AN INVESTIGATION OF MECHANICAL PROPERTIES OF BAGASSE FIBRE COMPOSITE AND MAKING DOOR WINDOW MODEL

A.Ajithkumar, R.Gajendramoorthy, S.Naveen Kumar, G.Satheesh kumar
Guided by
A.Senthilkumar , HOD
Department of Mechanical Engineering,
Sengunthar College of Engineering, Tiruchengode, Tamil Nadu,INDIA.
ajithmechs007@gmail.com ; gaja6301@gmail.com; nksubramani01@gmail.com; satheeshkumar152274@gmail.com;

Manuscript History
Number: **IJIRAE/RS/Vol.06/Issue03/Special Issue/SI.MRAE10080**
Received: 20, February 2019
Final Correction: 05, March 2019
Final Accepted: 20, March 2019
Published: **March 2019**
Editor: Dr.A.Arul L.S, Chief Editor, IJIRAE, AM Publications, India

Abstract-Fibre reinforced polymer composites has been used in a variety of application because of their many advantages such as relatively low cost of production, easy to fabricate and superior strength compare to neat polymer resins. Reinforcement in polymer is either synthetic or natural. Synthetic fibre such as glass, carbon etc. has high specific strength but their fields of application are limited due to higher cost of production. Recently there is an increase interest in natural fibre based composites due to their many advantages. In this connection an investigation has been carried out to make better utilization of bagasse fibre for making value added products. The objective of the present research work is to study the physical and mechanical behaviour of E-glass fibre reinforced with bagasse fibre based hybrid composites. The effect of fibre loading and length on mechanical properties like tensile strength, flexural strength, hardness of composites is studied.

I. INTRODUCTION

The development of composite materials and their related design and manufacturing technologies is one of the most important advances in the history of materials. Composites are the material used in various fields having exclusive mechanical and physical properties and are developed for particular application. Composite materials having a range of advantages over other conventional materials such as tensile strength, impact strength, flexural strengths, stiffness and fatigue characteristics. Because of their numerous advantages they are widely used in the aerospace industry, commercial mechanical engineering applications, like machine components, automobiles, combustion engines, mechanical components like drive shafts, tanks, brakes, pressure vessels and flywheels, thermal control and electronic packaging, railway coaches and aircraft structures etc, When two or more materials with different properties are combined together, they form a composite material. Composite material comprise of strong load carrying material (known as reinforcement) imbedded with weaker materials (known as matrix).The primary functions of the matrix are to transfer stresses between the reinforcing fibres/particles and to protect them from mechanical and/or environmental damage whereas the presence of fibres/particles in a composite improves its mechanical properties like tensile strength, flexural strength, impact strength, stiffness etc. Composites can be classified according to different criteria. Depending on the type of matrix materials, composite materials can be classified into three categories such as metal matrix composites, ceramic matrix composites and polymer matrix composites. Each type of composite material is suitable for specific applications. When the matrix material is taken as metal like aluminium, copper, it is called as metal matrix composite.

These are having high ductility and strength, good fracture toughness, inter-laminar shear strength and transverse tensile strength and also having superior electrical and thermal conductivity. These materials are high dimensional stable due to low thermal expansion coefficient of matrix and withstand to a high temperature. Due to high elastic modulus of reinforcements they have very high stiffness. When the matrix material is taken as ceramic it is called as ceramic matrix composite. Ceramic material include a wide verity of inorganic materials likes bricks, pottery, titles also include oxide, nitrides and carbides of silicon, aluminium, zirconium etc. They are normally non-metallic and processed very often at high temperature. The main objective in producing ceramic matrix composites is to enhance the toughness, high strength and hardness, high temperature properties, wear resistance etc. Polymer matrix composites consist of a polymer resin as the matrix material which filled with a variety of reinforcements. This kind of composite is used in the greatest diversity of composite applications due to its advantages such as low density, good thermal and electrical insulator, ease of fabrication, and low cost. The properties of polymer matrix composites are mainly determined by three constitutive elements such as the types of reinforcements (particles and fibres), the type of polymer, and the interface between them. Polymers are divided into two categories such as thermoplastics and thermosets. Thermoplastic are in general, ductile and tougher than thermoset materials. They are reversible and can be reshaped by application of heat and pressure. Thermoplastic molecules do not cross-link and therefore they are flexible and reform able. Generally, thermoplastics show poor creep resistance, especially at elevated temperatures, as compared to thermosets. Their lower stiffness and strength values require the use of fillers and reinforcements for structural applications. The most common materials used in thermoplastic composites are nylon, polyetheretherketone, Acetyl, polyphenylene sulphide, polycarbonate, Teflon, polyethylene etc. Thermoset are materials that undergo a curing process through part fabrication and once cured cannot be re-melted or reformed.

