Comparison of Mechanical Properties on Composite Fiber material Prepared by hand lay up method and Fiber Reinforced Plastic method

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Abstract—There is a lot of demand for composite materials in the industries now day's .The Composite materials are replacing the traditional materials, because of its superior properties such as high tensile strength, low thermal expansion, high strength to weight ratio. In this project the Fabrication of Laminated Silk-Glass Fiber, coconut-glass fiber Epoxy Composites is developed and their Mechanical properties such as tensile strength, compression strength, impact strength flexural strength are evaluated. Fiber reinforced plastics (FRP) means the reinforcement of plastics with fiber; FRP provides light weight, high strength-to-weight ratio, Design freedom, high levels of stiffness, chemical resistance. In this project fabrication of FRP and mechanical properties such as impact strength, compression strength is evaluated. Compression GFRP and FRP is done based on their properties

Index Terms— Composite Fiber, Fiber Reinforced Plastic method, hand layup method, tension test, compression test, Impact test, flexural test.

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1 Introduction

The Use of Composite Materials Polymer based composite materials are characterized by their high stiffness and strength-to weight ratio, and owing to their inherent anisotropy it is possible to optimize load bearing capacity on the material level. The main drawback is that they are relatively expensive to manufacture, especially continuous, or advanced, fiber composites. Therefore, continuous fiber composites have so far found their application in areas where weight is of great concern and cost is not. Advanced composites are commonly used in sporting equipment (where perhaps cost is a concern!) such as rackets, hockey sticks and golf clubs. Another example is sailing boats, both for recreation and competition. The prime examples are, however, aerospace applications. It is of course very important to save weight on objects launched into space, and the increased manufacturing cost is of less concern since many of the objects are made in very small numbers - if not unique - so in these cases design is much more expensive than manufacture. A classical area for light and stiff construction is airplane design. Prior to World War II, wood was the most commonly used structural material. The stronger engines developed prior to and during the war, however, increased the forces on the airplanes and called for more complex fuselage and wing designs, so the material choice shifted to the newly developed aluminum alloys. This has been, and still is, the most important material in the airplane industry, but the amount of composite materials in airplane structures is increasing.

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A composite material can roughly be defined as a material with two (or more) distinct macroscopical phases. Often the morphology of the composite is such that one material, the matrix, surrounds the other. The surrounded material can for example have spherical, fibrous or disc shaped form, and when it comes to structural materials, fiber composites are most common. This has its origin in the fact that many materials can be manufactured with a much higher tensile to strength in fibrous than in bulk form. Glass for example has a relatively high stiffness-to-weight ratio but is virtually worthless as a structural material. The reason is, as everybody knows, that glass is very brittle. One small imperfection within a body of glass can trigger instable crack growth, and for glass in bulk form this is critical, whereas the fracture of one fiber in a bundle is not. The advantages of surrounding the fibers with a matrix material are that the matrix keeps the fibers in place, distributes load among them and protects them from external damage. In the case of structural fiber composites, polymers, such as epoxy, are commonly used as matrix materials. Laminates are made of plies, in which all fibers often have the same direction. The fibers are usually much stronger and stiffer than the matrix so a ply is stiffer and stronger in the fiber direction - it is anisotropic. A laminate, such as the one shown in Figure 1 usually contains plies with different fiber directions even if the load is primarily in one direction. The reason is that a laminate with fibers in only one direction would be very weak in the direction transverse to the fibers, and small transverse loads due to uneven lateral contraction, for example, could trigger fracture of such a laminate.

1.1 Glass Fibre Reinforced Polymers (GFRPs)

The term composite can be defined as a material composed of two or more different materials, with the properties of the resultant material being superior to the properties of the individual materials being superior to the properties of individual material that make up the composite. [1]Glass fibre Reinforced Polymers (GFRPs) is a fibre reinforced polymer made of a

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plastic matrix reinforced by fine fibre of glass. Fibre glass is a lightweight, strong, and robust material used in different industries due to their excellent properties. Although strength properties are somewhat lower than fibre and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are very favourable when compared to metals, and it can be easily formed using melding processes. Now a day's natural fibre such as silk, and jute fibre composite materials are replacing the glass and carbon fibres owing to their easy availability and cost. The use of natural fibres is improved remarkably due to the fact that the field of application is improved day by day especially in automotive industries. Several researches have been taken place in this direction. Most of the studies on natural fibres are concerned with single reinforcement. The addition of [4][5] natural fibre to the glass fibre can make the composite hybrid which is comparatively cheaper and easy to use.

