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A study on tensile and flexural properties of polymer composites made of different natural fiber and different filler materials: A Review

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Abstract - *The aim of this study is to estimate and understand the effect of different natural fibers and filler materials that are used in fabrication of polymer composite material and analyze the verified results like tensile and flexural. In this study different composites are prepared with jute, hemp, coir, sisal, bamboo and, banana fibers and filler materials like silicon carbide, tungsten carbide, fly ash, egg, rubber, and rice husk are consider. An attempt is made to compare and analyze the tensile and flexural strength based on experimental results.*

Key Words: **composite materials, natural fibres, filler materials, tensile strength, flexural strength**

1. INTRODUCTION

In these present world there is much interest shown in developing material on fiber reinforced polymer composites to minimize weight of the material, cost of the material, at the same time the material must have to withstand strength over certain criteria by utilizing naturally available fibers along with some filler materials. Where in polymer composite material the two important criteria is reinforcement and matrix. Reinforcement is a type of material that give mechanical strength to the composites some of the mechanical properties like tensile, flexural, impact, hardness etc. Some of naturally available reinforced materials are jute, hemp, coir, sisal, bamboo, banana etc. Matrix is nothing but the material which gives binding strength to the composites example for matrix material are epoxy, polyester, polyethylene, etc. The required mechanical strength between fiber and resin is not obtained along them some of the fillers have been used to increases the properties of the composites. Many ceramic and metal based fillers are available and can composites are mate at low cost with high strength.

1.1 Natural fibers

Fibers that available naturally are referred as natural fibers where natural fibers are classify into 3 forms namely fibers from plants, animals, and mineral fibers. Natural fibers are used for reinforcing material. These have complicated structure, with crystalline cellulose micro fibril- reinforced amorphous lignin or/and hemi-cellulose matrix. Natural fibers are constitutes of cellulose, hemi-cellulose, lignin, waxes and some water-soluble compounds. The major component of it are cellulose (60%-80%), hemi-cellulose (5%-20%), lignin and moisture (20%) This study focused on fibers from plants some of these are jute, hemp, coir, sisal, bamboo and rice husk etc. chemical composition and properties for some natural fibers are shown below table 1[22] and table 2[21] respectively;

Types of fibers	Cellulose (wt%)	Hemicellulose (wt%)	Lignin (wt%)	Waxes (wt%)
Jute	66	17	12.5	0.5
Hemp	72	20.1	4.7	0.8
Sisal	73	12	12	2
Coir	32-43	0.15-0.25	40-45	-
Kenaf	51	21.5	10.5	-
Bamboo	26-43	30	21-31	-
Ricehusk	35-45	19-25	20	-

Table 1: Chemical composition for natural fibers

Fibers	Density (g/cc)	Elongation	Tensile strength (MPa)	Elastic modulus (gpa)
Jute	1.3	1.5-1.8	393-773	26.5
Hemp	1.47	2-4	690	70
Sisal	1.5	2.0-2.5	511-635	9.4-22
Coir	1.2	30	593	4.0-6.0
Kenaf	1.45	1.6	930	53
Bamboo	0.5-0.9	16.0	14.8-38.4	20

Table 2: Properties of natural fibers

1.2 Matrix materials

Mainly for polymer composite material epoxy is commonly used matrix material due to their many advantages such as adhesion to wide variety of fibers, superior mechanical and electrical properties and good performance at elevated temperature. In addition to that they have less shrinkage upon curing and good chemical resistance. Other matrix material are also used in polymer composites they are; polyester, vinyl ester, and phenolic, mechanical properties for different matrix materials are shown below;

1.2.1 Epoxy resin

Properties	Values
Viscosity @ 25°cμ (cp)	12000-13000
Density	1.16
Heat distortion temperature @ °c	50
Modulus of elasticity (gpa)	5.0
Flexural strength (MPa)	60
Tensile strength (MPa)	73
Maximum elongation (%)	4

Table 3: Properties of epoxy resin (values are taken from catalog)

