Mechanical Properties of Bamboo Fibre filled with Fly Ash filler Reinforced Hybrid Composites

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Abstract: **- The favoured material properties for a particular application, it is important to know how the material performance changes with different natural fiber filled with filler reinforced composites. These natural fibers offer a number of advantages over traditional synthetic fibers. The most attractive advantage is high strength –to-weight ratio. This experimental study has aims to investigate the mean tensile strength, tensile modulus, specific tensile strength, specific tensile modulus, mean flexural strength, flexural modulus and impact strength of bamboo fiber filled with Fly ash filler reinforced Hybrid composites. The specimens were prepared by Hand lay-up technique as per ASTM standards to perform Test.Tensile, flexural tests specimens are carried out by using Tensometer .**

Key Words: Bamboo fiber, fly ash particulate, polyester matrix, Tensile strength, flexural strength, Impact strength.

1.INTRODUCTION:

Composite materials are made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. One of the advantages of composite is that two or more materials could be combined to take advantage of the good characteristics of each of the materials. Favorable properties of composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, coefficient of thermal expansion, corrosion resistance, improved wear resistance etc. This has provided the main motivation for the research and development of composite materials. Composite materials will consist of two separate components, the matrix and the filler. The matrix is the component that holds the filler together to form the bulk of the material [1-2].The physical and mechanical characteristics of composites can be modified by adding a filler phase to the matrix body during the composite preparation. The incorporation of filler in composite is to improve its mechanical properties and to reduce its cost. There are several kinds of filler materials such as Fly ash, Redwood and Sand[3-4].

Fly ash is a finely divided powder generated as a solid waste during power generation. As the consumption of power is increasing day by day the solid waste is also increasing. There is a direct result of huge quantities of fly ash, about 80-90 million tonnes in India. Out of which less than half is used as a raw material for concrete manufacturing and construction; the remaining is directly dumped on landfills or simply piled up. Only a small fraction is used in the development of high value products. Due to environmental regulations, new ways of utilizing fly ash are being explored in order to safeguard the environment and provide useful ways for its utilization and disposal[5-7].

Bamboo is one of the oldest building materials used by mankind in tropical and subtropical regions. Bamboo is a kind of fast- growing and renewable resource, which is cheap and widely available. Since the 20th century, bamboo has received increasing attention for industrial applications, especially as raw material for wood-based composites[8-12].Moreover, it has the advantages of straight grain, beautiful colour, high strength and toughness, and excellent abrasion resistance. According to the mechanical properties, appropriate for composite products should be considered based on their strength to weight ratio [13-17]. As a result, bamboo has a low strength to weight ratio, it is desirable for some applications. Bamboo composites have similar properties to wood composites. Then, bamboo-based composites will become a highly competitive alternative to wood-based composites and will become an important forest based product in the future[18-19].In general, bamboo is stronger than wood in bending strength, compression strength parallel to grain and is similar in shear strength parallel to grain. The strength of bamboo in grain direction is extremely high. Due to the thick wall and long Culm, bamboo can be processed into many forms of particles, such as flour, fibers, flakes, chips, excelsior, strips, strands and veneer. Moreover, bamboo has a long straight grain which can compensate the potential shortcoming [20-21].

2. METHODS AND MATERIALS

2.1.Matrix:

The unsaturated polyester resin of the grade ECMALON 4411 was purchased from Ecmass Resins (Pvt.) Ltd., Hyderabad, India. The resin has 1358 kg/m^3 density,500 cps viscosity at 25 ^{0}C and 35% monomer content. Cobalt naphthanate as accelerator and methyl ethyl ketone peroxide (MEKP) as catalyst were used.

2.2. Extraction of Fiber: This process involves the action of bacteria and moisture on dried bamboo strips to dissolve and rot away cellular tissues and gummy substances that surround the fiber bundles in the strips. And this soaking process loosens the fibers and can be extracted out easily. Finally, the fibers were washed again with water and dried at room temperature for about 5 days.