1.2 Fiber-reinforced Composite

A fiber-reinforced composite (FRC) consists of three components: (i) the fibers as the discontinuous or dispersed phase, (ii) the matrix as the continuous phase, and (iii) the fine inter phase region, also known as the interface. This is a type of advanced composite group, which makes use of rice husk, rice hull, and plastic as ingredients. [6]This technology involves a method of refining, blending, and compounding natural fibers from cellulosic waste streams to form a high-strength fiber composite material in a polymer matrix. The designated waste or base raw materials used in this instance are those of waste thermoplastics and various categories of cellulosic waste including rice husk and saw dust FRC is high-performance fiber composite achieved and made possible by cross-linking cellulosic fiber molecules with resins in the FRC material matrix through a proprietary molecular re-engineering process, yielding a product of exceptional structural properties. Through this feat of [3]molecular re-engineering selected physical and structural properties of wood are successfully cloned and vested in the FRC product, in addition to other critical attributes to yield performance properties superior to contemporary wood. This material, unlike other composites, can be recycled up to 20 times, allowing scrap FRC to be reused again and again. The [7][8]failure mechanisms in FRC materials include intra laminar matrix cracking, longitudinal matrix splitting, fiber/matrix deboning, fiber pull-out, and fiber fracture.

2 Resin

The resins that are used in fiber reinforced composites can also be referred to as 'polymers'. All polymers exhibit an important common property in that they are composed of long chain-like molecules consisting of many simple repeating units. Man-made polymers are generally called 'synthetic resins' or simply 'resins'. Polymers can be classified under two types, 'thermoplastic' and 'thermosetting', according to the effect of heat on their properties. Polyamine based hardeners are used to cure epoxy resins at room temperature. Epoxies are usually sold as a two-pack system – Part A (epoxy resin) and Part B (hardener). There are many different types of hardeners available and polyamine based hardeners are a common type. Polyamine hardeners are made up of an organic molecule containing two or more amine groups. Other types of hardeners include polyamide hardeners and anhydride hardeners, although these types react only with heat.Polyamine hardeners used by the composites industry are usually made up of more than one polyamine compound and other additives to give the required properties. Epoxy resin and hardener are both supplied as liquids. When epoxy resin and polyamine hardeners are mixed at room temperature, they react and crosslink's are formed between the two chemicals. When some of the crosslink's have formed, the system forms a gel and is said to be "gelled". When most of the crosslink's have formed, the system forms a solid and is said to be "cured.

3 Methods of Preparation of Polymer Composites

1. Hand Lay-Up

2. Bag Molding

3. Resin Transfer Molding (RTM)

4. Pultrusion

5. Spray-Up

6. Fiber Reinforced Plastic Processes

7. Light Resin Transfer Molding

3.1 Composite preparation by Hand Lay Up Process

1. Chopped silk and cotton fibres of 50 mm length were used to prepare the specimen preparation.
2. Initially the glass fibres polymer, silk fibre/coconut fibre are dried in sun light to remove the moisture.
3. The cutter glass fibre1.2mm thick is placed on the Mylar sheet and then the resin is coated on the glass fibre using roller brush.
4. Further silk or cotton is placed on the glass fibre and resin is coated the resin in natural fibre.
5. Then another glass fibre plate is placed above the silk.
6. Again the resin is coated on the glass plate and fibre silk or cotton if placed on the glass plate it is the fourth layer.
7. Resin coated further evenly distributed in the fibre using roller, the fifth layer is placed glass.
8. After five layers laminated sheet is placed in the compression machine with 10bar pressure and 80°C.

9. Obtained is the composite specimen consists of total five layers in which glass fibre layers are fixed in top middle and bottom of the specimen.
10. Now the specimen is cut into required dimensions.

S.N 0	Load(KN)	Displacement(mm)	Strain	Stress(N/ mm^2)
1	4.26	0.4	0.0016	0.0181
2	4.4	1.4	0.0058	0.0185
3	5.9	9	0.0375	0.0245
4	5.96	12.8	0.0533	0.0248
5	50.82	13	0.0541	0.0242

Table 1: Tensile test for silk GFRP

S.N 0	Load(KN)	Displacement(mm)	Strain	Stress(N/ mm^2)
1	4.2	0.2	0.0008	0.0175
2	4.24	0.8	0.003	0.0177
3	5.2	7.4	0.026	0.0216
4	6.2	11.2	0.046	0.0258
5	4.24	12	0.05	0.0176

