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HYBRIDISATION CHARACTERISTICS OF GLASS / BASALT FIBER EPOXY MATRIX COMPOSITE

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ABSTRACT
Researches show that fibre reinforced composite are the best suitable material for structural applications and it gain widest market share. But the limited capability of toughness made it less useful. So hybridisation is a very useful concept to flourish their toughness property. Hybridisation is the process of combining two or more fibres while manufacturing and thus produce great suitability for structural applications. The hybrid composite greatly produce better balancing properties than non hybrid composites. It is quite cumbersome to predict their properties since they have a magical sync with both fibres. This paper triesto establish the properties ofGlass fibre which is one of the natural fibre and Basalt fibre which is well-known rock fibre . Both are purely natural fibre and an over view of tensile, impact and shear properties of hybrid and non hybrid composite are established here to find the optimal one. Glasswas prepared in the form of strands and the properties of Glass cane are improved by invoking Basalt fibre in Araldite epoxy matrix. Here laminates of both fibres are used for manufacturing composite by hand lay – up method. Two laminates of Glass cane is replaced by the Basalt fibre mat.

Keywords: Glassfiber, Basalt fiber, Araldite Aw 106 epoxy resin, Hardener HV 953 U, Mechanical properties

1. INTRODUCTION

Synthetic fibres are widely used for Making composite for structural applications since it have specific material properties and less weight. In the past few lustrum bio based reinforced composite are used because it have reasonable properties and cost effectiveness (Shaoxiong Liang et al.2015). The bio based vegetable fibres are including flax, hemp, banana, Glass, jute, sisal and coir. The comprehensive research on sisal (Barreto ACH et al. 2011) jute (Behera Ajaya Kumar et al. 2012) and flax (Yongli Zhang et al.2013) reveals that natural fibres have inherent capacity to replace the synthetic fibres like glass and nylon. The designated interest in natural fibres are due to they are copious in nature and reversible too.

The natural fibres provide human friendly environment than glass fibres (Joshi SV et al. 2004). Also natural fibre composite has very good thermal properties and acoustic performance thus it is determinant choose for automobile and aeronauticalapplications. But their limited toughness may limit their use in safety sensitive applications.

On the past recent years, toughening of natural fibre reinforced composite has been play an important role in research area. Many differentconceptshave been proposed to strengthen the fibre reinforced composite. One of the most researched strategies is toughening by hybridization (Yentl Swolfs et al.2014). In hybrid composite there have at least two types of fibres are invoked in the matrix. This review focused on strengthening of Glass fibre by using basalt fibre which having the mineral origin bonded with Araldite epoxy matrix. Overthe recent years researches in hybrid composite is very popular due to the cost effectiveness while comparing with carbon composite (Shaoxiong Liang et al. 2015). This paper reviews about the inetrply type of hybrid composite since the composite pertains about the different stacking length of Glass and basalt fibre. Hybridization result in the advantage of one fibre could complement what are lowest in the other (Moe MoeThwe et al. 2003)

In other words the behaviour of non hybrid and hybrid composite of Glass and basalt in araldite epoxy matrix under tensile –tensile cyclic loading with fibre content and their orientation of stacking. The specimens are prepared by hand lay-up method.

In the last few decades the researches have advanced boosting on the study of cost effective, high performance thermoplastic composite like glass wool composite (Yongli Zhang et al.2013). But the glass wool composite have lot of disadvantages while considering human comfort. Glass fibres are non degradable so it should be a sediment in nature as a residue at the end of its life time. And also it can’t be reusable and can’t be abolish any environmentalfriendly method. Glass fibres are very abrasive and also have some ecological disadvantages. So in view of this some specimens are made with Glass/basalt fiberand found that the composite is a superior quality than glass. Thus having lot of environment friendly properties (N.V. Rachchh et al. 2014) and cost effective. Glass is one of the most popular materials for furnishing household items.

