50%) and Kevlar (50%), the tensile strength of the material can be enhanced	[29]
Hemp, S-glass, NaOH Treatment	Hybrid composite is prepared using Hemp and S-Glass fiber treated with NaOH produced good impact strength which can be used for automobile bodies.	[30]
Areca fiber, Effect of alkali treatment.	The impact strength of Areca fiber with epoxy resin can be maintained with fiber loading upto 40% to 60%	[31]
Kenaf, E-Glass fiber, Jute	Composite with Kenaf, Jute and E-glass fiber affects the flexural strength with respect to stacking sequence	[33]
Banana fiber, saw dust, polyvinyl chloride	The banana fibres, filled with sawdust and polyvinyl acetate is prepared and flexural properties are determined.	[43]

Table 2. Generalized Applications of Natural Fibers [20]

Fibre	Application Industry
Bamboo Fiber	Construction and carpentry industries.
Jute Fiber	Packing, geotextiles, door frames and shutters, building panels, chip board.
Kenaf Fiber	Mobile cases, insulations, bags, packing materials, animal bedding.
Flax Fiber	Tennis racket, snowboarding, window frame, decking, fencing, bicycle frame
Sisal Fiber	Construction industries such as door, panels, roofing sheets, etc.
Hemp Fiber	Furniture, electrical, paper industry, textile industry, cordage
Coir Fiber	Flush door shutters, mirror casing, filling material for upholstery, brushes and brooms, ropes and yarns for nets, seat cushions, roofing sheets
Ramie Fiber	Packing material, industrial sewing thread, fishing net, household furnishings and clothing, paper manufacture

Table 3. Natural Fibers in Automobiles

Material	Applications	Reference
Cortex Fiber	Car Interior parts	10
Kenaf Fibre	Door Trims, Interiors, Car seats, seatbacks, package tray, door panels and headliners	17, 25
Coir Composite Fiber	Bumpers, Roof, helmets, Seats	14, 17
Jute and Hemp	Car seats, roofs, dashboard coverings and trunk lids,	17
Flax/Sisal fiber	Door panels, door linings, instrument panel	17,25
Cotton Fiber	instrument panel support, insulation, seat backrest panel	25
Coconut Fiber	seat bottoms and cushions	25
Wood fiber	Seatback Cushions	25

Bio-composites with natural fibers can match the mechanical properties of glass fiber-based materials [12, 13] Treatments like NaOH, alkaline acrylate, and benzene diazonium chloride enhance fiber-matrix bonding and improve impact resistance and flexibility, as seen in banana, sisal, and bamboo composites [14, 15] Cannabis, though less common, shows strong mechanical properties in hybrid forms [16, 17]. Factors such as fiber treatment, orientation, size, and stacking significantly influence composite behavior [18, 19]. Sisal-reinforced polyester and bamboo-based epoxy composites demonstrate improved flexural strength with higher fiber content. Carbon and pineapple fibers outperform glass fiber in strength for leaf spring applications. Pomegranate peel composites show environmental resistance due to antioxidant properties. Sugar palm and glass fiber hybrids with alkali treatment enhance tensile and impact strength [20, 21]. Hybrid composites with fiber blends (e.g., 50% cattle fiber, 50% polyester) show substantial improvements in mechanical properties. Natural fibers also absorb more CO_2, making them environmentally beneficial. Their thermal, acoustic, and mechanical advantages make them strong alternatives to synthetic fibers in polymer reinforcement [22, 23]

COMPOSITE MATERIALS FOR IMPACT STRENGTH IN AUTOMOBILES

In frontal collisions, bumpers play a crucial role in occupant safety [24] Studies show that PLA/flax composite fenders retain stiffness under low-speed impact due to matrix cracking as the main failure mode [25]. Natural fiber-reinforced polymer composites show promise in automotive applications for low, medium, and high-velocity impact resistance [26]. Hybrid composites with 75% glass fiber and 25% natural fiber achieve similar tensile and impact strength as pure glass fiber, making them suitable for low-speed collisions [27]. Flax/vinyl ester plates outperform steel in impact energy tests. Layered fabric structures combining staple and glass cloth improve impact resistance and energy absorption [28]. Kevlar and palm fiber hybrids (50/50) also show strong performance under stress [29]. Hemp/glass hybrids treated with resin outperform untreated and synthetic composites in impact resistance [30]. NaOH-treated staple/glass/polyester composites show a 3.88% increase in Charpy impact strength. [31, 32].

