EXPERIMENTAL EVALUATION OF IMPACT STRENGTH OF CHEMICALLY EXTRACTED ELEPHANT GRASS -FIBRE POLYESTER COMPOSITES

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Abstract*—Natural fibres have played a significant role in human civilization since pre historic times with human having depended on them for garments and simple domestic uses as well as complex uses such as land dwelling, military, marine engineering etc. The conventional applications of natural fibres in relation to the technology of synthetic fibre composites for industrial applications. The natural fibre reinforced composites have the advance of being light weight, renewable, bio-degradable, cheap and eco-friendly compared to the synthetic fibres like grass, graphite etc. So there is every need to investigate potentially of natural fibres and its composites, which can be used in highly demanding situations. However, very small contribution of research work exists in the design and fabrication of composite materials using natural fibres. An attempt has been made to explore the possible use of variety of cultivated and wild grown fibres in nature in the development of new composites for load carrying structures. The objective of the present work is Elephant grass fibre is identified as potential reinforcement for making composites. It is one of the important raw materials obtained from the Elephant grass. Unsaturated polyester resin is selected as a matrix material due to its availability, low cost and easy to mould at room temperature. The fibre is extracted by using NAOH treatment. The standard test method ASTM D 256M for impact testing has been used for preparation and testing the impact properties of unidirectional composite specimens. The impact strength of the composites increases with increase in fibre loading and is 296.9 at 0.32 volume fraction of fibre. Impact strength of the composite is 238.5 J/mt for the mass of fibre of 1.75 grams at V.F=0.27995, 200.4 J/mt for mass of fibre of 1.5 grams at V.F=0.21476, 164.0 J/mt for mass of fibre of 1.0 grams at V.F=0.17312, 110.48 J/mt for mass of fibre of 0.5 grams at V.F=0.11214.The value of impact strength of composite with out fibre is 31.62 J/mt.

***Keywords*— Elephant grass, NAOH treatment, ASTM D 256M.**

I. INTRODUCTION

The word "composite" means two or more distinct parts physically bounded together". Thus, a material having two more distinct constituent materials or phases may be considered as a 'composite material'. Fibre-reinforced composite materials consist of fibre of high strength and modulus embedded in or bonded to a matrix with distinct interfaces (boundary) between them. In this form, both fibre and matrix retain their physical and chemical identities, yet they produce a combination of properties that cannot be achieved with either of the constituents acting alone. In general, fibre are the principal load-carrying members, while the surrounding matrix keeps them in the desired location and orientation, acts as a load transfer medium between them, and protects them from environmental damages due to elevated temperatures and humidity etc.

The properties that can be improved by forming a composite material include strength, stiffness, corrosion resistance, wear resistance, attractiveness, weight, fatigue life, temperature-dependent behaviour, thermal insulation, thermal conductivity, acoustical insulation and electrical insulation. Naturally, neither all of the properties are improved at the same time nor is there usually any requirement to do so.

Composite materials have a long history of usage. Their beginnings are unknown, but all recorded history contains references to some form of composite material. For example, straw was used by the Israelites to strengthen mud bricks. Plywood was used by the ancient Egyptians when they realized that wood could be rearranged to achieve superior strength and resistance to thermal expansion as well as to swelling owing to the presence of moisture. More recently, fibre reinforced resin composites that have high strength-to-weight and stiffness-to- weight ratios have become important in weight-sensitive applications such as aircraft and space vehicles.

1.1. Elephant Grass:

Elephant grass is a tall grass that originally came from Africa in 1913. It grows in dense clumps of up to 10 feet tall. In the savannas of Africa it grows along lake beds and rivers where the soil is rich. Local farmers cut the grass for their animals, carrying it home in huge piles on their backs or on carts.