Thermoset materials are brittle in nature and offer greater dimensional stability, better rigidity, and higher chemical, electrical, and solvent resistance. The most common resin materials used in thermoset composites are epoxy, polyester, phenolic, vinyl ester, and polyimides. Based on the types of reinforcement, polymer composites can be classified as particulate reinforced polymer composite and fibre reinforced polymer composites.

Particle reinforced composites also called particulate composites consisting of reinforcing material that is in the form particle. The shape of reinforcing particle may either spherical, a platelet, cubic, tetragonal, or of other regular or irregular geometry. The arrangement of the particles in the composites may be either random or preferred orientation. Generally, particles are used in composites to modify the thermal and electrical conductivities, improve performance at elevated temperatures, reduce friction, increase wear and abrasion resistance, improve machineability, increase surface hardness and reduce shrinkage.

Fibre reinforced polymer composites also called fibrous composites consisting of fibres as the reinforcement. Now- a-days, these composites have found applications in various areas such as automotive, marine, aerospace etc. due to their high specific stiffness and strength. Generally, fibres are the most important class of reinforcements in composite materials, as they satisfy the desired conditions and transfer strength to the matrix constituent, influencing and enhancing their desired properties. A fibre is characterized by its length being much greater as compared to its cross- sectional dimensions. The properties of matrix, fibre and its interface have greatly influencing the properties of composite materials. Fibres in polymer composites can either synthetic/man-made fibres or natural fibres. Some commonly used synthetic fibres for composites are glass, aramid and carbon etc. There are many types of glass fibre depending upon the type of application like E-glass fibre (electrical application), C- glass (corrosive environment), S-glass (structural application, high temperature). Glass fibres are available in various forms such as continuous, chopped and woven fabrics etc. If the fibres are derived from natural resources like plants or some other living species, they are called natural-fibres.

PHYSICAL PROPERTIES OF NATURAL FIBRES

Composites made of the same reinforcing material system may not give better results as it undergoes different loading conditions during the service life. In order to solve this problem hybrid composites are the best solution for such applications. A hybrid composite is a combination of two or more different types of fibre in which one type of fibre balance the deficiency of another fibre. The purpose of hybridization is to construct a new material that will retain the advantages of its constituents but not their disadvantages.

II. MATERIALS AND METHODS MATERIALS

The raw materials used in this works are

1. E-glass fibre
2. Bagasse fibre
3. Epoxy Resin.
4. Catalyst (METHYL ETHYL KETONE PEROXIDE)
5. Accelerator (COBALT NAPHTHENATE)

Fibre	Tensile strength (MPa)	Young's modulus (GPa)	Elongation at break (%)	Density (g/cm^3)
Abaca	400	12	3-10	1.50
Alfa	350	22	5.80	0.89
Bagasse	290	17	----	1.25
Bamboo	140-230	11-17	-----	0.60-1.10
Banana	500	12	5.90	1.35
Coir	175	4-6	30	1.20
Cotton	287-597	5.50-12.60	7-8	1.50-1.60
Curaua	500-1150	11.80	3.70-4.30	1.40
Date palm	97-196	2.50-5.40	2-4.50	1-1.20
Flax	345-1035	27.60	2.70-3.20	1.50
Hemp	690	70	1.60	1.48
Henequen	500 70	13.20±3.10	4.80 1.10	1.20
Isora	500-600	-----	5-6	1.20-1.30
Jute	393-773	26.50	1.50-1.80	1.30
Kenaf	930	53	1.60	----
Nettle	650	38	1.70	----
Oil palm	248	3.20	25	0.7-1.55
Piassava	134-143	1.07-4.59	21.90-7.80	1.40
Pineapple	1.44	400-627	14.50	0.80-1.60
Ramie	560	24.50	2.50	1.50
Sisal	511-635	9.40-22	2.0-2.50	1.50
E-glass	3400	72	------	2.5