1.2.2 Polyester resin

Properties	Values
Viscosity @ 25°cμ (cp)	250-350
Density	1.09
Heat distortion temperature @ °c	54
Modulus of elasticity (gpa)	3.3
Flexural strength (MPa)	45
Tensile strength (MPa)	40
Maximum elongation (%)	1

Table 4: Properties of polyester resin (values are taken from catalog)

1.2.3 Vinyl ester

Properties	Values
Tensile strength	60-75
Tensile strain	2-3
Tensile modulus	3.2
Density	1.14
Volume shrinkage	7-8 (%)

Table 5: Properties of vinyl resin (values are taken from catalog)

1.3 Filler materials

To enhance the strength of composite based on particular application some additives are used in the form of fillers or flakes along with matrix materials. Some of them are; silicon carbide, tungsten carbide, rice husk, natural rubber, etc. by adding filler not only strength of the composites is increased but also mechanical properties can also increase. Some of them are shown along with their properties.

Silicon carbide (SIC)

Physical property	Values
Density g/cc	3.1
Flexural strength (MPa)	550
Elastic modulus (gpa)	410
Compressive strength (MPa)	3900
Hardness (kg/mm2)	2800

Table 6: Properties of silicon carbide [19]

Tungsten carbide (WC)

Physical property	Values
Density g/cc	15.63
Tensile strength (MPa)	344
Elastic modulus (gpa)	530-700
Compressive strength (gpa)	2.7
Hardness (kg/mm2)	-

Table 7: Properties of tungsten carbide (values are taken from catalog)

Aluminum oxide Al_2O_3 (99.5%)

Physical property	Values
Density g/cc	3.89
Tensile strength (MPa)	-
Elastic modulus (gpa)	375
Compressive strength (gpa)	2.6
Hardness (kg/mm2)	1440

Table 8: Properties of aluminum oxide (values are taken from catalog)

Silica (SiO_2)

Properties	Values
Density	2.648
Boiling point	1600
Melting point	2230

Table 9: Properties of epoxy silica (values are taken from catalog)

2 LITERATURE SURVEY

It is found many works on natural fibers and filler materials have been carried to estimate property some of them are as follow; T. Madhusudhan et al [1] made experimental study by using silicon carbide as an filler material and conclude