Fig.1: Elephant grass

Yellowish or purple in colour, the stems are coarse and hairy, and about 1 inch thick near the base. The leaves are 2 to 3 feet long, pointed at the ends, and about 1 inch wide. The edges of the leaves are razor-sharp. This makes stands of elephant grass nearly impenetrable. Many bird species make their home in the stands.

The dense seed heads of elephant grass are about 9 inch tufted plumes, usually a tawny or purple color. Elephant grass does reproduce sexually, but the seeds are very small and don't germinate well. The grass reproduces mainly through its rhizomes (root-like underground stems that produce roots below and sends up shoots to the surface).

Elephant grass can be very invasive and clogs the natural waterways of Florida which have to be cleared periodically. It likes tropical weather and can be killed by a light frost. The underground parts will stay alive if the soil doesn't freeze.

The present work describes the procedure for extraction of Elephant grass fibre and its incorporation in a polyester resin matrix for preparing composite specimens at various volume fractions. Finally, the testing was described and the resulting composite property of impact strength was reported.

II. PROCEDURE

Extraction of Fibre:

The extraction of fibres was done by two methods namely:

(a) Retting and manual extraction, and
(b) Chemical and manual extraction

i. Retting and manual extraction method:

In this method, the culms of elephant grass were cut at their base and the leaves at the nodes and end of the culms were trimmed. After trimming, the culms were dried in shade for a period of one week. The node portions were removed by cutting, and the culms were separated into pieces of 120mm length. The short culms separated are composed of exodermis (bark), vascular bundle sheaths, soft tissue cells and endodermis (inner surface layers). The hollow cylindrical portion of culms was taken for extracting fibre and made into four strips peeling them in longitudinal direction. These strips were soaked in water for a period of about 10 days. After this process the strips were subjected to a mechanical process, by beating them gently with a plastic mallet in order to loosen and separate the fibre. The resulting fibre bundle was scrapped with sharp knife and combed until individual fibres were obtained. This fibre is denoted by Elephant grass (M).

ii. Chemical and manual extraction method:

In this method, the strips of elephant grass were soaked in 0.1-N NaOH solution (4 grams of NaOH crystals per one litre of water) for different periods. After a series of experiments, a period of 72 hours was taken as optimum period for chemical treatment. After this, the strips were washed in water and were subjected to the above mechanical process for separation of the fibres. This fibre is denoted by Elephant grass (C).

III. FABRICATION OF COMPOSITE SPECIMEN

The standard test method for bending properties of fibre-resin composites, ASTM-D790M-86 is used to prepare specimens as per the dimensions. The mould is prepared on smooth ceramic tile with rubber shoe sole to the required dimension. Initially the ceramic tile is cleaned with shellac (NC thinner) a spirituous product to ensure clean surface on the tile. Then mould is prepared keeping the rubber sole on the tile. The gap between the rubber and the tile is filled with mansion hygienic wax. A thin coating of PVA (polyvinyl alcohol) is applied on the contact surface of specimen, using a brush. The resulting mould is cured for 24 hours.

Hand layup method is adopted to fill the prepared mould with general-purpose polyester resin. ECMALON 4411 is an unsaturated polyester resin of ortho-phthalic acid grade with clear colorless or pale yellow colour. Its viscosity is 500-600 CPS (Brookfield Viscometer) and specific gravity is 1.13 grams/cc at 250C. Acid Number (mg KOH/g) is 22 and monomer content is 35%. Cobalt accelerator and MEKP catalyst are added for curing the resin at room conditions. The quantity of each of these materials, added is 1.5% of the volume of resin. The gel time is found to be about 20 min. The accelerator is mixed thoroughly with the resin and the catalyst is added later to avoid explosion. A thin coating of the resin is applied to the mould surface and known weight of the fibre is placed along the longitudinal direction of the specimen so that the fibres are oriented 00 along the axial direction of the specimen. Then the rest of the mould is filled with the resin making sure that there are no air gaps in the mould. Then, a thin Polyethylene paper of 0.2 mm thick is placed on the rubber mould. A flat mild steel plate is placed on the mould and a pressure of 0.05 MN/m² is applied and left for 24 hours to cure. Later the specimen is removed and filed to obtain the final dimensions. The specimen is cleaned with NC thinner and wiped off to remove dirt particles. The ends of both flat sides of the specimen are roughened enough using a sandpaper, so as to bond the end tabs.