1. E GLASS Fibre

Glass fibre (or glass fibre) is a material consisting of numerous extremely fine fibres of glass.Glassmakers throughout history have experimented with glass fibres, but mass manufacture of glass fibre was only made possible with the invention of finer machine tooling. In 1893, Edward Drummond Libby exhibited a dress at the World's Columbian Exposition incorporating glass fibres with the diameter and texture of silk fibres. Glass fibres can also occur naturally, as Pele's hair.Glass wool, which is one product called "fiber glass" today, was invented in 1932–1933 by Russell Games Slayer of Owens- Corning, as a material to be used as thermal building insulation.[1] It is marketed under the trade name Fiberglas, which has become a generic zed trademark. Glass fibres when used as a thermal insulating material, is specially manufactured with a bonding agent to trap many small air cells, resulting in the characteristically air-filled low- density "glass wool" family of products.Glass fiber has roughly comparable mechanical properties to other fibres such as polymers and carbon fibre. Although not as rigid as carbon fibre, it is much cheaper and significantly less brittle when used in composites. Glass fibres are therefore used as a reinforcing agent for any polymer products; to form a very strong and relatively lightweight fibre-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass". This material contains little or no air or gas, is denser, and is a much poorer thermal insulator than is glass wool.

2. Bagasse fibre

Bagasse is the dry pulpy fibrous residue that remains after sugarcane or sorghum stalks are crushed to extract their juice. It is used as a biofuel for the production of heat, energy, and electricity, and in the manufacture of pulp and building materials. A gave bagasse is a similar material that consists of the tissue of the blue agave after extraction of the sap. Bagasse is often used as a primary fuel source for sugar mills. When burned in quantity, it produces sufficient heat energy to supply all the needs of a typical sugar mill, with energy to spare. To this end, a secondary use for this waste product is in cogeneration, the use of a fuel source to provide both heat energy, used in the mill, and electricity, which is typically sold on to the consumer electrical grid.

3. Epoxy Resin:

Epoxy resin density of 1.15-1.20g/cm^3,mixed with hardener density of 0.97-0.99g/cm^3, is used to prepare the composite material resin from purchased local source.

4. CATALYST (METHYL ETHYL KETONE PEROXIDE):

Methyl ethyl ketone peroxide, also known as 2- butanone peroxide, is strongly oxidizing (caustic) organic peroxide that is commonly used in the manufacture of acrylic resins and as a room temperature hardening and curing agent for fiberglass-reinforced plastics and unsaturated polyester resins (HCN, 2002; NTP, 1993). At room temperature, it is a colourless to yellow liquid with a characteristic or mint-like odor (NIOSH, 2007; NTP, 2016). As MEKP is shock, sunlight, and heat sensitive, it is typically sold commercially in a solution of 30 – 60% MEKP mixed with diluents like dimethyl phthalate, cyclohexane peroxide, or diallyl phthalate to prevent explosions (HCN, 2002; NIOSH, 2007). It can also undergo spontaneous ignition or explosion if mixed with oxidizable organic, flammable, or chemical materials (HCN, 2002; NOAA, 2015). When MEKP is used as a hardening or curing agent, the duration of the reaction is dependent on both the type of resin being cured as well as the formulation of the MEKP solution. Typical reactions contain approximately 1 - 2% MEKP. In a series of experiments, the 'time to cure' was roughly 40 - 50 minutes for a commercial MEKP formulation (CI, 1999). The 'time to cure' is the time from the initiation of the reaction to when the peak temperature is reached (often in excess of 350°F), which is not necessarily the end of the reaction. Though it is sometimes incorrectly called a catalyst, MEKP is not a true catalyst as it is consumed in the reaction (Juska & Puckett, 1997). Studies of the health effects of MEKP are limited and primarily focus on short-term exposures to relatively large amounts of the chemical. Rats and mice exposed to MEKP (45% in dimethyl phthalate) on their skin for two and thirteen weeks developed a spectrum of necrotic, inflammatory, and regenerative lesions at the application site. Increased formation of red and white blood cells in the spleen and bone marrow was also observed (NTP, 1993). Direct exposure to the eyes of rabbits resulted in damage, with severe injury occurring with two drops of 40% MEKP. Three percent MEKP caused a more moderate reaction that improved after two days (Hathaway & Proctor, 2014). Several studies have examined inhalation exposure in mice and rats; the concentration needed to kill 50% of the animals (known as the LC50) in four hours was 170 parts per million (ppm) in mice and 200 ppm in rats.