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2. MATERIALS

Composite plates are prepared using Glass/basalt fibre and Araldite Aw 106 standard epoxy resin and hardener HV 953 U using hand layup technique. These plates are prepared by ASTM standardand tested to determine their mechanical properties.

2.1 Material Preparation

Glass is a naturally renewable plant that belongs to the palm family Arecales or Palmea. Africa, Asia and Australasia are the regions for their growth. Glass having slender stems, 2–5 cm diameter.Glasss are superficially similar to bamboo, butGlass and bamboo are drastically different materials. Glass is a solid while bamboo is hollow. Despite being one of the world's strongest woods, Glass is flexible and can be shaped into intricately designed furniture Glass sheaths have spines for protection, along with ‘whips’ that are also covered with spines. These play a major role in supporting the Glass as it grows over trees and other plants in the rainforest. Glass is an attractive resource because it is easier to harvest than timber, and is also easier to transport, while and it also grows faster than trees. Glass canes are cut in the forest and are partially processed before being sold. Canes with small diameters are dried in the sun and often smoked using sulphur. Large canes are boiled in oil to make them dry and to protect them from insects. Fibres are prepared 1mm thick, 2 mm width and 300 mm length and these fibres are used for preparing unidirectional woven fabric. Thedensity of Glasswas $0.52gm/cm^3$

Basalt is one of the most enormous quantities of rock in earth crust. It’s a mineral originated from volcanic explosions, dark or black in colour. It having glassy or crystalline structure and sometimes available in the form of porphyry. Its rocks are tough, heavy and resistant. Basalt fibre woven fabric is provided by Arrow Technical Textiles Private Limited (Type FAU 600-111) and having density of 2.65 gm/cm3. Araldite epoxy resin supplied by Huntsman Advanced Materials (India) Pvt. Ltd.,Mumbai was selected as polymer matrix. An Araldite Aw 106 epoxy(density 1.15 - 1.25 g/cm3 at 25 °C and viscosity 30 - 50 Pas at 25 °C) was mixed with a hardener HV 953 U(density .95 g/cm3 at 25 °C and viscosity 20 - 35 Pas at 25 °C .at await ratio of 100/80

According to N.V. Rachchh et al.(2014) The rattan cane composite having maximum tensile strength in 12.5% reinforcement .So in this review the specimens are prepared by 88% of matrix for better convenience. Reinforcing phase contains 12 % fabric; both fibres are mix together in the increasing weight percentage of basalt. Test specimens were made using woven type of arrangement. For handlayup in woven form first specimen is prepared in the form ofplate strip with 4 mm thick, 200 mm width and 200 mm length.

The interweaving of warp (0°) fibres and weft (90°) fibres in a regular pattern or weave style produces the reinforcement of Glass fibre. Mechanical interlocking in between each strand helps to perfect packing of woven fibres. Enhasability, surface lustre and stability ofcomposite are managed by the weaving style.One or morewarp fibres are alternativelywoven over some weft fibres in systematic recapitulate manner.

Excellent adhesion, chemical and heat resistance, mechanical properties, and outstanding electrical insulating properties bring the epoxies best suitable for composite manufacturing. The chemical resistance of epoxies is magnificent against basic solutions. The extended range of properties made them the best choice for critical applications even if they are more expensive and havelonger cure times.Araldite AW 106 epoxy resin/Hardener HV 953U epoxy adhesive is a multi-purpose, viscous material that is suitable for bonding a variety of materials including metal, ceramic, and wood. Araldite AW 106 resin/Hardener HV 953U epoxy adhesive cures at temperatures from 68ºF (20ºC) to 356ºF (180ºC) with no release of volatile constituents. The mechanical and bonding properties of matrix will help to hold thefibres in their proper position. The matrix having the capability to save the fibres from abrasion and helps to transfers loads between fibres. The most peculiar property of matrix is that theyprovides reasonable interlaminarshear strength.

