ANALYSIS OF HAIR REINFORCED COMPOSITE FIBRE

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Abstract: Composite Materials are ideal for structural applications where high strength to weight ratio is required. Aircraft and Spacecraft are typical weight sensitive structures in which composite materials are cost effective.The study of composite materials involves many topics for example Manufacturing processes, Anisotropic, Elasticity, Strength of Materials and Micromechanics.The present work has been undertaken, with an objective to explore the potential of the Human Hair fiber polymer composites and to study the mechanical properties of composites. The present work reports the use of Human Hair fiber, as reinforcements in polymer matrix. This review focused at providing knowledge to enhance further research in this area. The influence of the source of Human Hair fiber on the mechanical properties of composites is reported. Several natural fiber composites achieve the mechanical properties of composites and they are already applied, e.g., in furniture industries etc. At present, the most important and cheap natural fibers are Jute, flax, bagasse and coir & hairs. The future of Human Hair fiber composites appears to be bright. Therefore, manufacturing of composite material by mixing Human Hair fiber in 5%,10% and 15% of total specimen volumes in epoxy araldite and its strength testing on UTM is planned in this project.

Keywords- Tensile Strength, Tensile Modulus, Hair Fibre, Composite Material..

I. INTRODUCTION

The word composite in the term composite material signifies that two or more materials are combined on a macroscopic scale to form a useful third material. The key is the macroscopic examination of a material wherein the components can be identified by the naked eye. Different materials can be combined on a microscopic scale, such as in alloying of metals, but the resulting material is, for all practical purposes, macroscopically homogeneous, i.e., the components cannot be distinguished by the naked eye and essentially act together.

In composite material two or more distinct materials are combined together but remain uniquely identifiable in the mixture. The most common example is, perhaps, fibre glass/carbon fiber /coir fiber /sisal fiber/ground nut shell/ hairs; one or two of this mixed with a polymeric resin. Newly investigated use in composites is human hair fiber that to investigate in this project experimentally. If we cut the fibres and after suitable preparation of the surface, when we look at the material, the fibres and polymer resin would be easy to distinguish. This is not the same as making an alloy by mixing two distinct materials together where the individual components become indistinguishable. There are many composite materials and while we may be aware of some, there are many others ranging from the mundane, reinforced concrete a mixture of steel rod and concrete (itself a composite of rock particles and cement), pneumatic tyres (steel wires in vulcanized rubber), many cheap plastic moldings (polyurethane resin filled with ceramic particles such as chalk and talc) to the exotic metal matrix composites used in the space program (metallic titanium alloys reinforced with SiC ceramic fibres), and in automobile, such as engine pistons (aluminium alloys filled with fibrous alumina) and brake discs (aluminium alloys loaded with wear resistant SiC particles). Regardless of the actual composite, the two [or more] constituent materials that make up the composite are always readily distinguished when the material is sectioned or broken.

Some of the properties that can be improved by forming a composite material are-

1. Strength	2. Fatigue Life
3. Stiffness	4. Temperature-Dependent Behaviour
5. Corrosion Resistance.	6. Electric Insulation
7. Attractiveness	8. Acoustical Insulation

Naturally, not all of these properties are improved at the same time nor is there usually any requirement to do so. In fact, some of the properties are in conflict with one another, e.g., thermal insulation versus thermal conductivity. The objective is merely to create a material that has only the characteristics needed to perform the design task.

Composite materials have a long history of usage. Their precise 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 arid resistance to thermal expansion as well as to swelling caused by the absorption of moisture. More recently, fibre-reinforced, resin-matrix composite materials that have high strength-to-weight and stiffness-to-weight ratios have become important in weight-sensitive applications such as aircraft and space vehicles.

II. LITERATURE REVIEW

Composite materials are ideal for structural application where high strength to weight and stiffness to weight ratios are required. Aircraft and spacecraft are typical weight sensitive structures in which composite materials are cost effective. The composite material can be designed again according to desired properties for getting the required properties of composite material analysis of these properties is essential. Many researchers have devoted their research on analysis of composite material many organizations are also continuously working on composite material, some of them have discussed here. An advanced book on **mechanics of composite material by R. Jones** covers applications of composite materials and micromechanical and macro-mechanical behavior of lamina and laminates as well as the design of the composite structure. They have derived theoretical methods for the analysis of composite materials. An advanced **book on mechanics of composite material by Autar K. Kaw** covers applications of composite materials and micromechanical and macro-mechanical behavior of lamina and laminates as well as the design of the composite structure.

III. Material Selection

Human hair fibers obtained from local agencies were used for the present experimental study. Araldite solution of CY-230 with the hardener of HY-951 is used as epoxy (matrix) material which is available in liquid form.

