International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 12 | Dec-2017 www.irjet.net p-ISSN: 2395-0072

Enhancing mechanical properties of jute fibre/glass fiber and epoxy combined hybrid composite laminates

Hashim Mohd Khan[1], Sumitr Raj Shukla[2], Sarvi Shukla[3], Akshay Kumar Gupta[4]

[1,2,3,4] *Department of Mechanical Engineering, Krishna Institute of Technology, Kanpur, Uttar Pradesh, India*

Abstract - *The natural occurring material such as Jute has been using since a long ago. But now in modern era need of people have been changed and moving towards new advanced materials and should be of less cost. Jute fibre is a bio-degradable material so in time it will dispose off naturally. In this study we have enhanced the mechanical properties of Jute fibre and Glass fibre composite by mixing with epoxy. And now that composite are more reliable and sustainable than the conventional one and partially eco-friendly.*

***Key Words*: glass/jute fiber composite, SEM analysis of composite cross section, vacuum bagging, mechanical properties**

1.INTRODUCTION

The combination of jute and glass fibre composite has an excellent mechanical property than the conventional ones. And it is partially eco-friendly material in nature. In today's scenario peoples interest has been increased in epoxy based composite materials because of its durability and having better mechanical properties like higher tensile strength, increased surface hardness, higher impact resistance, higher insulating properties and many more. But natural fibres have some drawbacks like lower tensile strength; low durability, easily degradable material but when it is mixed in a proper ratio with synthetic materials like epoxy and glass fibre those drawbacks becomes its strength. The epoxy matrix protects the fibres from external environment. But these composites have limited applications due to its higher cost of manufacturing.

In recent times research on these materials has been carried out by various researchers. G. Raghavendra, Shakuntala Ojha, S.K. Acharya, S.K. Pal *et al*[1] carried out the study on woven jute/glass fibre polymer composite with fly ash particles and concluded that the tensile, flexural and impact properties of these composite have been enhanced significantly. And with the incorporation of fly ash particle these properties increased by 5%.

M. Ramesh, K. Palanikumar, K. Hemachandra Reddy *et al*[2] collectively worked on sisal-jute-glass polymer resin hybrid composite material orientation, 0^o composite samples are performing better than the 90^o composite samples and as per the fiber content sisal- jute, and glass fiber-reinforced samples are showing better results than the single fiber either sisal or jute-reinforced composite samples are tested. The water absorption property reduces when these natural fibres are combined with polyester resin.

M. Pinto, V.B. Chalivendra, Y.K. Kim, A.F. Lewis *et al* [3] worked with jute/epoxy hybrid composite materials for structural applications. They concluded that the woven fabrics show 28% more initiation toughness than the unidirectional ones. Md. Rafiquzzaman, Md. Maksudul Islam, Md. Habibur Rahman, Md. Saniat Talukdar and Md. Nahid Hasan *et al*[4] collectively worked on jute-glass fiber the incorporation of fibers in an optimum volume the mechanical strength is increased. They saw the de-lamination of fibers and fibers pull out of layers are near to numerical analysis and these caused fractures due to static loading.

This Study aims to evaluate the mechanical properties laminate composites of jute/glass fibers and scanning of the defects in the layers via SEM method and to enhance the mechanical properties of this composite material.

1.1 Materials

The Materials we used is Araldite epoxy (LY556), Hardener (HY951), Jute Fiber (*Corchorus olitorius*), Glass fibers, Acetone was used to clean the composite material surface to remove excess epoxy from it. Water is being used during cutting of composite material as a coolant. Jute fiber is a natural fiber obtained from plant *Corchorus olitorius* and its bio-degradable material. The table below gives the mechanical properties.

Table-1.1a: List of materials with their properties.

