Mechanical Property Analysis on Sandwich Structured Hybrid Composite Made from Natural Fibre, Glass Fibre and Ceramic Fibre Wool Reinforced with Epoxy Resin

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Abstract. Natural fibre composites find wide range of applications and usage in the automobile and manufacturing industries. They find lack in desired properties, which are required for present applications. In current scenario, many developments in composite materials involve the synthesis of Hybrid composite materials to overcome some of the lacking properties. In this present investigation, two sandwich structured hybrid composite materials have been made by reinforcing Aloe Vera-Ceramic Fibre Wool-Glass fibre with Epoxy resin matrix and Sisal fibre-Ceramic Fibre Wool-Glass fibre with Epoxy resin matrix and its mechanical properties such as Tensile, Flexural and Impact are tested and analyzed. The test results from the two samples are compared and the results show that sisal fibre reinforced hybrid composite has better mechanical properties than aloe vera reinforced hybrid composite.

1. Introduction
Stacking of several layers of different composite materials with many layers of natural and man-made fibre is a base for the development of hybrid composites. The main intention of using hybrid composite is to overcome the lacking properties of the fibres over the other in a single matrix material. In economical way, the unique features of hybrid composite have paved a way to meet the design requirements in a more subtle way, than the conventional materials. Natural fibres from plants [1] are reinforced with thermosetting plastics and they find their application in various industries, automobile sectors and so on. The surface properties of these natural fibres are enhanced by subjecting them to chemical treatments [2]. The fine fibres of glass are intermingled in mat form and they are reinforced with polymer matrix to get light weight robust material for industrial, automobile and aerospace application.

The ceramic fibre wool, a mineral fibre made by man and the main constituents present in it are alumina and silica. It has some phenomenal energy saving property, that dissipates heat from the furnace, so it has low thermal conductivity. The glass fibre and various natural fibre reinforced hybrid polymer composites are studied by cicala et al [3]. They have observed the properties and performance of these hybrid composites for the application of curved pipes. Idicula et al[4] have studied the thermo physical properties of natural fibre reinforced polyester composites and they found that, the heat transport ability of these composites are improved due to the reinforcement of polyester composite made with natural fibre along with glass fibre. Ye han et al[5] have studied the friction performance of ceramic fibre wool for automotive brake lining application and they endow that, wear rate of the material is increased and the heat fading resistance property of the material is improved because the aluminum and silicon contents present in the wool have increased to 5 % weight. In this study, two
different composition of hybrid composite specimens are prepared and subjected to mechanical property testing such as tensile, flexural and impact test. The test results and graphs of these two hybrid composite specimens are compared and described in detail. The results prevails that, one of the hybrid composite specimens has better mechanical property than the other.

2. Experimental

2.1. Materials
Aloe vera (Aloe Barbadensis), Sisal (Agave sisalana), Ceramic fibre wool and E-Glass fibre are the core materials based on which, two different hybrid composites are prepared and tested. Aloe vera and Sisal fibre mat from Jute Weaver Association, Anakaputhur, Ceramic fibre wool from B.M. Insulations Pvt. Ltd, Gerugambakkam and E-Glass fibre from Sakthi Fibres, Saidapet are procured and suitable binders for these fibres are chosen which include Epoxy Resin of grade LY 556 and hardener of grade HY 906, which are procured from Sakthi Fibres. Fabrication and Mechanical Testing of this specimen are carried out at L.M.P R&D, Laboratory, Pallipalayam, Erode, Tamil Nadu, India.

2.2. Hybrid Composite preparation
Two hybrid composite specimen are sandwiched to form the resultant hybrid composite of 300 x 300 mm dimension with 5.5 mm thickness. Sandwich structured hybrid composite specimen incorporates an innermost layer of Ceramic fibre wool covered by an intermediate double layered E-glass fibre, which again is enclosed by a double layered woven Aloe vera in the former and Sisal fibre in the later. Epoxy resin of LY 556 grade is mixed with HY 906 grade hardener at the proportion of 10:1. On each layers of the hybrid composite, a required amount of epoxy resin is applied on both fibre surfaces and then reinforcement is done in compression moulding machine. For curing of specimen, 100°C temperature for duration of 30 minutes is maintained within the machine. After the curing process, the specimen is taken out from the compression moulding machine.

2.3. Specimen preparation
The cured specimen taken from the compression moulding machine is properly barbered to carry out mechanical property testing such as Tensile, Flexural and Impact as per ASTM standard. The images of the barbered specimen before and after testing are shown in Figure 1.

Fig. 1 Specimen used before and after the testing
2.4. Mechanical properties

2.4.1. Tensile testing
The Universal Testing Machine of model number KIC-2-1000-C is used to carry out tensile test on the barbered specimen as per ASTM-D3039 standard [6]. At a speed of 2 mm/min, six strip shaped samples of (dimension 250 x 25 x 5.5 mm) specimen are tested and then, the values are taken and the graph (stress-strain and load-displacement) generated by the machine is shown in the figures 2 and 3.

![Stress-Strain curve and Load-Displacement curve](image1)

**Figure 2.** Stress-Strain curve and Load-Displacement curve are generated by UTM for Tensile test of Sisal fibre + E-Glass fibre + Ceramic fibre wool Hybrid composite.

![Stress-Strain curve and Load-Displacement curve](image2)

**Figure 3.** Stress-Strain curve and Load-Displacement curve are generated by UTM for Tensile test of Aloe vera fibre + E-Glass fibre + Ceramic fibre wool Hybrid composite.