Using glass fibers in hybrid layers with natural fibers like sisal, kenaf, and jute enhances tensile, bending, and compressive properties [32]. Kenaf-jute-E-glass composites exhibit superior performance when e-glass is placed in the base layer. 3D-Tow glass-fiber-reinforced thermoplastics also show high bonding strength and impact resistance [33, 34]. Al_2O_3 fillers in natural fiber composites increase tensile and impact strength [42, 43]. Banana and jute composites display strong impact resistance, with banana fibers performing slightly better [44]. Fillers like TiO_2 further enhance mechanical and wear properties [45, 46]. Natural fibers are also being explored for use in vibration damping, sound insulation, and thermal control, with growing commercial interest in sustainable applications [47–49].

CONCLUSIONS

- From the above discussion it can be researched that natural fibers have the ability to convert synthetic fibers or hybrid fibers into reinforcements into polymer compounds due to their advantages in properties like elasticity, friction, stress, compression, lightness, impact resistance, rigidity. And most importantly, the possibility of recycling.
- According to the research work done, the use of natural fiber composites with hybrid materials increases the tensile strength, strength, bending modulus and impact behavior of hybrid composites. The shape, size and composition of fibers play an important role in determining the effect properties of compounds.
- Differences in many parameters such as processing methods, temperature, chemical processing of fibers, fiber orientation, stacking sequence, fiber size fraction and knitting methods effectively affected the properties of the material.
- Common defects include resin hardening, fiber size and volume fraction, void volume content, fiber distribution, oblique or broken fibers, and polymer fiber matrix adhesion.

- The main drawback is that the production of synthetic compounds requires a lot of energy and the pollution created during the production and recycling of these synthetic substances has to deal with the quality of the environment.
- The use of natural fibers in polymer compounds involves various problems related to moisture absorption, stiffness, poor interfacial adhesion of fibers and matrix and poor mechanical properties.
- The main challenges limiting their use are comparisons between alloys and natural fiber compounds, process costs and consequential losses, uncertainty about relatively new and sometimes changing materials.
- Chemical compounds treated with sodium hydroxide, barium sulphate, melamine formaldehyde resins etc. They can be used to increase the strength of the material.
- TiO2, graphene and Al2O3 fillers can be used in composites to increase the durability of the material.
- Hand layup method, composite mold testing and pressure molding testing are cost effective techniques for making composite material. Using injection molding technology, a large number of materials can be fabricated into the required complex shapes.
- An overview of the work done by several researchers suggests that the optimal fiber content of the fiber-reinforced compound showed the best properties, and by omitting the fiber content, the mechanical properties of the compound decreased.
- Due to low density, high tensile strength, high tensile modulus and low increase in brake time, these fibers can occupy a definite place in automotive applications. Finally, natural fiber-based compounds can be formulated with attractive and affordable designs to further enhance their use.
- There is a significant lack of research in the field of composite materials based on natural fibers. It is difficult to predict the properties of different types of natural fibers with different alignments and therefore research studies are needed to find out the behavior of different natural fibers.
- Studies on new and existing natural fibers can be extended to identify the hidden potential of new natural fiber compounds.
- TiO2 fillers are effective in improving the properties of the natural fibres composite materials.
- Important factors to consider when producing natural fiber reinforced composites are fiber / matrix selection, composition, fiber size, shape, fiber treatment and post-fabrication.
- It is difficult to predict the characteristics of different types of natural fibers that have different types of alignment, and therefore research studies are required to know the behavior of different natural fibers.

REFERENCES

1. Yong Han, Jikuang Yang, Koji Mizuno & Yasuhiro Matsui, “Effects of Vehicle Impact Velocity, Vehicle -Front-End Shapes on Pedestrian Injury Risk”, Traffic Injury Protection, Taylor & Francis Publication, January 2012, Pp. 507-518.
2. Guibing, Mathew Lyons, Bingyu Wang, Jikuang Yange, Dietmar Otte, Ciaran Simms, “The influence of passenger car front shape on pedestrian injury risk observed from German in-depth accident data”, Accident Analysis and Prevention, Elsevier Publication, 2017, Pp. 11–21.
3. Muhamad Arjuna Putra Perdana, Sudirja, Abdul Hapid, Aam Muharam1, Sunarto Kaleg, Amin, Rina Ristiana, and Alexander Christantho Budiman, “Crashworthiness Enhancement: The Optimization of Vehicle Crash Box Performance by Utilizing Bionic-Albuca Spiralis Thin-Walled Structure”, EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 10, Issue 03, pp1961–1967, September 2023
4. A. Siva Kumar, G. Himabindu, M. Sankar Raman and K. Vijaya Kumar Reddy, “Experimental Investigations with Crush Box Simulations for Different Segment Cars using LS-DYNA”, International Journal of Current Engineering and Technology, Inpressco Publishers, February 2014, Pp. 670–676.