5. ACCELERATOR (COBALT NAPHTHENATE):

Accelerators are material which help the decomposition of peroxides and produce free radicals which start the propagation reaction resulting in the gelation and ultimate cure of polyesters. Soaps of Cobalt and certain amines act as accelerators in the haemolytic fission of peroxides generating from radicals. Therefore, the role of organic peroxides differs in their reactivity and response to accelerators depending upon their chemical constitution. The choice of accelerators very much depends on the type of organic peroxides selected for use. Cobalt naphthenate is widely used in polyester resins and paint driers. It is used as a curing accelerator, cross linker catalyst for unsaturated polyester resins. It is also used in the production of adhesives, varnishes and waterproofing agents for textiles. Further, it is used as corrosion inhibitors, lubricants, and fuel additives. It plays an important role as oil drying agents.

DETAILED DESIGNATION AND COMPOSITION OF COMPOSITES

S.NO	COMPOSITES	COMPOSITION
1	C1	Epoxy (75wt %) +E-glass (20wt.%) +Bagasse (5wt %)
2	C2	Epoxy (75wt %) +E-glass (15wt.%) +bagasse (10wt %)

NO. OF LAYERS TO BE FORMED = 5

III. TEST TO BE PERFORMED

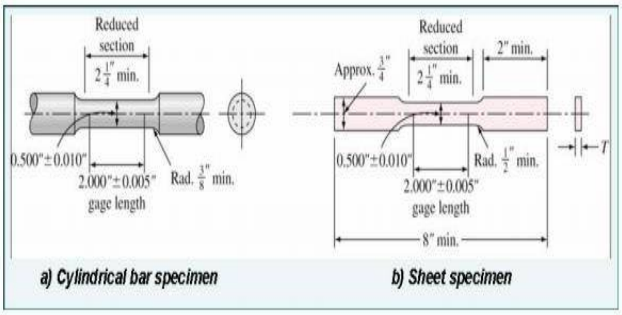
The following test are done for the prepared composite to determine its mechanical properties are listed and described briefly in the following session

1. Tensile test
2. MICRO Hardness test
3. Impact Test
4. Compression Test
5. Bending Test

1. TENSILE TEST UNIAXIAL TENSILE TESTING:

Uniaxial tensile test is known as a basic and universal engineering test to achieve material parameters such as ultimate strength, yield strength, % elongation, % area of reduction and Young's modulus. These important parameters obtained from the standard tensile testing are useful for the selection of engineering materials for any applications required. The tensile testing is carried out by applying longitudinal or axial load at a specific extension rate to a standard tensile specimen with known dimensions (gauge length and cross sectional area perpendicular to the load direction) till failure. The applied tensile load and extension are recorded during the test for the calculation of stress and strain.

A range of universal standards provided by Professional societies such as American Society of Testing and Materials (ASTM), British standard, JIS standard and DIN standard provides testing are selected based on preferential uses. Each standard may contain a variety of test standards suitable for different materials, dimensions and fabrication history.