IV. METHODOLOGY

This process is divided into four steps:

1. Material
2. Preparation of mould

Transparent acrylic sheet is used for mould preparation. Acrylic sheet of 3mm thickness is selected. The plates are cut from the sheet according to mould size. Plates are cut by some tolerance is kept for finishing. All sides of plates are finished and made perpendicular. All sheets are joined by the fevi-quick and box is made with one open side. After tightening of the plates, the mould is well cleaned.

3. Epoxy solution preparation

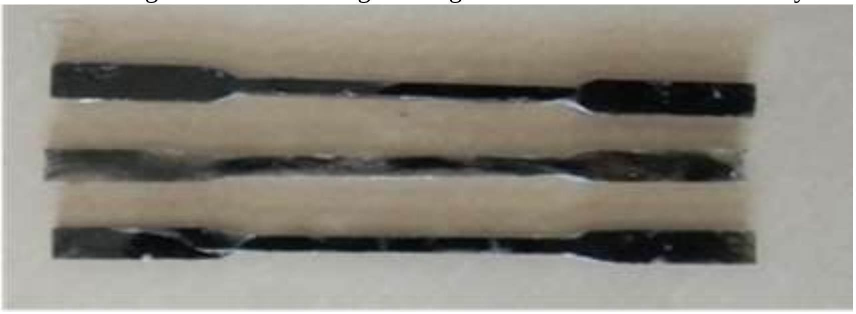
Araldite solution of CY-230 with the hardener of HY-951 is separately heated in the oven for about 2 hours at a rate of 70 to 100 degree to remove moisture and air bubble. The heated solution is cooled slowly at room temperature. The hardener HY-951 is added slowly to CY-230 & HY-951 mixture by weight is 100: 10.33. During mixing, mixture is stirred continuously in one direction for proper & thorough mixing. The mixture is stirred for about 20min. now it is ready for pouring into mould. The reaction between araldite & hardener is exothermic. Simultaneously acrylic mould is chemically cleaned. Then this mixture is poured in to mould very cautiously to avoid formation of air bubbles. The mould is completely filled by the mixture. At this position, the mould is kept for curing at room temperature for 24 hours. After that solution of hardener and resin becomes solid that solid formed can be easily removed from the mould.

4. Preparation of composite and test specimen

Hair fibres cut into specified length and is uniformly spread in the mould. The epoxy resin along with the hardner HY-951 in required quantities are mixed thoroughly as per the procedure and poured into the mould to fill it. Sufficient care is taken to have uniform distribution and full impregnation of fibre in the resin. The composite sample sheets are fabricated with different fibre weight ratios.

5. Tensile testing of specimen

human hair epoxy composite is carried out from mould after two days. It is kept on plane surface for four days so that it becomes hard that hard specimen is ready for testing. Finished specimen of composite is taken and its length and cross-sectional area is measured. The marking of centre line along the length is done. From centre line fifty mm marking on both sides is done.



Nominal the better

This case considered when specified value of response is most desirable, means no smaller or larger value is desired. Hence response is needed to be kept as close as target value. So nominal is the better response. S/N ratio can be given as,

$$n = 10 \log_{10} [\text{Square of means / Variance}] \quad [1]$$

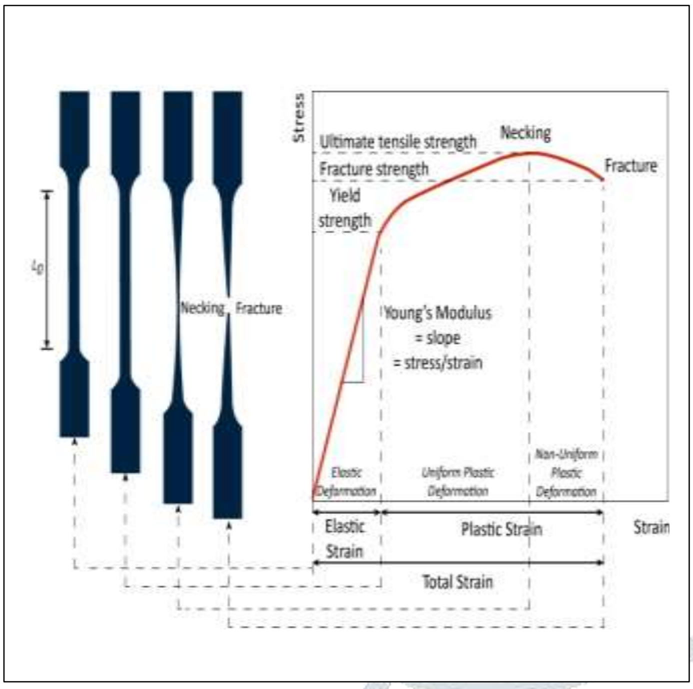
Table 1 Orthogonal array with detailed values