that silicon filled composites having high impact strength compared with other filled composites and also conclude that with increases in filler content of silicon carbide which leads to increases mechanical properties such as hardness, tensile strength, flexural strength, inter laminar strength. Madhusudhan et al [2] made experimental studies on Comparison of Hybrid Composites with Different Filler Material and revels that hybrid composites with 2 different fiber material and tungsten carbide as a filler as high tensile and hardness strength compare to 3 different fibers and silicon carbide as filler material and showed that flexural strength is more for 2 different fibers and sic as filler compared to 3 different fibers and tungsten as a filler material. Madhusudhan T, et al [3] Mechanical Characterization of Jute and Rubber Particles Reinforced Epoxy Polymer Composites. In this tensile and flexural properties are influenced by the fiber composition than the rubber particulate. The combination of these materials in composites can be used as alternative in any synthetic fiber filled polymer composites'. Praveen Kumar et al [4] made experiment on hybrid composites with or without filler material and silicon carbide as filler material and made conclude that Hybrid composites jute/E-Glass fiber has better properties than that of the jute fiber and the sisal/Glass fiber without filler material had Good tensile strength. And also conclude that increasing filler content tends to increase the modulus & hardness but decrease tensile strength of the composite. Priyankarpratim et al [5] made study on experimental investigation on mechanical properties of rice husk filled jute reinforced composites and conclude that due to filler where there is increases in tensile strength and decreases in compressive property and also showed that there is no much difference on flexural strength when compare with or without filler . KG Prakash et al [6] made experimental study on effect of filler material for hemp fiber reinforced polymer composites in automobile application and resulted that by using more filler percentage in adding the filler materials where there is increase in mechanical strength.Hemantpatel et al [7] made study on mechanical behaviors of banana and sisal hybrid composites reinforced with epoxy resin. V. Manikandan [8] et al made experimental study on effect of fly ash as filler on mechanical & frictional properties of jute fiber reinforced composite and showed that wear resistance increases by adding fly ash. R. S. Wani [9] made study on Tensile Testing of Bamboo Fiber Reinforced Epoxy Composite. NE Naveen [10] made study on experimental analysis of coir-fiber reinforced polymer composite materials and conclude that strength of composites can increase by increase the weight of the fiber. R. Sanjay [11] made experimental study on Investigation on Mechanical Properties of Hemp/E-Glass Fabric Reinforced Polyester Hybrid Composites and observed strength of the materials. S. Nallusamy [12] made on study on investigation on mechanical properties of coir fiber reinforced polymer resin composites saturated with different filling agents and conclude that by adding filler strength can increased. W S kharat [13] made study on development of epoxy based composites filled with boron carbide (b4c), tungsten disulphide (ws2) and evaluation of its mechanical properties. S.Sreenivasulu [14] made on experimental study on mechanical properties evaluation of bamboo fiber reinforced composite materials and conclude that strength depends on fibers. Ajith Kumar g et al [15] made study on coir fiber reinforced polymer matrix composites to estimate mechanical properties.Subbareddy d n et al [16] made study on evaluation of mechanical properties in banana reinforced fibers and estimate mechanical properties and recorded. ch.arunbabu et al [17] made study on experimental and analysis of polyester - jute- hemp fiber reinforced composite and conclude by analyze different mechanical properties. Priyadarshi tapas ranjan swain et al [18] made study on physical and mechanical behavior of al2o3 filled jute fiber reinforced epoxy composites and conclude that increase of fiber and filler increases the strength of the composites. Arpitha GR et al [19] made study on mechanical properties of Epoxy based hybrid composites reinforced with sisal/Sic/glass fibers and conclude that without filler shown better results.Ludmiladulebova et al [20] made study on the effect of particulate fillers on hardness of polymer composite with filler like talk and chalk and montmorillonite and concluded that hardness is increased with increase of filler materials. And exposed to UV rays without any significance changes in hardness'. W. Nguong, S et al[21] made a review on natural fiber reinforced polymer composites and conclude that by adding Nano materials improves tensile and wear properties.A.R.M.Nazim et al [22] made a review on natural fiber polymer composites and show that kenaf and jute having similar properties.

3. RESULTS AND DISCUSSIONS

Some of the mechanical properties like tensile and flexural results for jute, hemp, sisal, coir, bamboo, and banana fibers are discussed here.

3.1 Tensile strength without filler materials

- Tensile strength for sisal and epoxy composites having 50:50 fiber to resin ratio in the composites is 59.7 MPa [7]
- Tensile strength for banana and epoxy composites having (50:50)fiber to resin ratio in the composites is 20 MPa [7]
- Tensile strength for jute and epoxy composite having 60:40 fiber to resin ratio in the composites 32.3 MPa [8]
- Tensile strength for bamboo fiber epoxy composite is 26.41MPa [9]
- Tensile strength for coir depends on length of the fiber for maximum length of coir tensile strength is 13.05 MPa [10]
- Tensile strength for 9layers of hemp with polyester resin is 50 MPa [11]

Table 10: Tabulated tensile results for different fibers

Fibers	Tensile strength (MPa)	Resin used
Banana	20.00	Epoxy
Bamboo	26.41	Epoxy
Coir	13.05	polyester
Hemp	50.00	polyester
Jute	32.30	polyester
Sisal	29.70	Epoxy