STRESS AND STRAIN RELATIONSHIP

When a specimen is subjected to an external tensile loading, the metal will undergo elastic and plastic deformation. Initially, the metal will elastically deform giving a linear relationship of load and extension. These two parameters are then used for the calculation of the engineering stress and engineering strain to give a relationship as illustrated in figure 3 using equations 1 and 2 as follow

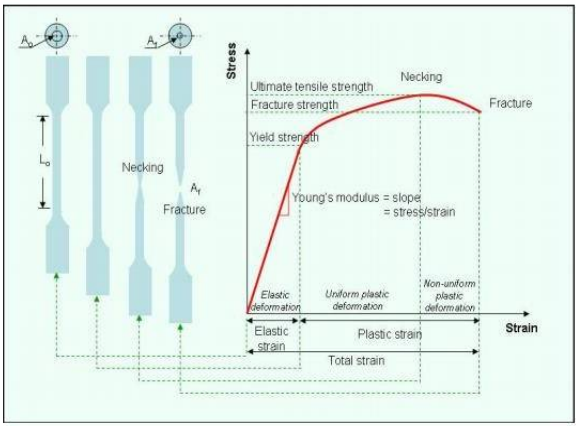
$$\sigma = \frac{P}{A_o} \quad ...(1)$$

$$\varepsilon = \frac{L_f - L_o}{L_o} = \frac{\Delta L}{L_o} \quad ...(2)$$

Where
σ is the engineering stress ε is the engineering strain
P is the external axial tensile load
Ao is the original cross-sectional area of the specimen Lo is the original length of the specimen
Lf is the final length of the specimen
The unit of the engineering stress is Pascal (Pa) or N/m2 according to the SI Metric Unit whereas the unit of psi (pound per square inch) can also be used
YOUNG'S MODULUS (E):
During elastic deformation, the engineering stress- strain relationship follows the Hook's Law and the slope of the curve indicates the Young's modulus (E)

$$E = \frac{\sigma}{\varepsilon} \quad ...(3)$$

Young's modulus is of importance where deflection of materials is critical for the required engineering applications. This is for examples: deflection in structural beams is considered to be crucial for the design in engineering components or structures such as bridges, building, ships, etc.The applications of tennis racket and golf club also



require specific values of spring constants or Young's modulus values.During elastic deformation, the engineering stress-strain relationship follows the Hook's Law and the slope of the curve indicates the Young's modulus (E)