S. No	Materials	Young's Modulus (GPa)	Specific Modulus	Density (g/cm^3)	Stiffness (kN/mm)	Fiber diameter
1	Jute Fiber	18	29	1.5	10-30	10~8 µm
2	Glass Fiber	72	32	2.65	65-75	98~45 µm
55573	Epoxy resin	2.6	---	1.15	---	-NA-

1.2 Fabrication

The jute fiber was woven in 0^o and 90^o and the glass fibers were woven in 90^0 only. Vacuum bagging technique

and Hand-layup technique is used to fabricate the laminates of four layers of fibers. Firstly the mallet sheet is cleaned with acetone and dried under sunlight. Epoxy resin and hardener is used in 10:1 ratio by weight and mixed up to 2 minutes. Epoxy is poured and spread by brush uniformly in 250x250 mm^2 area. First layer of fiber is embedded on the surface of epoxy and then it is adhered to the epoxy by using roller and then again we spread the epoxy on the surface of fiber and then another layer of fiber is embedded on the layer of epoxy resin. The first and last layer in composite laminate is oriented at +90^o angles and middle layer is oriented at an angle of ±45^o. This process is reaped until all 4 layers of fibers are stacked and embedded in the epoxy resin completely. Then a mallet sheet is used to cover up the composite and then a heavy metallic roller is used to squeeze out the air bubbles and excess epoxy resins. The laminate is put into a plastic bag and air-sealed and the remaining air is removed by using a vacuum pump and then the bag is put into the hydraulic press machine at pressure of 20Kg/cm^2 for 24 hours (Curing time) at room temperature.

Sequencing of fibre layers	% of fibers Jute(J) Glass(G)		Weight Fraction Of Fibre in composite	Fibre Volume fraction	Epoxy weight Fraction in composite
JJJJ	100	0	21	19.5	79
GGGG	0	100	27	16.5	73
GJJG	50	50	24	17.5	76
JGGJ	50	50	25	17.5	75

Table-1.2a: Weight Percentage of Matrix and fibers

1.3 Impact Test

The Impact test is carried out in two methods i.e. Izod and Charpy testing methods. For charpy testing ASTM E23 standard is used and for Izod testing ASTM D256 standard has been followed. Lab temperature was 29*C and 68% relative humidity. The hybridization of jute and glass fiber with epoxy resin has significantly increased the material impact strength. It can be observed that the incorporation jute fiber lamina at ±45* angles in the core shows the maximum impact strength in both izod and charpy methods.

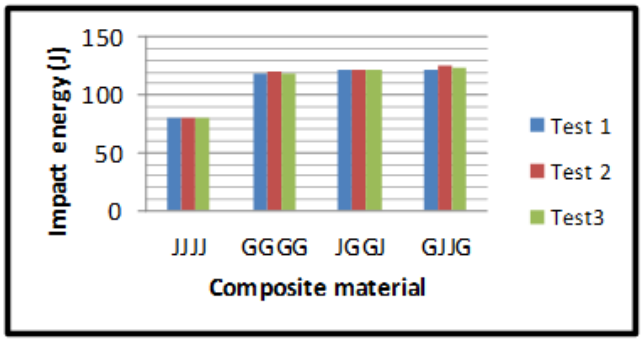

Chart-1.3a: Impact energy comparison of different composite material.

1.4 Tensile Test

The Tensile Test has been done on composite materials. The specimens are tested on Universal Testing Machine of capacity of 100kN (INSTRON 1195). The tensile test has been done under ASTM-D3039 standards. The UTM is powered by hydraulic screw driver mechanism. The environmental condition is 28*C temperature and relative humidity is about 65%. The tensile specimen is fixed in the UTM and load is applied until it breaks. The Ultimate tensile strength is recorded in a digital computer connected with UTM.