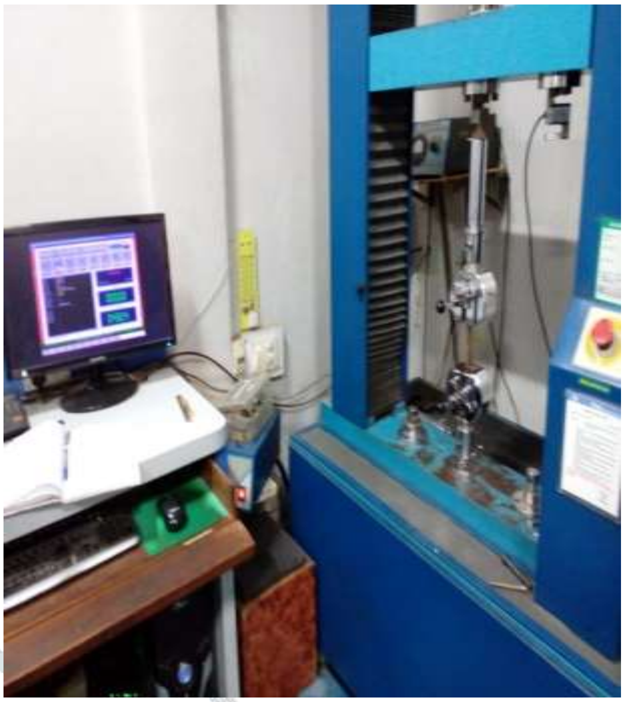
Expt No	Parameters		
	Corrugation Angle	**Types Of Wire Mesh**	**No Of Layers**
1	45	Round	1
2	45	Diamond	2
3	45	Rectangle	3
4	50	Round	2
5	50	Diamond	3
6	50	Rectangle	1
7	55	Round	3
8	55	Diamond	1

V. EXPERIMENTATION & MATHEMATICAL ANALYSIS

ASTM D638 tensile testing is used to measure the force required to break a polymer composite specimen and the extent to which the specimen stretches or elongates to that breaking point. Tensile tests produce a stress strain diagram, which is used to determine tensile modulus. The data is often used to specify a material, to design parts to withstand application force and as a quality control check of materials. Since the physical properties of many materials can vary depending on ambient temperature, it is sometimes appropriate to tests materials at temperatures that simulate the intended end use environment.

The specimen was loaded in servo assisted hydraulic universal testing machine having gauge length of 120mm. The grips were tightened evenly and firmly to prevent any slippage. The speed of testing was set at a proper rate of 1mm/min and the machine was started. As the specimen elongates, the resistance of specimen increases, and it was detected by a load cell. The vice was fitted firmly and zero reading was observed. Then step by step loading was carried out until the specimen failed at maximum load. A plotter plots load vs deflection curve results on the graph of the sheet.





Theoretical Model:

The mechanical properties of fiber reinforced composites can be derived from a variety of mathematical models or experimentally determined. The advantage of a comprehensive mathematical model is, it reduces costly and time-consuming experiments. A mathematical model may be used to find the best combination of constituent materials to satisfy material design considerations. These models can yield information in the fundamental mechanisms of reinforcement.

Micromechanical composite models are derived based on the properties of the individual components of the composite and their arrangement. Properties such as the elastic modulus of fiber and matrix, tensile strength of fiber and matrix and relative volume fraction of volume and matrix are the fundamental quantities that are used to predict the properties of the composite. In some cases, fiber aspect ratio and fiber orientation are also required.

Theoretical models for tensile properties of randomly oriented fiber distribution composites

Different theories are used to model the mechanical properties of the fiber reinforced composites. Some of them are:

1. Series Model **2. Parallel Model** **3.Hirsch's Model** **4.Einsten or Guth Model**

Amoung all these models Series Model gives the Highest value for the tensile Strength,

1. **Series Model**:

Tensile strength and tensile modulus are calculated using the equations

Series model

$$\sigma_c = \sigma_f V_f + \sigma_m V_f$$

$$E_c = E_f V_f + E_m V_m$$

Fibre Volume %	Volume Fraction		Tensile Strength
	V_f	V_m	(Mpa)
5	0.05	0.95	59.4
10	0.1	0.9	66.8
15	0.15	0.85	74.2

Where E, σ and V are Young's Modulus, Stress and volume fraction respectively. The subscripts c, f and m denote composite, fiber and matrix respectively.