Five such identical specimens are prepared for each fibre content in the specimen. Five different fibre contents (0.5, 1.0, 1.5, 1.75, 2.0 grams) are incorporated in the specimen.

Five plain polyester are also prepared in order to compare the results of natural fibre reinforced composites. The percentage volume of fibre present in the specimen is determined for each set.

IV. TESTING OF COMPOSITES

4.1. Equipment for Testing

An analog Izod/charpy impact tester, was used to test the impact properties of fibre reinforced composite specimens. The equipment has four working ranges of impact strength and is 0-2.71 J, 0-5.42 J, 0-10.84 J and 0-21.68 J, with a minimum resolution on each scale of 0.02 J, 0.05 J, 0.1 J and 0.2 J, respectively. Four scales and the corresponding four hammers (R1, R2, R3 and R4) are provided for all the above working ranges.

4.2. Method of Testing

Standard test method, ASTM D256-97, for impact properties of fibre reinforced composites has been used to test the unidirectional composite specimens. The specimens are prepared to dimensions of 63.5 x 12.7 x 10 mm width. A V-notch is provided with a sharp file having an included angle of 450 at the centre of the specimen, and at 900 to the sample axis. The depth of the specimen under the notch is 10.16 ± 0.05 mm.

The impact testing equipment complies with ASTM standards. Depending on the volume fraction of the specimen, one of the four hammers has to be selected to break the sample. The hammer is fixed to the pendulum in such a way that it will make initial contact with the specimen on a line 22mm above the top surface of the clamping vise. The sample is fixed to the vise as a vertical cantilever beam in such a way that the notch faces the striking edge of the hammer and aligned with the surface of the vise (Fig. 7.1b). The pendulum hammer is released from its locking position which is at an angle of 1500 with respect to the axis of the specimen with a striking velocity of 2.46 m/s. The sample is stripped and the energy is indicated in joules by the pointer on the respective scale. The impact energy is calculated as per the ASTM standards.

The Impact strength is given by

I = EI/T Joules/m

Where

EI = Impact Energy in joules

T = Thickness of the sample used

V. RESULTS AND DISCUSSION

Table-1: Width, Mass and Volume of Composites for various fibre weights.

Mass of Fibre M_F (gms)	Specimen Number	Width of Composite b (mm)	Mass of Composite M_C (gms)	Volume of Composite V_C (ml)
0.0	1	10.23	9.75	8
	2	10.35	9.45	8
	3	10.55	7.25	6
	4	10.15	9.95	8
	5	10.6	9.45	8
0.5	1	8.09	7.35	6
	2	10.41	8.2	8
	3	10.86	8.25	8
	4	8.27	7.05	6
	5	8.48	7.00	6
1	1	7.71	7.45	6
	2	8.19	7.4	6
	3	8.30	6.8	6
	4	8.25	6.7	6
	5	8.15	7.05	6
	1	10.16	8.6	8
	2	10.15	8.4	8
	3	8.28	7.55	6
	4	8.22	7.35	6
	5	10.8	8.85	8
1.5	1	10.85	8.55	8
	2	10.58	8.5	8
	3	10.45	8.75	8
	4	10.88	8.65	8
	5	11.33	8.85	8
2	1	10.55	8.8	8
	2	10.37	7.75	6
	3	10.75	8.35	8
	4	11.49	8.8	8
	5	10.23	9.8	10

Table-2: Density of composites, Mass of resin, V.F of resin and V.F of fibre for various fibre weights