3. METHODOLOGY

Sample specimens are made by hand lay-up method (C.S. Verma et al.2012). Glassand basalt fibres are added in woven type of arrangement (N.V. Rachchh et al. 2014). For hand layup in woven form Glass fibres are prepared in thin strip of 1mm thickness and arranged in woven form. For getting sufficient thickness four layers are enough. Eachlayer of Glass and basalt are properly arranged in mould. Releasing agent and polythene sheets are used in either side of mould for properly release laminate from mould. Then Araldite AW 106 epoxy resin is added with 80% HV 953U ashardener. After adding matrix to the mould curing starts. Its takes 24 hours in normal room temperature.

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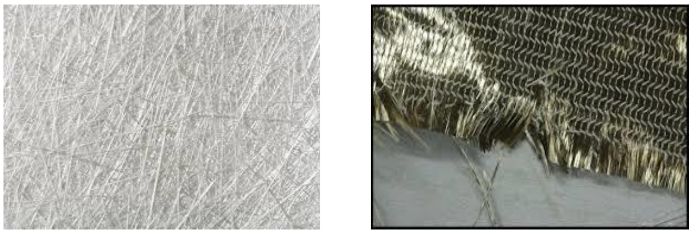

(A) (B)

Figure 1 Sample Fibres

Laminates are made with four different proportions of Glass/basalt fibre. Thevarious combination of fibre and epoxy resin for making sample plates are as shown in Table 1 and Figure 1(A) & (B).Now these plates are tested for different mechanical properties.

Table 1 Fibre and epoxy percentage in laminate

Plate No.	Representation	% of Epoxy	% of Glass fibre	% of Basalt fibre
1	GFRP	88	12	0
2	G8B4	88	8	4
3	G4B8	88	4	8
4	BFRP	88	0	12

4. TESTING

Mechanical testing is one of the most common testing procedures in the field of polymer materials since it evaluates the fundamental properties of engineering materials, which helps to identify future engineering materials and control the quality of materials. This helps to improve the use of engineering materials in structural and construction fields. If a material is used in structural applications and subjected to load, it is very essential to know the properties including tensile, shear and flexural strength. Because all structural application needs the materials with better reliability and life span without breakage. Plates made with Glass and basalt is tested for tensile strength, hardness, impact strength and shear strength (N.V. Rachchh et al. 2014). Specimens are prepared with different weight fraction of Glass and basalt as specified in table 1.

4.1 Tensile Strength

Tension test is probably the common testing method to find mechanical properties of engineering materials. This test is looking for how the materials behave under the action of force. This test gives the properties like yield strength, ultimate strength and percentage of elongation upon loading. This type of destructive testing thus the specimen should deform or permanently break during test. Testing specimens are prepared as per ASTM D 412 standard and testing are done in Universal Testing machine

4.2 Flexural Strength

Itis the measure of ability of a material to resist deformation under load. Flexural strength is not a basic property; it’s actually the combined benefit of tensile, shear and compressive properties. When flexural strength testing is the criteria for testing materials the above three properties are induced in the material upon testing. This is a very common method for testing electronics components. The wide market share of electronics made this as very popular. The important mechanical parameter provided by the flexural test is modulus of elasticity which provides the rigidity of materials. Three point bend test is popularly used since these test have more significance in human interface utility items including mobile phones and touch screens. These items need more reliability in their expected life time thus makes more market share. For testing ASTM D-790-10 standards are used and tested in Universaltesting machine.

4.3 Hardness Test

Hardness is the opposition of a materialto localized distortion that leads to permanent shape changes. The term can be applied to the shape changes by contortion, buckling, twisting, warping, bending and wrenching. In most of the polymer matrix composite the distortion can be considered as plastic deformation of surface. The behaviour of solid materials under stress is very complex and thus it indicates that hardness is not a basic property of a material. The well established property of composite material like yield strength, work hardening, true tensile strength and modulus made them very peculiar to the application which is very sensitive to shape changes. Hardness of all specimens is measured in Durometer as per ASTM D-2240 standard. Result is in unit-shore D.