2. Parallel Model:

Parallel Model

$$E_c = \frac{E_m E_f}{E_m V_f + E_f V_m}$$

$$\sigma_c = \frac{\sigma_m \sigma_f}{\sigma_m V_f + \sigma_f V_m}$$

Fibre Volume %	Volume Fraction		Tensile Strength
	V_f	V_m	(Mpa)
5	0.05	0.95	53.99
10	0.1	0.9	56.15
15	0.15	0.85	58.49

3.Hirsch's Model:

This model is the Modified version and combination of series and parallel model. According to Hirch's model, the stress and young's modulus are given by equation,

$$\sigma_c = x(\sigma_m V_m + \sigma_f V_f) + (1-x)\frac{\sigma_m \sigma_f}{\sigma_m V_f + \sigma_f V_m}$$

Fibre Volume %	Volume Fraction		Tensile Strength
	V_f	V_m	(Mpa)
5	0.05	0.95	54.53
10	0.1	0.9	57.22
15	0.15	0.85	60.06

Where 'x' is an emperical parameter that characterizes the stress transfer between the matrix and fiber. The value of x is taken as 0.4 for longitudinally oriented fiber composites and is 0.1 for random oriented fiber composites.

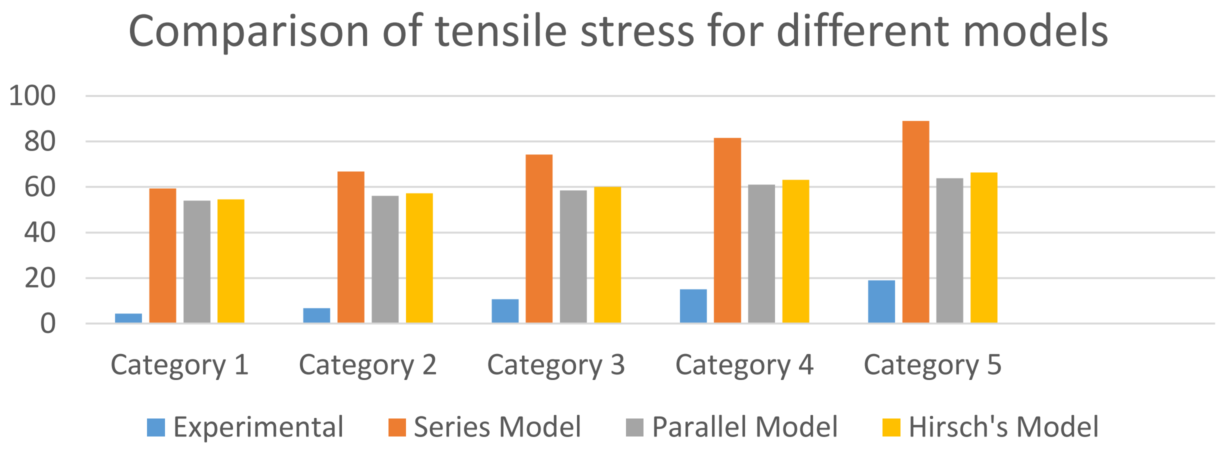
4.Einstein and Guth Model:

Tensile Modulus and Stress according to this model are given by equations,

$$\sigma_c = \sigma_m (1 - V_f^{2/3})$$

Fibre Volume %	Volume Fraction		Tensile Strength
	V_f	V_m	(MPa)
5	0.05	0.95	44.94
10	0.1	0.9	40.79
15	0.15	0.85	37.32

VII. Result and Discussion



CATEGORY	WIDTH (MM)	THICKNESS (MM)	CROSS SECTION AREA (MM2)	LOAD (N)	TENSILE STRENGTH (MPa)
5%	8.15	6.2	50.53	218.79	4.33
10%	8.15	6.2	50.53	348.66	6.9
15%	8.15	6.2	50.53	555.83	11

IX Conclusion

Hair based polymer composites. In the present work, hair composites are developed and their mechanical properties are evaluated. Also a step forwarded to use the waste material technically and enhance the properties of several existing material which can be more useful and can have advanced properties than the existing form.

Composite material can be designed and manufactured according to required properties. The key material properties for usual engineering mechanics applications are strength and stiffness. The usual design criterion for composite material is based on trying to align the fibres with most critically loaded directions of mechanical component. Again critical percentage of volume fraction of matrix material and fibre is also considered while designing the composite material. It is very important to find out elastic constants and other mechanical properties of an orthotropic (hair) composite lamina experimentally as many times theoretical and finite element approach for these may not give true results.

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