MATERIALS AND EQUIPMENT

1. Tensile specimens
2. Micro meter or venier callipers
3. Universal testing machine
4. Stereoscope

EXPERIMENTAL PROCEDURE

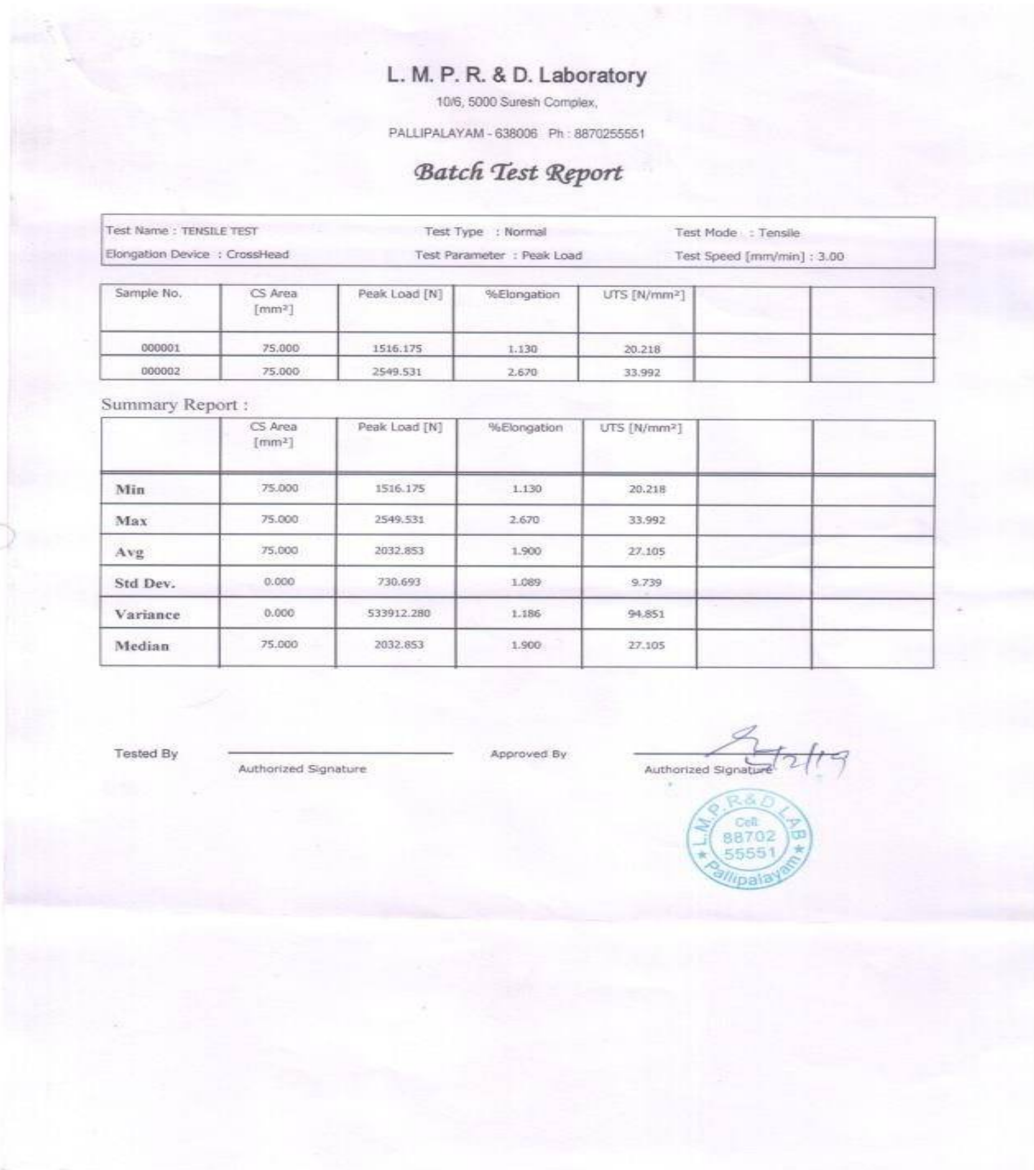
1. The specimens provided are made of composite materials. Measure and record specimen dimensions (diameter and gauge length) in a table provided for the calculation of the engineering stress and engineering strain. Marking the location of the gauge length along the parallel length of each specimen for subsequent observation of necking and strain measurement.
2. Fit the specimen on to the universal Testing Machine (UTM) and carry on testing. Record load and extension for the construction of stress-strain curve of each tested specimen.

RESULT

TENSILE STRENGTH OF COMPOSITES

TEST(TENSILE)	%ELONGATION	UTS[N/MM]
C1	1.130	20.218
C2	2.670	33.992

The composite specimens are tested for tensile properties in universal testing machine and obtained tensile strength are shown in the below figure. The value of tensile strength obtained is