5. Gabriel Jigaa, Ştefan Staminb, Gabriela Dinua, Daniel Vlăsceanua, Dorina Popovicic, "Material and shape crash-box influence on the evaluation of the impact energy absorption capacity during a vehicle collision", Ciência & Tecnologia dos Materiais, Elsevier Publishers, 2016, Pp. 67–72.
6. Samer Fakhri Abdulqadir, "Design a new energy absorber longitudinal member and compare with S-shaped design to enhance the energy absorption capability", Alexandria Engineering Journal, Elsevier Publishers, 2018, Pp. 3405–3418.
7. Rahul Nair, K.I Ramachandran, "Design and optimization of automotive energy absorber structure with functionally graded material", Materials Today: Proceeding, Elsevier Publishers, 2018, Pp. 25640–25648.
8. Sunil Nayak, M. Prasanna Kumar, Vinay K M, "Wear Behavior Evaluation of Natural Fibre Composite Using Taguchi Technique", EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 11, Issue 02, pp 722-728, June, 2024
9. Zhi Xiao, Jianguang Fang, Guangyong Sun, Qing Li, "Crashworthiness design for functionally graded foam-filled bumper beam", Advances in Engineering Software, Elsevier Publications, 2015, Pp. 81–95.
10. Dipak S. Patil, M. M. Bhoomkar, "Investigation on Mechanical Behaviour of Fiber-Reinforced Advanced Polymer Composite Materials", EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 10, Issue 01, pp55-62, March 2023
11. Syafiqah Nur Azrie Safri, Mohamed Thariq Hameed Sultan, Mohammad Jawaid, Kandasamy Jayakrishna, "Impact behaviour of hybrid composites for structural applications: A review", Journal of Composites, Elsevier Publications, 2017.
12. Zeid Fadel Albahash, M.N.M.Ansari, "Investigation On Energy Absorption Of Natural And Hybrid Fiber Under Axial Static Crushing", Composites Science and Technology, Elsevier Publications, 2017.
13. S.Rajesh, B.Vijayaramnath, C.Elanchezhian, S.Vivek, M.Hari Prasadh, M.Kesavan, "Experimental Investigation of Tensile and Impact Behavior of Aramid-Natural Fiber Composite", Materials Today: Proceedings, Elsevier Publications, 2019, Pp. 699–705.
14. Megalingam A., Kumar M. b, Sriram B., Jeevanantham K., Ram Vishnu, "Borassus fruit fiber reinforced composite: A review", Materials Today: Proceeding, Elsevier Publications, 2020.
15. Smith Salifu, Dawood Desai, Olugbenga Ogunbiyi, Rotimi Sadiku, Oluwagbenga Adesina, Olanrewaju Adesina, "Comparative study of high velocity impact response of aluminium 3105-H18 and carbon fibre-epoxy composite double hat bumper beams", Materials Today: Proceeding, Elsevier Publications, 2020.
16. V.V. Arun Sankar, P. Suresh, V. Arun kumar c, S. Dhanasekar c, E. Harissh Kumar c, R. Nandhakumar, "Experimental research into the mechanical behaviour of banana fibre reinforced PP composite material", Materials Today: Proceedings, Elsevier Publications, 2020.
17. Sreenivas H. T, N. Krishnamurthy, Arpitha G. R, "A Comprehensive review on Light weight Kenaf fiber for Automobiles", International Journal of Lightweight Materials and Manufacture, Elsevier Publications, 2020.
18. Harini Sosiati, Hidayatullah, Sinin Hamdan, "Effect of Woven E-glass and Bamboo Stacking Sequences on the Properties of Laminated Composites Using Polyester Matrix Filled with Eggshell Microparticles", EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 11, Issue 02, pp693–700, June, 2024
19. Nasmi Herlina Sari, Jauhar Fajrin, Suteja, Ahmad Fudholi, "Characterisation of swellability and compressive and impact strength properties of corn husk fibre composites", Composites Communications, Elsevier Publications, 2020, Pp. 49–54.
20. Love Kerni, Sarbjeet Singh, Amar Patnaik, Narinder Kumar, "A review on natural fiber reinforced composites", Materials Today: Proceedings, Elsevier Publications, 2020.
21. C. Militello, F. Bongiorno, G. Epasto, B. Zuccarello, "Low-velocity impact behaviour of green epoxy biocomposite laminates reinforced by sisal fibers", Composite Structures, Elsevier Publications, 2020.
22. K. Umanath, M.K. Prabhu, A. Yuvaraj, D. Devika, "Fabrication and analysis of Master leaf spring plate using carbon fibre and pineapple leaf fibre as natural composite materials", Materials Today: Proceedings, Elsevier Publications, 2020.