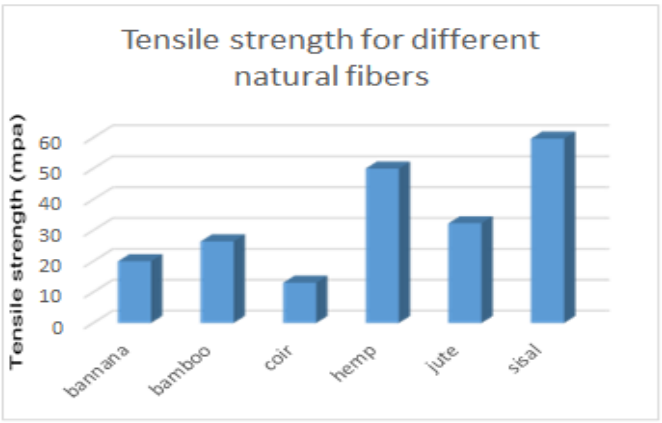


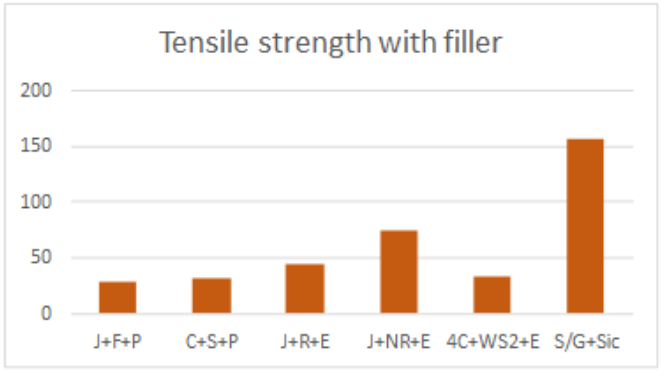
Fig-1: Variation of tensile strength for different fibers

3.2 Tensile strength for natural fibers with filler materials

In order to increase strength of the natural composites along some additives or fillers are used some of the results for different fibers are shown below;

Table 11: Tabulated tensile results with filler for different fibers

Fibers	Filler mater-ial	Resin used	Percentage of filler (%)	Tensile strength (MPa)	Journal reference	symbol
Jute	Fly ash	Polyester	10	28.94	[8]	J+F+P
Coir	Sea shell powder	Polyester	10	31	[12]	C+S+P
Jute	Rice husk	Epoxy	05	44.63	[5]	J+R+E
Jute	Rubber	Epoxy	10	74.81`	[3]	J+NR+E
Without fibers	Boron carbide +tungsten diSulphide	Epoxy (93.5%)	2.5+4	33	[13]	B4C+WS2+E
Sisal/glass	Silicon carbide	Epoxy	3	156.88	[19]	S/G+Sic



3.3 Flexural strength without filler

Table 12: Tabulated Flexural strength without filler results for different fibers

Fibers	Flexural strength	Resin used	Journal reference
Coir	35.42	Polyester	[10]
Coir	84.803	Polypropylene	[15]
Banana	89	Epoxy	[16]
Jute	105	Polyester	[16]
Hemp	99	Polyester	[17]
Jute	48	Epoxy	[18]

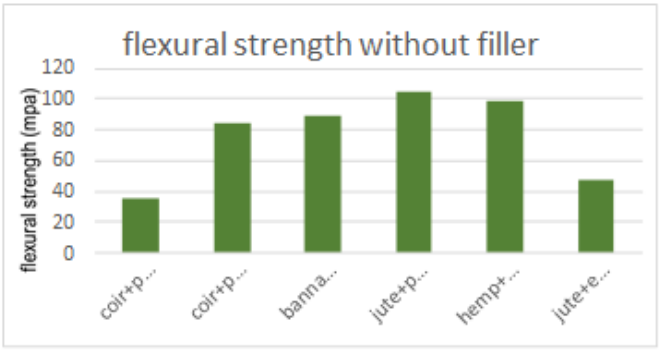
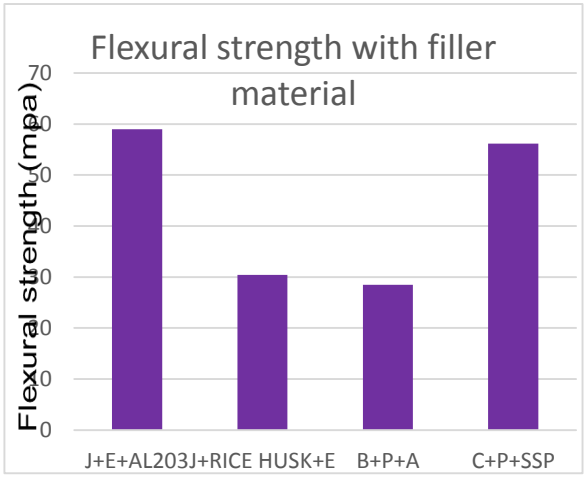