L. M. P. R. & D. Laboratory
10/6, 5000 Suresh Complex,
PALLIPALAYAM - 638006 Ph : 8870255551

Batch Test Report

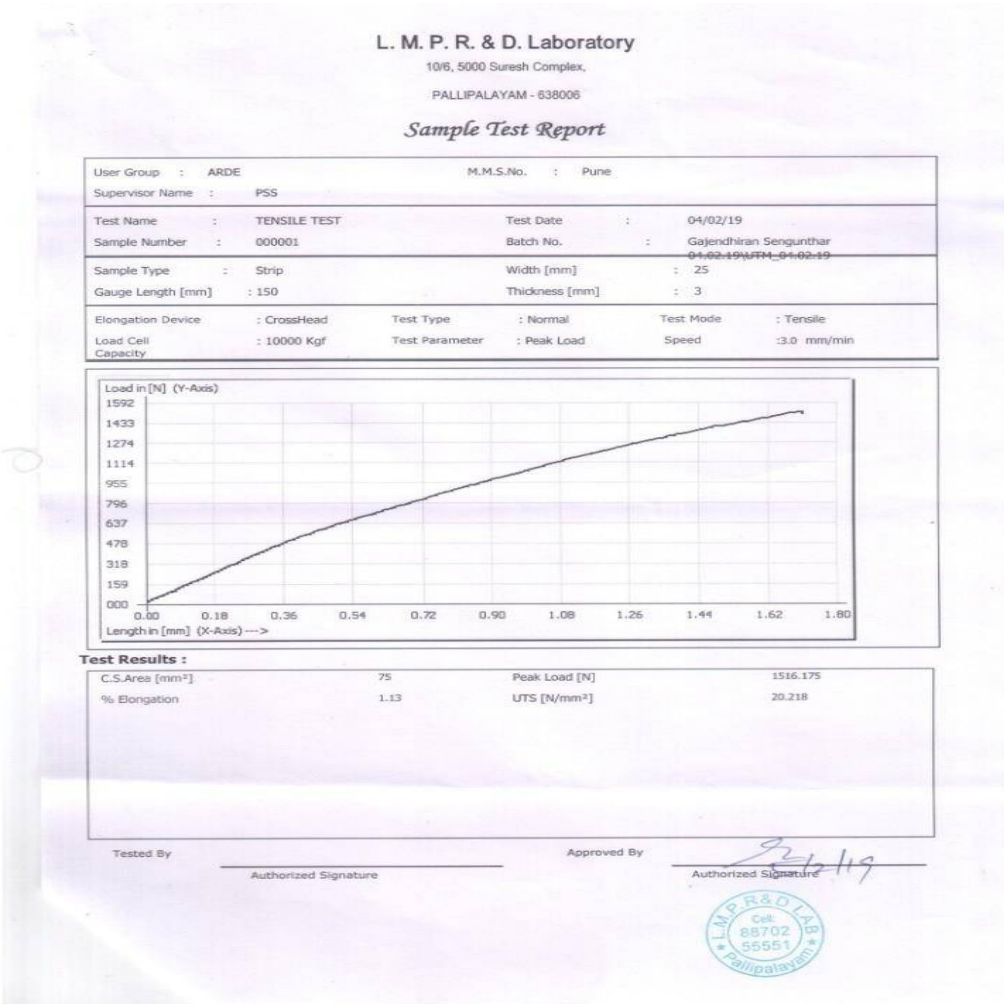
Test Name : TENSILE TEST	Test Type : Normal	Test Mode : Tensile
Elongation Device : CrossHead	Test Parameter : Peak Load	Test Speed [mm/min] : 3.00

Sample No.	CS Area [mm²]	Peak Load [N]	%Elongation	UTS [N/mm²]		
000001	75.000	1516.175	1.130	20.218		
000002	75.000	2549.531	2.670	33.992		

Summary Report :

	CS Area [mm²]	Peak Load [N]	%Elongation	UTS [N/mm²]		
Min	75.000	1516.175	1.130	20.218		
Max	75.000	2549.531	2.670	33.992		
Avg	75.000	2032.853	1.900	27.105		
Std Dev.	0.000	730.693	1.089	9.739		
Variance	0.000	533912.280	1.186	94.851		
Median	75.000	2032.853	1.900	27.105		

Tested By Authorized Signature Approved By Authorized Signature


L. M. P. R. & D. Laboratory
10/6, 5000 Suresh Complex,
PALLIPALAYAM - 638006

Sample Test Report

User Group	: ARDE		M.M.S.No.	: Pune	
Supervisor Name	: PSS				
Test Name	: TENSILE TEST		Test Date	: 04/02/19	
Sample Number	: 000001		Batch No.	: Gajendhiran Sengunthar 04.02.19\UTM_04.02.19	
Sample Type	: Strip		Width [mm]	: 25	
Gauge Length [mm]	: 150		Thickness [mm]	: 3	
Elongation Device	: CrossHead	Test Type	: Normal	Test Mode	: Tensile
Load Cell Capacity	: 10000 Kgf	Test Parameter	: Peak Load	Speed	:3.0 mm/min