Table-1.3a: Average Tensile and impact strength of specimens

Test	Tensile Strength (MPa)	Elongation (mm)	Impact Strength (Charpy) (Joules)	Impact Strength (Izod) (Joules)
Material				
GGGG	99.70	3.01	254.75	118.6
JJJJ	80.16	4.55	265.67	80.62
GJJG	58.73	3.9	265.26	123.43
JGGJ	76.22	5.2	263.05	121.83

Stress-strain graphs for composites

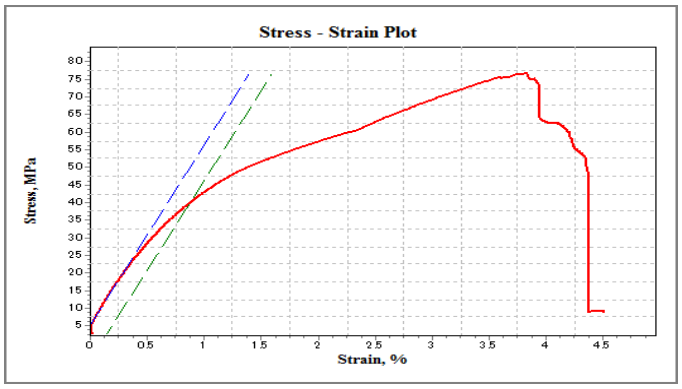

Fig -1.4a: JGGJ- laminate composite

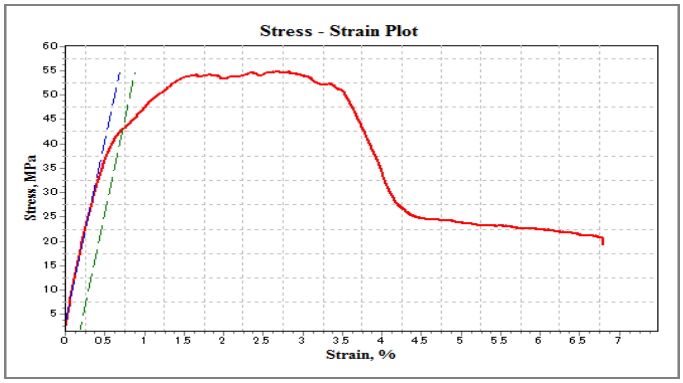

Fig -1.4a: GJJG laminate composite

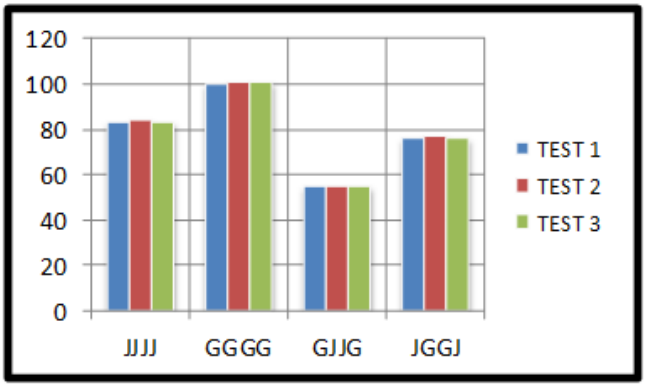

Chart-1.4a: Tensile strength comparison of different composite material

The variation in stress-strain curve of composites is due to orientation of fiber lamina. It has been observed that when the middle layer of composite is made of glass fiber (JGGJ) it shows higher tensile strength than GJJG laminate. But the strain is more in GJJG laminate than JGGJ laminate.

1.5 Hardness Test

Hardness of specimen is tested on Brinell hardness tester machine. A load of 100 kg and 187.5 kg is applied on the surface of material for 30 seconds using 2.6mm diameter indenter ball. The indentation diameter was measured via microscope at 10X, 25X magnification. The Indentation was taken in 3 different locations on the same surface for all composite laminate to obtain an average hardness value of the specimen.