Bamboo: Bamboo is a wide spread plant family occurring in all countries. Bamboo utilization as alternative wood materials. Used in some of the fields are Construction, Household Products, Charcoal, Pulp and Paper, etc

Fly ash: Fly ash is finely divided mineral residue resulting from combustion of coal in electric generating plants. Fly ash consist mostly of SiO_2, Al_2O_3, and Fe_2O_3 and are present in inorganic incombustible matter present in coal that has been fused during combustion to glassy amorphous structure. Fly ash used in cement industry etc.

3. COMPOSITE PREPARATION:

Hand-lay-up technique is the simplest method of composites processing. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (1.5%curing agent) and bamboo fiber placed on the mould and then polymer poured onto the mold. The polymer is uniformly spread with the help of brush. A roller is moved with a little pressure on the mold-polymer layer to remove any air trapped as well as the excess polymer present. After placing the plastic sheet, release gel is sprayed on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is applied. After curing at room temperature for 24hr mold is opened and the developed composite part is taken out.

4. TESTING OF THE COMPOSITES:

4.1. Tensile Test: The unidirectional composite specimens were made as per the ASTM D 638-89 to measure the tensile properties. The length, width and thickness of the specimens were 160, 12.5 and 3 mm, respectively.

4.2. Impact Test: Izod impact test notched specimens were prepared in accordance with ASTM D256-88 to measure impact strength. The specimens were 63.5 mm long, 12.7 mm deep and 10 mm wide.

4.3. Flexural Test: Three point bend tests were performed in accordance with ASTM D 790 M-86 to measure flexural properties. The samples were 100 mm long by 25 mm wide by 3 mm thick. In three point bend test, the outer rollers are 64 mm apart. A three point bend test is chosen because it requires less material for each test and eliminates the need to accurately determine centre-point deflections with test equipment. The flexural modulus and the maximum composite stress were calculated using the relationships. Five identical samples were prepared for each volume fraction of fiber and all the specimens were tested using an electronic tensometer.

5. RESULTS:

5.1. Tensile Properties: The tensile properties (strength, modulus and density) values of untreated bamboo fiber filled fly ash filler reinforced composites are presented in Table 1. These values are also representing as graphs in Fig. 2 and 3. From Table 1 and Fig. 2 and 3, it can be observed that both tensile (strength and modulus) properties increased up to certain value o.5 and then decreasing slowly if increasing of volume fraction of fiber.

Calculation of Tensile properties:
The tensile stress, tensile strain, tensile modulus and percentage of elongation at break values of the composites were determined by substituting load and elongation values in the below formulae.
Tensile stress σ_t =P/A(for a rectangular cross section)
Tensile strain ε_t=DL/L
Tensile modulus $E_t = \sigma_t / \varepsilon_t$
Following are the notations used in above formulae
σ_t =Tensile Stress , (MPa)
ε_t =Tensile Strain , (mm/mm)
E_t =Tensile Modulus of elasticity, (MPa)
P=Load, (N)
A=cross sectional area specimen (mm^2)
L=Length span, (mm) b=Width of test beam, (mm)
d=Depth of test beam, (mm) dl=change in length, (mm)