2.4.2. Flexural testing
As per the ASTM-D790 standard [7], six samples of (dimension 125 x 13 x 5.5 mm) of two different composition specimen are subjected to three point testing. The compressive and tensile forces are experienced by the upper and lower surface of the specimen and hence, the shear force is induced in the central part of the specimen, so that, the flexural behaviour is examined up to its yield point. During testing, the stress-strain graph generated by the machine is shown in figures 4 and 5.

![Stress-Strain curve and Load-Displacement curve](image3)

**Figure 4.** Stress-Strain curve and Load-Displacement curve are generated by UTM for Flexural test of Sisal fibre + E-Glass fibre + Ceramic fibre wool Hybrid composite.

![Stress-Strain curve and Load-Displacement curve](image4)

**Figure 5.** Stress-Strain curve and Load-Displacement curve are generated by UTM for Flexural test of Aloe vera fibre + E-Glass fibre + Ceramic fibre wool Hybrid composite.
Figure 4. Stress-Strain curve is generated by UTM for Flexural test of Sisal fibre + E-Glass fibre + Ceramic fibre wool Hybrid composite.

Figure 5. Stress-Strain curve is generated by UTM for Flexural test of Aloe vera fibre + E-Glass fibre + Ceramic fibre wool Hybrid composite.

2.4.3. Impact testing
The hybrid composite specimen samples of two different compositions mentioned above are subjected to heavy impact load to measure the impact force of the specimen against rupture. The testing was carried out as per the ASTM-D256 standard [8] for three specimens of (dimensions 65 x 13 x 5.5 mm) two different compositions to get an average value and the specimen’s image is shown in figures 1.

3. Result and Discussion
Nowadays, hybrid composite materials are used in various field, because their mechanical properties have surpassed the conventional materials. Mechanical testing’s such as Tensile, Flexural and Impact test on the two different hybrid composite are performed and their mean average values are correlated with each other, which are described in the Table 1, where Sample 1 represents Sisal fibre + E-Glass fibre + Ceramic fibre wool Hybrid composite and Sample 2 represents Aloe vera fibre + E-Glass fibre + Ceramic fibre wool Hybrid composite.

Table 1. Mechanical properties of tested Hybrid composites.

| Composite sample | Tensile properties | Flexural properties | Impact strength (J) |
|------------------|--------------------|---------------------|---------------------|
|                  | Peak load (KN)     | Ultimate Tensile Strength (MPa) | % Elongation | Flexural load (KN) | Flexural Strength (MPa) |                  |
| Sample 1         | 7.639              | 101.857             | 3.067             | 0.461            | 110.951               | 1.90              |
| Sample 2         | 5.848              | 77.98               | 1.467             | 0.371            | 89.35                 | 1.75              |

3.1. Tensile properties
In Universal Testing Machine, six samples from two different compositions of hybrid composite specimen are tested until rupture and the ultimate tensile strength of the specimens is determined. While testing the specimen, at peak load the rupture takes place, along with percentage elongation is determined and the graph generated by the machine for stress-strain and load-displacement is plotted and they are shown in the figures 2 and 3 respectively. From the figure 2, load-displacement curve of Sample 1 has the high value of ultimate tensile strength of 101.857 MPa than the Sample 2 of 77.98 MPa. Also, the peak load of Sample 1 value 7.639 KN is higher than the Sample 2 value 5.848 KN. Similarly, the stress-strain curve showed in the Figure 2 for the above two samples shows the same result as that of the load-displacement curve in which the percentage elongation of Sample 1 value 3.067 is higher than Sample 2 value 1.067.

3.2. Flexural properties
The flexural strength for Sample 1, with the value of 101.961 MPa is higher than Sample 2 value, 89.35 MPa and the flexural load is higher for Sample 1 value, 0.461 KN than the Sample 2 value, 0.371 KN and this is perceived from the Table 1. The stress-strain curves for the above two samples reveals the same as shown in Figures 4 and 5. The measure for the flexural strength is stiffness. The stiffness of the Sample 1 is increased to a little extent than Sample 2, because of the proper binding force between the fibres, wool and matrix of Sample 1 than Sample 2.

3.3. Impact properties
The capability of impact for the above mentioned specimens is carried out in Izod impact machine and the energy loss of the specimens is found out through the reading given by the machine. The response of impact leads to the formation and development of crack and breakage of resin, fibre and wool interface. The readings from the machine are presented in the Table 1 and it clearly shows that the
Impact strength for Sample 1 value, 1.90 J is little higher than Sample 2 value, 1.75 J. This prevails that, the resistivity of Sample 1 is higher than Sample 2.

4. Conclusion

In this present study, one type of specimen is made of Sisal fibre, E-glass fibre, Ceramic fibre wool and epoxy resin matrix and another one is made of Aloe vera fibre, E-glass fibre, Ceramic fibre wool and epoxy resin matrix. These are fabricated and subjected to mechanical property test such as tensile, flexural and impact test. The test results of these two specimens are compared and then, the conclusions are drawn:

- The tensile test prevails that sample 1 has higher ultimate tensile strength value, 101.857 MPa and higher peak load, 7.639 KN.
- The sample 1 has the capability of higher flexural strength value, 110.951 MPa and higher flexural load, 0.461 KN than sample 2.
- Impact strength is high for sample 1 with the value of 1.90 J, while, sample 2 has lower impact strength of 1.75 J.

5. References

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