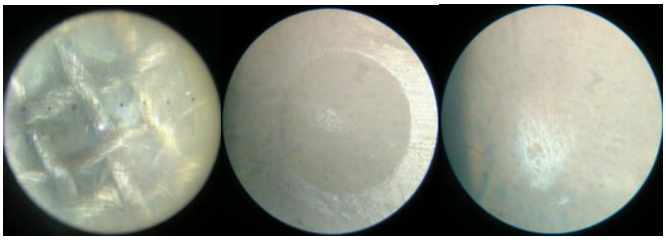

Fig -1.5a: Measuring and examining the Indentation on the surface of Composite laminate at 10x, 25x and 45x magnification respectively.

Material	TEST 1		TEST 2		TEST 3	
	BHN		BHN		BHN	
LOAD(kgf)->	100	187.5	100	187.5	100	187.5
JJJJ	122	361.71	124.9	285	127.9	229.1
GGGG	623.6	1012	504.2	1169	539.9	945.3
JGGJ	78.26	170.4	84.66	155.5	72.61	228.7
GJJG	102	254.5	111.4	228.8	93.74	232.8

Table-1.5a: Readings of Brinell hardness number for all specimens

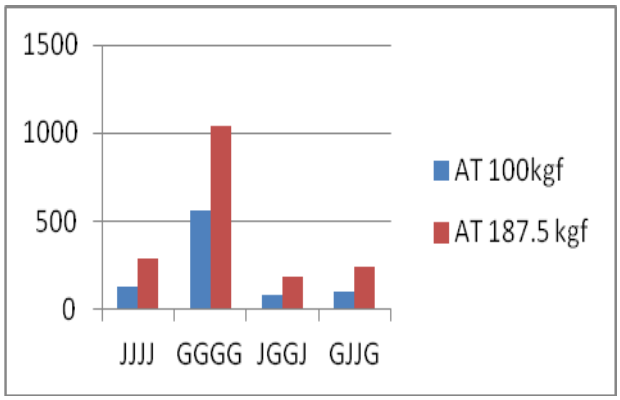

Chart-1.5a: Hardness Comparison bar plot

1.6 Scanning Electron Microscopy (SEM) Analysis

The composites are scanned under electron microscope (Carl Zeiss EVO 50) for studying the defects and fiber behaviors. The morphology of fiber and epoxy resin in failure modes are analyzed in SEM. The fiber failure can be seen in-between layer of jute fiber. Fig (1.6a) shows the air gap between the lamina interfaces. A dust particle is trapped in the air bubble can be seen in that figure. Glass fiber breakage and fiber misalignment is also visible in the lower layer in fig (1.6a).

In the fig (1.6b) it is the interface between the layers of jute and glass fiber, the air gap can be seen clearly in between the layers and jute fibre is overlapping the glass fiber layer and causing the de-lamination effect in the composite laminate. In fig (1.6d) layer slipping and erosion of epoxy has been observed due to shear load on the composite. Fig (1.6c & 1.6f) also shows that the bonding between the jute fiber and epoxy is better than glass fibers.