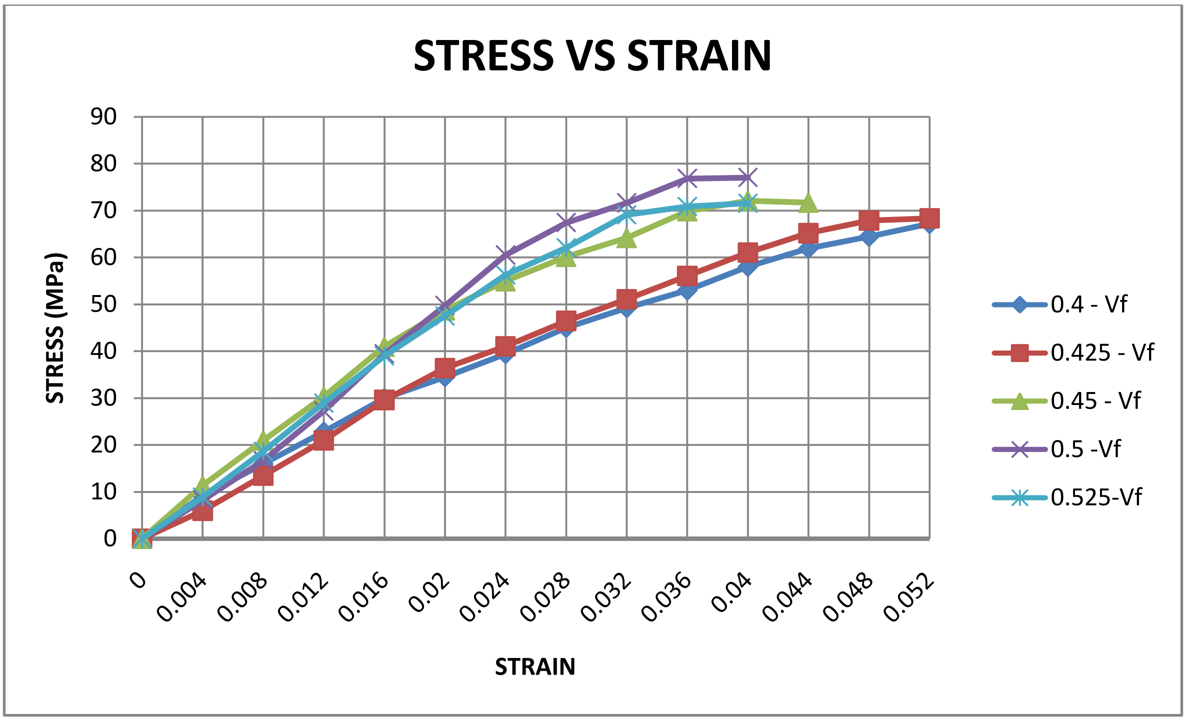

Fig No:1

Stress verses strain for various volume fraction bamboo fiber filled with fly ash reinforced composites.

S.No:	Volume fraction	Tensile strength (MPa)	Specific Tensile strength (Mpa)/(kg/m^3)	Tensile modulus (Mpa)	Specific Tensile Modulus (Mpa)/(kg/m^3)	Density (kg/m^3)
1.	Plane (0)	16.13	0.012	810	0.627	1290
2.	Flyash (0.3)	25.68	0.020	1050	0.823	1275
3.	0.4	66.32	0.051	1694.3	1.31	1286
4.	0.425	69.07	0.053	2015.6	1.57	1282
5.	0.45	73.62	0.062	2500	2.12	1175
6.	0.50	84.61	0.077	2847.5	2.62	1085
7.	0.525	77.53	0.076	2546.87	2.5	1010

Table no: 1. The tensile properties for various volume fraction of bamboo fiber filled with fly ash reinforced composite.

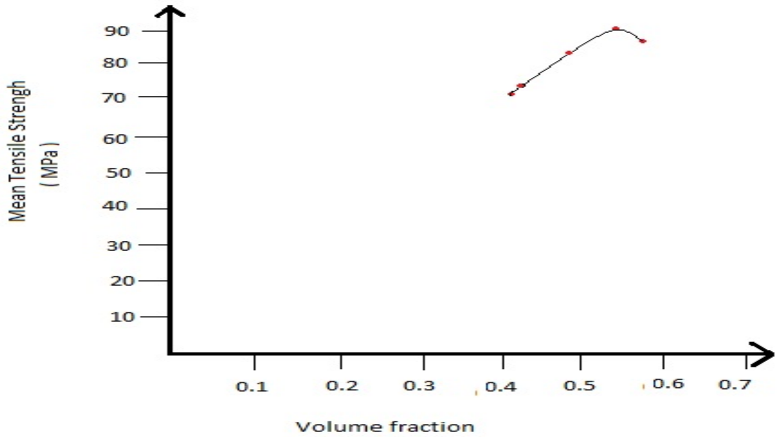

Fig. 2. Effect of volume fraction of fiber on mean tensile strength of bamboo fiber filled with fly ash reinforced hybrid composites.