23. Anil Kumar, Bhawna Dahiya, Dipti Grover, "Optimizing Agricultural Waste Powder Epoxy Composite for Enhanced Strength Using a Hybrid Taguchi-GRA-PCA Approach", EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 11, Issue 02, pp713–721, June, 2024
24. A. Díaz-Álvareza, L. Jiao-Wangb, C. Fengc, C. Santiuste, "Energy absorption and residual bending behavior of biocomposites bumper beams", Composite Structures, Elsevier Publications, 2020.
25. Deepak Verma and Irem Senal, "Natural fiber-reinforced polymer composites: feasibiliy study for sustainable automotive industries", Biomass, Biopolymer-Based Materials, and Bioenergy, Elsevier Publications, 2019.
26. Muhammad F. Ismail, Mohamed T.H. Sultana,∗, Ahmad Hamdana, Ain U.M. Shaha,b, Mohammad Jawaid, "Low velocity impact behaviour and post-impact characteristics of kenaf/glass hybrid composites with various weight ratios", Journal of material research and technology, Elsevier Publications, 2019, Pp. 2262–2273.
27. Gilsu Park, Hyunbum Park, "Structural Design and Test of Automobile Bonnet with Natural Flax Composite through Impact Damage Analysis", Composite Structures, Elsevier Publications, 2016.
28. Praveen Kumar, M. Shunmugasundaram, S. Sivasankar, L. Ponraj Sankar, "Static axial crushing response on the energy absorption capability of hybrid Kenaf/Glass fabric cylindrical tubes", Materials Today: Proceedings, Elsevier Publications, 2019.
29. R. Muthalagu, J. Murugesan, S. Sathees Kumar, B. Sridhar Babu, "Tensile attributes and material analysis of kevlar and date palm fibers reinforced epoxy composites for automotive bumper applications", Materials Today: Proceedings, Elsevier Publications, 2020.
30. N. Murugu Nachippan, Mathew Alphonse, V.K Bupesh Raja, Soma Shasidhar b, G. Varun Teja, R. Harinath Reddy, "Experimental investigation of hemp fiber hybrid composite material for automotive application", Materials Today: Proceedings, Elsevier Publications, 2020.
31. S. Dhanalakshmi, P. Ramadevi And B. Basavaraju, "Areca Fiber Reinforced Epoxy Composites: Effect of Chemical Treatments on Impact Strength", Oriental Journal Of Chemistry, 2015, Pp. 763–769.
32. Prabhu.La, Krishnaraj.V, Gokulkumar.Sc, Sathish.Sd, Ramesh.M, "Mechanical, Chemical and Acoustical Behavior of Sisal – Tea Waste – Glass Fiber Reinforced Epoxy Based Hybrid Polymer Composites", Materials Today: Proceedings, Elsevier Publications, 2020, Pp. 653–660.
33. N. Chethan, S.N. Nagesh, L. Sunith Babu, "Mechanical behavior of Kenaf-Jute-E-glass reinforced hybrid polymer composites", Materials Today: Proceedings, Elsevier Publications, 2020.
34. Sung-Jun Jooa, Myeong-Hyeon Yua, Won Seock Kimb, Jong-Wook Leeb, Hak-Sung Kim, "Design and manufacture of automotive composite front bumper assemble component considering interfacial bond characteristics between over molded chopped glass fiber polypropylene and continuous glass fiber polypropylene composite", Composite Structures, Elsevier Publications, 2020.
35. Kishore Dinakarana, Harish Ramesha, Allan Dojo Josepha, Dr. Ramu Murugana, Dr. Sathishkumar Jothi, "Development and characterization of areca fiber reinforced polymer composite", Materials Today: Proceedings, Elsevier Publications, 2019, Pp. 934–940.
36. Man Wu, Meijie Zhao, Guozhang Chang, Xiude Hu, Qingjie Guo, "A composite obtained from waste automotive plastics and sugarcane skin flour: Mechanical properties and thermo-chemical analysis", Powder Technology, Elsevier Publications, 2020, Pp. 27–34.
37. Chang Qi, Yong Sun, Shu Yang, "A comparative study on empty and foam-filled hybrid material double-hat beams under lateral impact", Thin-Walled Structures, Elsevier Publications, 2018, Pp. 327–341.
38. Surender Kumara, R.S Bharj, "Emerging composite material use in current electric vehicle: A review", Materials Today: Proceedings, Elsevier Publications, 2018, Pp. 27946–27954.
39. Vishwas M, Sharnappa Joladarashi, Satyabodh M Kulkarni, "Behaviour of Natural Rubber in Comparison with Structural Steel, Aluminium and Glass Epoxy Composite under Low Velocity Impact Loading", Materials Today: Proceedings, Elsevier Publications, 2017, Pp. 10721–10728.