M_F (gms)	Specimen Number	ρ_C	M_R=M_C-M_F	V_R	$V_{F=}1-V_R$
0.0	1	1.225	6.85	0.946	0.053
	2	1.025	7.7	0.797	0.202
	3	1.031	7.75	0.802	0.197
	4	1.175	6.55	0.904	0.095
	5	1.166	6.5	0.897	0.102
1.0	1	1.241	6.45	0.890	0.109
	2	1.233	6.4	0.883	0.116
	3	1.133	5.8	0.800	0.199
	4	1.116	5.7	0.786	0.213
	5	1.175	6.05	0.835	0.164
	1	1.075	7.10	0.735	0.264

1.5	2	1.05	6.9	0.714	0.285
	3	1.258	6.05	0.835	0.164
	4	1.225	5.85	0.808	0.191
	5	1.106	7.35	0.761	0.238
	1	1.068	6.8	0.704	0.295
	2	1.062	6.75	0.699	0.300
	3	1.093	7.0	0.725	0.274
	4	1.081	6.9	0.714	0.285
	5	1.106	7.1	0.735	0.264
1.75	1	1.1	6.8	0.704	0.295
	2	1.291	5.75	0.794	0.205
	3	1.043	6.35	0.657	0.342
	4	1.1	6.8	0.704	0.295
	5	0.98	7.8	0.646	0.353
2	1	1.225	6.85	0.946	0.053
	2	1.025	7.7	0.797	0.202
	3	1.031	7.75	0.802	0.197
	4	1.175	6.55	0.904	0.095
	5	1.166	6.5	0.897	0.102

Table-3: Impact properties of Elephant grass fibre composites for various fibre weights.

M_F (gms)	Specimen Number	Impact Energy (Joules)	Impact Energy (Joules/mt)
0.0	1	0.64	62.56
	2	0.16	15.45
	3	0.3	28.43
	4	0.1	9.8
	5	0.2	18.86
0.5	1	1.24	153.27
	2	1.24	119.11
	3	0.8	77.66
	4	0.76	91.89
	5	0.86	101.41
1.0	1	1.35	175.09
	2	1.25	152.62
	3	1.35	162.65
	4	2.35	284.84
	5	1.35	165.64
1.5	1	2.5	202.83
	2	2.45	241.37
	3	1.65	199.27
	4	1.65	200.72
	5	2.15	199.07
	1	2.65	244.23
	2	2.6	245.74
	3	2.1	200.95
	4	2.6	238.97
	5	2.55	225.06
1.75	1	3.1	293.83
	2	3.45	332.69
	3	3.3	306.97
	4	3.15	274.15
	5	3.2	312.80
2	1	0.64	62.56
	2	0.16	15.45
	3	0.3	28.43
	4	0.1	9.8
	5	0.2	18.86

Table-4: Impact properties of fibre composites and Volume fraction fibre for various fibre weights

M_F (gms)	Specimen Number	Impact Energy (Joules/mt)
0.5	1	153.27
	2	119.11
	3	77.66
	4	91.89
	5	101.41
1.0	1	175.09
	2	152.62
	3	162.65
	4	284.84
	5	165.64
1.5	1	202.83
	2	241.37
	3	199.27
	4	200.72
	5	199.07
	1	244.23
	2	245.74
	3	200.95
	4	238.97
	5	225.06
1.75	1	293.83
	2	332.69
	3	306.97
	4	274.15
	5	312.80
2	1	153.27
	2	119.11
	3	77.66
	4	91.89
	5	101.41

Table-5: Average Impact Energy and Volume fraction of fibre for various fibre weights

S. No	Mass of Fibre M_F (gms)	Average Impact Energy (Joules/mt)	Average Volume Fraction of Fibre V_F
1	0.5	110.48	0.11214
2	1.0	164.00	0.17312
3	1.5	200.4	0.21476
4	1.75	238.5	0.27995
5	2.0	296.9	0.32165