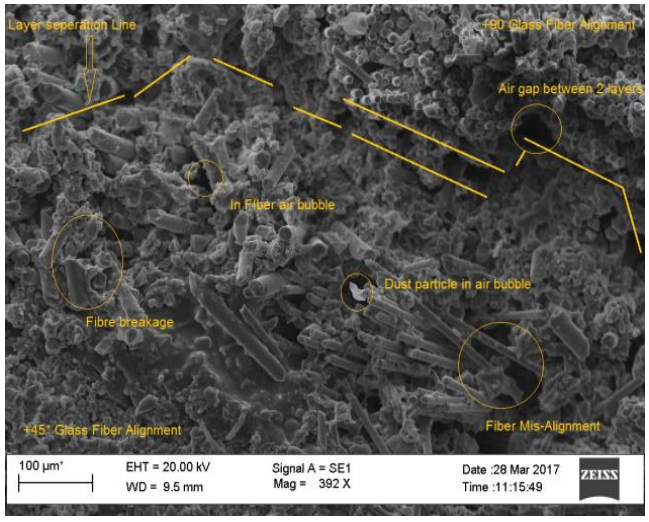

Fig 1.6a: Glass Fibre Cross Section

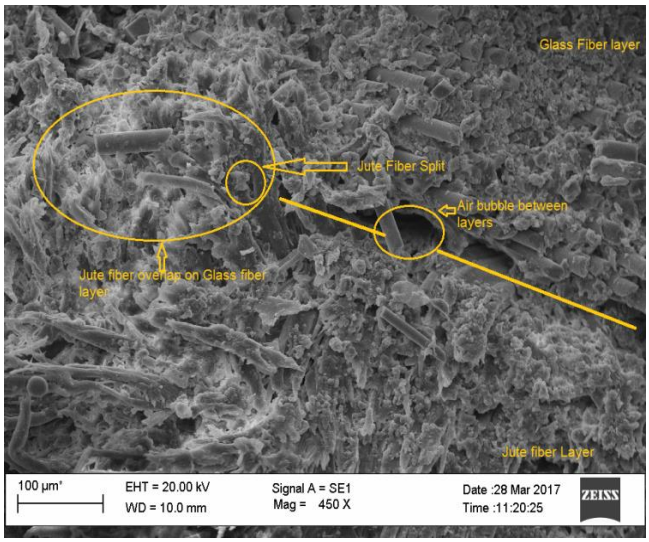

Fig 1.6b: Glass-Jute cross section

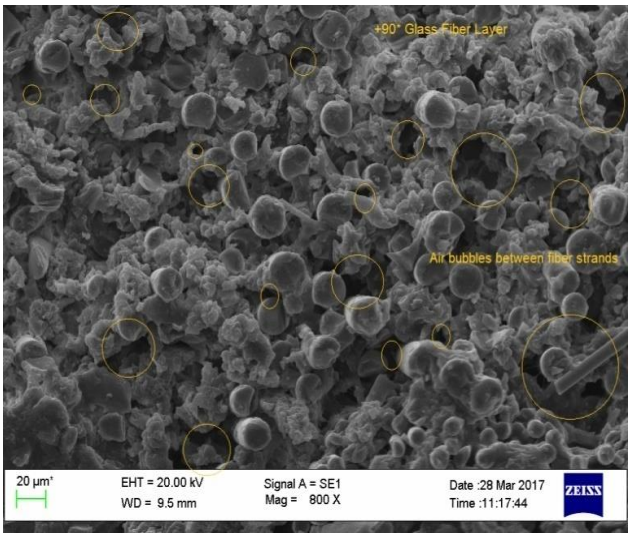

Fig 1.6e: Trapped air bubbles

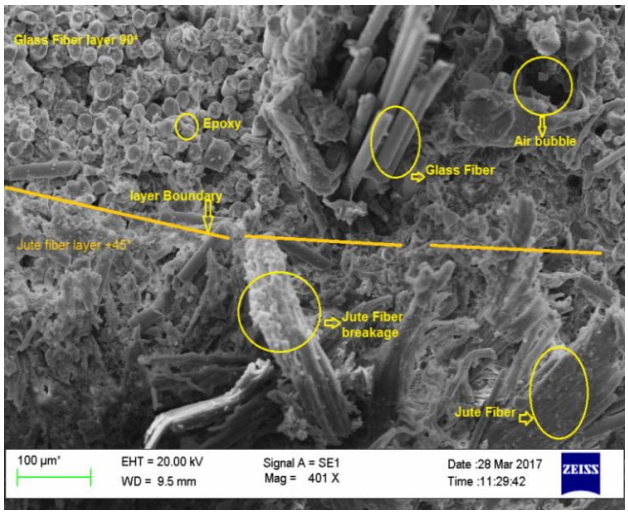

Fig 1.6c: Jute-Glass fiber interface

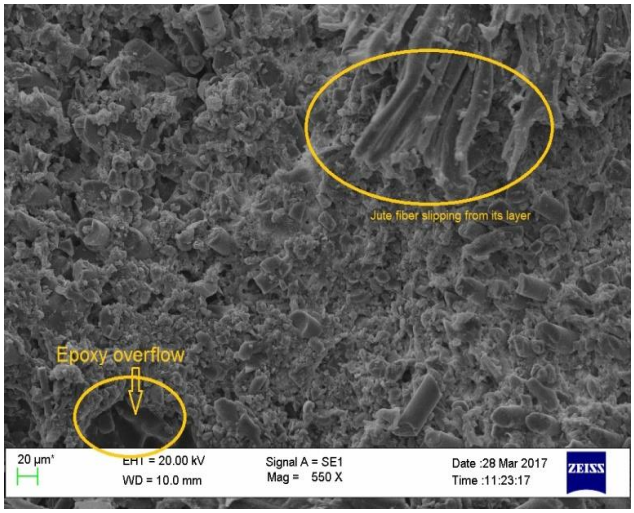

Fig 1.6f: Jute fiber slipping and resin overflow

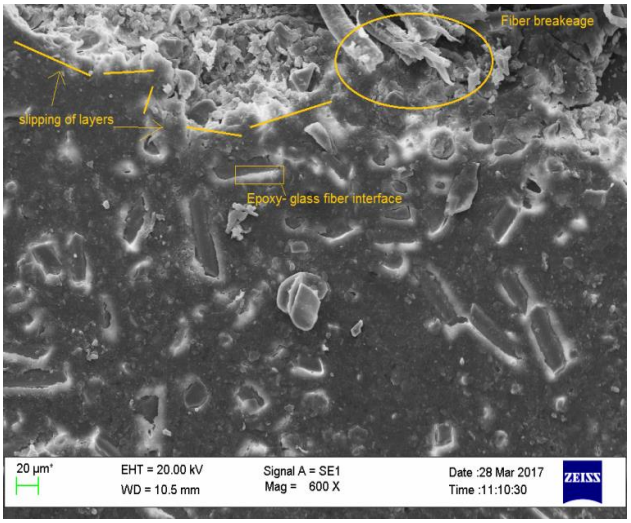

Fig 1.6d: Layer slippage in glass fiber composite

2. EDS Analysis

Energy dispersive X-ray spectroscopy was used to determine the chemical composition of composite material. The peaks formed for C, O, Si and Ca in EDS curve for spectrum is