Table 2: Tensile test for coconut GFRP

3.2 Composite Preparation composite Fiber Reinforced Plastic Processes

1. First take the mild steel plate and make it into the rectangular box shape having a slot inside in it (mould) of required dimensions.
2. Wax is coated inside the mould.
3. Now the plastic granules are poured in to the injection molding machine and heated until the granules are converted to plasma state.
4. Now the plasma state plastic is poured in to the mould prepared as a layer.
5. Now the coconut fibers are placed on the plasma plastic layer.
6. .Again the hot plasma state plastic is poured on the fiber and process is repeated to get two layers of coconut fiber and three layers of plastic.
7. Now the mould is allowed to cool until it is converted into solid form and removed as shown in Fig 3.
8. Now the specimen is cut into required dimensions to perform tests.

4 TESTS AND CALCULATIONS

4.1Tensile Test:

The hybrid composite material fabricated is cut into required dimension using a saw cutter and the edges finished by using emery paper for mechanical testing. The tensile test specimen is prepared with Length = 290mm, width = 24mm, thick= 5mm.

Fig.2. Specimen for tensile test.

Fig.3 Specimen of coconut and silk GFRP.

A tensile test involves mounting the specimen in a machine and subjecting it to the tension. The testing process involves placing the test specimen in the universal testing machine and applying tension to it until it fails.

4.2 Calculation for Coconut GFRP:

Load =5820N

Displacement=12.8mm, maximum displacement=13mm.

Original area of cross-section A_0 =WXT=10X7.5=75mm^2

Area of cross section at neck A_X=wxt=10X6.5=65mm^2

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Original length L_0 =240mm, final length L_F=250mm.

Percentage reduction in area=A_0-A_FX100=75-65/75*100=13%

Percentage elongation=L_F-L_0X100=25-24/24X100=4.1%

Tensile strength=0.0242/0.0541=0.44.

4.3 Calculation for SILK GFRP:

Load =4240N
Displacement=11.8mm, maximum displacement=12mm.
Original area of cross-section A_0 =WXT=10X7.5=75mm^2
Area of cross section at neck AX=wxt=10X6=60mm^2
Original length L_0 =240mm, final length L_F=260mm.
Percentage reduction in
Area=A_0-A^FX100=75-60/75X100=25%.
Percentage elongation=L_F-L_0X100=26-24/24X100=8.3%.
Tensile strength=0.0176/0.0500=0.352
Length = 13mm, Width = 13mm, thick = 11mm

S.N 0	Load(KN)	Displacement (mm)	Strain	Stress(N/ mm^2)
1	7.1	0.1	0.00062	0.0443
2	11.08	1	0.0062	0.0692

Table 3: Compression test for silk GFRP

S.N 0	Load(KN)	Displacement (mm)	Strain	Stress(N/ mm^2)
1	7.1	0.1	0.00062	0.0443
2	11.08	1	0.0062	0.0692

Table 4: Compression test for coconut GFRP

4.4 Calculation for Compression Test:

Calculation for silk GFRPA:
Load =9580N
Displacement=1.1mm, maximum displacement=1.2mm
Area =20x7.5=150mm^2
Compression strength =0.0638/0.0700=0.91

Calculation for coconut GFRP:
Load =9960N
Displacement=1.1mm, maximum displacement=1.4mm
Area =20x7.5=150mm^2
Compression strength =0.0664/0.0700=0.94

Calculation for coconut FRP:
Load =4600N
Displacement=6.6mm, maximum displacement=8 mm
Area =20x7.5=150mm^2
Compression strength =0.0255/0.0366=0.69

4.5 Impact Test

Length = 75mm
Width = 10mm
Thick = 7.5mm
Length = 119.5mm
Width = 12mm
Thick = 5mm

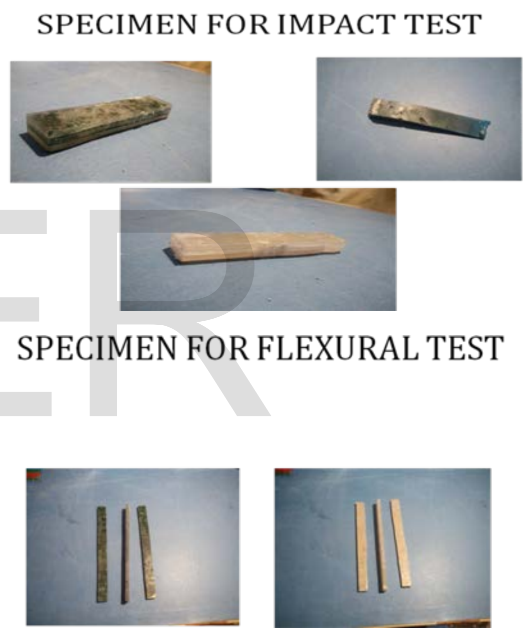

Fig. 4. Specimen of coconut and silk GFRP and also FRP

S.No	Specimen Material Name	Area of the Specimen at Notch(mm^2)	Energy absorbed at breaking point(J)	Specific Impact power(J/mm^2)
1	Silk Glass Fiber laminated polymer	44	8	0.18
2	Coconut Glass Fiber laminated polymer	44	8	0.18
3	Coconut Fiber reinforced	44	30	0.68