Table-6: Average Density of composite and Volume fraction of fibre for various fibre weights

S. No	Mass of Fibre M_F (gms)	Average Density of composite	Average Volume Fraction of Fibre V_F
1	0.5	1.14931	0.11214
2	1.0	1.13432	0.17312
3	1.5	1.11406	0.21476
4	1.75	1.07656	0.27995
5	2.0	1.05598	0.32165

VI. CHARTS

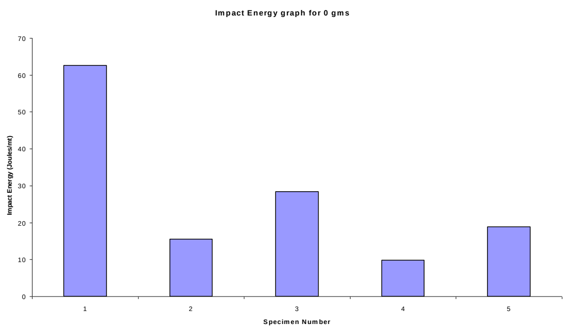

Chart-1: Variation of Impact energy of five different specimens without fibre

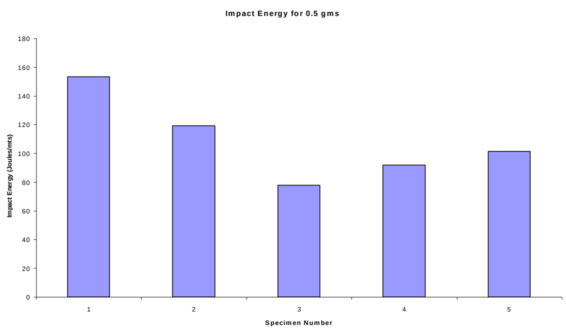

Chart-2: Variation of Impact energy of five different specimens with fibre. (MF=0.5gms)

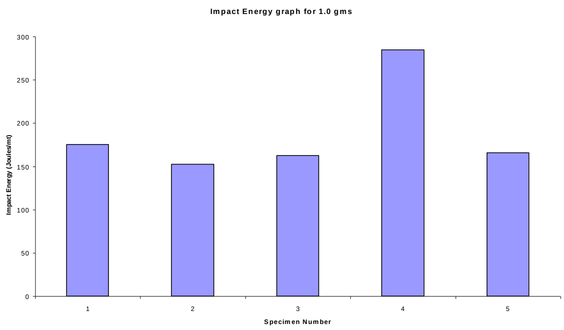

Chart-3: Variation of Impact energy of five different specimens with fibre. (MF=1.0gms)

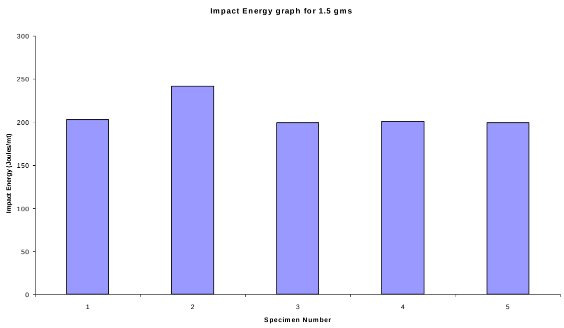

Chart-4: Variation of Impact energy of five different specimens with fibre. (MF=1.5gms)

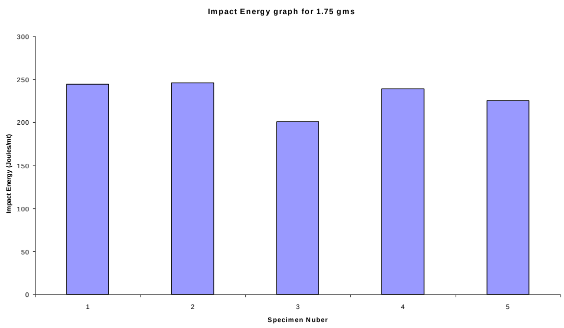

Chart-5: Variation of Impact energy of five different specimens with fibre. (MF=1.5gms)