Fig-3: Variation of Flexural strength without filler for different fibers

3.4 Flexural strength with filler

Table 13: Tabulated Flexural strength with filler results for different fibers

Fibers	Resin used	Filler material and %	Flexural strength (MPa)	symbol	Journal reference
Jute	Epoxy	Al203 10%	59	J+E+AL2O3	[18]
Sisal/glass	Epoxy	Sic 9%	467.75	S/G+E	[19]
Bamboo	Polyester	Alumina 10%	28.448	B+P+A	[11]
COIR	Polyester	Sea shell powder	56.174	C+p+ssp	[14]



4. CONCLUSIONS

We can few conclusion from reference to these work conducted by different researchers;

- Compared to natural fiber reinforced polymer composites, PMC with filler material show enhanced results in terms strength and stiffness and maximum tensile strength under material under study.
- Filler materials improve strength of the composites to a considerable amount.
- Among all the natural choose for study Jute (1.3 g/cc) fiber has less density compared to hemp (1.45 g/cc), sisal (1.5g/cc)
- Composite with use of banana fiber as reinforcement has least strength compared to composites reinforced with other natural fiber.
- Flexural strength increases by increasing the weight of the fibers
- Silicon carbide (3.21 g/cc) having less density compared to tungsten carbide (15.63g/cc)
- Epoxy resin having more good mechanical properties and can cure at room temperature
- Hand layup is simple method to fabricate fiber based polymer composites
- Natural fiber reinforced polymer composites with rice husk as filler material has least tensile and flexural strength.
- Glass fiber having more strength compare to other natural fibers

REFERENCES

[1] T Madhusudhan, KeerthiSwaroop G , A review on mechanical properties of natural fiber reinforced hybrid composites, international research journal of engineering and technology (irjet) e-issn: 2395 -0056 volume: 03 issue: 04 | apr-2016 www.irjet.net p-issn: 2395-0072 ©.

[2] T Madhusudhan, Senthil Kumar m comparison of hybrid composites with different filler material international journal of engineering research and general science volume 4, issue 2, march-April, 2016 issn 2091-2730.

[3]Madhusudhan T, Senthil Kumar m. mechanical characterization of jute and rubber Particles reinforced epoxy polymer composites. IOSR journal of pharmacy, (e)-issn: 2250-3013, (p)-issn: 2319-4219, volume 6, issue 12 version. 1 (Dec 2016), pp. 23-27.

[4]K.PraveenKumar, M.ManzoorHussain, Sridharareddy, G.Gopala Krishna an overview on thermal and mechanical properties of natural fiber reinforced hybrid composites Technical research organization India

[5] Priyankarpratimdeka, SutanuSamanta experimental investigation on mechanical properties of rice husk filled jute reinforced composites world academy of science, engineering and technology international journal of materials and metallurgical engineering vol:9, no:12, 2015

[6] B J .Praveen Kumar k. Pradeep Kumar natural fiber jute and egg shell powder as filler material international journal of engineering trends and technology (IJETT) – volume23 number 1- may 2015 issn: 2231

[7] Hemant Patel , prof. Ashish Parkhe, Dr P K. Sharma mechanical behaviors of banana and sisal hybrid composites reinforced with epoxy [Patel et. al., Vol.4 (Iss.1): January, 2016] ISSN- 2350-0530(O) ISSN- 2394-3629(P) Impact Factor: 2.035 (I2OR) .

[8] V. Manikandan, S. Richard, M. ChithambaraThanu, J. Selwinrajadurai effect of fly ash as filler on mechanical & frictional properties of jute fiber reinforced composite international research journal of engineering and technology (irjet) e-issn: 2395 -0056 volume: 02 issue: 07 | oct-2015 www.irjet.net p-issn: 2395-0072.