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4.4 Impact Strength

Impact strength is the amount of energy that can be absorbed by a material under plastic deformation developed at high speed. Charpy and Izod test are commonly used to investigate the property of material under impact loading. The natural fibre polymer composite have comparatively reasonable property than glass fibre polymer composite. Impact strength of all specimens was measured in Charpy testing device as per ISO 1487-1:2016 standards.

4.5 Scanning Electron Microscope

The cross sectional view of tensile- tested specimens were inspected using scanning electron microscopy (SEM)(JEOL,JSM-7610F) to evaluate the damage process during tensile loading. SEM is type of electron microscope that produces surface images by using focused high beam electrons. The electron beams interact with the specimen produces some designated signals that include the topography of the sample.

5 RESULTS AND DISCUSSION

This paper reviews the hybridization characteristics of Glass/basalt fibre composite. The present investigation reveals the mechanical property and surface characteristics of polymer matrix composite. The result includes the evaluation of tensile strength, flexural strength, and hardness and SEM analysis. The specimen preparation and all tests are conducted in laboratory in ambientroomtemperature.

5.1 Tensile Test Result

Tensile properties of the composite were measured based on ASTM D412 and the test speed was 10mm/min. The width, thickness and gauge length of the specimen are 20 mm, 2 mm and 35 mm respectively. The specimens were cut in dog-bone shape as per ASTM standard. From each specimen three testing samples are prepared and the average value is provided in the table. The result obtained is shown in the table 2 and figure 3. It is observed thatthe tensile strength of the specimen is increased with the increasing weight percentage of basalt fibre. The specimens were visually investigated to get the best samples which are free from pores, blow holes and crack. From this study we can conclude that basalt is one of the strength boosting fibre can be used along with Glass.

Table 2 Tensile test result

Plate No.	% of Glass Fibre	% of Basalt Fibre	Tensile Stress in MPa
1	12	0	36.543
2	8	4	61.535
3	4	8	70.506
4	0	12	74.730

5.2 Flexure Test Result

Flexural strength specimens were investigated based on ASTM D-790-10 standard.The test was carried out in Universal testing machine and test speed was 1mm/min. The specimens were prepared as per ASTM standard and having the shape of dog-bone. From each laminates three samples are prepared for test. The obtained flexural property values are shown in the table 3 and figure 4.It was observed that the flexural strength of the specimen were increased drastically up to 8% (by weight) of Glass fibre and after that it decreased The specimens were visually investigated to get the best samples which are free from pores, blow holes and crack.

Table 3 Flexural test result

Plate No.	% of Glass Fibre	% of Basalt Fibre	Flexural Strength in MPa
1	12	0	34.028
2	8	4	45.450
3	4	8	65.958
4	0	12	59.218

5.3 Hardness Test Result

The test was carried out in Durometer as per ASTM D-2240 standard. The result obtained was shown in the table 4 and figure 5. The result is in unit Shore- D. The range off result should fall between 0 and 100, the higher value indicate harder material. The loading value for Shore- d type is 4536 g. The hardness of the specimen is increased with increase in weight percentage of basalt fibre.

Table 4 Hardness test result

Plate No.	% of Glass Fibre	% of Basalt Fibre	Hardness in Unit Shore-D
1	12	0	35
2	8	4	38

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3	4	8	39
4	0	12	41

5.4 Impact test result

The test was carried out in Charpy impact tester (AIT-300-EN) as per ISO 1487-1:2016 standards. The nominal dimension of specimen was 10 mm x 4 mm x 55 mm. The capacity of the instrument is limited to 300 J. The testing was carried out in ambient room temperature. The specimens were visually investigated to get the best samples which are free from pores, blow holes and crack. The result obtained is shown in table 5 and figure 6.It is observed that the impact energy of the specimens is decreased with the increase in weight percentage of Glass fibre.