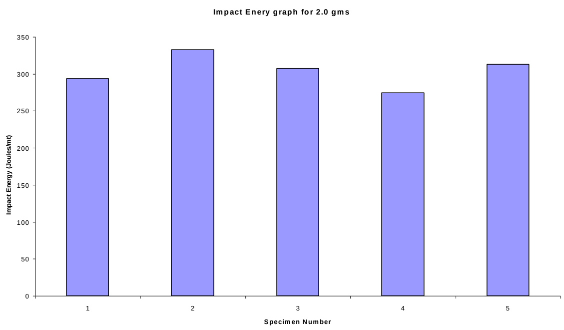

Chart-6: Variation of Impact energy of five different specimens with fibre.(MF=1.75gms)

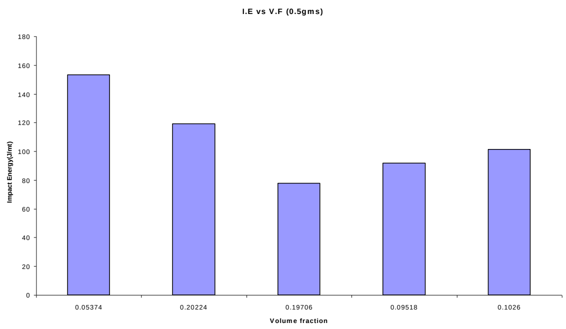

Chart-7: Effect of Volume fraction of Elephant grass fibre on impact strength of the composite for 0.5 gms

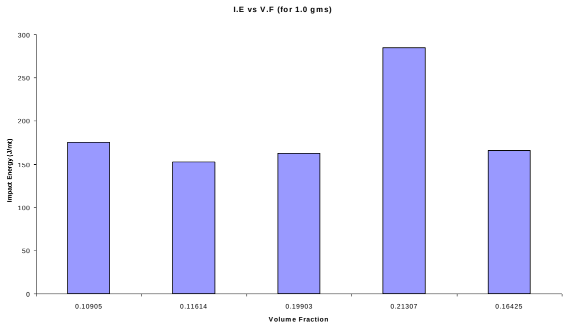

Chart-8: Effect of Volume fraction of Elephant grass fibre on impact strength of the composite for 1.0 gms

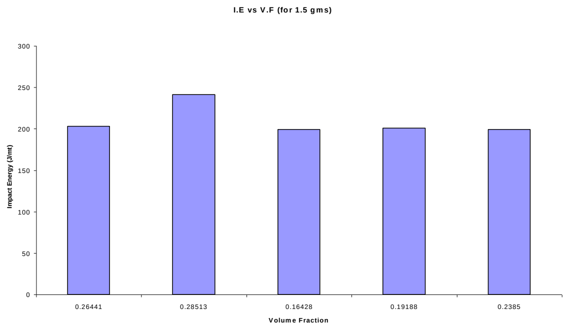

Chart-9: Effect of Volume fraction of Elephant grass fibre on impact strength of the composite for 1.5 gms

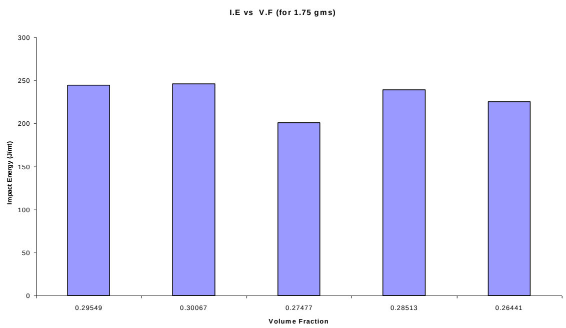

Chart-10: Effect of Volume fraction of Elephant grass fibre on impact strength of the composite for 1.75 gms