Test Results :

C.S.Area [mm²]	75	Peak Load [N]	1516.175
% Elongation	1.13	UTS [N/mm²]	20.218

Tested By Authorized Signature
Approved By Authorized Signature
L.M.P.R&D LAB Cell: 88702 55551 Pallipalayam

CONCLUSION

The experimental study on the hybrid composite with natural fillers on physical, water absorption, wear and mechanical behaviour test leads to the following conclusions

S.NO	TEST DETAILS	SAMPLE
1.	Tensile Test	33.992 **UTS[N/MM]**
2.	MICRO Hardness Test	21.0**HV(H)**
3.	Impact Test	1.65.
4.	Compression Test	**PEAK LOAD** 311.997N
5.	Bending Test	06.49MPa.

On the upcoming study the natural fillers are added with the prescribed weight ratio to the E glass polyester composite and its mechanical characteristics are analysed by the same testing procedure and by comparing the obtained results, the better material composition is finalized.

REFERENCE

1. Oksman K and Clemons C 1997 Mechanical properties and morphology of impact modified polypropylene–wood flour composites Journal of Applied Polymer Science pp 1503-1513
2. Ismail H, Salmah M and Nasir 2001 Dynamic vulcanization of rubber wood-filled polypropylene/natural rubber blends Polymer Testing pp 819-824
3. Begum K and Islam M A 2013 Natural fiber as a substitute to synthetic fiber in polymer composites: A review, Res. J. Eng. Sci. pp 46–53
4. De Sousa M V, Monteiro S N J and D'Almeida J R M 2004 Evaluation of pre-treatment, size and molding pressure on flexural mechanical behavior of chopped bagasse polyester composites, Polym. Test. pp 253–258
5. Yadav S , Gupta G and Bhatnagar R 2015 A Review on Composition and Properties of Bagasse Fibres International Journal of Scientific & Engineering Research 6, Issue 5 pp 143-148

6. Swain P T R and Biswas S 2014 Physical and mechanical behavior of Al2O3filled jute fiber reinforced epoxy composites Int J Current Engg Tech pp 67-71
7. Mishra A 2013 Strength and corrosion testing of jute/ glass- epoxy hybrid composite laminates Plastic and Polymer Technology pp 48-54
8. Keller A 2013 Compounding and mechanical properties of biodegradable hemp fiber composites Compos. Sci. Technol. pp 1307–1316
9. Bhatnagar R, Gupta G and Yadav S 2015 A Review on Composition and Properties of Banana Fibres International Journal of Scientific & Engineering Research 6 Issue 5 pp 49-52
10. Boopalan M, Niranjanaa M and Umapathy M J 2013 Study on the mechanical properties and thermal properties of jute and banana fibre reinforced epoxy hybrid composites part b pp54- 57
11. Srinivasan V S, Rajendra Boopathy S, Sangeetha D and Vijaya Ramnath B 2014 Evaluation of mechanical and thermal properties of banana–flax based natural fiber composite Materials & Design 60 pp 620-627
12. Arumugaprabu V, Uthayakumar M, Manikandan V, Rajini N and Jeyaraj P 2014 Influence of redmud on the mechanical, damping and chemical resistance properties of banana/polyester hybrid composites, Materials & Design, 64 pp 270-279
13. Gupta G, Gupta A and Pratap B 2014 a Review on Banana Fibre Composites. 2nd National Conference on Recent Advances in Mechanical Engineering, GBPEC Pauri Rosa S M L, Santos E F, Ferreira C A, Sônia and Nachtigall S M 2009 Studies on the properties of rice-husk-filled-PP composites-effect of maleated PP Mat. Res. 12 ISSN 1516-1439
14. Choi N W, Mori I and Ohama Y 2006 Development of rice husks–plastics composites for building materials 2006 science direct, Waste Management 26 Issue 2 pp 189–194
15. kumar A, Mohanta K, Kumar D and Parkash O 2012 Properties and Industrial Applications of Rice husk: A review International Journal of Emerging Technology and Advanced Engineering ISSN 2250-2459 2, Issue 10 pp 86-90