for jute and glass fibers. It has 73.74% of carbon, 20.12% of oxygen, 3.88% of silicon, 2.26% of calcium and rest are sulphate groups. The following table shows the percentage of elements by weight in the composite material. Fig (2.0a) shows the chemical spectrograph for spectrum 1.

Statistics	C	O	Si	Ca
Max	73.74	20.12	3.88	2.26
Min	73.74	20.12	3.88	2.26
Average	73.74	20.12	3.88	2.26
Standard Deviation	0.00	0.00	0.00	0.00

Spectrum Label	Spectrum 1
C	73.74
O	20.12
Si	3.88
Ca	2.26
Total	100.00

Table-2.0a: Chemical Composition by weight for Spectrum 1

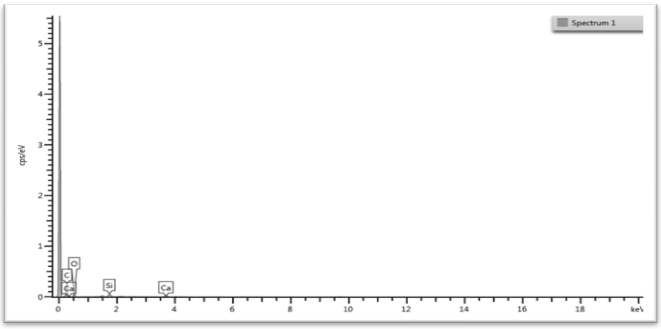

Fig 2.0a: Chemical spectrograph of Glass + Jute composite materials for spectrum1.