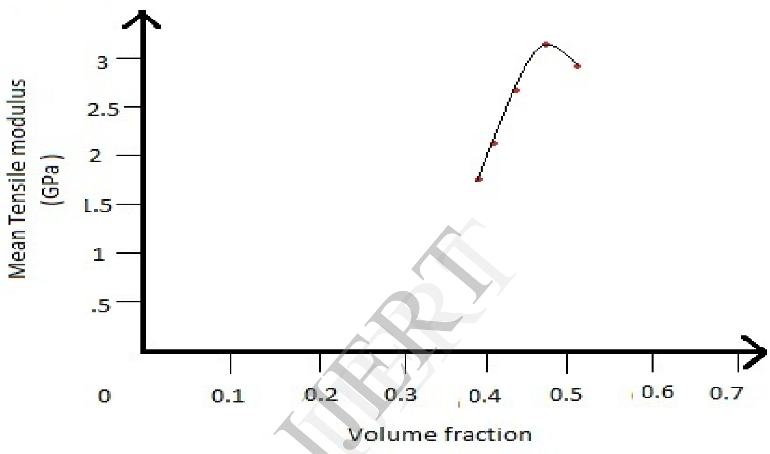

Fig. 3. Effect of volume fraction of fiber on mean tensile modulus of bamboo filled with fly ash reinforced hybrid composite.

5.2.Impact Properties: In table no:2.The variation of impact strength of bamboo fiber filled with fly ash filler reinforced composite by adding bamboo fiber corresponding removing of fly ash up to certain value increased and then decreased slowly respectively is shown in figure4.

Calculation of Impact Strength:
Impact Strength I =EI/T
EI=Reading,(J)
T= Thickness of specimen, (mm)

S .No	Code	Compositions	Impact Strength KJ/m
1	V1	P + B (40%) + F (60%)	1
2	V2	P + B (45%) + F (55%)	1.87
3	V3	P + B (50%) + F (50%)	1.212
4	V4	P + B (55%) + F (45%)	1.702
5	V5	P + B (60%) + F (40%)	1.38

Table no:2 Impact strength for various composition bamboo fiber filled with fly ash reinforced composites.

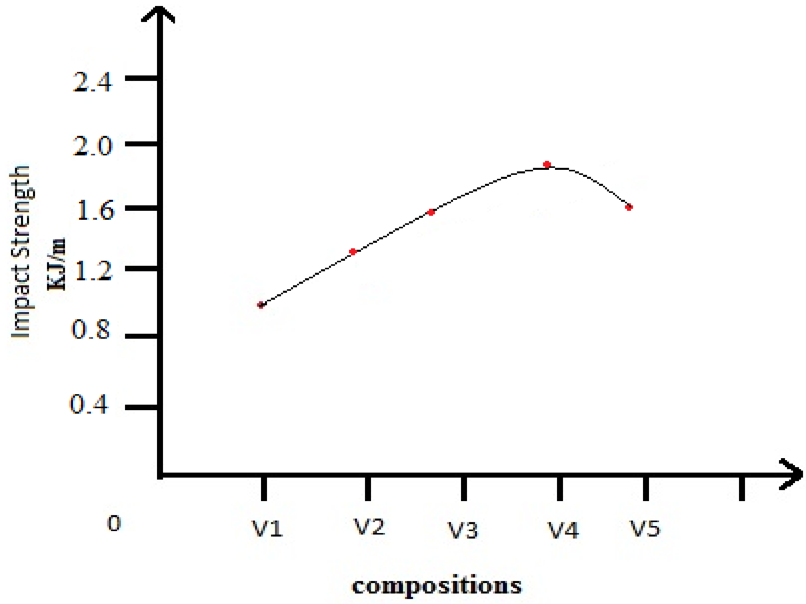

Fig no:4. Effect Impact strength for different compositions.

5.3. Flexural Properties: The flexural properties (strength, modulus and density) values of untreated bamboo fiber filled fly ash filler reinforced composites are presented in Table 3. These values are also representing as graphs in Fig. 5 and 6. From Table 3 and Fig. 5 and 6, it can be observed that both flexural (strength and modulus) properties increased up to certain value 0.5 vf and then decreasing slowly if increasing corresponding volume fraction of fiber.