[9] R. S. Wani, R. R. Shitole Tensile Testing of Bamboo Fiber Reinforced Epoxy Composite IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X PP. 07-11 www.iosrjournals.org.

[10] P N E Naveen1 and M Yasaswi1 Experimental analysis of coir-fiber reinforced polymer composite materials issn2278 – 0149 www.ijmerr.comVol. 2, No. 1, January 2013 © 2013 IJMERR. All Rights Reserved

[11] M. R. Sanjay a, G. R. Arpitha a, L. LaxmanaNaikA, B, K. Gopalakrishna b, B. Yogesha A Experimental Investigation

on Mechanical Properties of Hemp/E-Glass Fabric Reinforced Polyester Hybrid Composites Journal of materials and engineering structures 3 (2016) 117–128

[12] S. Nallusamy*, R. SuganthiniRekha , A. Karthikeyan Investigation on Mechanical Properties of Coir Fiber Reinforced Polymer Resin Composites Saturated with Different Filling Agents ICMAEM-2017 IOP Publishing IOP Conf. Series: Materials Science and Engineering 225 (2017) 012283 doi:10.1088/1757-899X/225/1/012283

[13]W S Kharatnd J S Sidhu Development of Epoxy Based Composites Filled With Boron Carbide (B4C), Tungsten Disulphide (WS2) and Evaluation of its Mechanical Properties International Journal of Mechanical Engineering Research. ISSN 2249-0019 Volume 6, Number 1 (2016), pp. 19-30 © Research India Publications http://www.ripublication.com.

[14] S.Sreenivasulu, Dr. A chennakeshava Reddy Mechanical Properties Evaluation of Bamboo Fiber Reinforced Composite Materials International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print) Volume No.3 Issue No: Special 1, pp: 187-194 22nd March 2014

[15] Ajith Kumar G, Aravindh R, Chellakarthikeyan R.M, Gwalbert Maurice G COIR FIBER REINFORCED POLYMER MATRIX COMPOSITES International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 04 Issue: 08 | Aug -2017 www.irjet.net p-ISSN: 2395-0072

[16]Subba Reddy D N, Thyagaraj N R, Manjunatha.K.N evaluation of mechanical properties of banana fibers © SEP 2017 | IRE Journals | Volume 1 Issue 3 | ISSN: 2456-8880

[17] 1Ch. ArunBabu, 2Sd. Abdul Kalam, 3P. Ravi Kumar Experimental and Analysis of Polyester - Jute- Hemp Fiber Reinforced Composite© 2017 IJEDR | Volume 5, Issue 4 | ISSN: 2321-9939

[18] Priyadarshi Tapas RanjanSwainaand SandhyaraniBiswasaPhysical and Mechanical Behavior of Al2O3 Filled Jute Fiber Reinforced Epoxy Composites International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 - 5161 ©2014 INPRESSCO®, All Rights Reserved Available at http://inpressco.com/category/ijcet

[19] Arpitha G R1, Sanjay M R1, L Laxmana Naik1, B Yogesha Mechanical Properties of Epoxy Based Hybrid Composites Reinforced with Sisal/SIC/Glass Fibers International Journal of Engineering Research and General Science Volume 2, Issue 5, August-September, 2014 ISSN 2091-2730

[20] Ludmila dulebova1, Tomasz garbacz2 the effect of particulate fillers on hardness of polymer composite advances in science and technology research journal volume 11, issue 3, September 2017, pages 66–71 doi: 10.12913/22998624/76601 research article

[21] C. W. Nguong, S. N. B. Lee, and D. Sujan A Review on Natural Fibre Reinforced

Polymer Composites World Academy of Science, Engineering and Technology International Journal of Materials and Metallurgical Engineering Vol:7, No:1, 2013

[22] A.R.M.Nazim, M.N.M. Ansari A Review on Natural Fiber Polymer Composites International Journal of Scientific Research Engineering & Technology (IJSRET), ISSN 2278 – 0882 Volume 6, Issue 2, February 2017