Table 5 Impact test result

Plate No.	% of Glass Fibre	% of Basalt Fibre	Impact Energy in J
1	12	0	2.715
2	8	4	2.542
3	4	8	2.107
4	0	12	2.001

5.5 Scanning electron Microscopy

SEM analysis is carried out in the failure area of the specimen under tensile loading. The images are shown in figure 2

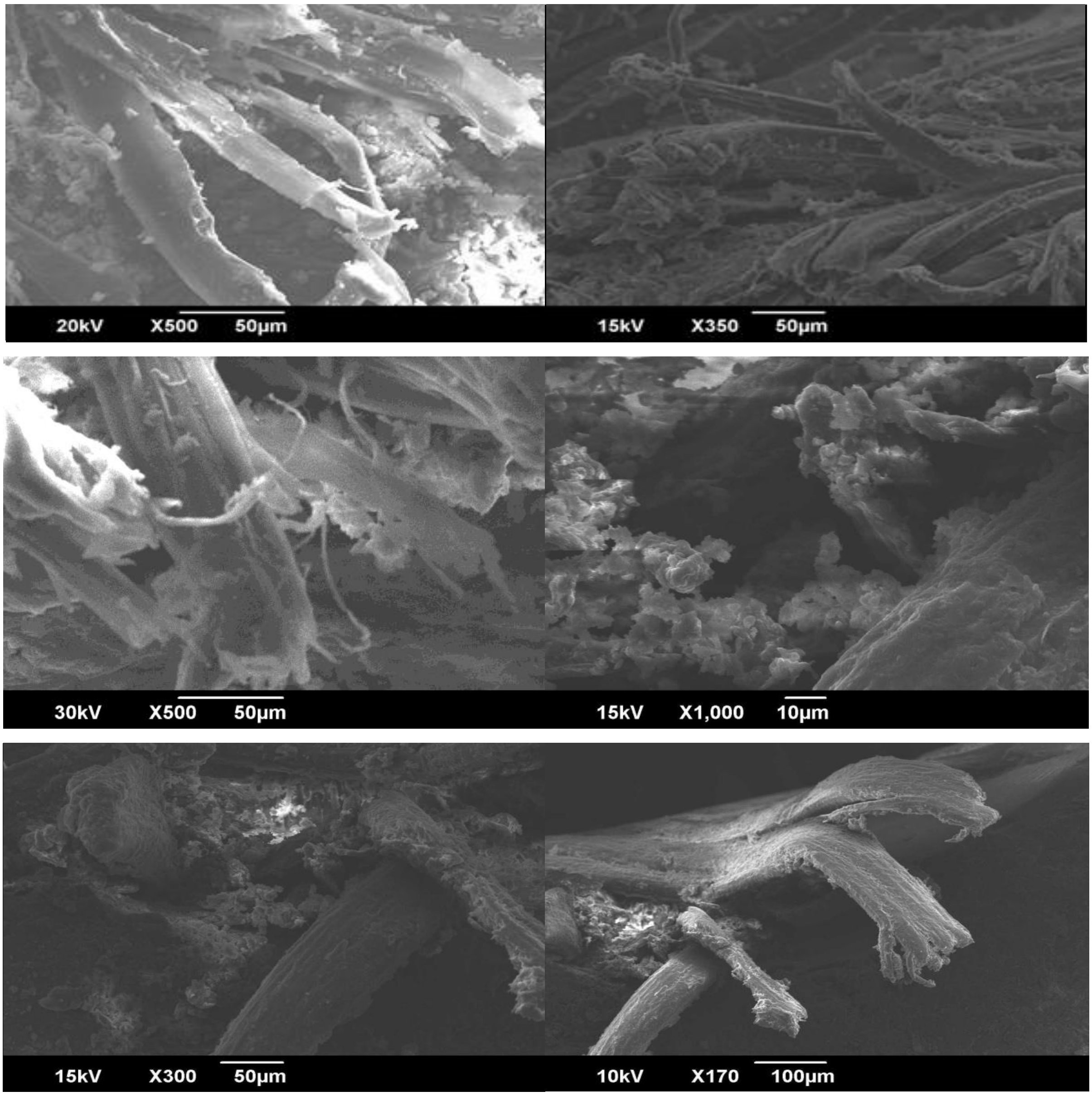

Figure 2 SEM images

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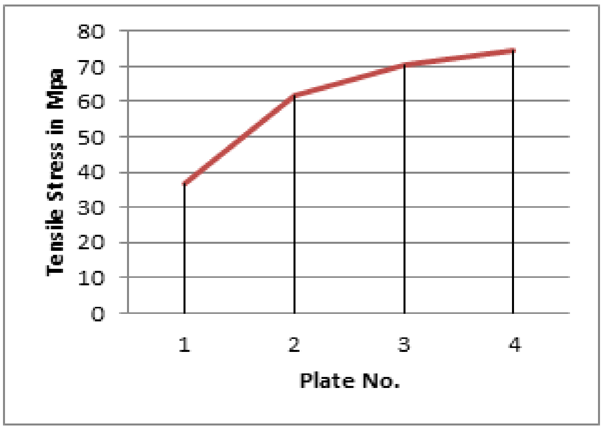

Figure 3 Tensile test results

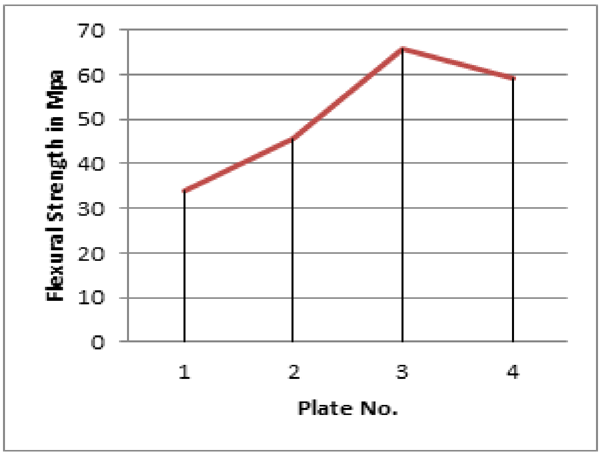

Figure 4 Flexural test results

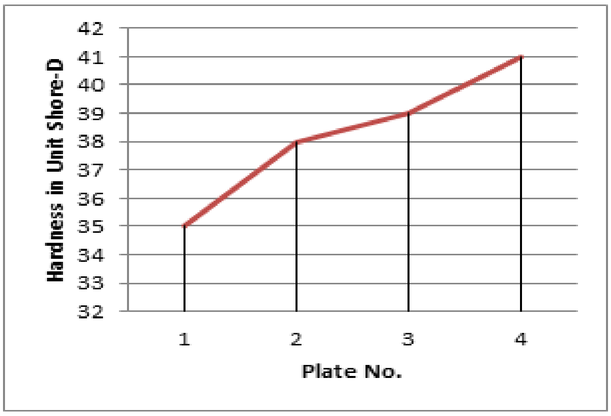

Figure 3 Tensile test result

Figure 6 Impact test result

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6. CONCLUSION

The main conclusion observed upon hybridization of Glass with basalt were as follows

- It is observed that the tensile strength of the specimen is increased with the increasing weight percentage of basalt fibre.
- It was observed that the flexural strength of the specimen were increased drastically up to 8% (by weight) of Glass fibre and after that it decreased.
- The hardness of the specimen is increased with increase in weight percentage of basalt fibre.
- The impact energy of the specimens are decreased with the increase in weight percentage of Glass fibre.

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