Calculation of flexural properties:

The flexural stress, flexural strain, flexural modulus and percentage of elongation at break values of the composites were determined by substituting load and elongation values in the below formulae.

Flexural stress σ_f =$3PL/2bd^2$ (for a rectangular cross section)

Flexural modulus E_f=$L^3m/4bd^3$

Following are the notations used in above formulae
σ_f = Stress in outer fibers at midpoint,(MPa)
E_f =Flexural Modulus of elasticity, (MPa)
P=Load, (N)
L=Support span, (mm)
b=Width of test beam, (mm)
d=Depth of test beam, (mm)
D=Maximum deflection of the center of beam, (mm)
m= The gradient (i.e., slope) of the initial straight-line portion of the load deflection curve,(P/D), (N/mm)

S. No	Volume Fraction (Vf)	Flexural Strength (Mpa)	Specific Flexural Strength (Mpa)/(kg/m^3)	Flexural Modulus (Gpa)	Specific Flexural Modulus (Mpa)/(kg/m^3)	Density (kg/m^3)
1.	Plane (0)	64.5	0.05	5.3	4.124	1285
2.	Flyash (0.3)	113.35	0.08	8.1	6.347	1276
3.	0.4	167.74	0.132	13.44	10.66	1260
4.	0.45	177.2	0.151	15.17	13.01	1166
5.	0.475	191.7	0.179	17.71	16.7	1060
6.	0.5	230.02	0.242	19.85	20.89	950
7.	0.525	215.01	0.216	18.71	18.86	992

Table no:3. The flexural properties various volume fraction of bamboo fiber filled with fly ash reinforced composites

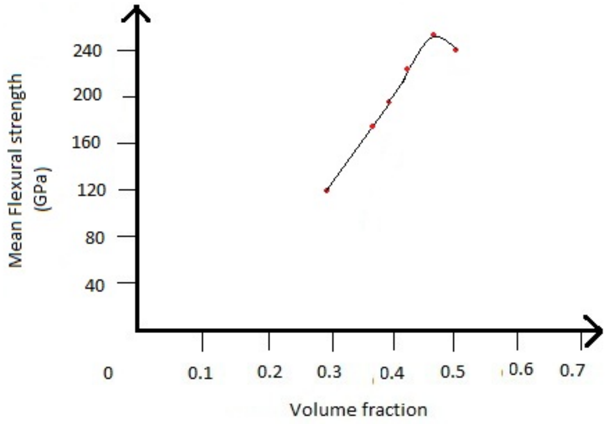

Fig:5. Effect of volume fraction of fiber on mean flexural strength of bamboo fiber filled with flyash reinforced hybrid composites..

S.NO	NAME OF THE COMPOSITE	VOLUME FRACTON OF FIBER	FLEXURAL STRENGTH MPa	FLEXURAL MODULUS GPa
1	JOWAR	0.4	134	7.87
2	SISAL	0.4	99.5	2.49
3	BAMBOO	0.4	128.5	3.7

TABLE 4:COMPARISION OF FLEXURAL STRENGTH AND FLEXURAL MODULUS OF DIFFERENT NATURAL FIBERS ARE

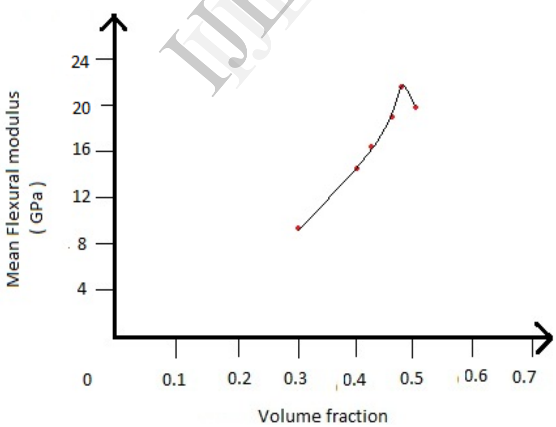

Fig: 6.Effect of volume fraction of fiber on mean Flexural modulus of bamboo fiber filled flyash reinforced hybrid Composites.