Spectrum 2 is for jute fiber laminate composite. The peaks are formed for C and O in EDS curve for spectrum is for jute and glass fibers. It has 80.02% of carbon, 19.98% of oxygen and rest is sulphate groups. The following table shows the percentage of elements by weight in the jute fiber composite material in Spectrum 2. Fig (2.0b) shows the chemical spectrograph for spectrum 2.

Statistics	C	O
Max	80.02	19.98
Min	80.02	19.98
Average	80.02	19.98
Standard Deviation	0.00	0.00

Spectrum Label	Spectrum 2
C	80.02
O	19.98
Total	100.00

Table-2.0b: Chemical Composition by weight for Spectrum 1

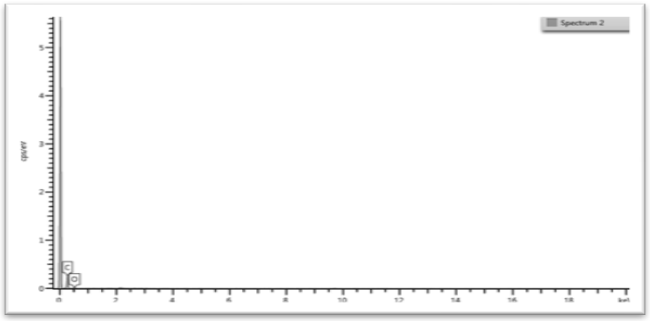

Fig 2.0b: Chemical spectrograph of Jute composite materials for spectrum 2.

3. CONCLUSIONS

1. The mechanical properties of jute and glass fiber is increased by incorporating the epoxy resin and increasing their tensile and impact strength.
2. The Tensile strength of hybrid composite JGGJ is greater than GJJG composite laminate by 28.78%.
3. The Impact strength of GJJG composite laminate is highest of all composite laminates.
4. SEM images shows that the bonding of jute fiber is better than glass fibers.
5. The JGGJ laminate composite is more flexible and less brittle than GJJG laminate composite material.
6. The GGGG laminate composite shows pure brittleness and having highest tensile strength of all hybrid composites.
7. From Stress strain curve of both JGGJ & GJJG composite laminate the GJJG laminate is more ductile than JGGJ laminate composite.
8. The GJJG laminate composite having the highest impact strength and therefore it can be used in structural applications in medium load without affecting the surrounding environment.
9. Hardness of GGGG composite laminate is highest among all composites.

REFERENCES

[1] A comparative analysis of woven jute/glass hybrid polymer composite with and without reinforcing of fly ash particles in Polymer Composites 37(3), G. Raghavendra, Shakuntala Ojha, S.K. Acharya, S.K. Pal DOI: 10.1002/pc.23222 .

[2] Influence of fiber orientation and fiber content on properties of sisal-jute-glass fiber-reinforced polyester composites Manickam Ramesh, Kayaroganam Palanikumar, K. H. Reddy DOI: 10.1002/app.42968.

[3] Improving the strength and service life of jute/epoxy laminar composites for structural applications M. Pinto, V.B. Chalivendra , Y.K. Kim, A.F. Lewis, Composite Structures 156 (2016) 333–337.

[4] Mechanical property evaluation of glass–jute fiber reinforced polymer composites; Md. Rafiquzzaman, Md. Maksudul Islam, Md. Habibur Rahman, Md. Saniat Talukdar and Md. Nahid Hasan (wileyonlinelibrary.com) DOI: 10.1002/pat.3798.

[5] Callister's Material Science and Engineering by R. Balasubramaniam.

[6] Analysis and performance of fiber composite by BD Agarwal and LJ Broutman.

[7] Glass-Jute Fiber Reinforced Epoxy Composites Velu .S , Srinivasan .R (IJSR) ISSN (Online): 2319-7064.