40. Mohammad Asim, Naheed Saba, Mohammad Jawaid and Mohammad Nasir, “Potential of natural fiber/biomass filler-reinforced polymer composites in aerospace applications”, Sustainable Composites for Aerospace Applications, Elsevier Publications, 2016, Pp. 253–267.
41. T. Ganapathy, R. Sathiskumar, P. Senthamaraikannan, S.S. Saravanakumar, Anish Khan, “Characterization of raw and alkali treated new natural cellulosic fibres extracted from the aerial roots of banyan tree”, International Journal of Biological Macromolecules”, Elsevier Publications, 2019.
42. L.C. Hao, S.M. Sapuan, M.R. Hassan and R.M. Sheltam, “Natural fiber reinforced vinyl polymer composites”, Natural Fiber Reinforced Vinyl Ester and Vinyl Polymer Composites, Elsevier Publications, 2018.
43. Yerdawu Zeleke and Gideon K. Rotich, “Design and Development of False Ceiling Board Using Polyvinyl Acetate (PVAc) Composite Reinforced with False Banana Fibers and Filled with Sawdust”, International Journal of Polymer Science, Hindawi Publications, 2021.
44. Shubham Singh, Leeladhar Nagdeve, Harish Kumar, Krishnakant Dhakar, “Rice Straw Based Natural Fiber Reinforced Polymer for Sustainable Bio- Composites: A Systematic Review”, EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 10, Issue 02, pp1041–1052, June 2023.
45. Dengfeng Wang, Shenhua Li & Chong Xie, “Crashworthiness optimisation and lightweight for front-end safety parts of automobile body using a hybrid optimization method”, International Journal of Crashworthiness, Taylor and Francis Publication, 2021.
46. Rajiv Kumar, Mir Irfan Ul Haq, Ankush Raina & Ankush Anand, “Industrial applications of natural fibrereinforced polymer composites – challenges and opportunities”, International Journal of Sustainable Engineering, Taylor and Francis Publication, 2018.
47. Habib Awais, Faheem Ahmad, Farooq Azam, Salma Shahid, Yasir Nawab & Sheraz Ahmad, “An economical and environmentally benign approach to extract banana fibres from agricultural waste for fibre reinforced composites”, The Journal of The Textile Institute, Taylor and Francis Publication, 2021.
48. Naveen Kumar Yadav, Nitesh Singh Rajput, Shweta kulshreshtha, Manoj Kumar Gupta, “Investigation of the Mechanical and Wear Properties of Epoxy Resin Composite (ERCs) Made With Nano Particle TiO2 and Cotton Fiber Reinforcement”, EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 10, Issue 01, pp63–77, March 2023
49. M. Saleem, E. Gopi, Sri Chandan, P. Shenbagavalli & Arun Nema, “Material energy absorption capability by crushing mode process”, International Journal of Ambient Energy, Taylor and Francis Publication, 2019.