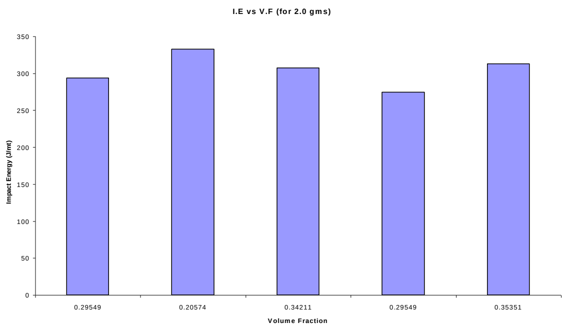

Chart-11: Effect of Volume fraction of Elephant grass fibre on impact strength of the composite for 2.0 gms

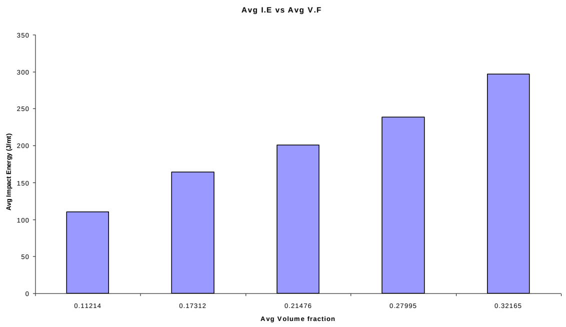

Chart-12: Effect of Volume fraction of Elephant grass fibre on impact strength of the composite for all fibre weights

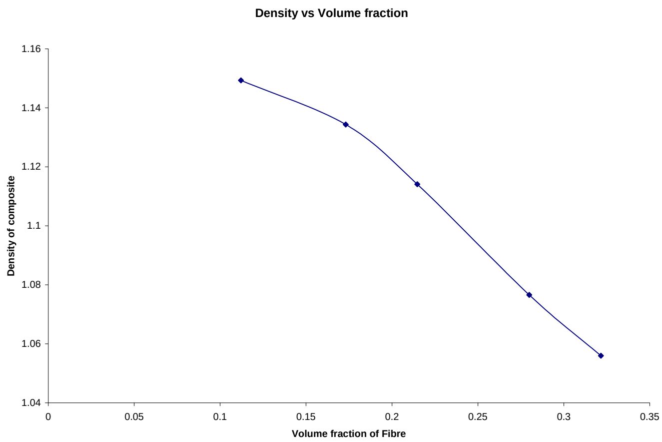

Chart-13: Effect of Density of composite on Volume fraction of fibre for all fibre weights

VII. CONCLUSIONS

The main objective of this investigation is to gauge the possibility of utilizing the Elephant grass fibre which is abundantly available as an alternative filler material in a polyester matrix. The following conclusions are made basing on the above analysis.

The incorporation of Elephant grass fibre into the polyester matrix has resulted the moderate improvement in the impact properties of the composites. The poor performance has been attributed to the poor filler-matrix interaction or compatibility.

Due to the low density of Elephant grass fibre compared to the established fibres like sisal, jute, coir and bamboo, the composite can be regarded as a useful light weight engineering material. And also the manufacturing cost of the composite can be reduced considerably by adding elephant grass fibres as fillers to the matrix. Future work will investigate the methods for increasing the fibre content in the composite to improve the mechanical properties further.

VIII. SCOPE FOR FUTURE WORK

The future work will investigate the performance of other lower cost resin systems, particularly phenolic resins. The cost of chemically removing the silica-rich layer at the surface of the epidermis or plasticizing the fibre may outweigh any improvements in the mechanical performance, however corn fibre reinforced composite properties can be significantly improved by the selection and alignment of long fibres and it is by careful handling and processing of fibres during composite manufacture that optimum properties will be achieved.

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