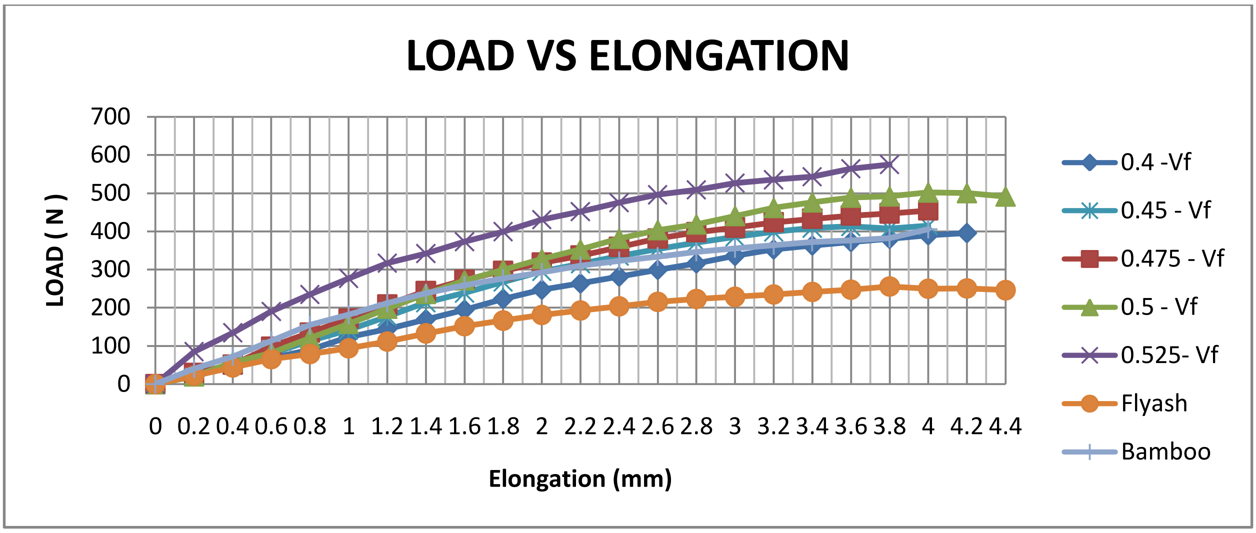

Fig. 7. Load against Elongation curve for various volume fraction bamboo fibre filled flyash reinforced composites

6. CONCLUSION:

The incorporation of filler in composite is to improve its mechanical properties and to reduce its cost. The lower density of bamboo fiber filled with Fly ash filler reinforced Hybrid composites is also an interesting parameter in designing light weight materials compared to other fibers like sisal ,hemp etc considered in the present study. The mean tensile strength of bamboo fiber filled with Fly ash filler reinforced Hybrid composites composite is increased as the increasing of volume fraction of fiber for certain value up to 0.5 and then decreased slowly. The maximum mean tensile strength of bamboo fiber filled with Fly ash filler reinforced Hybrid composite is occur at 84.61 MPa It is also concluded that the mean tensile modulus of bamboo fiber filled with Fly ash filler reinforced Hybrid composites increased as increasing of volume fraction of fiber for certain value up to .5 and then decreased slowly. In maximum mean tensile modulus of bamboo fiber filled with Fly ash filler reinforced Hybrid composites is occur at 2847.5MPa.As the volume fraction of fiber increases in the composite the specific tensile strength and specific tensile modulus of the bamboo fiber composite increased up to certain value and then decreased slowly. Maximum Impact strength of is occur at 17.02 KJ/m. The mean flexural strength of bamboo fiber filled with Fly ash filler reinforced Hybrid composites is maximum at volume fraction of 0.5 as 233.02 MPa. In maximum mean flexural modulus of bamboo fiber composite is occur at 19.85GPa. As the volume fraction of fiber increases in the composite the specific flexural strength and specific flexural modulus of the bamboo fiber composite increased up to certain value and then decreasedslowly.

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