Table 5: Charpy test

S.No	Specimen Material Name	Area of the Specimen at Notch(mm^2)	Energy absorbed at breaking point(J)	Specific Impact power(J/mm^2)
1	Silk Glass Fiber laminated polymer	44	8	0.18
2	Coconut Glass Fiber laminated polymer	44	8	0.18
3	Coconut Fiber reinforced	44	32	0.72

Table 6: Izod test

4.6 Flexural Test

The flexural test measures the force required to bend a beam under three point loading conditions. The data is often used to select materials for parts that will support loads without flexing. Flexural modulus is used as an indication of a material's stiffness when flexed. Since the physical properties of many materials (especially thermoplastics) can vary depending on ambient temperature, it is sometimes appropriate to test materials at temperatures that simulate the intended end user environment.

S.N0	Load(KN)	Displacement(mm)	Strain	Stress(N/mm^2)
1	4.78	4.7	0.0338	0.0322
2	9	6.5	0.0468	0.0648
3	4.34	7	0.0504	0.0312

Table 7: Flexural test for silk GFRP

S.N0	Load(KN)	Displacement(mm)	Strain	Stress(N/mm^2)
1	4.92	4.2	0.0354	0.0302
2	5.4	5.8	0.0418	0.0389
3	4.86	6.2	0.0446	0.035

Table 8: Flexural test for coconut GFRP

Calculation for Flexural Test

Formula
M/I=F/Y=E/R
I=$bd^3/12$=75x203, 12=5000mm^4
M=4.34/7x5000=3100N/mm

Calculation for Coconut GFRP:
Gauge length =185mm, Thickness =7.5mm

Tensile Test for Silk GFRP:
Force = 4240N Displacement =11.8mm
Maximum displacement =12mm
Cross-sectional area =240mm^2
Tensile strength = 0.0176N/mm^2
Elongation = 8.3 % Reduction in area = 24 %

Tensile Test for Coconut GFRP:
Force = 5820 N
Displacement = 12.8mm
Maximum displacement = 13mm
Cross-sectional area = 240mm^2
Tensile strength = 0.0242N/mm^2
Elongation = 4.1 %
Reduction in area = 23 %

Compression Test For Silk:
Force = 9580 N
Displacement = 1.1mm
Maximum displacement = 1.2mm
Cross-sectional area = 185mm^2
Compression strength = 0.87N/mm^2

Compression Test Coconut GFRP:
Force = 9960 N
Displacement = 1.1mm
Maximum displacement = 1.3mm

Formula
M/I=F/Y=E/R
I=$bd^3/12$=75x203, 12=5000mm^4
M=4.86/6.2x5000=3920N-mm
Cross-sectional area = 185mm^2
Compression strength = 0.92N/mm^2
Compression Test Coconut GFRP:

Force = 9960 N
Displacement = 1.1mm
Maximum displacement = 1.3mm
Cross-sectional area = 185mm^2
Compression strength = 0.92N/mm^2

Flexural Test for Silk GFRP:
Force = 4340 N
Displacement = 7mm
Cross-sectional area = 138.75mm^2
Flexural strength = 0.61N/mm^2

Flexural Test for Coconut GFRP:
Force = 4920 N
Displacement = 6.2mm
Cross-sectional area = 138.75mm^2
Flexural strength = 0.78N/mm^2

Impact Test:
Area of the specimen = 22x2 = 44mm2

$$\text{Specific impact power} = \frac{Energyabsorbed}{areaofcross\sec tion}$$

30/44 = 0.68

5. Conclusion

Form table 1 and 2 Coconut laminated GFRP is having the high tensile strength than silk GFRP (0.72). compression strength has no much variation based on fibers From table 5 and 6 Coconut FRP is having the high specific impact strength than coconut laminated GFRP & silk laminated GFRP.From table 7 and 8 Coconut laminated GFRP is having the high flexural strength than silk laminated GFRP (0.69).

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